Enterprise Value Assessment Based on Real Option Approach: The Case of SEMCORP

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Abstract. As the core power source of new energy vehicles, the lithium battery industry has ushered in a high-speed development, and has become the most widely used battery technology system. Due to the industry's high technical barriers, imperfect system, high volatility risk and other characteristics of the lithium battery enterprise value the overall assessment of the difficulty of ordinary investors to make a more accurate judgment. As an important representative of the lithium new energy materials industry, SEMCORP is in a golden development period. Based on the research results of previous researchers on enterprise value assessment, this paper examines the value assessment of n SEMCORP. Specifically, this paper applies a two-stage growth model to calculate the present value and evaluates the potential value separately with the help of an option pricing model to obtain its overall value. After analyzing, conclude that SEMCORP 's shares are overvalued. This paper can provide decision-making references for the investment and financing of Chinese lithium new energy materials enterprises, as well as further enriching the application of enterprise value assessment methods.

Keywords: Enterprise value evaluation; real option method; lithium Battery Company.

1. Introduction

SEMCORP is the world's leading supplier of lithium battery separators. Starting from the packaging and printing business, through transformation, mergers and acquisitions, restructuring and other struggles for more than 20 years, SEMCORP transformed from a traditional manufacturing enterprise to a high-tech enterprise with "lithium battery diaphragm" as its core industry, and in September 2016, SEMCORP was listed on the Shenzhen Stock Exchange. The company has two business systems, "new energy" and "packaging", and its main products can be divided into three categories: film products, packaging and printing products, and paper packaging products. Among them, lithium-ion battery isolation film is the company's core business, its production capacity, product quality, cost efficiency, technology research and development are the world's leading.

This company was chosen as a case study for the following three reasons: First, as an A-share listed company, it is less difficult to obtain data, and the daily trading prices of relevant securities can be obtained through major financial databases.

Second, compared with start-ups in the lithium battery industry, SEMCORP, after more than 20 years of development, has passed the difficult start-up period and is gradually moving towards maturity. Therefore, it is less difficult to predict the relevant indicators.

Last, the company is the world's leading lithium battery diaphragm industry leader. The company has entered the supply chain system of the majority of the world's mainstream lithium battery manufacturers. In 2022, the company's rapid development, production capacity and revenue scale have increased significantly, and the diaphragm production capacity and shipments ranked first in the world.

By studying the overall value of the new energy lithium battery industry and its representative enterprises, this paper tries to explore the applicable methods of enterprise valuation in this emerging industry, which is conducive to enriching the specific practice of enterprise valuation in emerging industries. The completeness and accuracy of the real options are high, which can provide the reference basis of enterprise value for the investment or M&A subjects in the lithium battery industry.

At the same time, for enterprise managers and investors, more comprehensive and accurate valuation results will help their decision-making.

Based on the basic theory of enterprise value assessment and real option pricing model, this paper calculates the current value of the enterprise based on the two-stage growth model, and then uses the real option method to calculate its potential value, so as to fully assess the overall value of the enterprise. By analyzing, this paper concludes that SEMCORP stock is overvalued in 2021 and the stock price is expected to trend downward in 2022, in line with the 2022 stock price trend.

The rest of the article are arranged as follows. In Section 2, the literatures are reviewed. In the following Section 3, this paper presents the methodology for valuing new energy materials enterprises. Then in Section 4, based on the two valuation methods identified in the previous section, the potential and current values of the company on the two valuation reference dates separately are calculated and are summed to obtain the overall value. In Section5, this paper analysis the results of the valuation of SEMCORP. Finally, the research is concluded by describing the results and deficiencies.

2. Literature Review

2.1. Related Research on Traditional Business Valuation Theories

Fisher believed that capital can bring a series of future income, and the current value of capital is essentially equal to the discounted value of the expected future income [1]. Modigliani and Miller put forward the famous MM theory, which argues that if the investment and financing decisions of the enterprise are independent of each other, in the absence of income tax and bankruptcy risk, and the market is efficient, corporate value is not affected by capital structure [2]. Stern and Stewartm proposed the theory of economic value added based on the idea of residual income by considering the cost of capital of a firm in a comprehensive way and adjusting the net profit with the perspective of the growth of the firm's value, which constructed a set of innovative methods for assessing the value of a firm and measuring the firm's performance [3].

