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Valuation of High-Tech Enterprises Based on FCFF and B-S Combined Model: A Case Study of Hengrui Pharma

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Abstract

Since high-tech enterprises are characterized by a large proportion of intangible assets, high investment, high risk, high uncertainty, etc., simply choosing traditional valuation methods to assess the high-tech enterprises does not take into account the potential value of the future uncertainty of such enterprises. Taking Hengrui Pharma as an example, this paper adopts the combination model of FCFF and B-S combined model to evaluate the value of high-tech enterprises. The results show that the combination model effectively reduces the deviation from the market price and greatly increases the accuracy of the valuation, which verifies the validity of the method for the valuation of high-tech enterprises and provides a reference for the selection of valuation methods for other enterprises of the same type.

Keywords

High-Tech Enterprises, Valuation, FCFF Model, B-S Model

1. Introduction

Correct enterprise valuation is a prerequisite for financing and listing, business decision-making and fair trading. Compared with general enterprises, high-tech enterprises are characterised by a large proportion of intangible assets, high investment, high risk and high uncertainty. The case enterprise involved in this paper—Hengrui Pharma is precisely a high-tech enterprise belonging to the pharmaceutical industry, and the project of research and development is facing greater risks and opportunities. The value of this type of enterprise is not only constituted by the existing profitable value, but also includes the value of its future development capability, such as the growth potential and market competitiveness of high-

tech enterprises, which are of great potential value space. Therefore, the value of Hengrui Pharma should be composed of both existing value and potential value. However, it is difficult to calculate its potential value if only traditional valuation methods are used. Therefore, for this kind of enterprise, the real option valuation method should be introduced on the basis of the traditional valuation method.

Next, the methods of enterprise valuation are reviewed in terms of traditional valuation method and real options valuation method. In particular, traditional valuation methods include absolute valuation method and relative valuation method.

2. Valuation Methods

2.1. Traditional Valuation Methods

1) Absolute valuation methods

Absolute valuation method is a method to estimate the value of an enterprise by building a financial model based on factors such as future profitability, cash flow or growth potential of the enterprise. Among them, the Free Cash Flow to the Firm (FCFF) model is a commonly used absolute valuation method, which was first proposed by American scholar Alfred Rappaport in the 1980s, who defined the cash flow of an enterprise after meeting its capital expenditures and working capital needs, and discounted it to the present value to determine enterprise value (Rappaport, 1981). Prof. Tom Copeland, one of the senior leaders of McKinsey & Company, Inc. further elaborated on the concept of free cash flow in 1990 and gave specific calculation methods (McKinsey & Company Inc. et al., 2000).

In addition, the Economic Value Added (EVA) model is also a type of absolute valuation method, which assesses the value of an enterprise by calculating its net operating profit after tax minus the cost of capital. The introduction of EVA is an innovation in financial valuation thinking, which was first proposed by Stern Stewart Consulting in 1990 and quickly gained widespread use around the world (Madsen et al., 2020).

2) Relative valuation methods

The relative valuation method, on the other hand, is a method of estimating the value of a target enterprise by comparing market valuation indicators of similar enterprises (e.g., price-earnings ratios, price-net ratios, price-sales ratios, etc.). This method is simple and easy to implement, but relies on the accuracy and comparability of market data.

2.2. Real Options Valuation Methods

In addition to the above two main methods, there is also the valuation method based on option pricing model, which was first proposed by Black and Scholes (1973). Geske (1979) analyzed the parameters of the B-S model and came up with the theory that the enterprise has a compound option value, and later put forward

the theory of the classic compound option pricing model, which can calculate the potential value of the enterprise.

The real option method treats the future investment opportunities owned by the enterprise as an option, and considers that the value of the enterprise should be the sum of the value of the cash flow created by its existing assets and the value of the option hidden in the future investment opportunities. The proposal of real option value largely makes up for the shortcomings of the traditional valuation method, so the real option method is widely used in the value assessment of high-tech industries and strategic emerging industries nowadays (Liang, 2011; Zhao, 2021).

To summarize, enterprise valuation is a multi-dimensional and multi-method comprehensive assessment process, which requires flexibility in selecting and applying different valuation methods according to specific situations. In practical application, the selection of enterprise valuation methods needs to consider factors such as the characteristics of the enterprise, the industry in which it operates, its financial situation and the market environment. At the same time, enterprise valuation is also closely related to risk assessment, and reasonable risk assessment can help to conduct enterprise valuation more accurately.

