

Constructing Portfolios Based on Different Weight Schemes

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Abstract. The growing concerns for environmental problems, as well as the recent confrontation between Russia and Ukraine, pushes people to the exploring and development of alternative resources other than conventional fuel, oil, and coal. The renewable resource market is in its great time. Therefore, finding an efficient way to build portfolios for its stocks becomes worth investigating. The paper collects 5 stock's daily pricing data for a two-year period to build portfolios based different portfolio weight schemes. With the different combinations of weighting, a subsequent period of time is also used to test if the result from previous two-year period persists. As the result, because of the recent fluctuation in the stock market, the portfolio based on the previous two-year period doesn't seem to fit the current market. The result demonstrates the fluctuation experienced by renewable resource industry and the high risk of investing in recent stock market. It also proves the importance of consistently incorporating updated data when constructing portfolios.

Keywords: Renewable resource; Stock market; Portfolio weight schemes.

1. Introduction

Concerns for world environment, including commonly heard “global warming” to some sophisticated and seemingly far-from-us problems like depletion of ozone, are continually catching the public's attention. There's no doubt that conventional energies like fuels are effective in generating electricity if power production is the only thing to concern. However, the bitter fact is that they'll run out in the long run and their harmful effect is not negligible [1]. People now are more aware of the how connected human's well-being and the condition of this blue planet's environment are. Factors including population growth, industry development and increasing in income level all lead to a greater demand for energy, which is now one of the most crucial factors for a country's social welfare and sustainable development [2]. Described as dependable and copious and will potentially be very cheap, “renewable energy” becomes one of the hottest topics nowadays.

Not only are government-funded public sectors eager about developing cleaner renewable energy to replace energies like fossil fuel, which can be detrimental to our environment by causing problems like acid rain, private profit-seeking companies are also passion about it and have putted tremendous effort in this industry. As predicted in 2008, in the next 10 to 15 years the price of renewable energy would fall dramatically [3]. The advances of technology have lowered the cost and improved efficiency in this industry: for instance, the development in solar energy has drawn down the cost of solar panels over 99% since 1977 [4]; costs for wind, batteries and other technologies also come down continuously. The shared commitment of governments and companies to renewable energy helps this industry to gain huge investment for both existed projects as well as for new innovations. It is reported that, despite the difficulty faced by the economy because of COVID-19, clean energy attracted surprisingly high investment in United States in 2020, with a large part coming from the federal government [5]. A \$1.2 trillion infrastructure package that includes funding to facilitate the clean energy industry was also passed in August 2021 [6]. Data from 30 crowdfunding platforms specific to renewable energy also revealed nearly 305 million euro of contribution [7]. With all these sanguine facts in this industry, renewable energy technology is improving fast and becoming more and more competitive with conventional non-renewable energy like coal.

The advantages in renewable energy catch investors' attention. The development of this industry seems promising, and it is also proved that investors in renewable resources continue to grow faster than fossil fuel globally, and the total return has been 367% higher over the last ten years, and the annualized volatility is also lower [8]. As the renewable resources' portfolio fluctuates less with the

overall market than traditional resources, especially during economic downturns like what was caused by COVID-19, more and more investors are turning to renewable energy stocks.

Apart from the advantages renewable resource industry hold, the recent conflict in Ukraine forced people to realize how much the world still relies on fossil fuel and oil, the two typical nonrenewable resources. The higher energy prices due to the conflict pushed the public to seek for the more economically efficient renewable energy. It is estimated by the International Energy Agency that “global renewable energy capacity will rise more than 60% from 2020 levels by 2026 and account for nearly 95% of all world power capacity growth in that time” [9].

The intrinsic values of renewable resources and the economic as well as environmental conditions make it clear that renewable resource industry is a promising foreground to invest in.

In this paper, the invest ability of renewable resource industry is analyzed. To effectively build the portfolio that is most probable to maximize our profit, different weight schemes are compared by using the two-year period data of selected stocks. After the portfolios of different weight combinations are built, their outputs are compared. Then, data from a subsequent short period are applied to test the applicability of our schemes by comparing the two periods’ portfolios’ outcomes and see if the most outstanding portfolio from the two-year period still perform well in the subsequent period.

The result can provide insights for investors about the current renewable resource market and it’s invest ability—whether it is worth of investing. Because of the special features of this industry—newly developed and can be easily influenced, the result will also reveal about the stock market as a whole.

