Value evaluation of high-tech enterprises based on Black-Scholes model -- a case study of Hikvision

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Abstract. High-tech enterprises refer to enterprises that carry out research and development in the fields of high-tech and emerging technologies, form independent intellectual property rights and carry out corporate activities based on them. In the process of high-speed development, due to the needs of corporate mergers and acquisitions, listing and financing, high-tech enterprises The value evaluation is particularly important. This paper discusses the valuation of high-tech enterprises based on Black-Scholes model.

1. Introduction

High-tech enterprises refer to enterprises that carry out research and development in the fields of high-tech and emerging technologies, form independent intellectual property rights and carry out corporate activities based on them. In the process of high-speed development, due to the needs of corporate mergers and acquisitions, listing and financing, high-tech enterprises The value evaluation is particularly important.

The main characteristics of high-tech enterprises are as follows: long investment period, high risk, high returns, and great differences in each stage. The characteristics of high-tech enterprises determine the difficulties they face when conducting value evaluation, including the following aspects.

(1) Many high-tech enterprises, especially those in the start-up stage, have large fluctuations in profit, and it is difficult to make profit or even no profit. This feature determines that the profit status of high-tech enterprises cannot be measured according to the current profit indicators.

(2) Lack of enterprise operating information and less historical data. Due to the short time of establishment of high-tech enterprises, there are often only two or three years of financial data, so many important financial indicators, such as price-earnings ratios and working capital, are not relevant and historical. Comparability makes it difficult for investors to use relevant indicators for evaluation.

(3) High-tech enterprises vary widely, and it is difficult to confirm industry standards and benchmarking enterprises. There are two main reasons for this. First, due to the large differences in technology, scale, and operating environment of high-tech enterprises, various factors will make it difficult for companies to compare. In addition, China's high-tech industries are still in the development stage, the external regulatory environment of enterprises is immature, and the total number of high-tech enterprises and the market size are limited, making it difficult to make overall comparisons at the market level.

In summary, due to the above difficulties in the valuation of high-tech enterprises, traditional corporate valuation methods such as market method and cost method may not be applicable. Therefore, when assessing the value of high-tech enterprises, it is necessary to target specific enterprises according to their characteristics. Select the valuation method of the assessed company.
2. Overview of corporate valuation methods

The value evaluation of an enterprise is a process of evaluating and estimating the long-term development of an enterprise from the perspective of the market. It integrates the impact of corporate profitability, economic environment, and human judgment. Today's domestic and foreign experts and scholars' methods of evaluating enterprises include cost method, market method, and income method. In recent years, emerging technology methods such as option pricing method have also been used. The following will introduce the calculation methods and applicable scope of the above four methods, and discuss various methods for high-tech enterprises. Applicability of valuation.

2.1. Cost method

Cost method, also known as cost summation method or asset-based method, is the most traditional method of corporate valuation and is most often used in corporate liquidation. This method is mainly based on the book value of various assets and liabilities of the enterprise, which will be The assets and liabilities of the assessed enterprise are summed up, and the value of each basic element is evaluated item by item, and the total value of the enterprise is obtained after auditing and verification. The replacement cost method is the core concept of the cost method, which refers to the current period. The total cost of repurchasing the asset. For high-tech enterprises, the cost method has obvious limitations because the cost method is mainly applicable to enterprises with a large proportion of tangible assets and easy to evaluate, and because the value of intangible assets of high-tech enterprises is more obviously, and the value of intangible assets is highly uncertain and subjective, this method is obviously not applicable.

2.2. Market method

The use of the market method for corporate valuation can be understood as confirming the fair value of the assessed enterprise. It is generally assumed that the value is equivalent to the price of similar assets in the same active market, and the price is measured by the equity information of other companies with similar transactions. Contrast. Market law emphasizes that future income is reflected in the current value and can reflect market investors' views on the company. Market law is applicable to the valuation of stable operating companies, especially listed companies, when the market is efficient. High-tech companies do not have corresponding market conditions, it is difficult to confirm the prices of similar assets, and they are subject to accounting restrictions. Many important indicators, such as price-to-book ratios and price-to-earnings ratios, have no reference value. In addition, when using the market method to assess the value of enterprises, the external macro Environmental factors have a large impact, which may cause large fluctuations and deviations in value estimates.

