

# Analysis of the Energy Company Stock's Portfolio in the Past Twenty Years by Using the Markowitz Model and the Index Model

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**Abstract.** Setting an optimal portfolio is an important issue to all the people who are in the stock market. Some people use their experience to get profit by buying and selling the energy company's stocks, but they lack a good portfolio for them to not only decrease the risk but also get more profits. Therefore, the goal of this paper is to decide which one between Markowitz Model and Index Model is best tool for investors to set their energy companies' portfolio. The research method is to collect data from Yahoo Finance, and then using the data to calculate the minimum variance point, maximum sharp ratio, minimum variance frontier, efficient frontier, inefficient frontier, and capital allocation line for both models. By comparing and analyzing these data, the optimal portfolio can be obtained for investing the energy companies. The result of this research is that both models are good tools for investors to establish their portfolio regard to the energy market.

**Keywords:** Portfolio Construction; Markowitz Model; Index Model.

## 1. Introduction

### 1.1 Background

Nowadays, people will not only get their paycheck as their income, but also people will set a appropriate portfolio for themselves to make money. By buying different values of stocks, bonds and other investments, people can set their portfolio. With the advancement of economy after the epidemic, the stock market gradually went back to the normal situation and started to grow. Therefore, it is important for people who wants to get make profits from buying and selling in the stock market. This paper mainly concentrates on energy company, such as Chevron Corporation, Exxon Mobile Cooperation and so forth. These companies are selling gasoline and the related product of energy. Energy influences people's life in many aspects. For example, people need gasoline for their daily drive. People need natural gas for their house cooking. People need the metal to produce the high-tech products, like computer. Not only does energy impact people's own life, but also the energy part in the whole stock market is an essential part. Based on the US energy employment report 2020, in 2019, the US energy industry employed about 6.8 million Americans, accounting for nearly 5% of the US labor force. Therefore, setting an optimal portfolio is important for investors who focus on energy companies' stocks. The rest of the paper will mainly analyze two models and determine which model is more helpful to set the optimal portfolio.

### 1.2 Related research

Zhang et al. emphasized that the impact of oil shocks is broken down into two impact channel: 'direct' and 'indirect'. To embed additional oil price risk exposure into the traditional market beta, the researcher uses the empirical asset pricing model to illustrate that the oil shocks can not only influence the energy-related stocks but also indirectly impact the stock by general market risk [1].

Bladh pointed out that total energy consumption act an important role in a limited resources world. It is the result of two fundamental trends in two opposite directions: the rapid increase of both amount and use. The researcher suggested that the increasing supply-demand is offset by measures to improve overall energy efficiency, and it is increasing to a greater extent than in the past [2]. Ghoilpour reviewed many kinds of previous studies and updated materials and indicated that energy prices have an impact on stock returns in various sectors. The purpose of the authors' study is to examine the impact of the price of energy-based products such as natural gas or oil on stock returns in the Iranian industry. To recognize the impact 35 Iranian industry records were broke down for the period from January 2005 to March 2010. The discoveries recommend that oil costs are a significant determinant of profits for banks other monetary organizations and energy-related businesses [3].

Sadorsky estimated the expected returns on stock prices in the large oil and gas sector using the multifactor market model. The result showed that stock prices in Canada's energy sector, such as oil and gas, are largely influenced by return exchange rates, crude oil prices and interest rates. The research has found that the oil and gas industry has less risk compared with the market while its trend is pro-cyclical. The authors also present oil and gas stocks may not be a good hedge against inflation [4]. Apergis and Miller pointed out that the international stock market returns do not respond well to oil market shocks. The authors research a sample of eight countries, ultimately reflecting clear structural shocks endogenously characterized by oil price changes. The concentrate primarily involves vector blunder remedy or vector autoregressive models to decide the effect of these primary shocks on financial exchange returns in our example of eight nations [5]. Wireless distributed microsensor systems will provide reliable environmental monitoring for civil and military applications. Compared with the traditional routing protocol, the energy consumption of the LEACH protocol is reduced by 8 times. In addition, the effective lifetime of the simulation network is doubled. Several industrial and military applications require accurate environmental monitoring. The focus primarily uses vector error correction or vector autoregressive models to determine the effect of these crucial shocks on the financial trade returns in our example of eight countries. [6].