2. Data and Methodology

In this paper, dataset is imported from finance.yahoo.com. Data including adjusted close, close, open, high, and low prices, and dollar volume on a daily basis for stocks is collected. The global pandemic starting from 2020 hit the global economy without any exception, therefore, the dataset covers the period from 01-April-2020 to 01-April-2022, a two-year period after COVID-19 starting striking the globe. 5 stocks with the top market capitalizations based on data collected from companiesmarketcap.com on 22-Jun-2022 are selected, including LONGi Green Energy Technology, Adani Green Energy, Vestas Wind System, EDP Renovaveis, and Brookfield Renewable Partners.

Each single stock’s performance is first analyzed by its mean return, volatility, maximum drawdown, sharp ratio, and market capitalization, as shown in Table 1.

Table 1. Historical performance of the five selected stocks from 01-April-2020 to 01-April-2022.

Stock	Return	Volatility	Annual Return	Max Drawdown	Sharp Ratio	Market Cap
601012.SS	0.318%	51.92%	80.162%	83.178%	116.946%	68.66 B
Adanigreen.NS	0.525%	46.285%	132.38%	92.582%	274.973%	34.78 B
BEP	0.158%	32.642%	39.799%	58.061%	100.376%	23.22B
EDPR.LS	0.182%	36.657%	45.783%	60.307%	98.443%	22.02 B
VWSB.F	0.195%	50.149%	49.137%	68.605%	76.095%	21.35 B

Mean return is calculated by adding up each stock’s every daily return and then divided by the number of days; annualized return, volatility and sharp ratio is annualized by multiplying 252 and $\sqrt{252}$ respectively (252 is the number of trading days in a year).

As shown by the table 1, every stock has a positive mean return even during the economic hardship of COVID-19. This further manifests the investability and the worth of investigation for the renewable resource industry. One can easily find that for the five stocks investigated, the one with highest mean return, which is Adani Green Energy, also has a relatively high, although not the highest, volatility; the one with lowest mean return, which is Brookfield Renewable Partners, also have the

lowest volatility. This trend generally catches the relationship between mean returns and volatilities for these five stocks.

Figure 1 presents the correlation matrix of the 5 stocks. It should not be a big surprise that some of the 5 stocks are highly correlated. They come from the same industry of renewable resources, which has relatively short length of development and history comparing to other conventional industries that are more fully developed and diversified. Also, during the period of COVID-19, stocks tend to be more correlated due to the heightened volatility and instability of the whole society.

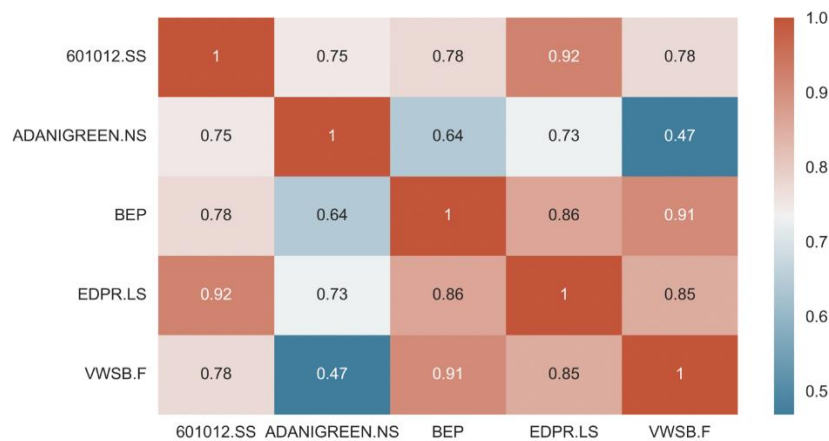


Figure 1. Seaborn correlation matrix heatmap of the five selected stocks from 01-April-2020 to 01-April-2022.

The portfolio weighting methods to be considered in this analysis include: 1/N equal weighted rule, maximum sharp ratio, minimum volatility, and market cap value rule.

