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Valuation analysis of China national petroleum corporation

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Abstract

Oil is considered the lifeblood of several countries due to the political need to offer energy security. Moreover, world economies depend on the state's supervision and control of oil prices. Thus, the relevant policies of oil companies are carefully formulated in conjunction with government policymakers. Hence, the valuation of oil enterprises is of great significance to global security and economic development. As traditional valuation models tend to underestimate petroleum enterprises, this study adopts the economic value added (EVA) model and incorporates environmental, social, and governance (ESG) indicators to ascertain a new absolute valuation indicator for China National Petroleum Corporationbased on the weighted average adjusted enterprise value, providing a new evaluation indicator for the petrochemical industry.

Keywords: Petroleum enterprise; EVA model; ESG model

1. Introduction

China's State-owned Assets Supervision and Administration Commission (SASAC) encourages central enterprises to use the economic value added (EVA) indicator, which has a high degree of recognition in the field, for performance appraisals. Furthermore, EVA is calculated by subtracting the cost of debt and equity, which is the residual income after deducting costs, from the adjusted net operating profit. From the asset owners' perspective, this calculation method redefines corporate profits after accounting for capital expenditures, simultaneously connecting shareholder equity and corporate value to the equation, thereby offering the means to thoroughly and accurately judge an enterprise's true earning ability.

The use of EVA in oil enterprises' valuation is more conducive to ensuring and increasing shareholders' rights and interests, followed by maximizing national interests. However, the actual controllers of petroleum and petrochemical enterprises generally belong to the state, and under the EVA method, shareholder value and national security follow the same vector. Notably, petroleum enterprises hold numerous fixed assets with high original values. Hence, their depreciation amounts are stably apportioned over long periods to maintain a conducive ratio of investment to income. Therefore, this study leverages the EVA model to evaluate the absolute valuation construct.

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2. Case study—China National Petroleum Corporation (CNPC)

2.1. EVA model

2.1.1. . Financial situation analysis

This study examines PetroChina's annual report and analyzes its current financial situation to ensure an accurate EVA prediction.

Profitability analysis

Table 1 Analysis indicators of enterprise profitability

Time	2018	2019	2020	2021	2022
Gross Profit Margin (%)	22.49	20.44	20.02	20.76	21.96
ROE (%)	4.40	3.70	1.60	7.40	11.30
TTM (%)	2.17	1.77	0.73	3.69	5.77

Table 1 shows that during 2018–2022, the gross profit margin of PetroChina was relatively stable. Furthermore, the net profit margin of sales showed an upward trend, and the company had strong earning ability. Return on equity first decreased and subsequently increased, showing an overall upward trend. Moreover, comprehensive profitability has been excellent, because PetroChina adhered to efficient exploration and profitable development policies, expanded its exploration and development efforts, promoted an increase in oil and gas reserves, and maintained its output growth. Furthermore, it adhered to a market-oriented approach, promoted the transformation and upgrades of chemical refinement techniques, optimized product mixing, improved marketing, and ensured market supplies. Therefore, the firm enjoyed year-on-year growth in the sales volumes of domestic diesel, natural gas, and chemical products. Furthermore, PetroChina will be committed to adhering to green and low-carbon transformations, promoting the integrated development of oil and gas with new energy, building an integrated oil and gas thermoelectric hydrogen industry, and steadily expanding its wind power generation and geothermal output. These steps will entail strict adherence to low-cost development and effective cost and expense indicator controls. Finally, the company's operating benefits in 2022 increased significantly due to rising international crude oil prices and the consistent enforcement of quality and efficiency.

Solvency analysis

Table 2 Analysis indicators of the solvency of enterprises

Time	**2018**	**2019**	**2020**	**2021**	**2022**
CR	0.74	0.71	0.80	0.93	0.98
QR	0.44	0.43	0.59	0.65	0.71
TDR (%)	42.00	47.15	45.07	43.69	42.47

As listed in Table 2, PetroChina's current and quick ratios increased year by year from 2018 to 2022, revealing a gradually increasing short-term solvency. Notably, there was no large debt repayment risk, and operational conditions remained relatively stable. Its asset–liability ratio rose in 2019 while remaining overall stability in the appropriate range of 40%–60%. Moreover, its long-term debt repayment ability remained good.

Operating capacity analysis

Table 3 Analysis indicators of enterprise operating capacity

Time	**2018**	**2019**	**2020**	**2021**	**2022**
AR Turnover	42.16	40.69	33.20	47.98	51.92
Inventory Turnover	11.43	11.14	9.96	15.21	16.23

Fixed Asset Turnover	3.41	3.61	3.46	6.26	7.35
Total Asset Turnover	0.97	0.97	0.74	1.05	1.25

Table 3 reveals that PetroChina's inventory turnover rate showed an overall upward trend from 2018 to 2022, indicating good inventory liquidity. During this period, the accounts receivable turnover first declined and subsequently increased for three consecutive years, suggesting that the company's asset flow speed also increased due to its impressive debt-paying ability. Compared with Sinopec Corp., PetroChina's accounts receivable performance was better. Its turnover rate of fixed assets during the given period demonstrated an upward trend, and its turnover rate of total assets was relatively stable, rising steadily in the final three years. Moreover, its asset utilization efficiency remained generally good.

