

Could Investment Portfolio Ameliorate the Investment Risk and Return Under Covid-19 in the US Pharmaceuticals Industry?

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ABSTRACT

To relieve the huge blow to the economy caused by the COVID-19 pandemic, this article is to verify that investment portfolio is an efficient method when investing in the US pharmaceuticals industry by utilizing daily stock prices of 4 out of the top 10 US pharmaceutical companies and treasury bill during the last 2 years (Aug 2019 to Aug 2021). We obtained the monthly rate of return and applied mean-variance strategies to individual companies and portfolios. We drew CAPM and efficient frontier and used the Sharpe ratio as a measurement to test portfolio efficiency. The empirical results are given 3 special portfolios: minimum variance, maximum expected return and maximum Sharpe ratio. The highest Sharpe ratio in portfolios is higher than all single stocks. Portfolios with treasury bills have a higher return, higher risk, and similar Sharpe ratio with portfolios without risk-free rate as treasury bills also experienced a huge shock during the pandemic. According to these results, we can conclude that investment portfolios do help investors alleviate the impact of COVID-19 on the economy and get better returns in the economic downturn.

Keywords: portfolio, investment, mean-variance, Sharpe ratio, treasury bill

1. INTRODUCTION

To ameliorate the uncontrollable situation of pervading Covid-19 in 2020, which seriously threatens citizens' health worldwide, governments of many countries chose to sacrifice the activities of people who are probable to infect others, precluding the further diffusing of the pandemic. In the United States, thousands of people have been subjected to legally enforceable quarantines or are in "self-quarantine." The federal government has also banned entry by non-U.S. nationals traveling from China, Iran, and most of Europe and is screening passengers returning from heavily affected countries [1]. Worldly, more than 80 countries have closed their borders from transitioning countries, ordered businesses to close, instructed their populations to self-quarantine, and closed schools to an estimated 1.5 billion children [2].

Under the ban related to covid-19, fewer people went to the street and were quarantined at home; more workers could not work in the office; less frequency of trade

among countries happened worldwide. These inhibitions of social distance and activities made the economy not as free as before. Although the freedom of the economy is partly qualified, either potential opportunities or indiscernible crises exist in markets and stocks. As for the crisis taken by covid-19, the suppressive market of various bans made business become very uncertain. The COVID-19 pandemic outbreak continues its tremendous spread in the US, causing unprecedented effects of the US stock markets volatility and the economic policy uncertainty where the recent stock volatility levels rival or exceed those observed during October 1987, December 2008 and during the 1929 crash [3]. Although the uncertainty existed in the stock with high level volatility, huge opportunities were lurking in the market. The menace of pandemics stimulated researchers to develop more ways to protect citizens and citizens from utilizing more approaches to forestall the infection of viruses. Therefore, the contiguous virus pushed the global desire for medicine products, especially vaccines. Overall, 69% (1374/2006) of participants were classified as willing to get a COVID-19 vaccine (48% were

definitely willing and 21% were probably willing), and 31% (632/2006) were classified as not willing (17% were not sure, 5% were probably not willing, and 9% were definitely not willing) [4]. The United States, as one of the strongest pharmaceutical producers in the world, played an important role in medicine products research and development. Especially the top ten pharmaceutical-related companies are valuable for investors to take into consideration. Therefore, the investment of univocal cooperation in a sector is not satisfied by investors, to invest in a portfolio witnessed the balance among multiple companies.

To search for whether the investment portfolio is valuable, it is meaningful to evaluate whether the investment portfolio will have a higher return and less volatility to investors. In the beginning, we extracted the stock price of the top ten pharmaceutical companies and calculated the change of rate of average price per day in the current month to last month. Then, we utilized the time series to keep four comparatively independent companies to form the portfolio, and the tangent point between the efficient frontier of portfolio and a line through both original point and risk-free rate to find the maximum Sharpe ratio of the portfolio with and without risk-free rate. Finally, we find out that the maximum Sharpe ratio of a portfolio is larger than the Sharpe ratio of a singular company, which means that an investment portfolio can help investors to get a comparatively higher return and comparatively lower risk.

Under the covid-19, the uncertainty of policy and economy continuously blows the stock. Controlling potential crises of investment became especially vital for investors. An investment portfolio is a useful approach for investors to get higher returns and preclude the further risk of a singular company. It is a way for investors to render the investment under market risk to increase its return. It can stimulate investors' further consideration of investment approaches. Moreover, the United States, as one of the countries with the highest level of pharmaceutical industries around the world, to do the research of investment portfolios of top ten pharmaceutical industries could be a good sample for worldly investors to get experience to consider how they could combine its investment portfolio of multiple companies in the same sector.

In the following sections, we introduced the data, methodology that we used, and the conclusion based on our findings.

2. DATA AND METHODS

2.1. Data

2.1.1. Pharmaceutical company and Covid-19

To do this research, we started with searching for the top 10 American pharmaceutical companies and extracted the last two years (from Aug.06, 2019, to

Aug.06 2021) stock price from Capital IQ [5]. During this time period, the society was experiencing an unimaginable pandemic ---Covid-19. This outbreak has dealt a huge blow to the world economy in varying degrees [4].