The case enterprise involved in this paper, Hengrui Pharma, belongs to the high-tech enterprises in the pharmaceutical industry, and the project of research and development is exposed to large risks and opportunities. The value of this type of enterprise is not only composed of the existing profitable value, but also includes the value of its future development ability, such as the growth potential and market competitiveness of high-tech enterprises, which are of great potential value space. However, this part of the potential value is difficult to calculate by using the traditional valuation method. Therefore, for this kind of enterprises, the real option valuation method should be introduced on the basis of the traditional valuation method.

3. Cases Background

3.1. Company Profile

Jiangsu Hengrui Pharmaceuticals Co., Ltd. (hereinafter referred to as "Hengrui Pharma") was founded in 1997. In 2000, It was listed on the Shanghai Stock Exchange (stock code 600276.sh).

According to the company profile on Hengrui Pharma's homepage, we know that Hengrui Pharma is a pharmaceutical company engaged in the development and commercialization of innovative and high-quality drugs. It is a well-known supplier of oncology drugs, surgical drugs, and interventional imaging solutions in China. Hengrui Pharma ranked 21st among the top 1000 global pharma companies announced by Torreya in 2020. Hengrui Pharma has been on the Pharma Exec's annual listing of the top global pharmaceutical companies for the third consecutive year, rising from 47th in 2019 to 38th in 2021.

Innovation is the core of Hengrui Pharma's development strategy. Hengrui

Pharma's R&D investment in recent years has accounted for about 17% of revenue. It spent 768 million USD (4.99 billion RMB) in R&D in 2020, which is nearly 18% of the 2020 revenue. It has built a large-scale, professional, and comprehensive innovative drug research staff of more than 4500 people. Sixteen R&D centers were built around the world and several subsidiaries were established in the US, EU, Australia, and Japan. It has 8 innovative products marketed, more than 50 innovative candidates in the R&D stage, and more than 20 innovative products under clinical development around the world. As of October 2021, 1275 patent applications have been submitted, with 346 patents granted in China and 463 patents granted worldwide, such as the US, EU, and Japan.

Hengrui Pharma has also made great efforts in the construction of high-end human resources, investing a large amount of money to build a research and development team of more than 3000 people, and building its own laboratories and research and development bases both at home and abroad. The emphasis on research talent has resulted in Hengrui Pharma's industry-leading technological advantages.

3.2. Assessment of Applicability Analysis

1) Highly representative

The purpose of this paper is to construct a reasonable pharmaceutical enterprise value assessment model, in order to verify the applicability and accuracy of the model, it is necessary to select representative pharmaceutical enterprises as the assessment object for case study. Due to the late development of China's pharmaceutical industry, a large number of enterprises are in the start-up stage, and these enterprises have defects such as smaller scale, fewer R&D projects, and less comprehensive business layout, which make it impossible to assess them as representatives of the industry. Hengrui Pharma, as a leading enterprise in the pharmaceutical industry, not only has a mature sales model, but also has a rich product line, strong operating ability and profitability, and a mature management model, making it highly representative.

2) To meet the basic conditions of the real options method

Compared with traditional industries, pharmaceutical enterprises are characterized by high level of science and technology, large investment in research and development, susceptibility to national policies, and high enterprise risk, which also leads to a different value composition of pharmaceutical enterprises. Pharmaceutical companies have many R&D projects, huge investment amount, high risk of R&D products on the market, and many R&D projects make the future earnings and development of enterprises full of uncertainty. Taking Hengrui Pharma as an example, Hengrui Pharma's R&D investment is very high, the future of the research and development of drugs listed or not for the development of the enterprise has a great impact, and the R&D process of new drugs are basically more than ten years, the project success of the high degree of uncertainty, which is also in line with the scope of application of the real options method of valuation.

Therefore, Hengrui Pharma, as the valuation object of this paper, has high applicability.

