Research on Petroleum Industry Supply Chain in China: Performance and Predictive Analysis of Sinopec Group

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Abstract. As a major producer of oil and gas, China has historically adopted a variety of different approaches to managing its overall oil and gas supply chain. It also incorporates decisions and forecasts of trends in the overall petroleum supply chain in the context of existing domestic and international societal trends, such as the impact of national policies and the supply chains of China's domestic petrochemical companies in the context of Sinopec's past annual reports and assessments and recommendations for sustainable supply chains. This article uses the case study of Sinopec, a major Chinese chemical company, to provide statistics on the domestic market context and to propose and discuss risk management and sustainable supply chains for the company's supply chain, as well as quantitative analysis to forecast and analyze China's domestic oil consumption, with case studies and data on all indicators, and to show the impact of plans and trends on the chemical supply chain over time. The implications and trends of developing trends in the chemical supply chain are presented, and conclusions and final recommendations are drawn.

1 Introduction

As one of the world's largest chemical production and consumption markets, China's chemical industry is important in the global supply chain network. And China's chemical industry covers many sectors, including petrochemicals, basic chemicals, and specialty chemicals. The supply chain of China's chemical industry consists of multiple links involving multiple players and processes, such as raw material procurement, production and processing, and product distribution.

Supply chain management focuses on "the integration and coordination of business processes and strategic alignment across the supply chain", where CNPC has planned and coordinated its supply chain management to ensure the procurement and transportation of crude oil and has created several departments to coordinate and control each other to maintain the integrity of the existing supply chain [1]. However, China National Petroleum's supply chain still faces risks and uncertainties in the future, such as the impact of past global epidemics, the Bohai oil spill, and other unknown risks, and these uncertainties need to be considered when making decisions. This will enable the entire supply chain to analyze the forecast results and make decisions and changes to internal supply chain management strategies.

Meanwhile, this paper presents a quantitative discussion of the current state of China's domestic oil supply chain and Sinopec's supply cost-effectiveness, a comprehensive assessment of cost-benefit analysis and forecasts of China's future oil consumption, the extraction of data on China's domestic oil consumption in the past and the use of model analysis, and the integration of Sinopec's cost-effectiveness, market and financial situation to clarify the interaction between forecasts of future domestic oil consumption and the current state of the supply chain.

2. Cost-benefit Analysis of Petroleum Supply Chain in Sinopec Group

2.1 Cost structure analysis

2.1.1 Purchasing cost analysis

In recent years, rising commodity prices, especially crude oil, have impacted the procurement cost for companies like Sinopec and PetroChina. For example, the gross margin of Sinopec fell by 2.6% due to the increased procurement cost of raw materials. Companies need to consider strategies to optimize procurement and manage costs, perhaps by locking in prices when possible or exploring more cost-effective suppliers [2].

Given the ongoing trends, it may be beneficial for companies to lock in prices when possible or seek more cost-effective suppliers. The fluctuation in operating profit and pre-tax profit seen over the years suggests that

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procurement costs could play a role in these variances, indicating a need for strategic purchasing management [3].

2.1.2 Production cost analysis

Oil companies could seek efficiencies in production to reduce costs. This might include investing in more efficient machinery or technology, improving workflows to minimize waste, or training to improve worker productivity [4]. Energy costs are also a significant part of production costs in this industry. Therefore, energy efficiency measures could also help to reduce costs. This also indicates a similar trend to the operating profit. The significant increase in pre-tax profit from 2020 to 2022 shows an improvement in the company's profitability before accounting for tax expenses. Improving production efficiencies is key to managing costs. This might include investments in new technologies or machinery, refining workflows to minimize waste, or providing employee training to boost productivity. Given the increased pre-tax profits from 2020 to 2022, measures to manage production costs may bear fruit. Energy efficiency could be another area of focus for cost reduction, given the industry's significant energy [2].