2.3. Income method

With the development of management concept and financial market, the fundamental goal of enterprises has shifted from profit maximization to shareholder equity maximization. The application of income method is an important embodiment of this transformation. Under the income method, the value of the enterprise does not depend on the amount of existing assets, but on the future profitability of the enterprise and the net inflow of cash. Therefore, the main idea of the income method is to discount the expected future earnings of the assessed enterprise according to the expected rate of return of the market. As a method to reflect the intrinsic value of enterprises, income method has become an international method to evaluate the overall intrinsic value of enterprises, including cash flow discount method, internal rate of return method, capital asset pricing model and other methods. The discounted cash flow method is the most commonly used valuation method for enterprises at present. It mainly evaluates the value of the future predicted cash flow generated by the current assets of enterprises, but it lacks the measurement of the potential value of the assets formed in the future, so the income method also has some defects.

2.4. Option pricing method

In 1973, Professor Fischer Black of the University of Chicago and Myron Scholes of Stanford University jointly proposed the famous option pricing model, the Black-Scholes model, which laid the
foundation for various derivatives pricing methods. Options refer to power. Within the agreed period, the holder can, at his discretion, decide whether to buy or sell an asset at a predetermined price. According to the nature of the underlying asset (financial or physical assets), it is divided into financial options and real options. The value of the option $C$ is determined by factors such as the market price $S$, the exercise price $X$, and the holding period $T$. For a buyer option, the market price $S$ is higher than the exercise price $X$ and the value is $S - X$, and the market price $S$ is less than or equal to the exercise price. The value at $X$ is 0. The value is based on 0, which represents the price of power will not exceed the market price. The Black-Scholes model can be used for a large number of options-like assets.

3. Principles of Option Pricing

In the selection process, the following conditions must be considered.

3.1. Basic assumptions of the Black-Scholes model

1. The price of the underlying asset follows a log-normal distribution;
2. The risk-free interest rate is constant;
3. There is no friction in the market, that is, ignoring tax and transaction costs;
4. The target asset does not distribute dividends during the validity period;
5. The option is a European option, that is, it can be exercised only on the expiration date.
6. There is no opportunity to use market spreads to arbitrage;
7. Investors can borrow at risk-free rates;

3.2. The expression of the Black-Scholes model

$$C = SN(d_1) - Xe^{-rT}N(d_2) \tag{1}$$
$$d_1 = \frac{\ln\frac{S}{X} + (r + 0.5\sigma^2)T}{\sigma\sqrt{T}} \tag{2}$$
$$d_2 = d_1 - \sigma\sqrt{T} \tag{3}$$

Where $C$ is the value of the call option, $S$ is the market price of the underlying asset, $X$ is the exercise price, $T$ is the holding period, $N(d)$ is the probability that the standard normal distribution is less than $d$, $r$ is the risk-free interest rate, and $\sigma$ is the asset price volatility.

When high-tech enterprises evaluate whether to invest in a patent result, they can choose to continue to invest in research and development results for commercialization, or they can choose not to use it. This choice of opportunity can be regarded as the power provided by the company’s held call options in the market. When the economy is booming, investing in the project can bring profits and future cash inflows to the company. The value of this option is greater than zero; if it is not adopted, the value of this choice opportunity is equal to zero. The enterprise as a whole is a carrier of real options, and its equity and debt are regarded as the underlying assets. The exercise price is the total debt. When the total assets are greater than the liabilities, the enterprise value is greater than zero.