4. Case Studies

4.1. Valuation of Existing Assets Based on the FCFF Model

1) Determination of the discount rate

One of the important roles of the discount rate, as a core parameter of the discounted free cash flow model, is to provide some measure of the risk of the business in order to match the returns to the risk factors in the valuation model. In the discounted free cash flow model, the discount rate is often replaced by the weighted average cost of capital calculated (WACC) based on historical data, and this value remains constant over the forecast period of earnings. Therefore, the weighted average cost of capital is used as the discount rate in assessing the value of Hengrui Pharma's existing assets. In order to measure the operation of Hengrui Pharma in the production process, it can be done by comparing the rate of return of the company with the rate of cost of capital. If the rate of return is greater than the rate of cost of capital, it indicates that the company's operation is profitable.

A company's long-term capital consists of long-term debt and owner's equity, so WACC can next be calculated from both the cost of debt capital and the cost of equity capital respectively.

a) Cost of debt capital

Enterprises may have many different types of debt, and long-term and short-term borrowing have different interest rates, so theoretically, it is necessary to calculate the corresponding costs of different debts, and then arrive at a comprehensive weighted average cost of debt. Considering that in practice this indicator is mainly used for capital budgets and long-term budgets, the impact of long-term debt on this indicator is mainly considered in the calculation process, therefore, other short-term debt is usually ignored and only long-term debt is considered. Considering that the benchmark lending rate can be obtained directly and can be used as a guiding rate for lending, this paper selects the lending rate of 4.30% for loans with a maturity of more than 5 years announced by the People's Bank of China in September 2022 as the basis for accounting, i.e., 4.30% is the pre-tax cost of debt capital.

According to the actual situation, Hengrui Pharma has been recognized as a high-tech enterprise by Chinese government, and it is expected that Hengrui Pharma will continue to be recognized as a high-tech enterprise in the next few years. So it is considered that after a number of years Hengrui Pharma will still be subject to the high-tech income tax rate of 15%. Therefore after calculation it can be concluded that the company's after-tax cost of debt capital is:

$$4.30\% * (1\% - 15\%) = 3.66\%$$

b) Cost of equity capital (K_e)

This paper uses the Capital Asset Pricing Model (CAPM) to calculate the cost of equity capital of the company (Sharpe, 1964; Myers & Turnbull, 1977). The capital asset pricing model links the risk and return of the stock, which can be used to calculate the cost of equity capital based on the parameters such as the beta coefficient of Hengrui Pharma's stock and the market interest rate, with the following formula:

$$K_e = R_f + \beta (R_m - R_f)$$

R_f: risk-free rate. This paper selects 2.64%, the yield of the 5-year treasury bonds on December 31, 2022 as the risk-free rate of return.

R_m: market portfolio return. The market portfolio average return can be calculated based on the average return of A-share CSI 300 index. By checking the database, the average return of A-share CSI 300 index in the past five years is 11.64%.

β: beta coefficient of the stock. β is a very important factor in the capital asset pricing model and refers to the systematic risk coefficient, which is mainly used to measure the price volatility of a stock or fund relative to the market as a whole, and the higher the value of volatility, the higher the risk and return. The beta coefficients of Hengrui Pharma for the years 2018-2022 are shown in **Table 1** below:

Then the cost of equity capital of Hengrui Pharma can be obtained as **Table 2**:

Table 1. β of Hengrui Pharma, 2018-2022.

year	2018	2019	2020	2021	2022
β	1.21	0.85	0.75	1.06	1.06

Data source: Author's compilation based on RESET database.

Table 2. Cost of equity capital of Hengrui Pharma, 2018-2022.

year	2018	2019	2020	2021	2022
R_f	2.64%	2.64%	2.64%	2.64%	2.64%
β	1.21	0.85	0.75	1.06	1.06
R_m	11.64%	11.64%	11.64%	11.64%	11.64%
Cost of equity capital	13.53%	10.31%	9.37%	11.15%	11.18%

Data source: Author's compilation based on RESET database.

c) Weighted average cost of capital (WACC)

Calculating the WACC of a company requires first analyzing the capital structure of that company. This can be analyzed by calculating the ratio of total liabilities and total equity in its balance sheet to total assets, respectively. The following **Table 3** shows the situation related to the capital structure of Hengrui Pharma from 2018-2022:

By calculating the historical capital structure data of Hengrui Pharma from 2018 to 2022, based on the above data, the WACC of Hengrui Pharma for the

years 2018-2022 is calculated according to the formula as shown in **Table 4** below:

Table 3. Capital structure of Hengrui Pharma, 2018-2022.

year	2018	2019	2020	2021	2022
Total assets/RMB 100 Million	223.61	275.56	347.30	392.66	423.55
Total liability/RMB 100 Million	25.63	26.19	39.43	36.94	39.42
Total equity/RMB 100 Million	197.98	249.38	307.87	355.72	384.13
Debt capital ratio	11.46%	9.50%	11.35%	9.41%	9.31%
Equity capital ratio	88.54%	90.50%	88.65%	90.59%	90.69%

Data source: Author's compilation based on corporate annual reports.