2.1.3 Warehousing and logistics cost analysis

Rapid growth in the number of gas stations implies expansion in the storage and logistics sector. There are inherent costs in establishing and maintaining these facilities, including transport costs between production facilities, warehouses, and retail locations [3]. Streamlining this can reduce cost and time, potentially using improved forecasting methods and leveraging technology. Technology and improved forecasting methods could streamline these operations and reduce costs. This is also suggested by the fluctuating cash flow from operating activities per share observed from the accounting data, indicating potential areas for optimization in logistics [5].

2.1.4 Management and operating cost analysis

The gross profit margins of Sinopec and PetroChina were 15.76% and 21.12%, respectively, in Q3 2022, indicating differing management efficiency and operational costs between the companies. Investing in management best practices, technology, and innovation can improve these rates. The R&D investments of both companies, 21.1 billion yuan for Sinopec and 23.73 billion yuan for PetroChina in 2021, could contribute to increased efficiency and reduced operational costs [4].

Investments in technology, innovation, and best management practices could help improve these figures. The accounting data also shows a steady increase in equity attributable to shareholders over the years, suggesting that cost management measures may have been effective. Nevertheless, further inquiries into the company's cost structures and comparative analyses with prevailing industry benchmarks could yield supplementary elucidations. Moreover, examining research and development (R&D) expenditures undertaken by both entities further highlights their dedication to innovation, potentially resulting in heightened operational efficacy and future cost mitigations.

2.2. Quantitative analysis

Based on the key indicators, ratios, and numeric resources obtained from Sinopec, the leading oil supplier in China, the quantitative analysis of the supply chain costs yields the following findings:

When examining the Asset Turnover Ratio, which gauges the efficiency of a company's asset utilization in generating sales revenue, the calculated ratio for 2022 stands at 1.70. This signifies that the company generates 1.70 units of currency in sales revenue for each unit of the currency invested in assets.

The annual report reveals a significant increase in the Return on Equity (ROE) from 2020 to 2021, indicating that the company successfully generated a higher return on the invested equity. However, a slight decrease in ROE from 2021 to 2022 suggests a slight decline in the company's efficiency in generating profits from each unit of shareholder's equity [4].

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Regarding Debt-to-Equity Ratio, a metric assessing a company's financial leverage, the figure for 2022 stands at 1.29. This indicates that the company employs a combination of debt and equity in its financing structure, with a slightly higher reliance on debt.

These metrics provide significant insights into operational efficiency, financial well-being, and profitability. Consequently, they can be utilized for cost and benefit analysis.

3 Predictive analysis of Sinopec and China’s Petrolum Supply Chain

This study aims to forecast China's oil demand based on current price levels and production and consumption trends. Cost-benefit analysis helps to make an accurate prediction. The current or prevailing statistical analysis shows that; the return on equity ROE has had a constant increase, but a slight decrease occurred for 2021 and 2022.ROE shows the efficiency of profit generation from equity shares by a company. The asset turnover ratio, which helps to measure the efficiency of asset utilisation for profit generation in a company, is positive in this company.

The company has a chance of making more profit with the assets it has. The company's steady progress towards profit makes it stable and helps it to cover all its expenses and keep up with the competition. This gives it a good chance of better performance in the future. The

company experiences a growth in income from the year 2020 to 2022, from 2.1 million to 3.0 million. An increase in income shows increased sales and efficiency in the company's sales operations. This allows the company to have a better stock turnover for a short period of time, which increases the company's income. The company has increased the profit attributes to the shareholders of the company. This makes the share sale healthy and attractive ensuring that the shareholders get a better share and are encouraged to make more funding to the company. The shares also fetch a reasonable price on the stock market, ensuring that the company has a good source of finance. The company has more assets than liabilities, which means that it can still pay all its liabilities from its assets in the future.

The company is able to perform well in the future based on its current financial position, which is in line with its ratios. The company has a good history of production and consumption. Based on this information, the demand for petrol in China will tend to increase and grow. The fierce competition between the two dominant companies is healthy and will keep petrol prices low. The companies have had a healthy performance, which shows their stability in offering low petrol prices. The country is advised to find alternative energy sources instead of petrol; diversifying the concentration and dependence on petrol as the sole energy source will lower prices. Lower prices will lead to an increase in demand for oil.