Growth ability analysis

Table 4 Analysis indicators of enterprise growth capacity

Time	**2018**	**2019**	**2020**	**2021**	**2022**
Increase rate of main business revenue (%)	16.75	5.97	−23.16	35.19	23.90
NPR (%)	130.71	−13.87	−58.40	385.01	62.08
Total assets growth rate (%)	1.15	11.96	−8.96	0.57	6.84
RONA (%)	1.74	1.35	−1.22	3.98	8.37

As can be seen in Table 4, the growth rate of PetroChina's operating revenue was negative in 2020, declining due to falling oil prices during COVID−19. In the first half of 2021, influenced by the increased demand brought about by the recovery of the world economy, international crude oil prices increased significantly year-on-year, and the market demand improved significantly. PetroChina's net profit increased significantly, and its net profit growth rate changed from negative to positive. Its total and net asset growth rates showed new upward trends, and the company's development prospects continue to be very promising.

In summary, with the advancement of the post-COVID energy revolution, several factors need to be incorporated into subsequent valuation processes. These factors include the intensification of exploration and development of oil and gas resources, the increase of reserves and production, and the acceleration of planning and construction of new energy systems. Based on this outlook, PetroChina has a leading position in the industry as it is in a mature stage of steady growth. Therefore, this study adopted a two-stage model to construct the desired valuation process.

2.1.2. Definite accounting adjustments

Financial expenses

Capital-cost EVA calculations already include equity and debt capital costs, and net profit after task (NOPAT) measures the normal operating income of enterprises. Hence, the influence of non-operating income must be excluded. Regarding financial expenses, interest income and exchange gains and losses should not be added to NOPAT.

Exploration expenditure

In the oil and gas industry, exploration expenditures are large due to high investments, risk, and returns. One may choose to apply achievement or complete-cost methods to account for this phenomenon. However, based on the Accounting Standards for Chinese Enterprises, oil enterprises use the achievement method to calculate exploration expenditures. Thus, economic recoverability is considered a judgment condition. If met, the exploration expenditure is considered "capitalized;" otherwise, it is expensed into current profit and loss. However, according to EVA methods, the full-cost method is applied, and unsuccessful exploration expenses and dry holes are capitalized similar to successful exploration expenses. This is because EVA focuses on long-term value creation. Therefore, even unsuccessful exploration expenditures may capitalize value in the distant future. Furthermore, SASAC has proposed EVA assessment rules in which enterprises with large exploration costs can re-add them at a certain proportion. This study considers this practice in terms of simultaneously adjusting the increase in net operating profit after tax and total capital, followed by amortization as research and development (R&D) expenses. Subsequently, the amortization amount should be included in the writedowns of current profit and total capital.

Goodwill

With EVA, purchased goodwill is treated as a permanent asset, and its value does not easily depreciate over time. Therefore, it must be adjusted using accounting measures that mirror the method of adjusting various impairment provisions. Therefore, this study does not list goodwill adjustments separately; instead, it adjusts for purchased goodwill to impairment provisions.

Deferred income tax

From an economic perspective, deferred income tax assets should not be included in total capital but deducted. Although deferred income tax assets reduce an enterprise's future tax payment, realistically, they are already paid. Hence, an increase in the current deferred income tax assets of the enterprise should be subtracted from the NOPAT. Meanwhile, from EVA's perspective, the balance of deferred income tax liabilities is added to the total cost of capital, and the increase in the deferred income tax credit is used to increase the enterprise's after-tax net operating profit.

Provision of various reserves

Based on the prudent requirements of the Accounting Standards for Chinese Enterprises, firms should set aside reserves for potential asset impairment expenses that may reduce profits. However, the provisions are not real capital outflows. Accoridng to EVA practices, asset and price changes are not impairments, and treating them as such can lead to an underestimation of current profit. Therefore, the increased amount of asset impairment reserve (provision reserve) is added back to the enterprise's after-tax net operating profit, and this reserve balance is added to total capital.

. R&D expenses

R&D standards require that research expenses be expensed to current profit and loss; meanwhile, certain development expenditures can be capitalized. Otherwise, they are expensed to profit and loss. However, this rule allows the manipulation of operating profits to a certain extent, as the benefits of R&D investment are observable only at certain points in the future. However, this construct is not conducive to the long-term development of enterprises; hence, to ensure the objectivity and rationality of EVA calculations, R&D costs must be appropriately adjusted prior to specific calculations.