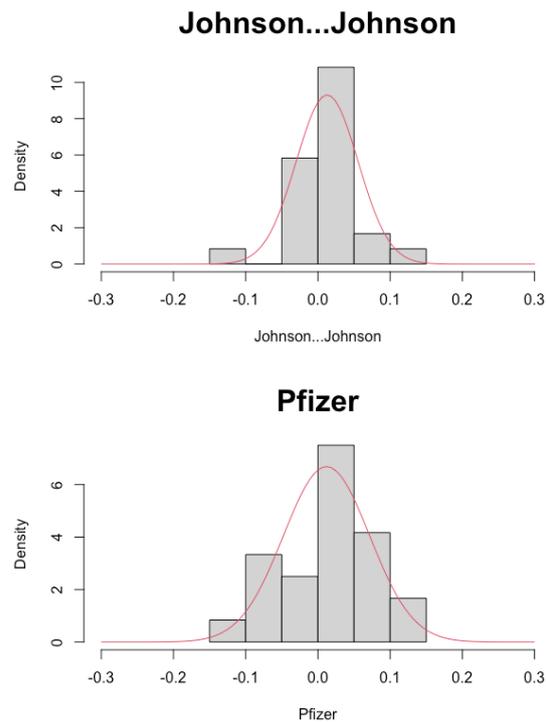
Since the values we obtain from Capital IQ are daily values, we need to first calculate the monthly prices by using the following equation.

$$Monthly\ Price = \frac{\sum(Daily\ price)}{Day\ of\ month} \tag{1}$$

After that, we used these data to calculate the monthly rate of return on these 10 companies by using the following equation.

$$Monthly\ Rate\ of\ Return = \frac{(Price_t - Price_{t-1})}{Price_{t-1}} \tag{2}$$

By graphing histogram, normal distribution and acf plot in R studio to check the i.i.d assumption, we first removed some companies that did not follow this assumption well and ended up with four companies that did best to continue doing this research. The four companies are Johnson and Johnson, AbbVie Inc., Biogen, and Stryker Corporation. We also considered both with and without risk-free situations, that is, whether to include the Treasury bill or not.



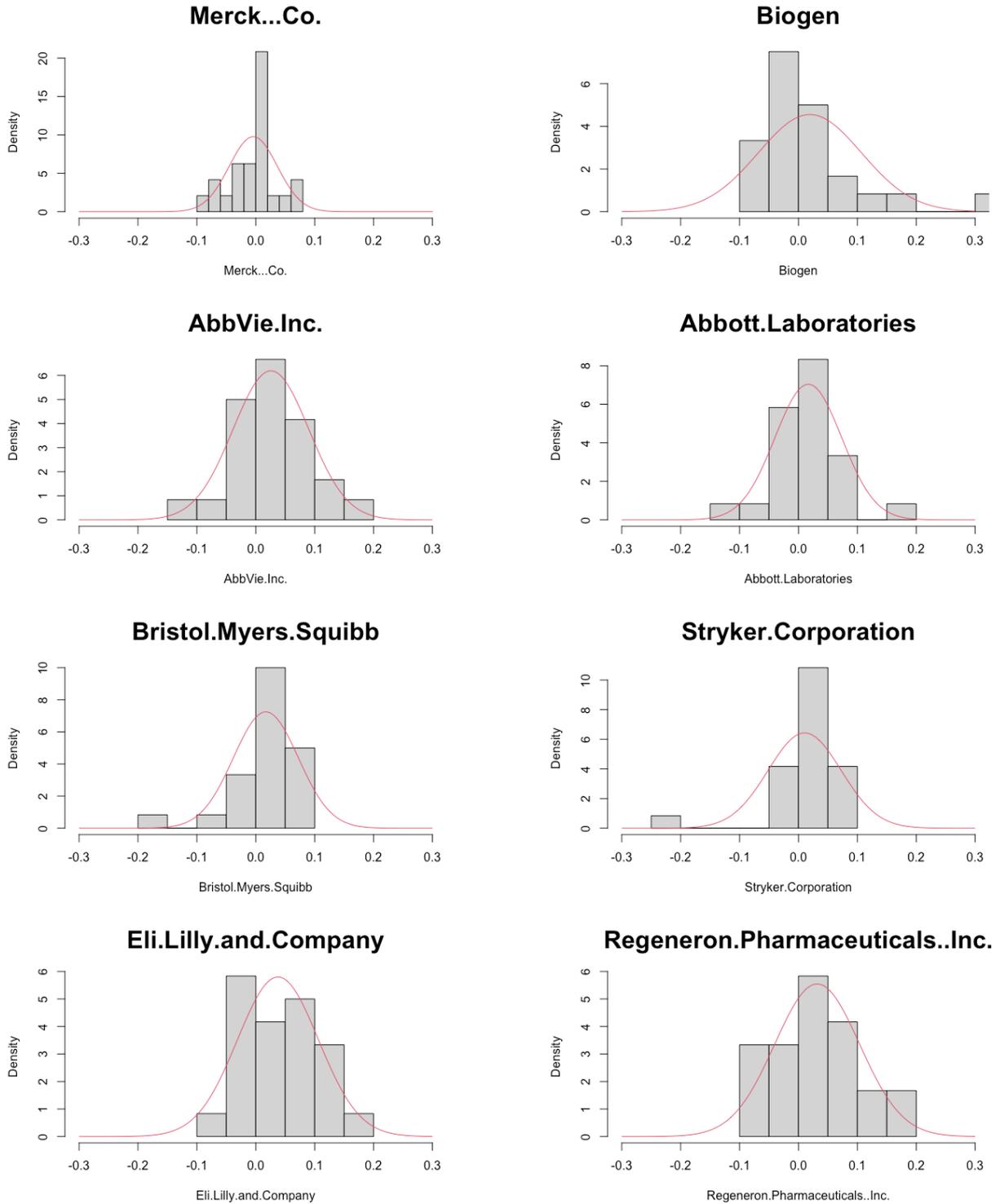
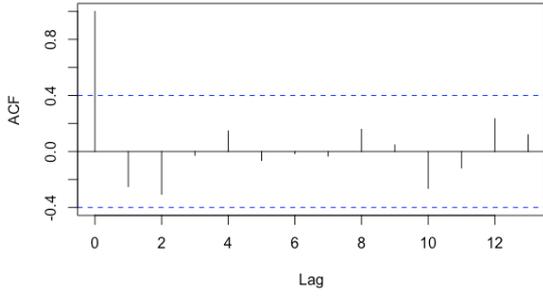
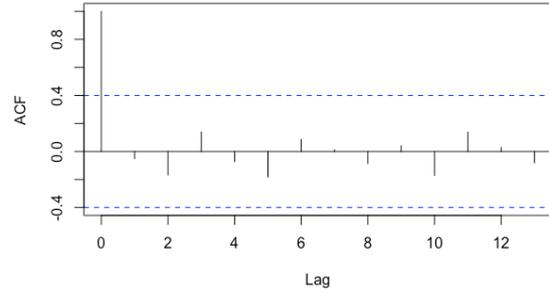