For a portfolio with N stocks, 1/N equal weighted rule will assign each stock with equally weight: $\frac{1}{N}$ of the whole portfolio. For the maximum sharp ratio scheme, we maximize the objective function $\frac{\mu w'}{\sqrt{w \sum w'}}$ subject to constraints that $1^T w = 1$ and $w \geq 0$. For the minimum volatility scheme, we minimize the objective function $\sqrt{w \sum w'}$ subject to constraints that $1^T w = 1$ and $w \geq 0$. For the market cap value rule, stocks are weighted in proportion to their market capitalization. Therefore, each stock takes up $\frac{MC_i}{\sum MC}$ of the proportion of the portfolio, where MC_i is the market capitalization for the i_{th} stock.

Methods are to be compared by return, volatility, annualized return, and sharp ratio. The sharp ratio is obtained by the formula $\frac{(R_p - R_f)}{\sigma_p}$, where R_p is the return on the portfolio, R_f is the risk-free rate of return, and σ_p is the portfolio standard deviation. In this analysis, we consider the risk-free rate of return as 0, so the formula for sharp ratio is therefore $\frac{R_p}{\sigma_p}$.

Apart from the 4 schemes, to consider the impact of each individual investor's reaction and tolerance towards risk on the portfolio construction, risk aversion level γ is introduced to further the analysis since for different investors with different risk aversion levels, they tend to prefer portfolio with different diversification levels.

To further test the 4 methods, a 2-month period after the period of time we investigated are used to see if the performances of these models persist.

3. Empirical Results

In this section, 4 portfolio weighting schemes are implemented and compared. Implementation and calculation are based on historical data from 01-April-2020 to 01-April-2022, a two-year-period after the outbreak of Coronavirus.

Different combinations of weights of the 5 stocks are achieved by using Monte Carlo Simulation: 10^5 randomized sets of weights are generated, and their resulting portfolios' returns and volatilities are calculated. Figure 2 presents the efficient frontier of these portfolios. The 5 stocks are scattered on this plot, with Adani Green Energy on the upper right, LONGi Green Energy Technology and Vestas Wind System on the bottom right, and Brookfield Renewable Partners and EDP Renovaveis at the bottom left and middle. The locations of these stocks further reveal the individual performance of each stock we have discussed in Table 1, and the distances between them can be viewed as the difference between each pair of stock. For instance, Brookfield Renewable Partners and Adani Green Energy are the most separated pair in the figure, and they are indeed the pair with the greatest difference in their returns and, though not the greatest, high difference in their volatilities.

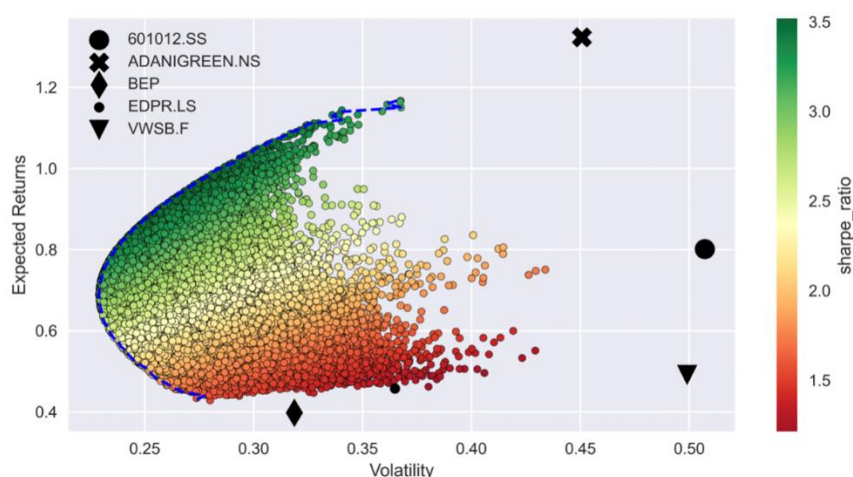


Figure 2. Efficient frontier of the five selected stocks from 01-April-2020 to 01-April-2022.

The 1/N equal weighted rule for this case has a 20% weight for each stock. The maximum sharp ratio and minimum volatility weighting schemes are obtained through the building of efficient frontier. As mentioned, Monte Carlo simulation is introduced and implemented. By plotting the returns and volatilities of 10^5 randomized combinations of weights, we are able to build the efficient frontier, which is expected to provide the highest return at any given level of risk, and find the one with maximum sharp ratio and the one with minimum volatility. The market cap value rule is based on information collected from companiesmarketcap.com on 20-June-2022. Weights of different stocks are determined by dividing the market capitalization of a single stock by the sum of the market capitalizations of all stocks in the portfolio. In this analysis, data of the market caps is presented in table 1, and their corresponding weights are therefore 0.40, 0.20, 0.14, 0.13, and 0.13.