Table 4. Weighted average cost of capital for Hengrui Pharma, 2018-2022.

year	2018	2019	2020	2021	2022	average
Cost of debt capital	3.66%	3.66%	3.66%	3.66%	3.66%	
Debt capital ratio	11.46%	9.50%	11.35%	9.41%	9.31%	-
Cost of equity capital	13.53%	10.31%	9.37%	11.15%	11.18%	
Percentage of equity capital	88.54%	90.50%	88.65%	90.59%	90.69%	
WACC	11.40%	9.68%	8.72%	11.35%	11.38%	10.71%

Data source: Author's compilation based on corporate annual reports.

As can be seen, the 2018-2022 WACC data is not volatile and the average of WACC is determined to be 10.71%.

2) determination of the Free cash flow

Next, this paper will calculate the FCFF of Hengrui Pharma based on the methodology and steps in Greenwood & David (2012).

a) Forecast of operating revenues

The forecast of a company's future operating revenues growth rate is generally based on the analysis of the company's past operating conditions, and reasonable forecasts are made based on the company's historical financial data. The operating revenues of Hengrui Pharma for the past ten years are shown in **Table 5** below:

Table 5. Hengrui Pharma's revenue and growth rate, 2013-2022.

year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Operating revenues /RMB 100 Million	62.03	74.52	93.16	110.94	138.36	174.18	232.89	277.35	259.06	211.75
growth rate (%)	-	20.14	25.01	19.09	24.72	25.89	33.70	19.09	−6.59	−17.9

Data source: Author's compilation based on corporate annual reports.

As can be seen from above **Table 5**, 2013-2020 Hengrui Pharma operating revenues have increased, of which the operating revenue growth rate in 2019 is the

largest. 2021 and 2022 operating revenues are negative growth, Hengrui Pharma attributed to the generic drug collection, innovative drugs, health insurance negotiations, the epidemic caused by the shrinkage of the business volume of the medical institutions of the three reasons, the most important is the impact of the generic drug collection. is the impact of generic drug collection and procurement. However, in the 2022 annual report, the collection risk has been basically released, with innovative drugs ushering in the harvest period, Hengrui Pharma's future performance is expected to open a sustained growth. Therefore, in order to ensure the accuracy of data calculation, this paper excludes the negative growth rate of operating revenues in 2021-2022, and the calculation is based on the average growth rate of operating revenues in 2014-2020 as the growth rate of operating revenues in the forecast period, and the average value is 23.95%.

b) Operating costs and expenses

In forecasting other major financial indicators, the percentage of sales method is used, by analyzing and calculating each indicator as a percentage of operating revenues, and then calculating the specific value of each indicator based on the forecasted operating revenues, and the percentage of each indicator in the forecast period is shown in **Table 6**:

Table 6. Hengrui Pharma costs and expenses value and percentage, 2018-2022.

year	2018	2019	2020	2021	2022	average
operating revenues/RMB 100 Million	174.18	232.89	277.35	259.06	211.75	-
business costs/RMB 100 Million	23.35	29.13	33.49	37.42	34.87	-
Business taxes and surcharges /RMB 100 Million	2.37	2.16	2.57	2.02	1.90	-
sales expense/RMB 100 Million	64.64	85.25	98.03	93.84	73.48	-
overhead/RMB 100 Million	16.26	22.41	30.67	28.60	23.06	-
Operating costs as a percentage	13.40%	11.51%	11.07%	14.44%	16.39%	13.76%
Business taxes and surcharges as a percentage	1.36%	0.93%	0.93%	0.78%	0.89%	0.98%
Cost of sales as a percentage	37.11%	36.61%	35.34%	36.22%	34.54%	35.96%
Overheads as a percentage	9.34%	9.62%	11.06%	11.04%	10.84%	10.38%

Data source: Author's compilation based on corporate annual reports.