2.2. Relevant Studies on Real Option Pricing Models

The framework of the economic value-added theory was developed by Black and Scholes: Black and Scholes published the first complete European option pricing model, which considered that a company's equity, natural resource assets, and invention patents are call options of the company and can be valued using the B-S option pricing model [4]. Cox and Ross improved the European option pricing model by introducing the mathematical idea of binomials and created the binomial tree option pricing model [5]. Panayi, by studying the association between patent development, equity value and corporate option attributes in high-tech enterprises, concluded that the overall value of a company consists of two parts, i.e., return income from the investment in current projects and expected future potential development of the firm [6].

2.3. Research Related to the New Energy Industry and the Valuation of Lithium Battery Companies

Honeywill and Tristan constructed a more complete valuation method applicable to new energy enterprises [7] based on the brand value assessment model proposed by Interbrand in the Lee and Shihtook Taiwan's new energy industry as an example [8], and incorporated the cost-benefit theory into the traditional real option pricing model to create the policy-benefit valuation method for new energy industry

3. Methodology

3.1. New Energy Materials Enterprise Value Assessment and Method Introduction

As the decision implementation path of lithium battery enterprises may have more divergent grey areas or contingent investment decisions, decision-making flexibility must be considered [9]. The real options method can more accurately assess the value changes resulting from the modification of decision-making and strategic adjustments made by the implementation of the flexibility investment [10]. In addition, as lithium battery enterprises have distinctive characteristics of high growth, high R&D investment, high risk and high innovation, which are more in line with the application of the real options method, this paper is based on the real options method for lithium battery enterprise valuation research.

3.1.1. Assessment of the Current Value of Lithium Battery Enterprises

In the value composition of lithium battery enterprise, the present value of the enterprise is composed of the expected remuneration generated by the certainty elements such as assets and investment projects, which lays the foundation of the enterprise's production and operation; while the potential value of the enterprise is composed of the future potential remuneration brought by the uncertainty elements such as new technology R&D innovation and dynamic management decision, which has the attribute of option and can generate value appreciation. The composition of the overall value of the lithium battery enterprise can be reflected by formula (1):

$$V = V_c + V_F \tag{1}$$

Where V is the overall value, V_c is the current value, and V_F is the potential value.
Because of the high growth of lithium battery enterprises, the two-stage growth model is chosen to evaluate the current value of lithium battery enterprises, the development phase is divided into two stages: the first stage is the observation period, extraordinary growth, generally 5~7 years; the second phase is the perpetual period, perpetual growth. That is, the transition from high-speed growth to stable growth, and predict the future cash flow of the two phases respectively. As a result, the current value of lithium battery enterprise can be reflected by formula (2).

$$V_C = \sum_{t=1}^{n} \frac{FCFF_t}{(1+R_{WACC})^2} + \frac{FCFF_{(n+1)}}{(1+R_{WACC})^n \times (R_{WACC}-g)} \tag{2}$$

3.1.2. Assessment of Potential Value of Lithium Battery Enterprises

The potential value of the new energy lithium battery enterprise has significant option attributes, so the B-S option pricing model in the real option method is chosen to evaluate it. The Black-Scholes European option formula is shown in the formulas (3) ~ (5).

$$C = SN(d_1) - Xe^{-RT}N(d_2) \tag{3}$$

$$d_1 = \frac{\ln\left(\frac{S}{X}\right) + \left(R + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}} \tag{4}$$

$$\begin{aligned} d_2 &= \frac{\ln\left(\frac{S}{X}\right) + \left(R - \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}} \\ &= d_1 - \sigma\sqrt{T} \end{aligned} \tag{5}$$

Where C is the fair price of the option, S is the current price of the traded asset, X is the delivery price of the option, T represents the effective period of the option, R is the risk-free interest rate, σ is the volatility of the asset's return, and N() is the cumulative probability of a normal distribution $\left(\frac{1}{\sqrt{2\pi}}\int_{-\infty}^{d_n} e^{-\frac{x^2}{2}}dx\right)$

4. Enterprise Valuation Process

4.1. Assessing the Present Value of a Business Based on a Two-stage Growth Model

The most commonly used method of financial forecasting is the percentage of sales method, which assumes that the operating assets and liabilities of a company remain stable as a percentage of its operating income.