Non-operating income and expenditure

These types of accounts represent the non-recurring profit and loss of an enterprise, whereas EVA focuses on normal operating income, including production, operation, and foreign investment income. Therefore, when calculating the EVA, the impact of non-recurring profit and loss items is excluded.

Net construction in progress

Construction in progress accounts for expenditures that occur before a fixed asset reaches its scheduled usable state after which it is measured using the actual cost method. However, the value of projects under construction is reflected in the future and cannot bring current benefits to the enterprise. Hence, matching income does not appear in financial statements.

2.1.3. Annual EVA valuation of enterprises

To calculate EVA, Eq. (1) is used:

$$EVA = NOPAT - TC \times WACC, \quad (1)$$

where *NOPAT* represents the after-tax operating net profit, *TC* is the total capital, and *WACC* is the weighted average cost of capital of the firm. According to SASAC requirements and the accounting adjustment described above,

$$NOPAT = [Total\ profit + (Financial\ expenses + Non\text{-}operating\ expenses + Increase\ in\ deferred\ tax\ credit + Increase\ in\ asset\ impairment\ provision\ for\ current\ period + R\&D\ expenses + Exploration\ expenses) - (Amortized\ R\&D\ expenses + Amortized\ exploration\ expenses + Operating\ income + Increase\ in\ deferred\ tax\ debit)] \times [1\text{-}25\%], \quad (2)$$

$$TC = Cost\ of\ interest\text{-}bearing\ debt + Shareholder\ equity + Accounting\ adjustments. \quad (3)$$

TC = (*Short-term borrowings* + *Non-current liabilities due within one year* + *Long-term borrowings* + *Bonds payable*) + *Total shareholder equity* + (*Balance of deferred tax lenders* + *Balance of asset impairment provisions* + *R&D expenses* + *Exploration expenses* + *After-tax non-operating expenses* − *After-tax operating income* − *Construction in progress*), (4)

2.1.4. Calculation of historical EVA

Calculation of historical *NOPAT*

Table 5 Calculation of net operating profit after tax of PetroChina for 2018–2022 Position: millions (Subsequent EVA tables are in "millions,"lacking special instructions)

Project/Year	**2018**	**2019**	**2020**	**2021**	**2022**
Total profit for the year	116,764	103,213	56,069	158,194	213,272
Plus: Financial expenses	18,879	27,816	24,304	17,043	19,614
Non-operating expenses	22,836	17,278	12,823	26,969	32,807
Increase in deferred tax credit	4355	4396	−5028	10258	−5622
Increase in impairment provisions	30106	8616	−3304	21129	34251
Net research and development expenses	12,826	15,666	15,746	16,729	20,016
Net exploration expenses	18,726	20,775	19,333	24,248	27,074
Less: Non-operating income	3,218	4,971	4,109	2,983	3,515
Increase in deferred debit	−3226	761	−12895	797	7538
Tax rate 25%	0.25	0.25	0.25	0.25	0.25
NOPTA (NOPAT is short for net operating profit after tax)	168375	144021	96546.75	203092.5	247769.25

The original data in the chart are all from the disclosure of CNPC's annual report from 2018 to 2022.

NOPAT=[Total profit for the year+Financial expenses+Non-operating expenses+Increase in deferred tax credit+Increase in impairment provisions+Net research and development expenses−(Non-operating income+Increase in deferred debit)]*0.75 （5）

According to Eq. (5), the NOPAT value of CNPC from 2018 to 2022 was obtained.

Calculation of historical TC

Table 6 TC calculation table of PetroChina from 2018 to 2022

Subjects	**2018**	**2019**	**2020**	**2021**	**2022**
Short-term borrowings	69,780	90,497	42,354	40,010	38,375
Non-current liabilities due within one year	75,370	92,879	81,769	19,893	70,561
Long-term borrowings	177,605	174,411	160,140	198,005	169,630
Bonds payable	91,817	116,471	91,239	89,170	52,848
Total interest-bearing liabilities	414572	474258	375502	347078	331414
Total shareholders' equity	1,409,176	1,444,578	1,366,885	1,409,124	1,538,103
Deferred tax credit balance	17,022	21,418	16,390	26,654	21,032
Balance of asset impairment provisions	138,557	147,173	143,869	164,998	199,249
Net research and development expenses	12,826	15,666	15,746	16,729	20,016

Net exploration expenses	18,726	20,775	19,333	24,248	27,074
Non-operating expenses after tax	17127	12958.5	9617.25	20226.75	24605.25
Less: Non-operating income after tax	2413.5	3728.25	3081.75	2237.25	2636.25
Less: Construction in progress	219,623	247,996	222,215	223,671	196876
TC(TC is the total investment)	1805969.5	1885102.25	1722045.5	1783149.5	1961981

The original data in the chart are all from the disclosure of CNPC's annual report from 2018 to 2022.