4 Analysis of demand situation in China

With the rapid development of China's economy and accelerated urbanisation, China's demand for oil continues to grow. As the world's largest energy consumer and second largest oil consumer, China's oil demand has attracted much attention. At the same time, China's oil market is becoming an increasingly important player in the global oil market, significantly impacting global oil prices and supply patterns.

4.1. Analysis of the Development of China's oil demand

China's oil demand, i.e. oil consumption, is also increasing, and the oil consumption in Chian generally shows a gradually increasing trend. In 2021-2022, China's oil consumption decreases slightly. In 2022, China's oil consumption is 594.28 million tonnes higher than in 1991. In 1999, China's oil consumption exceeded 200 million tons for the first time, then broke through 500 million tons in 2015 and 2017, directly exceeded 600 million tons, followed by 700 million tons in 2021.

As can be seen in Figure 1, the growth rate of China's oil consumption is positive in all years except for 2021-2022, which has a negative growth rate. China's oil production increases every year except for the annual time interval 2021-2022, but the growth rate is different due to fluctuations in the growth rate.

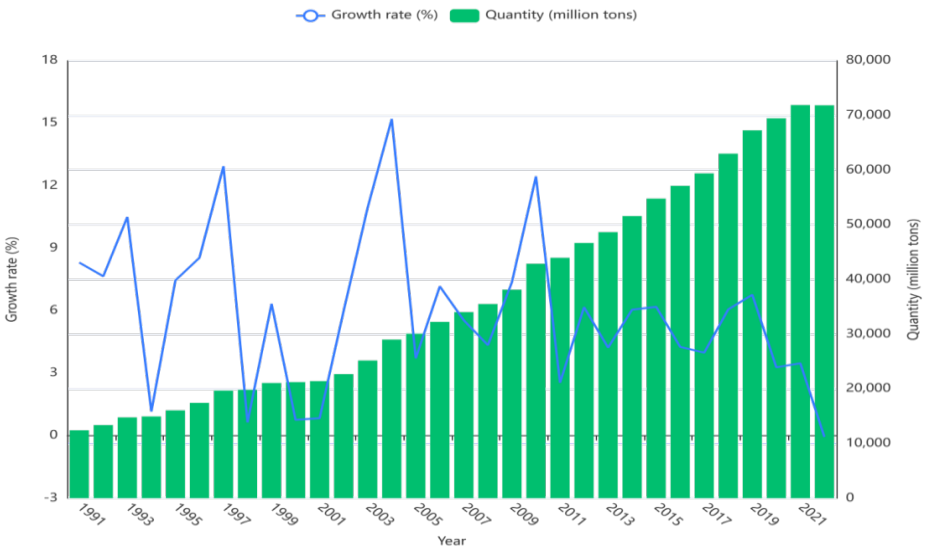

Fig. 1. Trend of oil consumption and growth rate in China. (Photo/Picture credit : Original)

4.2. Analysis of China's oil consumption by industry demand

As oil is an important resource for promoting national economic growth and maintaining national defence and security, the development of many industries is closely related to the level of oil consumption. According to the oil balance sheet in the China Statistical Yearbook, China's oil demand industries are divided into the following seven categories: industry; transportation, storage and postal services; agriculture, forestry, animal husbandry, fishery and water conservancy; construction; wholesale, retail trade, hotels and restaurants; other industries; and domestic consumption [6].

According to the China Statistical Yearbook, among the seven industries listed in oil demand, the two industries with the largest share of oil consumption are industry and transportation, storage and postal services, and the sum of oil consumption in these two industries accounts for about 70% of oil consumption in calendar years. China's oil consumption in industry and transport,

storage and communication shows an overall increasing trend, except for a few years when it decreases. In 2012, the transportation, storage and postal industry surpassed the industry for the first time and became the top industry in terms of oil consumption. This is directly related to the increase in the number of motor vehicles in the country due to the recent improvement in China's national economy. According to the data, the oil consumption of China's transportation, storage and postal industry was 16.832 million tonnes in 1990, and reached 220.29 million tonnes in 2017, which is 13.09 times more than in 1990. Similarly, industrial oil consumption has also increased significantly: in 1990, China's industrial oil consumption was 73.216 million tonnes, and it reached 195.46 million tonnes in 2017, which is 2.67 times more than in 1980. Among other industries with a relatively small share of oil consumption, the trend of oil consumption in wholesale and retail trade, hotels and restaurants, construction, household consumption and other industries has generally shown an upward trend over the years, while oil consumption in agriculture, forestry, animal husbandry, fishery and water conservancy has shown a fluctuating trend in recent years.