4.1.1. Operating Profit After Tax

In order to reasonably predict the profitability of SEMCORP from 2022 to 2027, this paper selects the last four years (2018-2021) as the base period for assessment and obtains the annual financial statements of the enterprise during the period, which can be collated to obtain the historical profitability of the enterprise as shown in Table 1.

Table 1. Operating Profit after Tax for SEMCORP Shares, 2018-2021.

Item (billion yuan)	2018	2019	2020	2021
I. Operating Income	24.57	31.6	42.83	79.82
Less: Operating costs	14.24	17.3	24.57	40.02
II. Gross profit	10.33	14.3	18.26	39.8
Less: Taxes and surcharges	0.20	0.15	0.32	0.37
Selling expenses	0.50	0.67	0.56	0.74
Administrative expenses	1.544	1.229	1.558	2.163
III. Earnings before interest and tax	8.086	12.251	15.822	36.527
Less: Income tax expense	0.98	1.26	1.38	3.33
VI. Operating profit after tax	7.106	10.991	14.442	33.197

4.1.2. Forecast of Operating Income

In order to reasonably and accurately assess the enterprise value of SEMCORP, this paper takes the basic framework of the discounted cash flow model as the starting point, and constructs an optimized discounted cash flow model: based on the forecast base period, the growth rate in the first two years of the forecast period is 90%, and the growth rate in the later period is 50% as assessed by the industry appraisal agency. The results are shown in Table 2.

Table 2. Operating Profit after Tax for SEMCORP Shares, 2018-2021.

2022	2023	2024	2025	2026	2027
50%	50%	20%	20%	20%	20%
119.73	179.595	215.514	258.6168	310.3402	372.4082

4.1.3. Cost and Expense Projections

After determining the future expected value of operating income, the next step is to forecast the main costs and expenses of the enterprise. As shown in Table 3, based on the percentage of sales method, this paper calculates the proportion of costs and expenses to operating revenues for each period based on the historical data in the annual financial reports of the past four periods (2018-2021), and takes the average value as the proportion of the corresponding costs and expenses to operating revenues for the forecast period, in order to enhance the robustness of the forecast results.

Table 3. Costs and Expenses of SEMCORP as a Percentage of Revenue.

Items	2018	2019	2020	2021
Operating Costs / Operating Revenues	57.96%	54.75%	57.37%	50.14%
Taxes and surcharges / Operating income	0.81%	0.47%	0.75%	0.46%
Selling expenses/revenue	2.04%	2.12%	1.31%	0.93%
Management fees/revenue	6.28%	3.89%	3.64%	2.71%

4.1.4. Depreciation and Amortization Forecasts

As shown in Table 4, based on the data of the past four periods, the change in the proportion of depreciation and amortization to total revenue is relatively smooth. Therefore, the average value of

25.60% is taken as the increase in the proportion of depreciation and amortization for the forecast period, and the proportion of depreciation and amortization to total revenue for the forecast period is calculated to be 10.14%.

Table 4. Depreciation and Amortization as a Percentage of Revenue.

Items(billion yuan)	2018	2019	2020	2021
Operating income	24.57	31.6	42.83	79.82
Depreciation of fixed assets and investment properties	1.61	2.97	5.46	7.82
Amortization of long-term amortized expenses	0.17	0.12	0.04	0.05
Amortization of intangible assets	0.04	0.07	0.12	0.15
Total	1.82	3.16	5.62	8.02
Depreciation and amortization/operating income	7.41%	10.00%	13.12%	10.05%

4.1.5. Forecast of Working Capital Additions

Working capital is the net amount of liquidity available for business operations. and is measured from the cash flow statement, thus: Working Capital = Inventory + Operating Receivables + Amortized Expenses - Operating Payables - Accrued Expenses; Operating Receivables = Accounts Receivable + Prepayments + Notes Receivable; Operating Payables = Accounts Payable + Prepayments + Notes Payable. As shown in Table 5, the increase in corporate working capital as a percentage of total revenue is relatively flat from 2017-2020. Therefore, the four-year average of 21% is taken as the forecast.