TC=Total shareholders' equity+Deferred tax credit balance+Balance of asset impairment provisions+Net research and development expenses+Netexploration expenses+Non-operating expenses after tax−(Non-operating income after tax+Construction in progress) (6)

According to Eq. (6), the TC of CNPC from 2018 to 2022 was calculated.

Calculation of historical WACC

$$WACC = \frac{B}{B+S} \times R_B \times (1 - t_C) + \frac{S}{B+S} \times R_S \quad (7)$$

First, the cost of debt capital is calculated based on the weighted average annual interest rate, which is disclosed in annual reports.

Table 7 Calculation of Rb of PetroChina from 2018 to 2022

Time	**2018**	**2019**	**2020**	**2021**	**2022**
Short-term borrowings	69,780	90,497	42,354	40,010	38,375
Weighted average annual interest rate on short-term borrowings	2.97%	2.84%	1.17%	0.99%	3.64%
Long-term borrowings	177,605	174,411	160,140	198,005	169,630
Weighted average annual interest rate on long-term borrowings	4.18%	4.08%	2.88%	2.62%	3.38%
Debt capital	247385	264908	202494	238015	208005
RB	3.84%	3.66%	2.52%	2.35%	3.43%

This study uses the capital asset pricing model to estimate the cost of equity capital, $R_S = R_f + \beta(R_M\text{-}R_f)$, where R_f represents the risk-free interest rate, β is the stock risk factor, and $R_M\text{-}R_f$ denotes the risk premium. The five-year treasury bond interest rate is used to approximate the risk-free interest rate, R_f, and the β of PetroChina was obtained from the Wind database. The firm's risk premium was not disclosed. Hence, the practice of most domestic scholars was used, and the risk premium was substituted with the growth of the domestic product growth rate.

Table 8 Rs calculation table of PetroChina for 2018–2022

Time	**2018**	**2019**	**2020**	**2021**	**2022**
Rf	2.45%	2.38%	2.59%	2.22%	2.21%
β	0.4067	0.2564	0.2892	0.0784	0.1414
$R_M\text{-}R_f$	6.70%	6%	2.20%	8.40%	3%
Rs	5.17%	3.92%	3.23%	2.88%	2.63%

Subsequently, the historical capital structure of PetroChina from 2018 to 2020 was determined.

Table 9 Capital structure of PetroChina from 2018 to 2022

Time	2018	2019	2020	2021	2022
Total capital	1656561	1709486	1569379	1647139	1746108
Debt capital	247385	264908	202494	238015	208,005
Debt capital weight	14.93%	15.50%	12.90%	14.45%	11.91%
Equity capital	1,409,176	1,444,578	1,366,885	1,409,124	1,538,103
Equity capital weight	85.07%	84.50%	87.10%	85.55%	88.09%

Finally, according to Eq. (7), the five-year WACC was calculated.

Table 10 Calculation of WACC of PetroChina from 2018 to 2022

Time	2018	2019	2020	2021	2022
Rs	5.17%	3.92%	3.23%	2.88%	2.63%
Equity capital weight	85.07%	84.50%	87.10%	85.55%	88.09%
RB	3.84%	3.66%	2.52%	2.35%	3.43%
Debt capital weight	14.93%	15.50%	12.90%	14.45%	11.91%
WACC (WACC is weighted average cost of capital.)	4.83%	3.74%	3.05%	2.72%	2.63%

Calculation of historical EVA value EVA = NOPAT − TC × WACC:

Table 11 EVA calculation table of PetroChina from 2018 to 2022

Time	2018	2019	2020	2021	2022
NOPAT	168375	144021	96546.75	203092.5	247769.25
WACC	4.83%	3.74%	3.05%	2.72%	2.63%
TC	1805969.5	1885102.25	1722045.5	1783149.5	1961981
EVA	81110	73594	43954	154647	196236

2.1.5. EVA calculation in the forecast period

Calculation of future *NOPAT*

Based on relevant income statement data from 2018–2022 annual reports, this study calculated the after-tax net operating profit of PetroChina from 2023 to 2027 in which the total profit was forecasted by combining the compound and variable growth rates. Other data were deduced via the average growth rate and/or trend analysis, and data lacking significant regular changes were forecasted via mean calculations.

Table 12 Future NOPAT forecast of PetroChina

Project/Year	2023	2024	2025	2026	2027
Total profit for the year	235463	260904	275983	278854	281760
Plus: financial expenses	18523	18523	18523	18523	18523

Non-operating expenses	44087	45168	47638	49075	52531
Increase in deferred tax credit	0	0	0	0	0
Increase in impairment provisions	24000	24000	24000	24000	24000
Net research and development expenses	22885	23784	26518	29648	31062
Net exploration expenses	28673	28895	30572	31158	33682
Less: Non-operating income	4710	5409	5764	6039	6626
Increase in deferred debit	0	0	0	0	0
Tax rate 25%	0.25	0.25	0.25	0.25	0.25
NOPTA	276690.75	296898.75	313102.5	318914.25	326199

According to Eq. (5), the NOPAT of CNPC for the next five years was calculated.

