Portfolio Construction of Energy-Related Assets

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Abstract. Portfolio construction is one of the most fatal issues of modern finance, which can effectively gain returns or reduce risks. This study constructs portfolios in energy-related assets. Specifically, the Monte Carlo simulations are carried out for a hundred thousand times in order to discover the efficient frontier and find the minimum variance and the maximum sharp ratio portfolio. According to the simulations, the American Electric Power possesses the largest share in minimum variance portfolio, while NextEra Energy for sharp ratio method. The results may benefit certain investor in financial markets and shed lights to focus more on portfolio allocation during constructing.

1 Introduction

With the improvement of the world economic system, more and more people tend to make their investments less risky (less max drawdown) with guaranteed returns. In retrospect, Markowitz introduced the concept of portfolio management in 1952 [1], which focuses on avoiding systematic and non-systematic risk by using diversified investment for unknown income. Markowitz theory shows that portfolio management is really important because investors could not only enjoy the benefits of many good stocks, but also could reduce the risk of overall investment. For example, if investor holds only one or a few stocks, it will certainly bring interest an unbearable losses when one of them fell sharply, i.e., this investment is very risky. Whereas, if one holds several stocks simultaneously following by certain rules as a portfolio, the risk might be hedged while still maintain in a high level of gains since the overall risk is spread out.

Followed by the idea of portfolio selection [1], a large number of scholars have conducted theoretical research related to asset portfolio management. For example, Roy put forward the Safety-First Portfolio Theory, which includes using the mean value and variance of a diversified portfolio [2]. As a consequences, it minimizes the probability that the portfolio return is less than the given "disaster risk level" by means of Safety-First Model, Minimum variance model and VaR model, etc.

The application of portfolio theory has also reached numerous achievements. Contemporarily, portfolio allocation is applied to many various fields. For instance, Shauna Carther Heyford referred to asset allocation in stock investment [3]. In 2018, Matthew Cochrane investigated asset allocation with different funds and bonds [4]. Zou and Ye applied Markowitz model occupational the application of asset portfolio theory in stock investment in practice [5]. Wang used occupational annuity investment to analyze the allocation among personal saving, equity and stock [6]. However, there are no energy-related companies involved right now. This raises our great concerns on the portfolio construction for energy-related companies. To the best of our knowledge, this paper makes the following contributions to the literature. First, we find efficient frontier base on a hundred thousand times Monte Carlo simulation results. According to the efficient frontier shows, the best assets allocation and assets performances are obtained. Moreover, we find two combinations on the efficient frontier: the minimum variance combination and the maximum Sharpe ratio combination. Base on the results of these two combinations combined with our analysis, the asset with the largest share is NextEra Energy. The results in this paper may shed lights for certain investors in the financial markets.

2 Data and methods

2.1. Data

In this paper, datasets were collected from Yahoo Finance (https://finance.yahoo.com) during Jan. 1st, 2019 to Jan. 31st, 2020. Specifically, this research select five representative companies in the energy-related industry, American Electric Power Company, Inc. (AEP), Dominion Energy, Inc. (D), Duke Energy Corporation (DUK), FirstEnergy Corp. (FE), and NextEra Energy, Inc. (NEE). This research chooses stocks solely based on their overall potential as a company. Price trend of these assets are shown in the Figure 1.
As illustrated in Figure 1, there is a sudden decrease for all the stocks from Feb. to Mar. 2020 partially due to the outbreak of COVID-19. After Apr. 2020, the price of FEE stock still does not perform well while others 4 companies gradually get better. Even though there is a sudden decrease, the prices of stock increase for the most of time in general.

This paper transfers all these prices to return data and list the descriptive statistics in the following Table 1. In line with numerous factors, we select cumulative returns to represent investor attention. To calculate return data, we use the current price of the stocks subtracting from the original price of the stocks. The result divided by original price and multiplied by a hundred to get the percentage. The paper generates the stock’s close price of each day from Yahoo Finance.

Cumulative returns express the total percentage increase in the value of an investment from the time it was purchased. The cumulative return is expressed as a percentage. Cumulative returns show advantages to represent the investor attention. When stocks are launched at the same time, it tends to make older stocks and funds looking impressive. Generally, a good return on investment for an active investor is 15% annually, i.e., 5 stocks do not perform well solely.