Table 5. Analysis of Enterprise Working Capital.

Items(billion yuan)	2018	2019	2020	2021
Increase in inventories	1.41	2.92	2.22	5.35
Increase in operating receivables	5.94	6.84	13.33	34.62
Increase in prepayments	0.58	1.05	1.81	2.27
Less: increase in operating payables	0.62	3.599	6.473	14.87
Less: increase in other accounts payable	2.67	0.99	5.85	0.7
Increase in working capital	4.64	6.221	5.037	26.67
Operating Income	24.57	31.6	42.83	79.82
Increase in working capital/operating income	19%	20%	12%	33%

4.1.6. Capital Expenditure Forecast

Capital expenditures mainly come from the purchase of fixed assets and intangible assets. Consistent with the calculation caliber of the increase in working capital above, capital expenditure is also measured from the cash flow statement, thus: Capital expenditure = Cash paid for the purchase and construction of fixed assets, intangible assets and other long-term assets.

As the ratio of capital expenditure to operating income of the company shows a decreasing trend, the average ratio of capital expenditure in 2021 and 2020 that is 35% is taken as the ratio of capital expenditure to operating income for the forecast period. The results of the capital expenditure forecast are shown in Table 6.

Table 6. Analysis of Enterprise Working Capital.

Items(billion yuan)	2018	2019	2020	2021
Cash received from recovery of investment	3.95	0.50	8.608	17.71
Cash received from investment income	0.82	0.16	0.98	0.40
Less: Cash paid for acquisition of fixed assets, intangible assets and other long-term assets	13.91	21.19	26.68	39.96
Net cash recovered from disposal of fixed assets, intangible assets and other long-term assets	-0.11	0.21	-0.15	0.31
Total	9.25	20.32	17.24	21.54
Operating Income	24.57	31.6	42.83	79.82
Capital expenditure/operating income	37.65%	64.30%	40.26%	26.99%

4.1.7. Corporate Free Cash Flow Forecast

Based on the percentage-of-sales method, the free cash flow for future periods is calculated based on the forecasts of costs and expenses, depreciation and amortization, working capital and capital expenditure as a percentage of operating revenue, combined with the forecasts of operating revenue for future periods. The results of the free cash flow forecast are shown in Table 7. The formula for calculating free cash flow is as follows: Free cash flow = EBIT + depreciation and amortization - working capital - capital expenditure EBIT = EBIT - EBIT × income tax rate.

Table 7. Free Cash Flow Forecast for SEMCORP.

Items(billion yuan)	2022	2023	2024	2025	2026	2027
Operating income	119.73	179.60	215.51	258.62	310.34	372.41
Less: Operating costs	65.91	98.87	118.64	142.37	170.85	205.02
Taxes and surcharges	0.75	1.12	1.35	1.62	1.94	2.33
Selling expenses	1.91	2.87	3.44	4.13	4.96	5.95
Administrative expenses	4.95	7.42	8.90	10.68	12.82	15.38
Earnings before interest and tax	46.21	69.32	83.18	99.81	119.78	143.73
Less: Income tax expense	6.93	10.40	12.48	14.97	17.97	21.56
Operating profit before interest and tax	39.28	58.92	70.70	84.84	101.81	122.17
Add: Depreciation and amortization	12.15	18.22	21.86	26.23	31.48	37.78
Less: Increase in working capital	8.36	12.53	7.52	9.02	10.83	12.99
Cash outflows from investing activities	41.91	62.86	75.43	90.52	108.62	130.34
Free cash flow	1.16	1.75	9.61	11.54	13.84	16.61

4.1.8. Calculation of WACC

(1) Cost of equity capital

Calculate the cost of equity capital based on the CAPM as shown in equation (6).

$$R_{it} = R_{ft} + \beta_i(R_{mt} - R_{ft}) \quad (6)$$

Where R_{it}denotes the return of security i at time t, R_{ft} is the risk-free rate of return at time t, and R_{mt} is the market rate of return at time t, which is the sensitivity of security i's return. The 10 -year treasury bonds ' rate of return is selected as the risk -free rate.