Figure 1. The normal distribution graph of the ten companies. From left to right and top down are: Johnson and Johnson, Pfizer, Merck & Co., AbbVie, Bristol-Myers Squibb Company, Eli Lilly and Company, Biogen, Abbott Laboratories, Stryker Corporation, and Regeneron Pharmaceuticals.

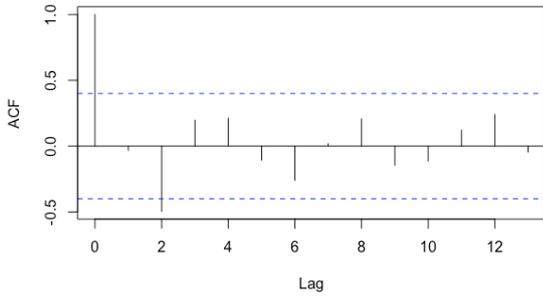
Johnson...Johnson



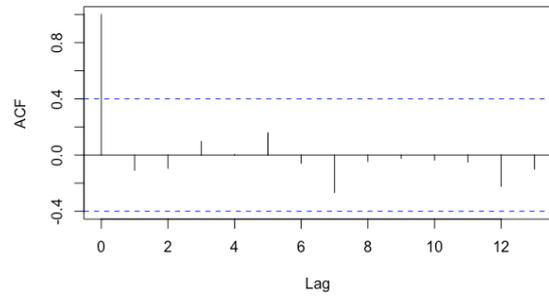
Bristol.Myers.Squibb



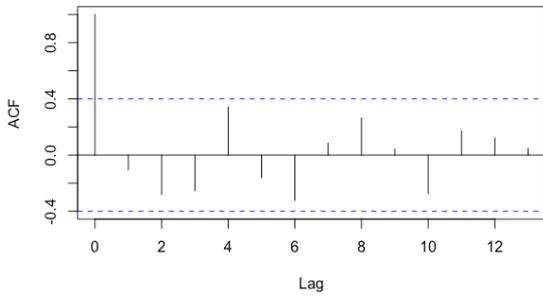
Pfizer



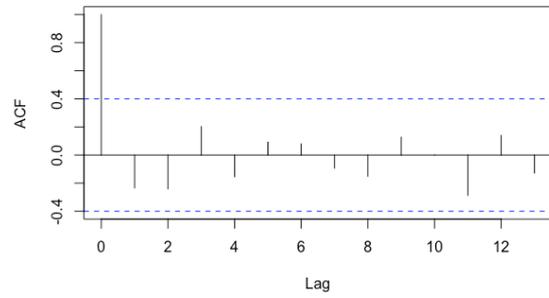
Biogen



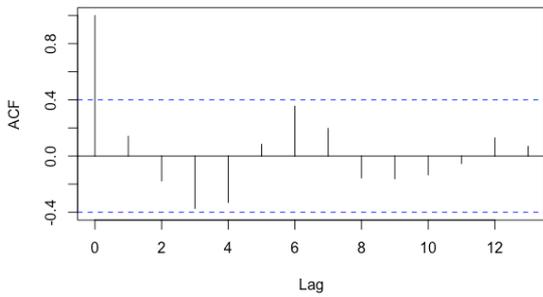
Merck...Co.