According to the data in above **Table 6**, Hengrui Pharma has done a good job of controlling the level of costs and expenses, and the proportion of operating costs and expenses to operating revenues has changed relatively little over the years. Therefore, according to the average proportion of costs and expenses to operating revenues in the past five years 13.76%, 0.98%, 35.96%, and 10.38% to predict its future costs and expenses.

c) Depreciation and amortization

According to the data in the 2018-2022 annual report of Hengrui Pharma, the depreciation and amortization data for the past five years are in **Table 7**.

Table 7. Depreciation and amortization values and percentage of Hengrui Pharma, 2018-2022.

year	2018	2019	2020	2021	2022	average
Depreciation and amortization /RMB 100 Million	3.79	6.19	4.48	4.96	5.39	-
Depreciation and amortization as a percentage	2.18%	2.66%	1.62%	1.91%	2.53%	2.18%

Data source: Author's compilation based on corporate annual reports.

The amount of the program varies relatively little from year to year, and the average share of the last five years, 2.18%, was used as the basis for the projections.

d) Net increase in working capital

Operating working capital is calculated as the difference between operating current assets and operating current liabilities. Operating current assets are assets that are frequently turned over and indispensable to the company's production process, and are key to sustaining production and thus sales revenues, which can bring the company's shareholders the desired operating results. When calculating the operating current assets, relevant improvements should be made, and the non-operating essential current assets should not be included, because these assets are not directly related to the company's supply, production and sales. Based on the above analysis, operating current assets mainly consist of notes and accounts receivable, prepayments, other receivable, and inventories.

Operating current liabilities are incurred by the company based on the good credit it has with its suppliers and are also incurred by the company for the purpose of ongoing production and operation. Similar to current operating assets, current liabilities that are not directly related to the company's production and sales are not included in current operating liabilities, so operating liabilities are mainly composed of notes and accounts payable, receipts in advance, taxes payable, and other payable.

The working capital calculations for 2018-2022 are shown in **Table 8** below:

The amount of change in the program from year to year is small, and the average of the net increase in working capital as a percentage of operating revenues for the assessment base period is 4.57%, which is used to project the net increase in working capital for the next five years.

e) Capital expenditures

Capital expenditure is the net cash paid for the acquisition of fixed assets, intangible assets and other long-term assets. Capital expenditures for 2018-2022 are calculated as shown in **Table 9** below.

The amount of change in the program from year to year is small, and the average value of capital expenditures as a percentage of operating revenues for the assessment base period is 4.61%, which is used to project capital expenditures for the next five years.

(f) Free cash flow projections

Based on the above analysis, the free cash flow forecasts for 2023-2027 are as **Table 10**:

Table 8. Working capital values and percentage of Hengrui Pharma, 2018-2022.

year	2018	2019	2020	2021	2022	average
Notes and accounts receivable/RMB 100 Million	44.32	54.35	50.74	57.14	63.94	
Prepayments/RMB 100 Million	5.69	5.91	5.62	9.73	10.55	-
Other receivable/RMB 100 Million	10.14	8.94	6.51	6.58	5.62	
inventory/RMB 100 Million	10.31	16.07	17.78	24.03	24.51	
Operating current assets/RMB 100 Million	70.45	85.27	80.65	97.47	104.62	-
Notes and accounts payable/RMB 100 Million	14.02	11.89	14.33	22.53	17.68	
Advance receipts/RMB 100 Million	2.23	2.23				-
Taxes payable/RMB 100 Million	1.32	2.25	1.76	1.66	1.19	
Other accounts payable/RMB 100 Million	7.36	7.35	17.96	7.00	2.82	
Operating current liabilities/RMB 100 Million	24.94	24.72	34.05	31.20	21.69	-
Working capital/RMB 100 Million	45.51	60.55	46.60	66.28	82.93	
Net increase in working capital/RMB 100 Million	10.44	15.04	-13.95	19.68	16.65	-
Net increase in working capital as a percentage	6.00%	6.46%	-5.03%	7.60%	7.83%	4.57%

Data source: Author's compilation based on corporate annual reports.

Table 9. Capital expenditures value and percentage of Hengrui Pharma, 2018-2022.

year	2018	2019	2020	2021	2022	average
Cash paid for acquisition of property, plant and equipment, intangible assets and other long-term assets/RMB 100 Million	5.29	5.61	5.54	16.65	19.92	-
Net cash recovered from disposal of fixed assets, intangible assets and other long-term assets/RMB 100 Million	0.04	0.01	0.04	0	0.36	-
Capital expenditure/RMB 100 Million	5.26	5.60	5.51	16.65	19.56	-
Capital expenditures as a percentage	3.02%	2.41%	1.99%	6.43%	9.19%	4.61%

Data source: Author's compilation based on corporate annual reports.