5 Forecast of China's oil consumption

Through the analysis of previous literature, the analysis of China's oil consumption in previous years and the current situation of China's oil consumption, this paper analyses the target time series data by modelling with a grey forecasting model and an exponential smoothing model. It establishes a combined forecasting model with higher accuracy through a single forecasting model to forecast oil consumption in 2023-2025. These models are described below.

5.1. Gray prediction model

When the time series has a changing trend, we can use the gray prediction model to predict it, but not when the time series is a random fluctuation time. At the same time, Markov's theory suits the state transfer behavior in a stochastic process. Therefore, the two theories are combined to predict the trend of change in the time series using the gray prediction model [7].

The level ratio test and smoothness test were performed on the oil consumption data of China from 1991 to 2022. It was found that the level ratios only fell within the interval of $(e^{-\frac{2}{41+1}}, e^{\frac{2}{41+1}}) = (0.9534, 1.0488)$. The smoothness ratio series $\rho(k)$ was not a decreasing function of k, so the original data series failed the level ratio and smoothness tests. Therefore, China's oil consumption data from 1991 to 2022 were transformed by translation, and the level-ratio test and smoothness test were performed on the transformed data series. The results show that both tests of the transformed data pass, and a gray model is further developed for the transformed data.

Based on the gray model theory, SPSS was used to analyze and develop a gray GM(1,1) model for China's domestic oil consumption data from 1991-2022. The prediction fitting diagram is shown in Figure 2.

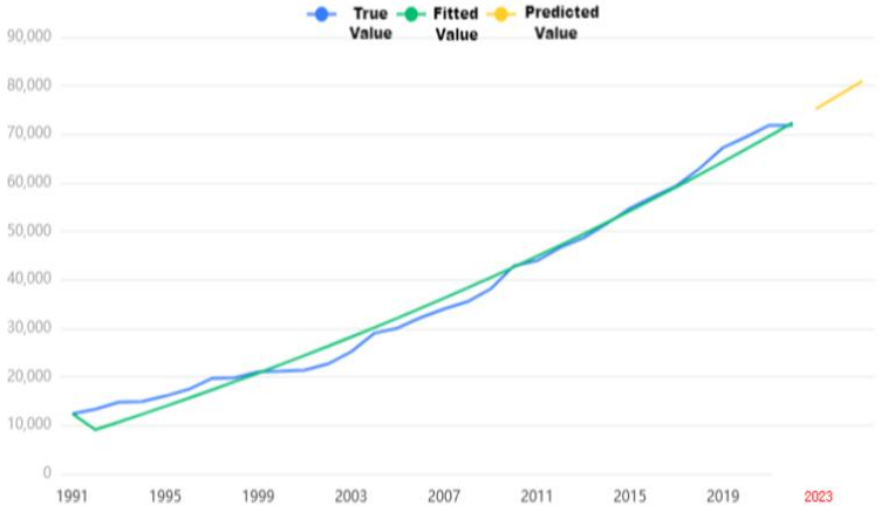

Fig. 2. Fitted GM(1,1) model prediction results. (Photo/Picture credit : Original)

Table 1 demonstrates the development coefficient, gray action volume, and posterior difference ratio values. The gray prediction model can be constructed from the development coefficient and the gray action volume. c<0.35, the model accuracy grade is: excellent, the average relative error of the model is 7.059%, which means that the model fits well, and the posterior difference ratio value is 0.012, the model accuracy is high [8]. The resulting gray forecast model predicts that China's oil consumption in 2023-2025 as shown in Table 2.