Calculation of future *TC*

Based on relevant balance sheet data and income statements in 2018–2022 annual reports, we forecasted PetroChina's total capital from 2023 to 2027 by calculating the means of compound growth rate, average growth rate, and/or trend analysis. Further, data without significant regular changes were predicted as the mean.

Table 13 Future TC forecast of PetroChina

Subjects	**2023**	**2024**	**2025**	**2026**	**2027**
Short-term borrowings	345,201	332,749	322,590	316,538	300,869
Non-current liabilities due within one year	1,630,211	1,589,673	1,658,623	1,788,934	1,802,579
Long-term borrowings	24,051	24,051	24,051	24,051	24,051
Bonds payable	205,387	211,495	228,374	256,873	269,041
Total interest-bearing liabilities	22,885	23,784	26,518	29,648	31,062
Total shareholders' equity	28,673	28,895	30,572	31,158	33,682
Deferred tax credit balance	33,065	33,876	35,729	36,806	39,398
Balance of asset impairment provisions	3,533	4,057	4,323	4,529	4,970
Net research and development expenses	210,623	218,963	220,476	237,543	239,612
TC	2,075,318	2,021,503	2,101,658	2,241,936	2,256,101

According to Eq. (6), the TC of CNPC for the next five years was calculated.

Calculation of future *WACC*

First, R_B and R_S were determined for the forecast horizon, and using the arithmetic average of PetroChina's cost of equity capital from 2018 to 2022, the cost of equity capital was forecasted. Meanwhile, the arithmetic average of the cost of debt capital in the five years was used to forecast the future cost of debt capital.

Second, the capital structure of PetroChina was described using the forecast period.

Table 14 Forecast of future capital structure of PetroChina

Time	2023	2024	2025	2026	2027
Total capital	1763108	1849027	1780652	1963570	1972469
Debt capital	215420	191188	187372	170986	162636
Debt capital weight	12.22%	10.34%	10.52%	8.71%	8.25%
Equity capital	1547688	1657839	1593280	1792584	1809833
Equity capital weight	87.78%	89.66%	89.48%	91.29%	91.75%

Finally, according to Eq. (7),the future-weighted average cost of capital was projected.

Table 15 Calculation of future WACC of PetroChina

Time	2023	2024	2025	2026	2027
Rs	7.27%	7.45%	8.24%	8.82%	9.11%
Equity capital weight	87.78%	89.66%	89.48%	91.29%	91.75%
RB	3.84%	3.66%	2.52%	2.35%	3.43%
Debt capital weight	12.22%	10.34%	10.52%	8.71%	8.25%
WACC	6.73%	6.96%	7.57%	8.21%	8.57%

Calculation of future *EVA* value

$EVA = NOPAT - TC \times WACC$

Table 16 EVA calculation table of PetroChina for 2023–2027

Time	2023	2024	2025	2026	2027
NOPAT	276691	296899	313103	318914	326199
WACC	0.067335016	0.06963227	0.075719951	0.082051776	0.085708378
TC	2075317.75	2021503.25	2101657.5	2241936	2256100.75
EVA	136949.1968	156136.8899	153965.0974	134959.4188	132832.2645

2.1.6. PetroChina value estimate

According to previous CNPC development prospect predictions, the two-stage growth evaluation model was adopted here, using the period from 2018 to 2022 as the range for variable growth. The period after 2022 was used to determine stable growth using the following model.

$$V = V_0 + \sum_{t=1}^{n} \frac{EVA_t}{(1+R_{WACC})^t} + \frac{EVA_{n+1}}{(R_{WACC}-g)(1+R_{WACC})^n} \quad , \quad (8)$$

where V represents the evaluated enterprise value, $V_0$is the total capital on the evaluated date, EVA_t is the *EVA* value in period t, $R_{WACC}$is the weighted average cost of capital, and g is the stable and sustainable growth rate of operating income, where g = 18.6%, based on current economic indicators.

Using Eq. (8), V = 1,495,692 million RMB. Hence, *Equity* = *Enterprise value* − *Interest-bearing liabilities* − *Minority shareholder equity* = 1,495,692 − 414,572 − 168,527 = 912,593 million RMB.

Embedded share price =Equity/total share capital (9)

As of December 31, 2022, the total share capital of PetroChina was 183,020.98million shares.Hence,Using Eq.(9), the embedded share price of PetroChina value based on EVA is RMB 4.99 per share. On the same date, the closing price of PetroChina's shares was 4.97 RMBper share, implying that the valuation result was slightly higher than the market price. To explain this, our study hypothesized that many influencing factors were in play, such as the market environment and economic policy. The stock market cannot fully reflect all of these factors in real time. Hence, PetroChina was undervalued by the market on this date.