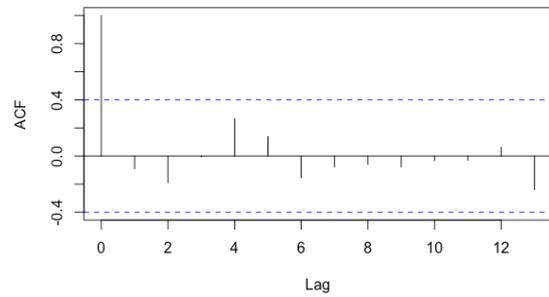
Abbott.Laboratories



AbbVie.Inc.



Stryker.Corporation



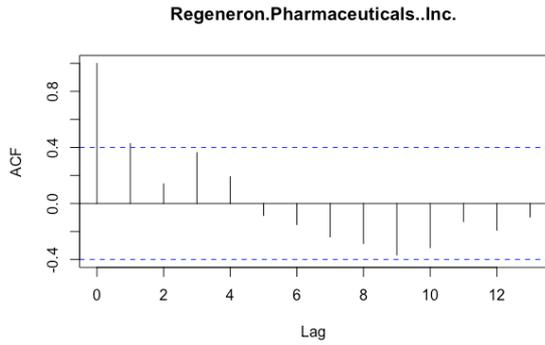


Figure 2. The time series plot of the ten companies. (If all the short lines in the picture except the first one is between the two blue dash lines, the company is independent.) From left to right and top down are: Johnson and Johnson, Pfizer, Merck & Co., AbbVie, Bristol-Myers Squibb Company, Eli Lilly and Company, Biogen, Abbott Laboratories, Stryker Corporation, and Regeneron Pharmaceuticals.

In Figure 2, we found that all companies are independent except Pfizer and Regeneron. Pharmaceuticals. Inc., they all have a bar exceeding the blue dash line.

2.2. Methodology

2.2.1. Modern Portfolio Theory

Modern portfolio theory is also called Markowitz Portfolio Theory which Harry Markowitz debuted in his paper “Portfolio Selection” [6]. This theory is to find the efficient combination of expected returns and variance portfolio. We can not only pay attention to expected return alone or variance since there are many factors that may influence the best portfolio: investor preferences, number of securities, and correlation of each security or industry. Markowitz emphasized investors should look at the portfolio selection instead of investing individually.

2.2.2. Formula

This is the portfolio weight formula where w_i represents the weight of company i in one portfolio. We considered short-selling, so we set $-1 < w_i < 2$. The sum of each company’s weight is equal to 1.

$$\sum w_i = 1 \tag{3}$$

This is the expected return formula where w_i is the weight of company i and R_i is the average return of company i on an annual basis.

$$E = \sum w_i * R_i \tag{4}$$

This is the variance formula where X_i is the revenue rate in i -th month, \bar{X} is the average revenue rate, and N is the existing months of investment.

$$Var = \sum \frac{(X_i - \bar{X})^2}{N-1} \tag{5}$$

This is the standard deviation formula where x_i is the revenue rate in the i -th month, \bar{x} is the average revenue rate, and N is the existing months of investment. Standard deviation is also equal to the square root of variance.

$$\sigma_p = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n-1}} \tag{6}$$

This is the Sharpe ratio without a risk-free rate. $E(R_p)$ is the expected return of investment. σ_p is the standard deviation of investment.

$$SharpeRatio = \frac{E(R_p)}{\sigma_p} \tag{7}$$

This is the Sharpe ratio with a risk-free rate. $E(R_p)$ is the expected return of investment. R_f is the risk-free rate, which we use the value interest rate of the US Treasury Bill to represent it. σ_p is the standard deviation of investment.

$$SharpeRatio = \frac{E(R_p) - R_f}{\sigma_p} \tag{8}$$

The idea of the Sharpe ratio was raised by William F. Sharpe, who defined that the Sharpe ratio measured the expected return of the risky portfolio compared to the non-risk portfolio [7]. In other words, if the Sharpe ratio is high, then we should hold more of the portfolio asset, and if the Sharpe ratio is low, then we should hold less of the portfolio asset. We used this concept to measure whether a portfolio could help us acquire more assets in our COVID-19 investments.

2.2.3. Efficient Frontier

To find the efficient portfolios, we need to find the efficient frontier. The efficient frontier is the upper part of the CAPM edge, that is, the line that contains the point with the highest expected return at a given variance or the point with the lowest variance at a given expected return [8].

3. EMPIRICAL RESULTS

In this section, we firstly compare the single companies’ performance. And then construct portfolios in both without and with risk-free situations. After that, we find the parameters and figure out the efficient portfolio.

3.1. Single assets' performance

Table 1. Historical stock price performance in the last two years (in % for mean and standard deviation). The mean and standard deviation are reported monthly. The Sharpe ratio is annualized.