For the valuation of the first phase of the enterprise with the appraisal base date set at 31 December 2021: the beta coefficient of the second phase is 1.34 by choosing the daily closing price from 1 January 2017 to 31 December 2021 and the average of the market rate of return from 2011 to 2021 is 8.31; correspondingly, the average of the yield on 10-year treasury bonds over the same period is taken as the risk-free rate of return, i.e., 3.22%. The cost of equity capital for the first tranche is calculated to be 7.34 percent. For the valuation of the second phase of the enterprise with the appraisal reference date set at 31 December 2022: Based on the same methodology, the beta coefficient of the second phase is 1.56 by choosing the daily closing price from 1 January 2018 to 31 December 2022 and the market comprehensive rate of return for the same period, and the average value of the annual market comprehensive rate of return for the ten years from 2012 to 2022 is chosen to determine the beta coefficient. The average of the 10-year Composite Market Return for the period 2012-2021 was chosen to measure the market rate of return, which was 7.73 percent; similarly, the average of the 10-year treasury bond yield for the same period was used as the risk-free rate of return, which was 3.00 per cent. The cost of equity for the second period was calculated to be 6.99%.

(2) Cost of Debt Capital

Considering that the debt structure of the enterprise is dominated by bank borrowings, this paper takes the 5-year loan base rate LPR as the overall cost of debt capital of the enterprise. Calculating from January 2021 to December 2022, the average value of 5-year LPR is 3.95%. Considering the interest tax credit effect, the after-tax cost of debt capital is calculated to be 3.95 per cent. Similarly, for the second period, the overall corporate cost of debt capital is 4.44 per cent.

(3) WACC

For the valuation of the first period, from the financial report in 2021, total assets are 26.12 billion yuan, total liabilities are 11.58 billion yuan, and the owner's equity is 14.54 billion yuan, which can be calculated to get the proportion of liabilities is 44.33%, and the proportion of equity is 55.67%, and then the first period of the weighted average cost of capital is as follows: Rwacc1=4.65%*44.33%+9.38%*55.67%=6.97%, Similarly, WACC for the second period is Rwacc2 = 9.67% * 48.81% + 7.34%% * 51.19% =7.33%.

Based on the above estimation of the relevant data, the calculation of the present value of free cash flow for the enterprises in Phase I and Phase II is shown in Table 8 and Table 9.

Table 8. Present Value of Free Cash Flows of Phase I Enterprise.

Items(billion yuan)	2021	2022	2023	2024	2025	2026
Free Cash Flow		1.16	1.75	9.61	11.54	13.84
Discount rate		6.97%	6.97%	6.97%	6.97%	6.97%
Present value of free cash flow		1.09	1.52	7.85	8.81	9.88
Total present value	29.16					

Table 9. Present Value of Free Cash Flow for Phase II Enterprises.

Items(billion yuan)	2022	2023	2024	2025	2026	2027
Free Cash Flow		1.75	9.61	11.54	13.84	16.61
Discount rate		0.07	0.07	0.07	0.07	0.07
Present value of free cash flow		1.63	8.34	9.33	10.43	11.66
Total present value	41.39					

The present value of the free cash flow of the enterprise in the period of high growth of phase I is: V_{m1}=14.622 billion yuan; the present value of the free cash flow of the enterprise in the period of high growth of phase II is: V_{m2}=23.264 billion yuan.

According to the theory of competitive equilibrium, after maintaining a certain period of high-speed growth in sales revenue, the sales growth rate of most enterprises will eventually converge to the nominal growth rate of the macro-economy. SEMCORP shares as a lithium-ion new energy technology-based enterprises, industry prospects, this paper assumes that it can maintain a continuous operation, the subsequent period of sales growth rate is set at 6.1%, slightly higher than the GDP growth rate.