Table 10. Free cash flow forecast for Hengrui Pharma, 2023-2027.

vintages	2023	2024	2025	2026	2027
I. Operating revenues/RMB 100 Million	262.46	324.49	401.16	495.95	613.14
Less: Operating costs/RMB 100 Million	36.12	44.65	55.2	68.24	84.37
Business taxes and surcharges/RMB 100 Million	2.57	3.18	3.93	4.86	6.01
sales expense/RMB 100 Million	94.38	116.69	144.26	178.34	220.49

Continued

overhead/RMB 100 Million	27.24	33.68	41.64	51.48	63.64
II. Earnings before interest and taxes/RMB 100 Million	102.15	126.29	156.13	193.02	238.64
Less: Income tax/RMB 100 Million	15.32	18.94	23.42	28.95	35.8
Net operating profit after tax/RMB 100 Million	86.83	107.35	132.71	164.07	202.84
Add: Depreciation and amortization/RMB 100 Million	5.72	7.07	8.75	10.81	13.37
Less: net increase in working capital/RMB 100 Million	11.99	14.83	18.33	22.66	28.02
capital expenditure/RMB 100 Million	12.1	14.96	18.49	22.86	28.27
Enterprise free cash flow	68.46	84.63	104.63	129.35	159.92

3) Calculation of the value of existing assets

The two-stage growth model is considered to analyze the future development of Hengrui Pharma in two stages: the first stage is the forecast period and the second stage is the perpetual stable growth period. This paper takes five years as the forecast period, i.e., 2023-2027 as the perpetual stable growth period, and assumes that Hengrui Pharma will enter the stable development stage after 2027. The perpetual growth rate of Hengrui Pharma is selected as the forecasted national GDP growth rate of China in 2027. Upon inquiry, it is known that China's GDP growth rate in 2027 predicted by the International Monetary Fund (IMF) is 4.6%, so the calculation can be obtained as **Table 11**:

Table 11. Present value of free cash flows to Hengrui Pharma, 2023-2027.

year	2023	2024	2025	2026	2027	total
free cash flows to the firm/RMB 100 Million	68.46	84.63	104.63	129.35	159.92	
discount factor	0.9033	0.8159	0.7370	0.6657	0.6013	
present value/RMB 100 Million	61.84	69.05	77.11	86.11	96.16	390.27

The present value of free cash flows to Hengrui Pharma in the forecast period is the sum of the present value of cash flows in each of the years 2023-2027, which is RMB 39.027 billions.

The present value of cash flows over the period of perpetual stable growth is calculated as follows:

$$\frac{\mathrm{FCFF}_{n+1}}{(\mathrm{WACC}-g)(1+\mathrm{WACC})^{n}}=\frac{15.992\times(1+4.6\%)}{10.71\%-4.6\%}\times 0.6013=164.621 \text{ billions}$$

As a result, summing the present value of the cash flows in the two phases yields the present value of Hengrui Pharma's corporate free cash flow:

$$39.027 + 164.621 = 203.648 \text{ billions}$$

In addition, the total liabilities of Hengrui Pharma on December 31, 2022 are

RMB 3.942 billions, so the equity value of Hengrui Pharma is:

$$V1 = 203.648 - 3.942 = 199.706 \text{ billions}$$

4.2. B-S Model to Assess Potential Option Value

1) Determination of B-S model parameters

a) Present value of the subject assets

In practice, although there is no trading platform for the overall enterprise value for physical assets, there are corresponding trading markets for the company's stocks and bonds, and all the assets included in the overall enterprise value can be chosen to represent the value of the underlying assets. Here, the value of total assets at the end of the period in the consolidated balance sheet of Hengrui Pharma's 2022 annual report of RMB 42.355 billions yuan is used as an estimate of the present value of the underlying assets (S) in the B-S model, i.e., S = 42.355 billions.

b) Option exercise price

The strike price of the option is the price of all the liabilities that Hengrui Pharma now needs to pay, RMB 3.942 billions. If the value of the company's assets is less than the value of its liabilities, the company's shareholders will choose to go into bankruptcy and give up the company's holdings in order to pay off its liabilities, i.e., X = 3.942 billions.