4. Case analysis

4.1. Selection of case enterprises

This article selects Hikvision as a case company, taking December 30, 2018 as the evaluation day, using the Black-Scholes model to evaluate the value of the company, and discussing the accuracy of the Black-Scholes model in the application of corporate valuation. Hikvision is a smart IoT solution and big data service provider with video technology as its core. In 2016, Hikvision combined deep learning algorithms and products to launch a full range of deep intelligent product families. In 2018, hikvision deepened and integrated the AI Cloud product line, and proposed the data architecture of AI
Cloud integration. During the reporting period, on the basis of video technology, the new businesses of hikvision have developed steadily and have the potential of long-term sustainable development.

4.2. Parameter estimation

1. Asset market price $S$. That is the total of Hikvision's total debt and the value of equity. According to the 2018 annual report of Hikvision, the total equity at the end of the period was 9,227,270,473 shares, and the total debt was 9,127,825,736.49 yuan; Provide data. The company's closing price on December 28, 2018 was 25.76 yuan. According to this calculation, the market price $s$ of available assets was 246,822,313,120.97 yuan.

2. Exercise price $X$. As mentioned above, the exercise price can be regarded as the total liabilities. According to the 2018 annual report of Hikvision, the company's total liabilities are 9,127,825,736.49 yuan.

3. Holding period $T$. As the development of high-tech enterprises is more flexible under the influence of the market, their development has greater uncertainty. This article limits the operating period of the enterprise to 3 years, that is, $t = 3$.

4. Risk-free interest rate $r$. The interest rate of government bonds is generally regarded as a risk-free rate. According to the 2018 financial market operation report released by the People's Bank of China, the value of the 3-year Treasury bond at the end of 2018 is 2.87%.

5. Asset price volatility $\sigma$. The total value of the company is equal to the sum of the value of its equity and debt. Because the debt has the characteristics of quantity and amount stability, its volatility can be ignored, so the volatility of available equity value is the fluctuation of stock price. The rate reflects the fluctuation of the company's value. Using Guotai'an database, select Hikvision (stock code: 002415) daily return rate on all trading days from January 1, 2018 to December 31, 2018. Calculate the standard deviation of the sample to get the daily volatility of 2.7042%, then multiply by the square root of the number of trading days in 2018 $\sqrt{246}$. You can get the annualized volatility $\sigma = 42.41\%$.

The calculation method and value of each parameter are shown in the following table:

| Parameter                      | Calculation method                                      | Value                  |
|--------------------------------|---------------------------------------------------------|------------------------|
| Asset market price $S$         | Total liabilities at the end of the year + total equity at the end of the year * closing price at the end of the year | 246,822,313,120.97     |
| Strike price $X$               | Total liabilities at the end of the year                | 9,127,825,736.49       |
| Holding period $T$             | Estimated value                                         | 3                      |
| Risk-free interest rate $r$    | 3-year government bond yield                            | 2.87%                  |
| Asset price volatility $\sigma$| Daily Volatility $\times \sqrt{246}$                   | 42.41%                 |

Substituting the above calculation results into formulas (2), (3), and (1), we can get: $d_1 = 4.9733$, $d_2 = 4.2388$, $C = 2.38448E+11$

Because the total share capital of Hikvision at the end of 2018 was 9,227,270,473 shares, the theoretical stock price estimated by using the Black-Scholes model is the estimated option price divided by the total share capital of 25.84 yuan.

5. Conclusion

Referring to the error comparison method proposed by Yuan Mingzhe and Pan Ailing (2016), the error between the theoretical stock price and the actual stock price is:

$$\eta = \left| \frac{\text{Theoretical Stock Price} - \text{Real Stock Price}}{\text{Theoretical stock price}} \right| \times 100\%$$

(4)

The theoretical stock price is 25.84 yuan. Regarding the determination of the actual stock price, this article uses the average closing price of Hikvision Co., Ltd. from January 1, 2018 to January 31, 2018 as a reference. Through the Guotai'an database, the average value can be calculated to be 40.94 yuan.
Therefore, the error rate is: \( \eta = \frac{|25.84 - 28.31|}{25.84} \times 100\% = 9.56\% \). The error rate is small, indicating that the Black-Scholes model is more accurate and effective for high-tech enterprises.

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