It is suggested that an approach for geographic graphics called geographical adaptive fidelity (GAF) could help AD hoc networks use less energy. GAF conserves energy by determining analogous nodes from the perspective of routing and then turning off extra nodes to keep the level of route fidelity consistent. An illustration of adaptive fidelity is GAF, which uses redundancy to save energy while maintaining application integrity to increase the lifespan of a self-configured system. Energy utilization is a crucial indicator in situations like sensor networks where it directly correlates to lifetime and utility [7].

Daily body energy requirements calculated from different parts of energy expenditure are inaccurate and often do not coincide with measured energy intake. We provided 177 subjects with a detailed description of the human breathing chamber and the method used to determine the rate of energy expenditure over 24 hours. The results of a study of 177 subjects with different body weights and body composition are presented and the possible determinants of energy expenditure are discussed. Individuals also vary greatly in their energy consumption rates and, as a result, in their energy requirements [8]. Based on the game theory, .Cai studied the concept of real option is introduced to study the investment value of new energy vehicle industry [9]. Feng studied the planning model. Also, the subsidy of new energy vehicles is studied, and the production and sales efficiency of manufacturers are analyzed [10].

In order to find the combination of companies with the lowest risk while having the high potential of making the greatest profit, there will be an analysis of several energy companies, of which all of them are in North America. By quoting the historical data including the daily return of the three companies, the daily return of S&P 500 and the risk-free rate from Yahoo Finance, we can finally calculate some significant parameters, which are the annualized average return, annualized standard deviation, beta, annualized alpha, annualized residual standard deviation and correlations, that will be used for building Index model and Markowitz model. Eventually, with the result of two models exploring an efficient and optimized way of constructing investment strategy, a portfolio with great

return and relatively low risk will be able to be figured out as a great investment opportunity during such a period the market has great volatility.

## 2. Data and Method

### 2.1 Data and companies' description

The necessary data comes from the Yahoo Finance, which includes the daily stock price of three major energy companies in North American stock market-Chevron Corporation (CVX), Exxon Mobil Cooperation (XOM), and Imperial Oil Limited (IMO)-from May 11st 2001 to May 12nd 2021. And other relative data includes the S&P 500 equity index and risk-free rate. The solution of collecting data uses mixture of direct API calls, HTML data scraping and pandas data scraping. The respondent includes three major energy companies in North American CVX, XOM, and IMO. The CVX is the second-largest integrated energy company in United States and this company mainly produces crude oil, natural gas, and other energy products. The company is located in San Ramon, California. Second, XOM is an American multinational oil and gas company based in Irvine, Texas. This company's business focuses on the exploration and production of crude oil, natural gas and the trade of natural gas, crude oil, petroleum products and petrochemicals. IMO is a second-biggest integrated oil company in Canada. The main shareholder of IMO is ExxonMobil with 69.9 percent ownership. IMO's businesses include the production crude oil, diluted bitumen and natural gas.

### 2.2 Method

The important data that will be used most is the daily return of three companies, S&P 500, and the risk-free rate because it is essential to use these data to calculate the annualized average return, annualized standard deviation, beta, annualized alpha, annualized residual standard deviation and correlations which are variables needed to establish two models – Markowitz Model and Index Model. Markowitz model is a portfolio optimization model proposed by Harry Markowitz in 1952. It establishes the efficient portfolio by analyzing the portfolio's Return, Standard Deviation, and the Sharpe Ratio. The Index Model is a Statistical model of security returns. The main goal of using Index Model is also find the most efficient selection of portfolios. There are some differences between these two models. The Markowitz Model constructs the portfolio through mean and variance, while the Index Model decomposes the risk into company-specific risk and macro risk to build the portfolio. The Index Model has some Advantages over the Markowitz Model, which is that Index Model reduce the number of estimates required. Furthermore, the calculation of return and standard deviation between these two models are completely different.