Table 2 presents the output of each model. Return, volatility, annualized return, and sharp ratio are considered to be important in determine the effectiveness of each model. The result is consistent with the expectation that higher return implies higher volatility, and vice versa. This relatively simple and predictable relationship between return and volatility leads the analysis to focus more on the risk aversion level γ . Figure 3 demonstrates different combinations of weights for different level of γ . Notice that for γ level less than 1, all investment allocation is given to Adani Green Energy, the stock with the highest return. As the γ level increases, the portfolio becomes more diversified: LONGi Green Energy Technology, Vestas Wind System, EDP Renovaveis, and Brookfield Renewable Partners are then added to the portfolio subsequently. A high γ level indicates a highly risk-averse investor, who may have a tendency to choose a portfolio with low risk over high risk, even if the return average risk (we consider sharp ratio in this case) is higher than that of a less risky portfolio. This result indicates that by allowing more stocks to be introduced into the portfolio, we can make the portfolio less volatile. This result corresponds with Markowitz's Modern Portfolio Theory, which, instead of focusing on individual stock's volatility, tends to investigate the volatility of a diversified portfolio.

Table 2. Outcomes of the 4 models for building a portfolio of the five selected stocks based on data from 01-April-2020 to 01-April-2022.

Scheme	Return	Volatility	Annual Return	Sharp Ratio
1/N Rule	0.275%	25.09%	69.452%	276.806%
Max Sharp Ratio	0.381%	27.257%	95.929%	351.94%
Min Volatility	0.273%	22.895%	68.851%	300.728%
Market Cap Rule	0.305%	26.967%	76.983%	285.472%

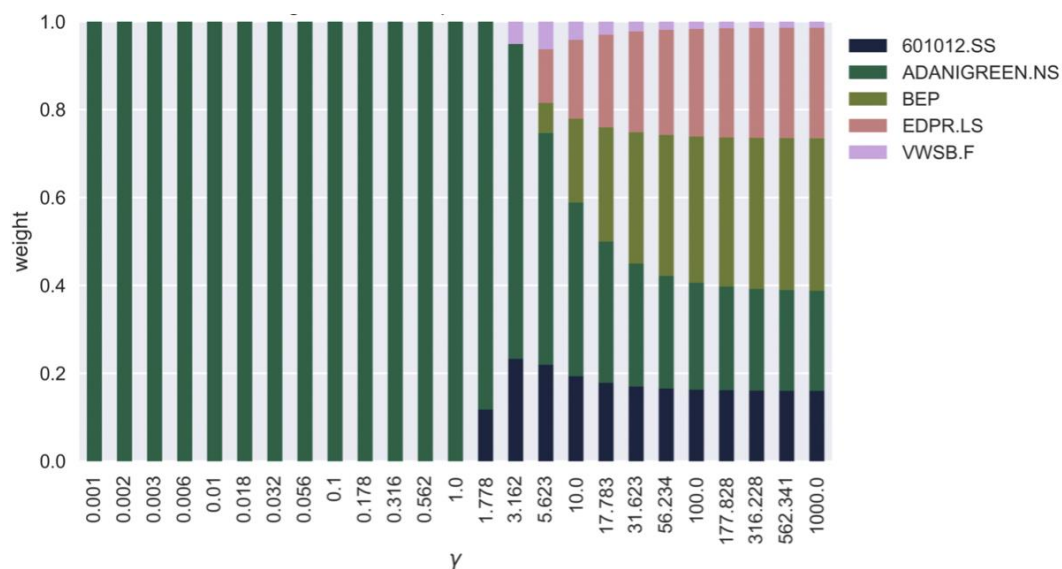


Figure 3. Weights allocation per risk-aversion level of the five selected stocks based on data from 01-April-2020 to 01-April-2022.

To further explore on the 4 models, we use a 2-month period after 01-April-2022—from 02-April-2022 to 02-June-2022—to test how these models perform. We want to see if these models' performances in this 2-month period match with their performance in the 2-year period.

Each single stock's performance over the new period is presented in Table 3. The table presents information that is largely different from the previous period. This time, 4 out of 5 stocks have negative mean returns and sharp ratios, and they are not negligible-- Vestas Wind System even has a negative return that is greater in absolute value than that of LONGi Green Energy Technology, the only stock that has positive return in the portfolio.