**Table 1.** Descriptive statistics of the selected assets (%)

<table>
<thead>
<tr>
<th></th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Std. dev</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>AEP</td>
<td>-11.583</td>
<td>11.683</td>
<td>0.043</td>
<td>1.819</td>
<td>0.069</td>
<td>12.580</td>
</tr>
<tr>
<td>D</td>
<td>-14.699</td>
<td>14.042</td>
<td>0.012</td>
<td>2.132</td>
<td>1.019</td>
<td>17.261</td>
</tr>
<tr>
<td>DUK</td>
<td>-10.953</td>
<td>12.997</td>
<td>0.003</td>
<td>1.931</td>
<td>0.546</td>
<td>13.245</td>
</tr>
<tr>
<td>FE</td>
<td>-14.485</td>
<td>26.430</td>
<td>0.069</td>
<td>2.623</td>
<td>3.639</td>
<td>36.386</td>
</tr>
<tr>
<td>NEE</td>
<td>-12.042</td>
<td>15.496</td>
<td>0.099</td>
<td>1.970</td>
<td>0.819</td>
<td>15.047</td>
</tr>
</tbody>
</table>

As shown in Table 1, the min values of the 5 selected assets are -11.583%, -14.699%, -10.953%, -14.485%, and -12.042%, respectively. The max values of the 5 selected assets are 11.683%, 14.042%, 12.997%, 26.430%, and 15.496%, respectively. The mean values of the 5 selected assets are 0.043%, 0.012%, 0.003%, 0.069%, and -0.099%, respectively. The standard deviation values of the 5 selected assets are 1.819, 2.132, 1.931, 2.623, and 1.970, respectively. Skewness and kurtosis show the distribution of the dataset. The skewness values of the 5 selected assets are 0.069, 1.019, 0.546, 3.639, and 0.819, respectively. The kurtosis values of the 5 selected assets are 12.580, 17.261, 13.245, 36.386, and 15.047, respectively. The skewness values are positive, which indicate datasets that are skewed right. The kurtosis values are greater than 3, i.e., the datasets have heavier tails than a normal distribution. These characteristics show that the series can be regard as a commonly used financial time series.

**2.2 Methods**

Monte Carlo simulations are used to model the probability of different outcomes. By generating random variables, Monte Carlo simulations show the risk or uncertainty in prediction and forecasting models [7]. Specifically, Monte Carlo simulations use the random variables sets to calculates results over and over (more than hundreds times) to conduct a quantitative analysis of risks. One will obtain a probability distribution of possible outcomes. Common probability distributions include normal, lognormal, uniform, triangular, and discrete [8]. Monte Carlo simulations allow us to consider any factor that has inherent uncertainty, i.e., helps us stimulate a range of possible outcomes and understand the variability in the process. Monte Carlo simulations provide us a comprehensive view to analysis.

This paper made one hundred thousand Monte Carlo simulations and calculated the expected returns, volatility of all corresponding portfolios [9]. In order to figure out the investment suggestion for investors, several steps are
given as follow. Firstly, we chose five stocks as the object of study and identify the equation. Then, we find out the distribution parameters for each input. As shown in Table 1, we calculate the mean, standard deviation, skewness, and kurtosis. Furthermore, one hundred thousand Monte Carlo simulations are carried out, which calculates the expected returns, volatility of all corresponding portfolios.

After getting the results of the probability distributions, the expected return and risk of the portfolio are obtained. The portfolio expected return is calculated as:

$$R_p = x^T \mu$$  \hspace{1cm} (1)

where $x$ represents the asset weight vector in the portfolio, $\mu$ is the expected return of the assets. The variance of certain portfolio is calculated as follows (2),

$$\sigma^2 = x^T \omega x$$  \hspace{1cm} (2)

where $\omega$ is the covariance matrix for the selected assets. By analyzing historical price data, we use Monte Carlo simulations to get 5 probability distributions of the portfolio. $X$ is a random vector satisfying 2 requirements: $X$ is greater than 0 and the sum of $X$ equals 1 [10].

Monte Carlo simulations provided the random variables, and then we use the 2 equations to calculate the combined variance of portfolio distribution.