The return for Index Model is the result of the sum of every weight multiplied by the beta multiplies by the market return, then adding the sum of the weights multiplied by alpha.

$$R = \sum W \times R \quad (1)$$

$$S^2 = mmult(mmult((W \times S), Correlation), transpose(W \times S)) \quad (2)$$

Equation (2) is Markowitz Model's standard deviation. S left to the equal sign represents the portfolio's variance. The S on the right side of the equal sign represents each company's standard deviation. The W represents the weight. The mmult indicates the matrix multiplication. The correlation represents the correlation between each company in the stock. The transpose represents the matrix transpose.

$$R = sumproduct(W, \beta) \times AnnulalizedAverageReturn(SPX) + sumproduct(W, \alpha) \quad (3)$$

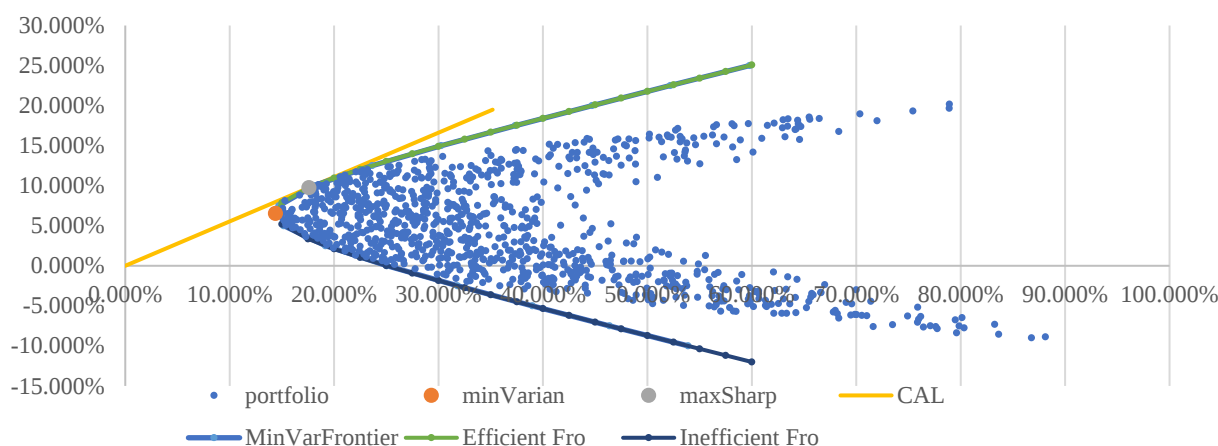
Equation (3) is Index Model's return value. R represents the total return. Beta is the slope between the SPX's residual return and each company's excess return. Alpha is the intercept between each company's excess return.

$$S^2 = (\text{sumproduct}(W, \beta) \times \text{AnnualizedAverageReturn})^2 + \text{sumproduct}(W, W, \text{AnuResStdev}, \text{AnuResStdev}) \quad (4)$$

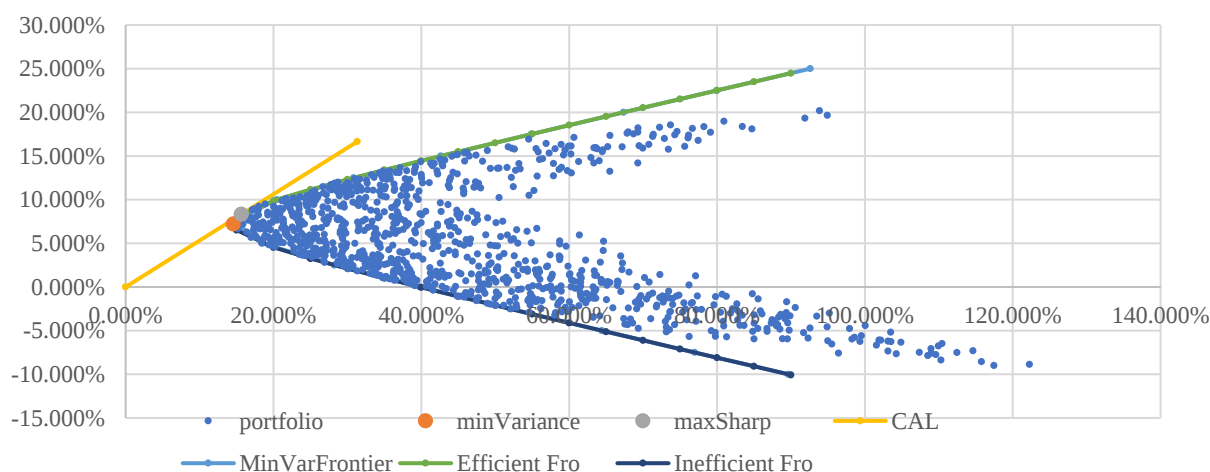
Equation (4) is the Index Model's variance. AnuResStdev represents each company's annualized average return.