Table 3. Historical performance of the five selected stocks from 02-April-2022 to 02-June-2022.

Stock	Return	Volatility	Annual Return	Max Drawdown	Sharp Ratio	Market Cap
601012.SS	0.395%	53.958%	99.478%	28.523%	156.981%	68.66 B
Adanigereen.NS	-0.302%	85.829%	-76.09%	37.775%	-22.857%	34.78 B
BEP	-0.291%	26.978%	-73.27%	18.062%	-288.622%	23.22B
EDPR.LS	-0.146%	35.33%	-36.476%	18.653%	-34.081%	22.02 B
VWSB.F	-0.439%	48.993%	-110.619%	31.453%	-244.099%	21.35 B

Figure 4 displays correlation matrix of the 5 stocks over the new period. It also presents some significant differences comparing to the previous 2-year period. Instead of merely high positive correlations, the figure indicates that correlations between some stocks are close to 0, meaning that they are nearly uncorrelated during the period, and some stocks have negative correlations, meaning that as one stock's return goes up, the return of the other tends to go down. The correlations between LONGi Green Energy Technology and 4 other stocks are all negative, matching our previous finding that it is indeed the only stock with a positive mean return.

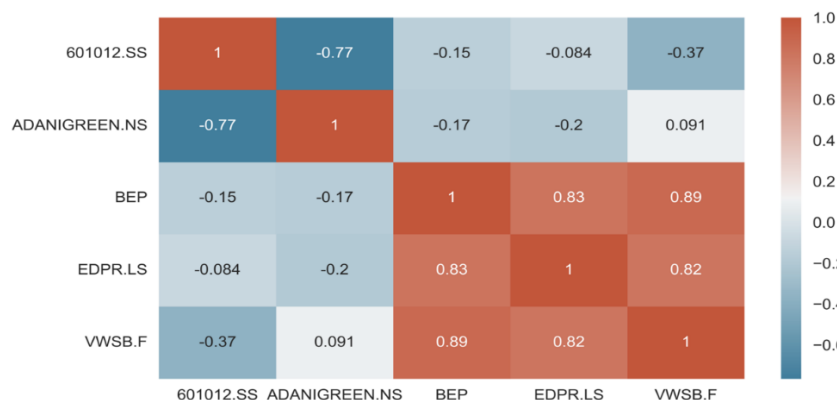


Figure 4. Seaborn correlation matrix heatmap of the five selected stocks from 02-April-2022 to 02-June-2022.

The new efficient frontier demonstrated by figure 5 also exhibits great disparity comparing to the previous one. Adani Green Energy, which was at the upper right corner of the plot, now comes to the bottom right, meaning that it continues to bear great risk, while its mean return suffers from a huge plunge. On the contrary, LONGi Green Energy Technology, which was previously high in risk, becomes less volatile, and its mean return, which was in the middle of the 5 stocks, now becomes the highest. The three other stocks, having no significant difference in their volatility levels, all experience a great downward pull in their mean returns.

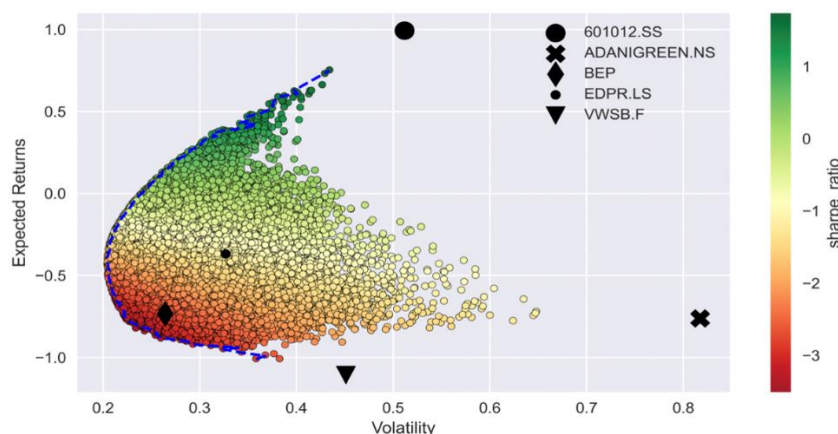


Figure 5. Efficient frontier of the five selected stocks from 02-April-2022 to 02-June-2022.