Companies	Mean	Standard deviation	Sharpe ratio	Sharpe ratio with risk-free rate
Johnson & Johnson	0.01281	0.04286	0.29895	0.27698
AbbVie Inc.	0.02579	0.06441	0.40037	0.38575
Biogen	0.01940	0.08761	0.22143	0.21068
Stryker Corporation	0.01048	0.06202	0.16906	0.15387
Treasury bill	0.00094	0.14758	-	-

Table 2. List of Portfolio Model in the Research

#	Model	Abb.	Type
1	Minimum variance	MV	Minimum
2	Maximum expected return	ME	Maximum
3	Maximum Sharpe ratio	MS	Maximum

According to Table 1, if we only consider investing in one company, the highest Sharpe ratio among these companies is AbbVie Inc. regardless of whether we consider subtracting risk-free rate (Treasury) or not.

Also, the abbreviations in Table 2 will be used in the following part of the report.

3.2 Portfolio's performance (without risk-free asset)

Table 3. The empirical result of the portfolio model (in % for mean and standard deviation)

Model	Mean	Standard deviation	Sharpe ratio
MV	0.01582	0.03916	0.40386
ME	0.06358	0.32719	0.19431
MS	0.02101	0.04575	0.45927

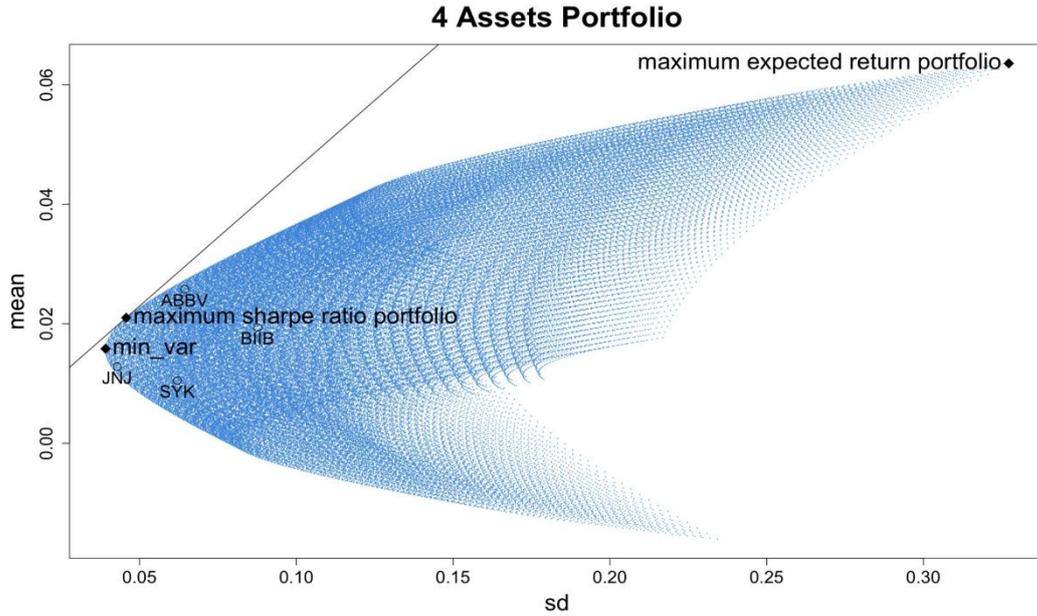


Figure 3. CAPM of 4 companies, JNJ represents Johnson and Johnson, ABBV represents AbbVie Inc., BIIB represents Biogen, and SYK represents Stryker Corporation. Min_var is the portfolio with the lowest risk; the maximum expected return portfolio is the portfolio with the highest return. The maximum Sharpe ratio represents the portfolio with the highest Sharpe ratio. The line from the original point on the graph is tangent to the efficient frontier line with the max Sharpe ratio point, and the slope equals the Sharpe ratio.