Table 1. GM(1,1) model test data table

Year	Oil consumption	Predicted value	Residuals	Relative error (%)	Average relative error (%)
2020	69477	66966.104	2510.896	3.614	2.499
2021	71892	69663.612	2228.388	3.1	
2022	71850	72413.523	-563.523	0.784	

Table 2. The grey model prediction results

Year	Predicted value
2023	75216.855
2024	78074.645
2025	80987.952

5.2. Exponential smoothing prediction model

The exponential smoothing method was first proposed by Robert-G-Brown. He believed that the past trends of time series might continue, so when forecasting the target series, the more time-honored data are assigned smaller weighting coefficients. In comparison, the more recent data receive larger weighting coefficients, so the forecast values obtained are more realistic and reflect the latest information [9].

China's oil consumption, in general, shows a clear upward trend. However, it is challenging to distinguish whether the upward trend is linear or curvilinear. Therefore, the quadratic, exponential smoothing and cubic exponential smoothing models are performed on the data for forecasting [10].

In the exponential smoothing model $s_0^{[1]}$, $s_0^{[2]}, s_0^{[3]}$, are the initial prediction values, and there are three ways to take them: (1) taking the first measured data value of the sample data; (2) taking the average value of the first few measured data of the sample data; (3) selected empirically. When the sample data is large, the first method is suitable to determine the initial prediction value $s_0^{[1]}$; when the sample data is small, the second method is suitable to determine the initial prediction value $s_0^{[1]}$, $s_0^{[2]}, s_0^{[3]}$. In this paper, based on general experience, the selection of $S_0^{[1]} = S_0^{[2]} = S_0^{[3]} = x_0 = 12422.$

Based on China's oil consumption data from 1978-2018, since the range of a is (0, 1), the best a is found by forecasting China's oil consumption in steps of 0.1, respectively, and calculating the relative error separately.

The prediction results are different when different values are taken. The average relative error can be calculated by calculating the average relative error for different cases of a and selecting the one with the smaller average relative error a value. The result as shown in Table 3 (The data in number 17 indicates the best parameters automatically found by the model) and Figure 3.

Table 3. RMSE test data for exponential smoothing prediction model

Number	Initial value S0	alpha value	Smoothing type	RMSE value
1	12422.000	0.100	Smoothing at once	14651.159
2	12422.000	0.100	Secondary Smoothing	6212.720
3	12422.000	0.100	Triple Smoothing	2590.539
4	12422.000	0.200	Smoothing at once	9038.723
5	12422.000	0.200	Secondary Smoothing	2330.107
6	12422.000	0.200	Triple Smoothing	1342.174
7	12422.000	0.300	Smoothing at once	6455.060
8	12422.000	0.300	Secondary Smoothing	1496.708
9	12422.000	0.300	Triple Smoothing	1272.709
10	12422.000	0.400	Smoothing at once	5012.134
11	12422.000	0.400	Secondary Smoothing	1284.514
12	12422.000	0.400	Triple Smoothing	1284.440
13	12422.000	0.500	Smoothing at once	4102.413
14	12422.000	0.500	Secondary Smoothing	1221.386
15	12422.000	0.500	Triple Smoothing	1316.040
16	12422.000	0.600	Smoothing at once	3481.173
17	12422.000	0.600	Secondary Smoothing	1203.161
18	12422.000	0.600	Triple Smoothing	1375.241
19	12422.000	0.700	Smoothing at once	3032.877
20	12422.000	0.700	Secondary Smoothing	1208.252
21	12422.000	0.700	Triple Smoothing	1480.408
22	12422.000	0.800	Smoothing at once	2696.489
23	12422.000	0.800	Secondary Smoothing	1236.109
24	12422.000	0.800	Triple Smoothing	1651.258
25	12422.000	0.900	Smoothing at once	2437.092
26	12422.000	0.900	Secondary Smoothing	1292.377
27	12422.000	0.900	Triple Smoothing	1909.867