3 Empirical results

Using the concept of Modern Portfolio Theory, we made one hundred thousand Monte Carlo simulations and calculated the expected returns, volatility of all corresponding portfolios shown in Fig. 2. The green star represents the minimum volatility portfolio in which has 27.98% volatility rate, and the maximum Sharpe ratio portfolio shown as red star has 104.23% Sharpe ratio rate.

![Efficient Frontier](image)

According to Fig. 2, there is a very large number of portfolios that will exhibit a risk of 29% but expected returns for these portfolios will range from 7% to 28%. We can get the Efficient Frontier which is the blue line in this plot. Any portfolios on the line offers the optimal portfolios of the highest expected return on each risky level [11]. The NextEra Energy is one of the optimal portfolios because it is on the extended line of the Efficient Frontier. The dots inside the blue line represents the portfolios that are inferior, which means the investors are less likely to spend the money on the portfolios with the same expected return but higher risky portfolios than the portfolios on the efficient Frontier [7]. The companies like American electric power, Duke energy corporation, Dominion Energy are all inferior to the portfolios on the efficient frontier.

Specifically, two portfolios raise our great concerns, the first one refers to the portfolio with minimum volatility, and the second one refers to the portfolio with maximized Sharpe ratio, which can be calculated as,

$$\text{Sharpe ratio} = \frac{R_p - R_f}{\sigma_p}$$  \hspace{1cm} (3)

where $R_p$ is the return of the portfolio, $R_f$ represents the risk-free rate, and $\sigma_p$ means the standard deviation of the portfolio return. The related empirical results are shown in Table 2.

<table>
<thead>
<tr>
<th>AEP</th>
<th>D</th>
<th>DUK</th>
<th>FE</th>
<th>NEE</th>
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<tr>
<td>Panel A. Portfolio with minimized volatility</td>
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</tr>
<tr>
<td>56.37%</td>
<td>5.77%</td>
<td>10.42%</td>
<td>5.79%</td>
<td>21.64%</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Portfolio return</th>
<th>volatility</th>
<th>Sharpe Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.25%</td>
<td>27.98%</td>
<td>58.07%</td>
</tr>
</tbody>
</table>
As listed in Table 2, the portfolio allocation with minimized volatility is more equally weighted than the portfolio with maximized Sharpe ratio, which gives 0.97% to Duke Energy Corporation and allocates a significant 82.44% to NextEra Energy Company. The minimum volatility portfolio plot shows the largest budget is allocated to the American electric power in which is 56.37%, which is in line with the Fig. 1 that American electric power is the least risky stock of the five stocks. The much risky stocks such as Dominion Energy and First Energy Corp. from the previous daily return plot get a lower return of 5.77% and 5.79% in the minimum volatility allocation. Hence, that would be a reasonable action if investors put a large amount of money into American electric power than others in order to get higher returns.

The budget for American electric power, which had more than 50% allocation in the minimum risk portfolio only, has a 3.63% budget allocated to it in the maximum Sharpe ratio portfolio. If investors would like to take a higher risk than the volatility rate in the portfolio with minimized volatility which is 27.98%, investing the NextEra Energy portfolio can get a significant 82.44% expected return in a similar volatility rate of 30.17%. Therefore, investors should also pay more attention to the NextEra Energy portfolio when building their investment combination.

4 Conclusion

In summary, this paper investigate portfolio on stocks of energy-related companies and made the investment suggestion for investors based on the result of Monte Carlo Simulation. Five stocks are selected as the object of study and the return rates are calculated of returns based on the data from Yahoo Finance. It is found that the First Energy Corporation is the riskiest one to invest due to its lowest stock prices over the date and largest negative spike distribution shown on the daily returns. The descriptive statistics of the selected assets also verify the First Energy corporation has the largest volatility based on its large kurtosis. In order to get the further investment suggestion of these five stocks, we made one hundred thousand Monte Carlo Simulations and demonstrated two optimal portfolios. According to the results, the American Electric Power company is the optimal stock to invest in the minimum volatility allocation. If investors are willing to take more risk with higher return, they could consider the company NextEra Energy portfolio which has a remarkable expected return on maximum Sharpe ratio portfolio. These results offer a guideline for investment in energy-related companies.

References