2.1.7. Sensitivity analysis

Using the two-stage growth evaluation model, the historical EVA data had limited impact on the enterprise valuation results, whereas the sustainable growth rate, *g*, *EVA*, and *WACC* may have had considerable impact. Sensitivity analyses were conducted on these variables to visualize valuation fluctuations.

Table 17 Sensitivity analysis of the sustainable growth rate *g*

Range of g change	V	Range of V change
5%	1812810.054	21.20%
−5%	548014.2853	−63.36%
10%	1971600.098	31.82%
−10%	−325367221	−21853.62%

Table 18 Sensitivity analysis of sustainable *EVA*

Range of sustainable EVA change	V	Range of V change
5%	1472377.221	−1.56%
−5%	2078226.314	38.95%
10%	1449062.756	−3.12%
−10%	1542320.618	3.12%

Table 19 Sensitivity analysis of perpetual *WACC*

Range of sustainable WACC change	V	Range of V change
5%	1464647.695	−2.08%
−5%	1524297.489	1.91%
10%	1430822.133	−4.34%
−10%	1550754.427	3.68%

Tables 17–19 shows that *g* had the strongest influence on the valuation results, followed by *EVA*, whose variation range corresponded to changes similar to enterprise value, and *WACC*, which had a slightly smaller impact and in the opposite direction to enterprise value. Thus, PetroChina can increase corporate value by increasing operating profit and reducing capital costs.

2.2. Model-building to incorporate ESG factors—Comprehensive CNPC valuation

ESG factors are incorporated into the evaluation index of enterprise comprehensive value to supplement traditional methods. When using absolute value evaluation methods (e.g., EVA), the ESG contribution or premium is added as an increment in enterprise value. The specific idea is as follows: building ESG standard factor system → calculating the weight of each index → calculating the score of each index → obtaining the correction coefficient → calculating enterprise value.

2.2.1. Construction of ESG factor index system

After analyzing the extant ESG rating systems, according to market environments and policies, the evaluation indicators differed slightly. For example, Morgan Stanley Capital International (MSCI) established a special key indicator system for each industry based on its characteristics. For the ESG performance of enterprises in the petrochemical industry, MSCI incorporates pollutants produced during production and operation, carbon emissions, energy consumption, development and innovation of clean technologies, product quality and safety, contractor safety and labor management, energy conservation and environmental protection, harmful chemicals presented in products, corporate governance systems, and business ethics and subdivided qualitative or quantitative evaluation indicators. By comparing these metrics with those of other authoritative ESG rating agencies, Table 20 presents the resulting ESG factor evaluation index system.

Table 21 ESG evaluation index system of the petrochemical industry

Layer of object	Layer of criterion	Layer of indicators	Description of indicators
Enterprise value of petrochemical industry	E: Environment Protection	Discharge of pollution and waste	What degree of pollution and waste discharge exists in the process of mining, refining in the chemical industry and whether measures are taken to reduce pollution and waste discharge
		Carbon emissions	Carbon emissions of enterprises in production and operation as well as investment, measures, and implementation effects of the implementation of green production and green office to reduce carbon dioxide emissions
		Energy consumption	Whether the enterprise has large energy consumption in the supply chain and implements methods to reduce energy consumption
	S: Social responsibility	Product quality and safety	Whether the enterprise has built a sound product quality management system and strict control of product quality; whether the product quality has been tested and certified by authoritative institutions; and whether the company had a safety accident or product recall recently, and how do consumers evaluate the quality of its products
		Scientific and technological innovation	Whether the enterprise has a large R&D investment and actual technological innovation
		Protection of employee rights and interests	Whether the enterprise has gender discrimination, illegal employment, and other behaviors; whether the enterprise offers a good working environment as well as training and development opportunities for employees; whether the enterprise makes efforts in ensuring the personal safety and physical and mental health of employees
	G: Corporate Governance	Board of directors	It mainly measures whether the board structure and personnel of the company are reasonable, whether the company's decision-making mechanism is perfect and strictly complied with, the implementation of the independent director system, whether the proportion and changes of independent directors are reasonable, and whether they actively participate in the company's decision-making and fulfill their supervisory obligations

		Executive compensation	Whether executive compensation and corresponding incentive policies are reasonable and whether they may cause damage to the interests of investors
		Risk management	The measures and effects of the company in preventing and controlling capital, operational, and financial risks
		Business ethics	The enterprise's supervision and management of business ethics issues, including fraud, corruption, bribery, tax evasion, financial fraud, or fraud and other illegal acts, with or without relevant scandals and whether the enterprise establishes a sound code of conduct punishment system and reporting mechanism, etc. to regularly carry out publicity and ideological education work

2.2.2. Determine index weights

This paper combines the entropy method with the analytic hierarchy process to determine indicator weights.