Thus, the value of the perpetual growth period of a two-stage enterprise V_{n1} can be calculated:

$$\begin{aligned} V_{n_1} &= \frac{FCFF_5\times(1+g)}{(R_{WACC_1}-g)(1+R_{WACC_1})^5} \\ &= \frac{13.84\times(1+6\%)}{(6.97\%-6\%)(1+6.97\%)^5} \\ &= 1079.84(\text{ billion yuan}) \end{aligned} \tag{7}$$

The value V_{n1} of the perpetual growth period of a Phase II Stage II firm is:

$$\begin{aligned} V_{n_2} &= \frac{FCFF_6\times(1+g)}{(R_{WACC_2}-g)(1+R_{WACC_2})^5} \\ &= \frac{16.61\times(1+6\%)}{(7.34\%-6\%)(1+7.34\%)^5} \\ &= 929.43(\text{ billion yuan}) \end{aligned} \tag{8}$$

As a result, the current value of the firm in the first period is

$$V_{c1}=V_{\mathrm{m1}}+V_{n_1}=146.22+1079.84=1109.00 \tag{9}$$

The current value of the firm in the second period is

$$V_{c2}=V_{\mathrm{m2}}+V_{n_2}=232.64+929.43=970.82 \tag{10}$$

4.2. Assessing the Potential Value of the Business Based on the Real Options Approach

For the valuation of the Phase I and Phase II businesses with appraisal reference dates of 31 December 2021 and 31 December 2022 respectively, the potential value of the businesses is assessed using the traditional B-S model.

4.2.1. Present Value of Trading Assets S

According to the financial report of SEMCORP in 2021, the total assets of the enterprise at the end of 2021 is 20.57 billion yuan, so the value of S_1 in the first phase of the real option pricing model is 22.20 billion yuan; according to the financial report of the enterprise published in 2022, S_2 is 26.12 billion yuan.

4.2.2. Option Delivery Price X

The total liabilities on the valuation date are chosen as the option settlement price. According to the financial report of SEMCORP in 2021, the total liabilities of the enterprise at the end of 2021 is RMB 8,976 million, so the value of X1 in the first real option pricing model is RMB 8,976 million; similarly, the value of X2 in the second real option pricing model is RMB 11,580 million.

4.2.3. Option Validity Period T

The forecast period of five years is taken as the validity period of the option, so the values of T1 and T2 are both 5.

4.2.4. Risk-free Interest Rate R

In order to be consistent with the option validity period and the duration of the forecast period, the 5-year bond yield is used as the risk-free interest rate. The 5-year treasury bond yield at the end of 2021 is used as the risk-free interest rate for the first period, and R1 is 2.62%; similarly, the 5-year treasury bond yield at the end of 2022 is used as the risk-free interest rate for the second period, and R2 is 2.93%.

4.2.5. Volatility of Asset Returns σ

Intercept the daily closing price p of SEMCORP shares on the trading days from 1 January to 31 December 2021. The annual volatility is obtained by $I = \ln(\frac{p_t}{p_{t+1}})$ to determine the standard deviation of daily returns, and then based on $\sigma = \sqrt{\sigma^2 \times Yearly\ trading\ days}$ to obtain an annual volatility of 0.56, and similarly, an estimate of the annual volatility of the firms for the year 2022 can be calculated σ2 is 0.43.

From the above analysis, the values of the parameters in the real option pricing model for Phase I and Phase II are shown in Table.10 and Table 11

Table 10. Parameter Values of the Real Options Pricing Model for Phase 1.

Current price of trading assets S1 (billion yuan)	Option delivery price X1 (billion yuan)	Option life T1 (years)	Risk-free interest rate R1	Volatility
261.2	89.76	5	2.62%	0.56

Table 11. Parameter Values of the Real Options Pricing Model for Phase 2.