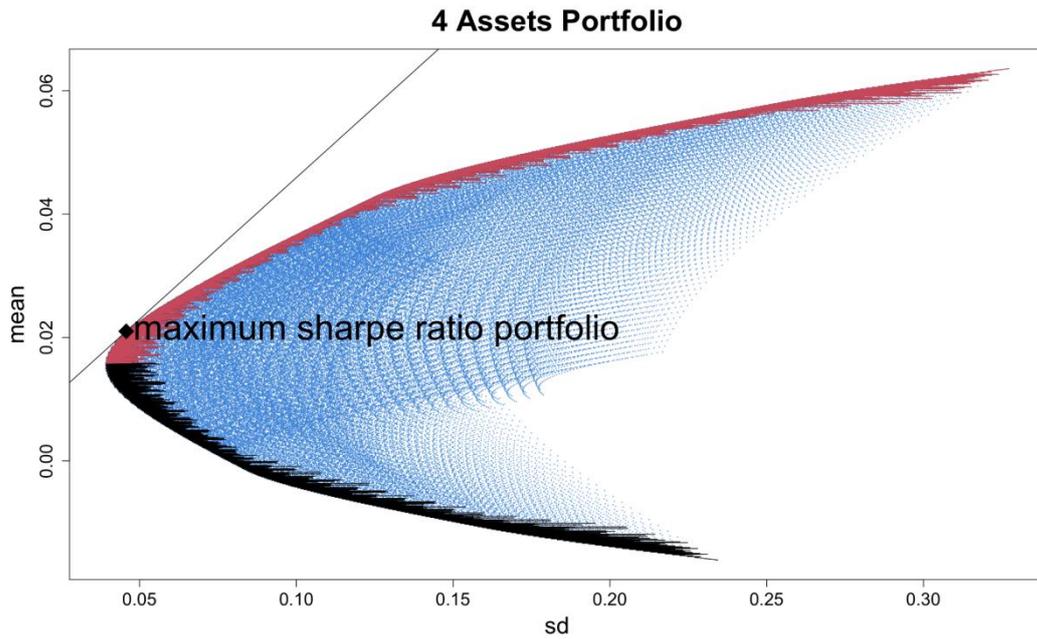


Figure 4. CAPM of 4 companies with a maximum Sharpe ratio in the efficient frontier. The red part dominated the black part.

The efficient frontier is a set of portfolios with the least standard deviation in the given expected value. The maximum Sharpe ratio portfolio is a tangent point between the efficient frontier and a line from the original point. The shape of an efficient frontier is parabola. It gives the lowest risk at each value of the return. The

frontier is divided into two parts: upper and lower parts. The upper part dominates the lower part of the frontier since the red part has a higher return than the black part. Investors should buy those red part portfolios as those they can maximize their returns while affording the lowest risk.

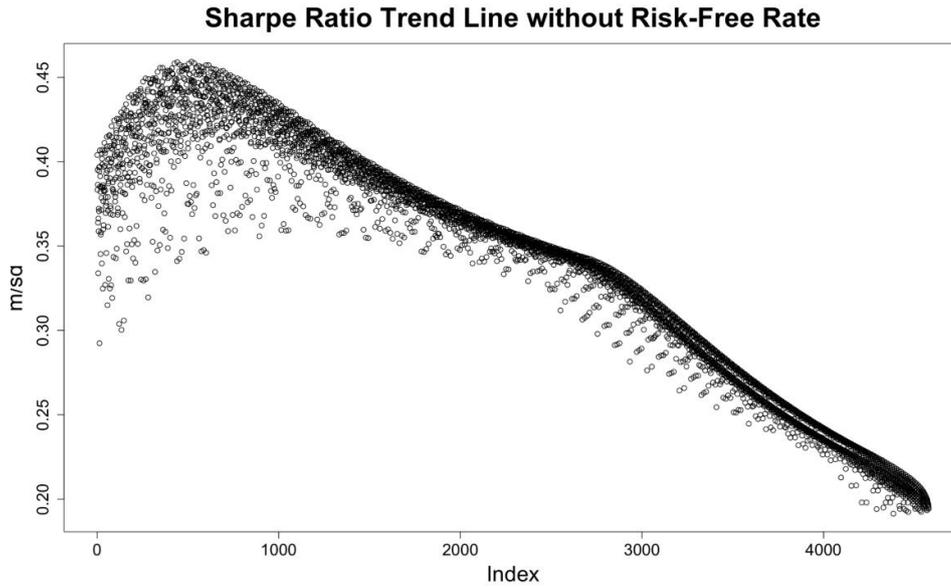


Figure 5. Points represent the Sharpe ratio of each portfolio

In this graph, we can observe the trend and value of the shape ratio. It increases first to a crest point and then decreases, which roughly ranges from 0.2 to 0.46. The maximum Sharpe ratio is around 0.46.

3.3. Portfolio's performance (with the risk-free asset)

Table 4. The empirical result of portfolio model (in % for mean and standard deviation)

Model	Mean	Standard deviation	Sharpe ratio
MV'	0	0	-
ME'	0.13697	0.33721	0.40339
MS'	0.08461	0.18421	0.45423