### 3. Results

To find which portfolios are best for energy companies, this study establishes two general models which are Markowitz Model and Index Model. The essential data in those two models include the maximum sharp point, minimum variance point, minimum variance frontier, efficient frontier, inefficient frontier, and capital allocation line. The graphs of the two models are shown as follows, and the portfolio of minimum variance point and maximum sharp ratio for the two models are shown as follows as well.



**Fig. 1** The results of the Markowitz Model



**Fig. 2** The results of the Index Model

**Table 1.** The Minimum Variance and Maximum Sharp Ratio for Markowitz Model

| Markowitz | SPX  | CVX   | XOM   | IMO   | Return | StDev   | Sharp |
|-----------|------|-------|-------|-------|--------|---------|-------|
| minVarian | 0.88 | -0.05 | 0.27  | -0.10 | 6.530% | 14.398% | 0.45  |
| maxSharp  | 0.95 | 0.43  | -0.53 | 0.15  | 9.747% | 17.590% | 0.55  |

**Table 2.** The Minimum Variance and Maximum Sharp Ratio for Index Model

| Index       | SPX  | CVX  | XOM   | IMO   | Return | S t D e v | Sharp | Return | S t D e v | Sharp |
|-------------|------|------|-------|-------|--------|-----------|-------|--------|-----------|-------|
| minVariance | 0.82 | 0.05 | 0.15  | -0.02 | 7.207% | 14.616%   | 0.49  | 7.207% | 14.575%   | 0.49  |
| maxSharp    | 0.76 | 0.17 | -0.06 | 0.12  | 8.323% | 15.770%   | 0.53  | 8.323% | 15.663%   | 0.53  |

## 4. Discussion

The general development trend of global energy industries illustrated that global oil, coal and gas production are all on the rise. However, for many unavoidable reasons, the world's energy sector is facing a serious crisis. Global electricity consumption also declines in 2020 as global production of three major energy sources shrinks due to the pandemic. The military conflict between Russia and Ukraine has also led to disruptions in the supply of global energy markets. It also leads to higher energy prices and lower stock prices in energy-related industries. In general, there is a shortfall in demand for conventional energy in countries around the world and production will rebound significantly.

This research chooses data from three major energy companies in North American stock market- Chevron Corporation (CVX), Exxon Mobil Cooperation (XOM), and Imperial Oil Limited (IMO)- from May 11th, 2001 to May 12nd 2021. Investment recommendations are evaluated based on industry conditions in three energy sectors. First Chevron Corporation (CVX) is an American multinational energy company whose products include all aspects of the oil, gas and geothermal energy industries. The Exxon Mobil Cooperation (XOM) is the world's largest non-government oil and gas producer, mainly in the energy and petrochemical sectors. Imperial Oil Limited (IMO) is an integrated energy company that explores for and produces energy products and transports crude oil.

According to the chart, in Markowitz Model, the minVarian of return reached 6.530% while there are approximately 9.747% took place in maxsharp. However, the Index Model showed a different trend. The return of maxsharp (8.323%) was larger than the return of minVarian (7.207%).

## 5. Conclusion

This research uses both Index and Markowitz models, trying to explore a portfolio during high market volatility and potential worldwide economic recession. As a result, both models show that those major energy companies (Chevron Corporation, Exxon Mobil Corporation, and Imperial Oil Limited) are ideal investment opportunities since the maximum sharp according to the Markowitz model is 9.747% and it according to the Index model is 8.323%. The maximum Sharpe ratios from the two models show that those companies may perform with a relatively high return under relatively low risk, compared to the sharp ratio of S&P500 using the Index model and Markowitz model being 0.76 and 0.95. Although energy consumption shrank due to the pandemic, the world's economy is gradually recovering with energy consumption going back to the pre-pandemic level. Besides, the geopolitical issue of Russia's invasion of Ukraine caused the supply of Russia's oil to the rest of the world largely declines. Therefore, the three companies the paper analyzes increase partly on the increased scarcity of their oil owned.

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