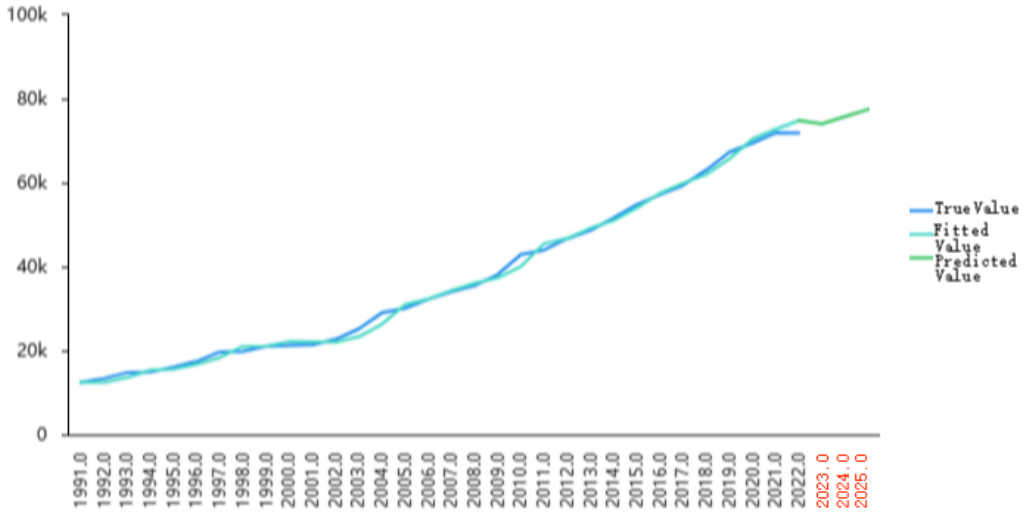

Fig. 3. Fit of exponential smoothing model prediction results at = 0.6. (Photo/Picture credit : Original)

According to Table 4, the average relative error obtained from the quadratic smoothing exponential model prediction is the smallest when $a = 0.6$.

Table 4. Test data table for quadratic exponential smoothing model at $a = 0.6$

Year	Oil consumption	Predicted value	Residuals	Relative error (%)	Average relative error (%)
2020	69477	70454.915	977.915	1.407	2.214
2021	71892	72716.469	824.469	1.115	
2022	71850	74810.109	2960.109	4.120	

The resulting quadratic exponential forecast model predicts that China's oil consumption in 2023-2025 as shown in Table 5.

Table 5. Exponential smoothing model prediction results

Year	Predicted value
2023	74044.172
2024	75764.726
2025	77485.281

6 Conclusion

In conclusion, the oil demand situation in China can be characterized by the initial decline in demand due to strict embargoes and restrictions imposed during the outbreak. However, as the epidemic was brought under control and the economy began to recover, oil demand showed a gradual recovery, albeit at a slower pace. It is important to note that during the epidemic, the Chinese government actively promoted the development of new and clean energy sources, leading to a reduced reliance on traditional oil. This shift in energy policies may have long-term implications for oil demand in China.

To address the oil demand situation in China, several suggestions can be considered. Firstly, Chinese oil companies should allocate more investment and focus on research and development in clean energy sectors, such as renewable energy and electric vehicles. This strategic shift will help reduce reliance on traditional oil and align with changing market demands.

Secondly, it is crucial for oil companies to strengthen international cooperation and explore new market opportunities. Given the global impact of the epidemic on oil demand, expanding sales channels and seeking new partners will enable Chinese oil companies to adapt to evolving market dynamics and increase revenues.

Thirdly, enhancing the resilience and flexibility of the supply chains is vital. The epidemic exposed vulnerabilities in the global supply chain, making it essential for oil companies to establish robust and adaptable supply networks. This will ensure a stable oil supply during similar contingencies and maintain operational continuity.

Furthermore, the government should increase support for research and development, as well as the application of clean energy technologies. Offering incentives such as tax benefits and subsidies can encourage the adoption of clean energy by companies and individuals, fostering innovation in the clean energy sector.

Lastly, strengthening energy cooperation with other countries can enhance the stability of the oil supply. By establishing energy partnerships, China can diversify its sources of oil and reduce dependence on specific regions, ensuring a secure and consistent oil supply.

Authors Contribution

All the authors contributed equally,
and their names were listed alphabetically.

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