Current price of trading assets S1 (billion yuan)	Option delivery price X2 (billion yuan)	Option life T2 (years)	Risk-free interest rate R2	Volatility
386.2	115.8	5	2.93%	0.43

Substituting the values of each parameter in the first period into the Black-Scholes option pricing model can be calculated:

$$d_1 = \frac{\ln\left(\frac{S_1}{X_1}\right)+\left(R_1+\frac{\sigma_1^2}{2}\right)T_1}{\sigma_1\sqrt{T_1}} = 1.39 \quad (11)$$

$$d_2 = \frac{\ln\left(\frac{S_2}{X_2}\right)+\left(R_2+\frac{\sigma_2^2}{2}\right)T_2}{\sigma_2\sqrt{T_2}} = 0.14 \quad (12)$$

According to the normal distribution function, $N(d_1)$= 0.9177 and $N(d_2)$ = 0.5557, so the option value for the first period is:

$$C_1 = S_1N(d_1) - X_1e^{-R_1T_1}N(d_2) = 261.2 \times 0.9177 + 89.76 \times e^{-2.62\%\times5} \times 0.5557 = 195.95 \quad (13)$$

Substituting the values of each parameter in the first period into the Black-Scholes option pricing model can be calculated:

$$d_1^* = \frac{\ln\left(\frac{S_1}{X_1}\right)+\left(R_1+\frac{\sigma_1^2}{2}\right)T_1}{\sigma_1\sqrt{T_1}} = 1.55 \quad (14)$$

$$d_2^* = \frac{\ln\left(\frac{S_2}{X_2}\right)+\left(R_2+\frac{\sigma_2^2}{2}\right)T_2}{\sigma_2\sqrt{T_2}} = 0.59 \quad (15)$$

Based on the normal distribution function, $N(d_1)$ = 0.9394 and $N(d_2)$ = 0.7224, so the option value for the second period is:

$$C_2 = S_2N(d_1^*) - X_2e^{-R_2T_2}N(d_2^*) = 386.2 \times 1.55 + 89.76 \times e^{-2.93\%\times5} \times 0.59 = 290.54 \quad (16)$$

Since the calculated option value is an estimate of the potential value of the enterprise, the potential value of the enterprise in the first and second periods are, respectively:

$$V_{F1} = C_1 = 195.95 \text{ (Billion yuan)} \quad (17)$$

$$V_{F2} = C_2 = 290.54 \text{ (Billion yuan)} \quad (18)$$

In summary, based on the traditional real option pricing model, combined with the two-stage growth model, the overall appraised value of the enterprise for the first and second phases are calculated as respectively:

$$V_1 = V_{c1} + V_{F1} = 1304.95 \text{(billion yuan)} \quad (19)$$

$$V_2 = V_{c2} + V_{F2} = 1261.36 \text{(billion yuan)} \quad (20)$$

5. Analysis of the Results of the Valuation of SEMCORP

Through the above two methods, it can be obtained that the overall value of SEMCORP in the first phase of valuation is 130.495 billion yuan. According to the annual report, the total number of shares in 2021 is 892,411,690 shares. Therefore, based on the estimated value, the stock price per share of SEMCORP as of December 31, 2021 was 1304.95 ÷ 8.92=150.2 yuan. The stock price of SEMCORP on the evaluation benchmark date was 250.4 yuan per share, with an error of 66.7% compared to the estimated stock price, which is not within a reasonable range. However, for the second phase of

valuation, the overall value of the company is RMB 1261.36 billion, with a total share capital of 892406822 in 2022. The estimated value of SEMCORP's stock price per share as of December 31, 2022 is 1261.36 ÷ 8.92=141.4 yuan. The stock price per share of SEMCORP on the benchmark date of valuation was RMB 131.3, which is a reasonable range with an error of 7.1% from the estimated stock price. Therefore, it can be concluded that during the first valuation period, the stock price of SEMCORP Shares was severely overvalued by the market, as shown in the Figure 1, which is consistent with the stock trend from 2022 to 2023. This indicates that the real option method can accurately estimate the value of new energy lithium battery companies