Using the analytic hierarchy process to calculate subjective weights

The expert scoring method was used to construct a relative index importance judgment matrix based on expert evaluations. Subsequently, the maximum eigenvalue, λ, of the matrix and its corresponding eigenvector were calculated. Then, consistency tests were conducted.

The consistency index, CI, and test coefficient were calculated by combining the RI coefficient (Table 21) as $CR = CI / RI$. When $CR < 0.1$, the judgment matrix passes the consistency test. The passing feature vector reflects the weight coefficient of each index at its given level.

Table 22 RI coefficients

Matrix Coefficients	3	4	5	6	7	8	9
RI Value	0.58	0.90	1.12	1.24	1.32	1.41	1.45

Using the entropy method to calculate the weight of objective indicators

The entropy method shown in Eq. (7) was used to calculate the weight of objective indicators:

$$pij=xij/\sum_{i=1}^{n} x_{ij} \; ; \; H_j= -1/\ln n \sum_{i=1}^{n} p_{ij}\ln(p_{ij}) \; ; \; wj=(1-H_j)/\sum_{i=1}^{m} (1-H_j) \quad . (7)$$

Using the ESG rating data of enterprises in the same industry, x_{ij} represents the score of enterprise i on indicator j. First, the contribution, p_{ij},of the i^{th} enterprise under the j^{th} index is calculated. Then, entropy H_j of the j^{th} index is calculated. Finally, weight w_j of index j is obtained.

2.2.3. Enterprise valuation model considering ESG factors

Incorporating ESG factors into corporate valuations is a challenging emerging trend. At present, no unified method exists to achieve this goal, and different evaluation institutions and investors use different models based on different assumptions. According to the results of domestic and foreign scholars and research institutions, two basic methods exist. The first uses ESG factors to determine valuation parameters based on the mechanisms that influence traditional enterprise value. The second uses ESG factors as the comprehensive value of an enterprise to supplement traditional methods. When considering the feasibility of both ideas, this study used the treatment methods of non-financial factors (Hu Jiejie, 2021), and the second method was adopted to construct Eq. (10), where the proposed energy vehicle enterprise value evaluation model considers ESG factors.

$$V=F\ (ESG,\ V_0) = \alpha \times V_0 \quad , \qquad (10)$$

where V represents enterprise value after considering ESG factors, α is the correction coefficient, which indicates the contribution rate of ESG factors to enterprise value, and V_0 is the enterprise value calculated by the traditional model. Correction coefficient α is obtained with Eq. (11):

$$\alpha = f\ (ESG)\ = \omega \times X \quad , \qquad (11)$$

where ω represents the weight coefficient of key ESG indicators affecting enterprise value, and X is the score vector of the enterprise's performance according to ESG indicators.

2.2.4. EVA evaluation model modification considering ESG factors

Calculation of indicator weights

This study takes enterprise scoring data using intra-industry standards based on the Runling Global ESG database. The entropy method is used to calculate the weight of each indicator while adopting the expert scoring method to count expert and accounting firm and investment bank opinions. IBM SPSS software was used to calculate index weights after which no significant difference in weights was observed between the two methods, and relative index importance rankings were essentially the same. These observations indicate that the proposed weight calculation method is valid and reliable. Therefore, the combined entropy weighting and analytic hierarchy process was used to provide the final ESG factor index system weight in this paper. The results are shown in Table 22.

Table 23 ESG factor indicators and weights

Layer of object	Weight	Layer of criterion	Layer of indicators	Description of indicators	Weight
Enterprise value of petrochemical industry	100%	E: Environment Protection	Discharge of pollution and waste	What degree of pollution and waste discharge exists in the process of mining, refining in the chemical industry, and whether measures are taken to reduce pollution and waste discharge	32.94%
			Carbon emissions	Carbon emissions of enterprises in production and operation, investment, measures and implementation effects in the implementation of green production and green office to reduce carbon dioxide emissions	33.12%
			Energy consumption	Whether the enterprise has large energy consumption in the supply chain and implements methods to reduce energy consumption	33.94%
		S: Social responsibility	Product quality and safety	Whether the enterprise has built a sound product quality management system and strict control of product quality; whether the product quality has been tested and certified by authoritative institutions; and whether the company had a safety accident or product recall recently, and how do consumers evaluate the quality of its products	30.10%
			Solving the problem of employment	Whether the enterprise solves the local employment problem to a certain extent	10.00%
			Scientific and technological innovation	Whether the enterprise has a large R&D investment and actual technological innovation	32.82%