5 Asset Portfolio

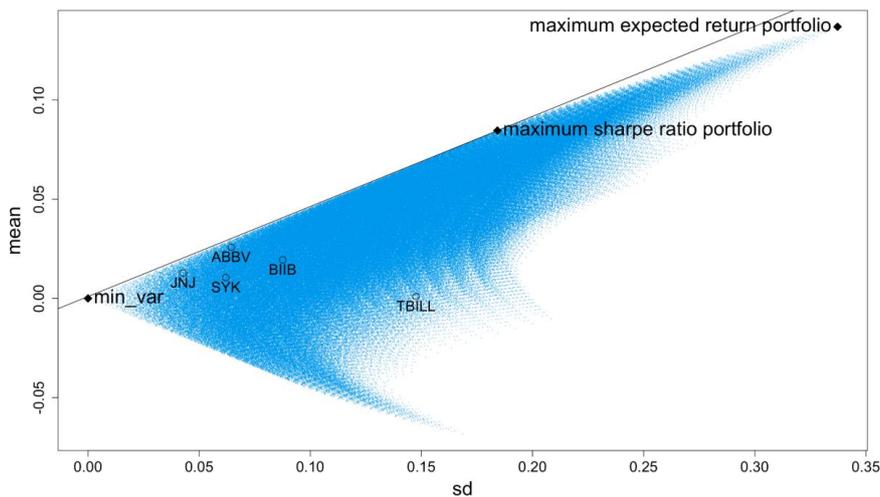


Figure 6. CAPM of 4 companies plus the risk-free asset, JNJ represents Johnson and Johnson, ABBV represents AbbVie Inc., BIIB represents Biogen, SYK represents Stryker Corporation. T-bill represents the 10 year Treasury rate. Min_var is the portfolio with the lowest risk; the maximum expected return portfolio is the portfolio with the highest return. The maximum Sharpe ratio represents the portfolio with the highest Sharpe ratio. The line from the original point on the graph is tangent to the efficient frontier line with the max Sharpe ratio point, and the slope equals the Sharpe ratio.

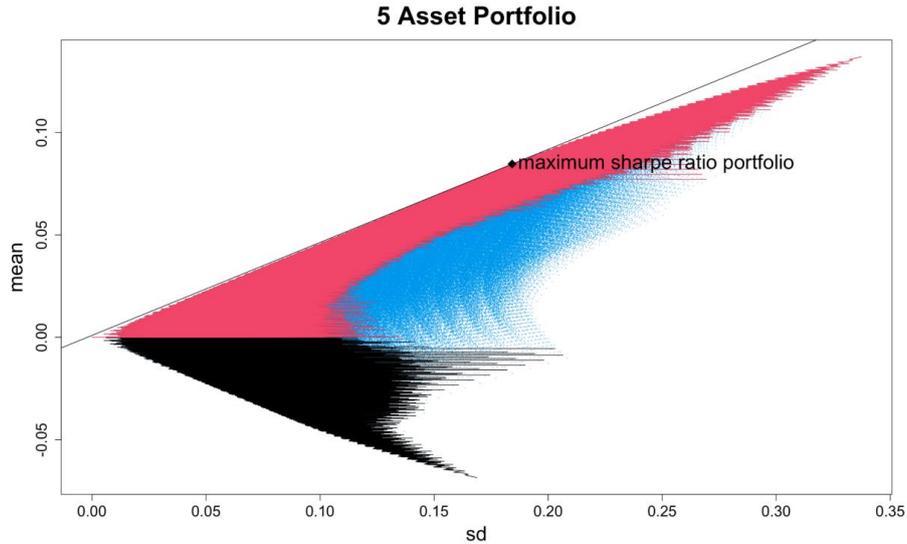


Figure 7. CAPM of 4 companies plus the risk-free asset with a maximum Sharpe ratio in the efficient frontier. The red part dominated the black part.

Fig. 7 represents the maximum Sharpe ratio of the portfolio with a risk-free rate. The tangent point between the efficient frontier and a line passing through the point equals a minus risk-free rate. The maximum Sharpe ratio

of the portfolio above is a ratio that has a comparatively large expected return and comparatively small standard deviation, which is larger than the Sharpe ratio of each of the four companies.

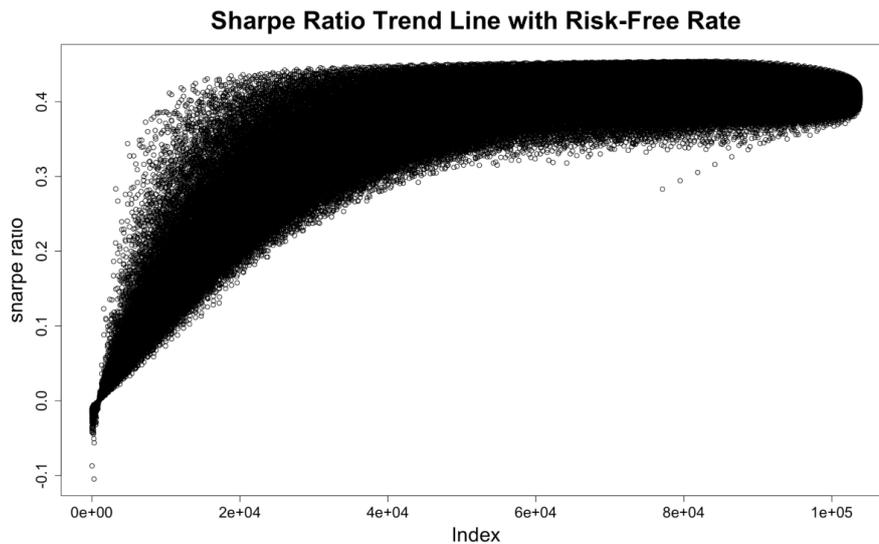


Figure 8. Points represent the Sharpe ratio of each portfolio

In Fig. 8, it is the trend of all Sharpe ratios of portfolios in different weights. It increased first to a crescendo and then decreased. The maximum Sharpe ratio in Fig. 7 is the maximum point in Fig. 8.