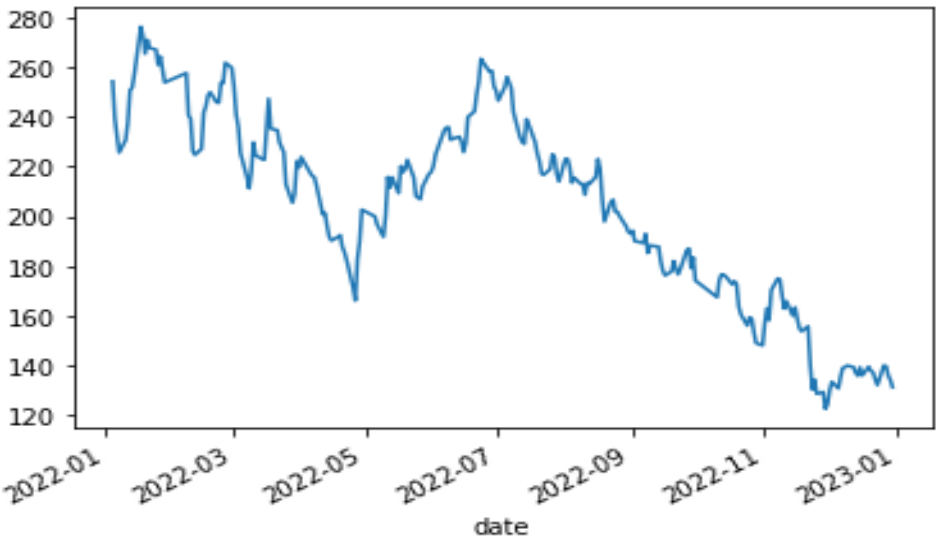

Fig 1. SEMCORP's Stock Movement from 2022 to 2023 (Picture credit: Original).

6. Conclusion

This paper focuses on the valuation of new energy lithium battery companies. Taking SEMCORP as a case study, the overall value of the enterprise at two different appraisal points was evaluated based on the traditional and improved real options method, which verified the reasonableness of the appraisal method. After research, it was finally concluded that SEMCORP's share price is overvalued. The significance of the study is that it proves that the two-stage growth model can well assess the current value of lithium battery companies, while the real option method is suitable for assessing the potential value of lithium battery companies. However, the research in this paper still has some shortcomings. The B-S option pricing model has a number of very strict preconditions and assumptions, and it is often difficult to fully meet all the conditions in reality. Therefore, in future research, researchers can try to use other assumptions that are closer to the actual situation to further investigate the value of the enterprise.

References

[1] Sanger C. P., Fisher. I. The Nature of Capital and Income. The Economic Journal, 1907, 21(8): 13-16.

[2] Modigliani F., Miller M. H. Corporate Income Taxes and the Cost of Capital: A Correction. The American Economic Review, 1963, 53(3): 433-443.

[3] Stern, J. And Stewart, G. B. Announcing the Stern Stewart Performance 1,000: A New Way of Viewing Corporate America. New York: Stern Stewart & Co, 1990.

[4] Black F., Scholes M. The Pricing of Options and Corporate Liabilities. The Journal of Political Economy, 1973, 81(3): 637-654.

[5] Cox J. C., Ross S. A., Rubinstein M. Option Pricing: A Simplified Approach. North-Holland, 1979, 7(3): 229-263.

[6] Panayi S., Trigeorgis L. Multi-stage Real Options: The Cases of Information Technology Infrastructure and International Bank Expansion. The Quarterly Review of Economics and Finance, 1998, 38(3): 675-692.

[7] Honeywill, Tristan. Impact Assessment. Automotive Engineer, 2008, 35(10): 15-16.

[8] Lee S. C., Shih L. H. Renewable Energy Policy Evaluation Using Real Option Model—The Case of Taiwan. Energy Economics, 2010, 32(4): 67-78.

[9] Han J. T. The application of real option method in the valuation of new energy enterprises' mergers and acquisitions. Modern Business,2021(27): 49-51.

[10] Van Den Boomen M., Spaan M. T. J., Schoenmaker R., and Wolfert A. R. M. Untangling decision tree and real options analyses: a public infrastructure case study dealing with political decisions, structural integrity and price uncertainty, Construction Management and Economics, 2019, 37:1, 24-43.