c) Risk-free rate

The risk-free rate follows the yield on the 5-year Treasury bond above, which is $R_f = 2.64\%$.

d) Exercise period

In order to align the exercise period of the option with the forecast period of the free cash flow of the forecasted firm for the year of the value of the existing assets, the exercise period of the option is taken to be T = 5.

e) Volatility of the underlying asset

For enterprises, the volatility of the underlying asset can be obtained by calculating the standard deviation of its expected rate of return. According to the customary practice in practice, as a listed company, the change of Hengrui Pharma's equity capital can be reflected by calculating the volatility of its stock price in a certain period of time. In this paper, the closing price of 242 trading days of Hengrui Pharma in 2022 is selected for analysis, and the logarithmic rate of return and standard deviation are calculated to get the daily volatility of 2.32%. In turn, the annual stock volatility is obtained: $\delta = 2.32\% \times \sqrt{242} = 0.3612$.

2) Calculation of option value

The final measure of option value is found by substituting each known parameter into the B-S model:

$$d1 = 3.507,\ d2 = 2.700,\ N(d1) = 1.000,\ N(d2) = 0.997$$

$$V2 = S[N(d1)]\text{-}Xe\text{-}rT\ [N(d2)] = 38.903 \text{ billions}$$

4.3. Assessment of the Overall Value of the Enterprise

In this paper, the equity value of Hengrui Pharma is calculated to be RMB 199.706

billions by FCFF model, and the potential option value of Hengrui Pharma is calculated to be RMB 38.904 billions by B-S model. Therefore, after fully considering the option characteristics of pharmaceutical high-tech enterprises with large R&D investment and high uncertainty, the equity value of Hengrui Pharma should be the sum of the following two parts:

$$V = V1 + V2 = 199.706 + 38.903 = 238.609 \text{ billions}$$

According to the annual report of Hengrui Pharma, the total number of outstanding shares on the valuation date was 6,379,002,274 shares. The closing price of the shares on December 30, 2022 was RMB 38.53. A variance analysis was performed and the results are as **Table 12**:

Table 12. Analysis of valuation results.

	in the end/RMB 100 Million	equity price/RMB	variance rate
FCFF model	1991.83	31.22	−18.96%
FCFF & B-S model	2386.09	37.41	−2.92%
Real market value	2457.83	38.53	-

As can be seen from **Table 12** above, the theoretical stock price is RMB 31.22 when valued using only the discounted free cash flow method FCFF model, with a variance rate of -18.96% compared to the true stock price. After constructing the portfolio valuation model by combining the real options B-S pricing model, the calculated theoretical stock price is RMB 37.41, and the discrepancy rate is significantly improved from −18.96% to −2.92%.

In this valuation, the assessed value of Hengrui Pharma is lower than the market value, reflecting that the market has overestimated the value of Hengrui Pharma. Although the generic drug collection, innovative drug health insurance negotiation, and the epidemic caused by the medical institutions business shrinkage triple impact, the market is still optimistic about Hengrui Pharma expectations. With the collection of risk being basically released, innovative drugs ushered in the harvest period, the company's future performance is expected to open a sustained growth.

5. Conclusion

In recent years, China's pharmaceutical enterprises have been developing rapidly, with large space for development, and the industry in general has entered a rapid development stage. Valuing pharmaceutical enterprises is also of particular importance. Pharmaceutical enterprises are characterized by high investment, long cycle, high market risk, etc. Therefore, the valuation based on the traditional method will be very different from the real value, which indicates that there are deficiencies in the value assessment of pharmaceutical enterprises, so a new method needs to be explored in the valuation process of pharmaceutical enterprises.

Based on the above background, this paper chooses to combine FCFF and B-S

model to value the pharmaceutical enterprises, and selects Hengrui Pharma as a case study company, measures its existing value with FCFF model, then calculates the option value of it with B-S model, and finally sums up the two parts of the value to arrive at the overall value of the enterprise. Through the case study, comparing the valuation results with the market value on the base date, this paper concludes that the method of valuation using the combination model can be closer to the market value when valuing pharmaceutical enterprises, thus proving the reasonableness of this valuation method in the value assessment of pharmaceutical enterprises.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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