			Protection of employee rights and interests	Whether the enterprise has gender discrimination, illegal employment, and other behaviors; whether the enterprise offers a good working environment as well as training and development opportunities for employees; whether the enterprise makes efforts in ensuring the personal safety and physical and mental health of employees	27.08%
		G: Corporate Governance	Board of directors	It mainly measures whether the board structure and personnel of the company are reasonable, whether the company's decision-making mechanism is perfect and strictly complied with, the implementation of the independent director system, whether the proportion and changes of independent directors are reasonable, and whether they actively participate in the company's decision-making and fulfill their supervisory obligations	5.60%
			Executive compensation	Whether executive compensation and corresponding incentive policies are reasonable and whether they cause damage to the interests of investors	8.92%
			Risk management	The measures and effects of the company in preventing and controlling capital, operational, and financial risks	14.74%
			Business ethics	The enterprise's supervision and management of business ethics issues, including fraud, corruption, bribery, tax evasion, financial fraud, or fraud and other illegal acts, with or without relevant scandals and whether the enterprise establishes a sound code of conduct punishment system and reporting mechanism, etc. to regularly carry out publicity and ideological education work	70.74%

Calculation of correction coefficient

To ensure the objectivity and accuracy of the resulting index score data, this paper determines all ESG factor indices for PetroChina using Runling Global ESG rating data. Using extant methods, this paper took the average industry score as the benchmark and adjusted the index scores appropriately from 0–100 points based on the benchmark leveled at 60 points. Hence, if the derived score is lower than 60, then PetroChina's for the given index has reduced its corporate value. After the adjusted scores were obtained, PetroChina's overall ESG score was 66.42 and the correction coefficient was 1.02 (66.42 ÷ 60). From the total scores listed in Table 4, it can be concluded that PetroChina's ESG performance is conducive to improving its corporate value.

Table 24 Calculation of overall ESG factor scores of PetroChina

Total score	Layer of criterion	Weight	Score	Layer of indicators	Weight	Score
	E	61.35%	59.48	Discharge of pollution and waste	32.94%	68.62
				Carbon emissions	33.12%	57.38
				Energy consumption	33.94%	52.67
				Product quality and safety	30.10%	70.51
				Solving the problem of employment	10.00%	72.58
				Scientific and technological innovation	32.82%	77.36

66.42	S	30.55%	76.03	Protection of employee rights and interests	27.08%	81.83
	G	8.10%	82.85	Board of directors	5.60%	83.94
				Executive compensation	8.92%	79.86
				Risk management	14.74%	72.22
				Business ethics	70.74%	85.36

Valuation of results and analyses

After applying the ESG factors to the EVA model, the comprehensive enterprise value of PetroChina was 1,495,692 × 1.13 = 1,690,131.96 million yuan. To verify the rationality of the revised valuation model, this study used the rating data of other ESG agencies to recalculate the coefficient and enterprise value. Notably, the non-Runling Global sources only disclosed comprehensive scoring data based on three indicators. Hence, sub-indicators were unavailable. Therefore, this study considered the average scores of the three given indicators and calculated ESG factor contributions according to the weights set in this study. Notably, for grading systems (e.g., 10-point scoring), the total score was converted into a percentage in the criterion layer according to the given proportion. Thus, the average value was calculated.

After adjusting the scores from the various institutions, PetroChina scored 56.32, 79.25, and 80.86 at the E, S, and G levels, respectively. The contribution rate of α was 63.52 ÷ 60 = 1.059 for all Chinese petroleum enterprises, calculated using the average scores of each rating agency. This finding is consistent with previous calculations, implying that the proposed valuation system is reasonable after considering ESG factors.

To bring the valuation closer to the real market value, the revised model can be used to compensate for any defects related to traditional valuation models that do not consider ESG factors, leading to more accurate valuations of new energy vehicle enterprises, thereby verifying this study's conclusion that good ESG performance improves petrochemical industry enterprise value.

3. Conclusion

Oil comprises a national strategic reserve resource; hence, it has a strong political color. Therefore, calculating reasonable and accurate valuations is of great significance for oil enterprises. This study employed the ESG index adjustment method based on the EVA model to evaluate CNPC's value, and the result was 1,690,131.96 million yuan. This valuation attaches suitable importance to the evaluation of on- and off-balance sheet values, which comprehensively reflect the value of an enterprise.

EVA is used to determine enterprise value, and it effectively connects shareholder rights and enterprise interests to value, allowing more thorough and accurate judgments of earning capabilities. From an asset owner's perspective, this method redefines corporate profits after accounting for capital expenditures and connecting shareholder equity and enterprise value, which are conducive to increasing shareholder equity while simultaneously maximizing the achievement of national interests. Moreover, the proposed method aligns more strongly with the long-term development strategies of the CNPC. Finally, the EVA model in this case was adjusted by incorporating ESG indicators into a single valuation system. Based on the results of subjective and objective weighting experiments, the entropy weight method and analytic hierarchy process were determined to be most conducive for obtaining accurate index weights, and the resulting scores led to a highly accurate total score.

In summary, this study establishes a new valuation system that incorporates long-term value, social value, asset safety, and policy impact into account, with the objective of improving the valuation system of the petroleum industry. This effort is expected to improve the industry's ability to accurately reflect the profitability of oil enterprises while offering new insights into modern valuation theory.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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