3.4 Analyze the portfolio

Table 5. The empirical result of the portfolio model (in % for mean and standard deviation)

Model	Mean	Standard deviation	Sharpe ratio
MS	0.02101	0.04575	0.45927
MS'	0.08461	0.18421	0.45423

Through calculation, we find that the maximum Sharpe ratio we can obtain is 0.0459 when the risk-free rate is not included and 0.0454 when the risk-free rate is included. Therefore, we can conclude that the inclusion of risk-free assets cannot increase the return of our portfolio.

However, our experiments demonstrate that building a portfolio can improve its returns. Because according to our results, the largest Sharpe ratio that can be obtained by constructing a portfolio is greater than that obtained by buying a single stock.

The other point is that when we include the risk-free asset (treasury bill), we can obtain a higher mean of return than when the risk-free asset is not considered. Still, the variance of the portfolio is set with the maximum Sharpe ratio increases too much. Though it is reasonable to take a bigger risk when we get a higher return, the variance we get is too different, so we further study the causes of this situation.

The reason why the variance of the maximum Sharpe ratio portfolio with risk-free rate obtained by us is so high is largely related to the unstable rate of the 10-year Treasury Bill during COVID-19 [9].

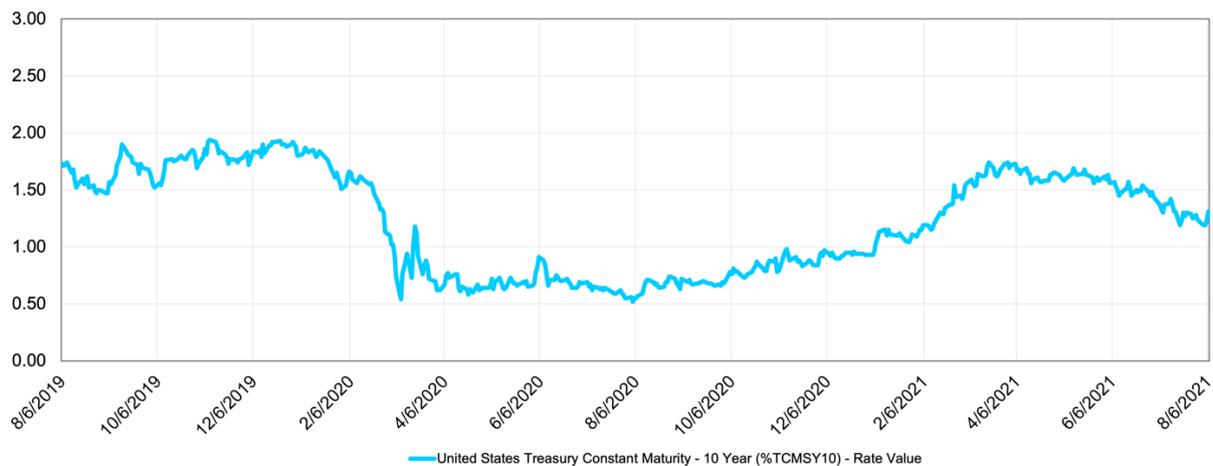


Figure 9. Graph of the rate value of the United States Treasury 10 Year bill.

It can be seen from this chart that from February 11, 2020, the 10 Year-Treasury rates suddenly decreased to below 1, and it did not gradually recover to above 1 until the beginning of 2021. This is due to the stock market crash during COVID-19. During this period, the market for U.S. Treasury bonds stopped growing, resulting in a drop-in demand and a sudden drop in both stock prices and Treasury rates [10]. Because of the instability of such a rate, the risk of the national debt has increased. Therefore, when we consider the risk-free rate, the variance of the portfolio we get has increased a lot.

4. CONCLUSION

In this experiment, we use the rate of return data of the 10 famous medical companies in the United States, obtained from Capital IQ, to research whether building portfolios could help increase the profit we can obtain by investing in these companies during Covid-19. The method we use is to establish CAPM and the efficient frontiers about two types of portfolios with and without risk-free rate and calculate the maximum Sharpe ratio we can get from them.

After the research, we find that building a portfolio can increase the maximum return we can get from the investment. We also find that the result of the maximum portfolio return is similar between the portfolio asset with

and without risk-free rates. After digging into this result, we find that volatile stock markets on Treasury bonds during COVID-19 have a huge impact on the portfolio's risk: the variance of the highest return of the portfolio considering risk-free rate is much larger than that without considering the risk-free rate.

It is worth mentioning that our research proves that reasonable portfolio construction can improve our returns on the medical field, and the stock market crash does influence Treasury bonds and will further affect the portfolio returns.

Unfortunately, there are still some problems with our research. The Treasury bond used in our experiment, as the risk-free rate, is not as stable as its normal status, so our conclusion of portfolio return may be slightly lower than our expected result. And this instability has to do with our choice of an unstable time frame, COVID-19. Therefore, in the future experiment, we can choose the data of a more stable Treasury bond as the risk-free rate or consider the Treasury bond for a longer period to obtain a more stable value. The experimental conclusion may be closer to the theoretical expectation.

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