With all these conspicuous changes happened to each single stock, one can easily doubt the adaptability of the 4 calculated weight combinations. Indeed, as we apply the weight combinations obtained from the 2-year period to the new 2-month period, it seems reasonable for an investor to hold his investment. Table 4 demonstrates the result of applying previous combinations to new data set, and the result is quit shocking: no model generates positive return and sharp ratio. Moreover, the return and volatility don't seem to follow the simple positive relationship this time. Among the four, the market capitalization value rule outperforms: it's not letting its investors losing too much.

Table 4. Outcomes of the 4 models (based on data from 01-April-2020 to 01-April-2022) for building a portfolio of the five selected stocks based on data from 02-April-2022 to 02-June-2022.

Scheme	Return	Volatility	Annual Return	Sharp Ratio
1/N Rule	-0.157%	25.11%	-39.450%	-157.105%
Max Sharp Ratio	-0.131%	40.771%	-33.123%	-81.2404%
Min Volatility	-0.150%	22.920%	-37.686%	-164.426%
Market Cap Rule	-0.016%	27.475%	-4.049%	-14.737%

Table 5 shows the new weight combinations of the 4 models based on new data. Maximum sharp ratio model is the only one that generate a positive return and sharp ratio, though it also has the greatest volatility among the four models. This result is striking, and it demonstrates how gloomy recent stock market is, at least for this industry.

Table 5. Outcomes of the 4 models (from 02-April-2022 to 02-June-2022) for building a portfolio of the five selected stocks based on data from 02-April-2022 to 02-June-2022.

Scheme	Return	Volatility	Annual Return	Sharp Ratio
1/N Rule	-0.157%	25.11%	-39.450%	-157.105%
Max Sharp Ratio	0.299%	43.411%	75.441%	173.784%
Min Volatility	-0.170%	20.411%	-42.879%	-210.073%
Market Cap Rule	-0.016%	27.475%	-4.049%	-14.737%

Figure 6 displays the new weights allocation for different risk-aversion level. As one can easily expect, LONGi Green Energy Technology dominates this time. One thing to notice is that Vestas Wind System is introduced to the portfolio only after the risk aversion level γ becomes very high. Though we expect that by adding one more stock, we can diversify the portfolio and thus lower the risk level, but in this case, Vestas Wind System's poor performance—it has the lowest return and quite high volatility—makes it uncompetitive comparing to other stocks and therefore unfavored by investors.

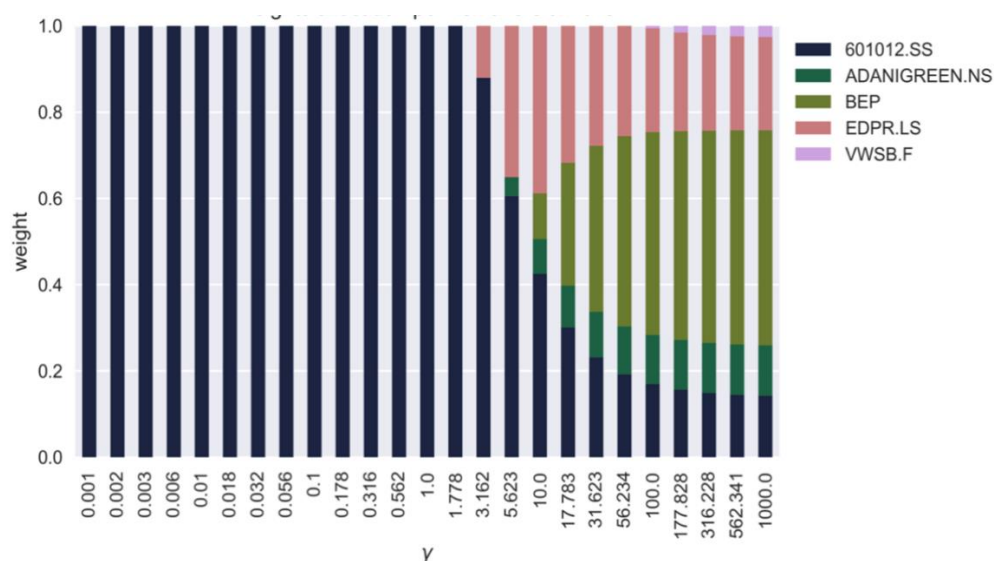


Figure 6. Weights allocation per risk-aversion level of the five selected stocks based on data from 02-April-2022 to 02-June-2022.

4. Further Discussion

Why is the outcome of the portfolio of the 2-month period so different from its precedent 2-year period? The answer is more than the unproductiveness of renewable resource market. The global pandemic has caused an economic recession among the globe. The need for natural resources shrunk, so did the prices of natural resources. As the result, renewable resource is also negatively influenced [10]. What's more, what renewable resource market experienced and is now experiencing actually apply to all stock market globally. Stocks from related industries, like Apple, Amazon, Google, and Microsoft from big tech industry and Tesla, Nio, and Riivan from electric vehicle industry, all have some noticeable fall in their stock prices. Ever since the outbreak of COVID-19, stock market becomes susceptible, and investors are consistently facing dampers on their investing confidence. Besides challenges imposed by the pandemic, other factors are also present. Inflation in the US hit

8.5% in March, the sharpest annual rate since 1981, driven by accelerating costs for food and energy. As BBC announced, in responding to this high inflation, the Fed shocked the economies with very large interest rate increases, actually the biggest announced rise in interest rate in 22 years [11]. As the Federal Reserve begins the process of monetary tightening, banks would make it more expensive for people, businesses and governments to borrow, hitting every industry and the value of every kind of asset. Therefore, the big fall in renewable resource industry doesn't indicate the low investing value of this industry, and the low adaptability of our models for recent period can't be decisive in deciding the value of them.

One may lose confidence in renewable resource industry because of recent miserable data. However, one of the greatest worldwide issues this year is about to tell a different story. The launching of invasion of Ukraine by Russia force intensified the global relationship. Playing the second most important exporter role in world energy markets, Russia has its economy that largely depends on energy production and exports for oil, natural gas, as well as coal. As the relationship between Russia and the western countries intensifies, the change in Russian energy supplies creates a tremendous problem for these western countries, especially for European countries that were previously dependent on Russian export and thus especially susceptible to this change. The rising prices of energy and inflation around the world caused by the tension warn people that the application of alternative resources other than traditional oil, natural gas, and coal is urgent for reasons more than environmental concerns. It has now become a global issue. Under this circumstance, we expect the renewable resource industry to surge in the future even when recent data proves to be pessimistic. Though the expansion in this industry may be slow because of the technological difficulty and its relative short developing time, we still expect to see a long-term potential and growth in it. Thus, investigation in building a portfolio of its stocks is worth of attention.

Though the weight allocations of the 4 models by using the 2-year period doesn't fit data of the subsequent 2-month period, we still can get some insights from them. The returns and volatilities tend to move in the same direction. Which portfolio to choose has a lot to do with the risk-aversion level of each individual investor? Though the long-term potential of renewable resource industry is undeniable, because of the political and economic fluctuations happened around the world and the sensitivity of this industry, when making investment, we suggest investors to be more aware of the risk they are exposed to.

5. Conclusion

This paper examines the investability and the role of diversification in constructing portfolio of stocks from renewable resource industry. 4 different weight schemes are applied to the 5 selected stocks with top market capitalization and uses data from 01-April-2020 to 01-April-2022. Portfolios' outcomes are then compared. The results follow our expectation that the higher the return, the riskier. Among the 4 schemes, the Maximum Sharp Ratio rule outperforms because of its highest return and moderate volatility. Then data of the subsequent 2 month are compared to see if the 4 weight schemes' performance persist. The result is striking: 4 out of 5 stocks have negative returns, and portfolios based on the 2-year period don't fit the subsequent period. Among the portfolios built based on new data from the subsequent period, maximum sharp ratio rule is the only one that has a positive return, though it's volatility also exceeds the other three a lot. For investigators with moderate risk aversion, Maximum Sharp Ratio rule is a great way of building portfolios.

Despite the fluctuation in recent renewable resource market, it's still worth of attention. The increasing and urgent demand for clean and renewable resource makes it a rapid-growing and promising industry from a long-term perspective. The low adaptability of the portfolios based on the 2-year period is due to multiple reasons, including political and economic ones. To potentially decrease the impact of Russia-Ukraine war on the investigation, one could split the time into period before the war and period after the war. Also, the extend of the impact social fluctuation on the 5 stocks may also decrease if we were to look at data from a longer period.

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