Research on the Markowitz Model-based Stock Investment Approach

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Abstract. In the world of financial investments, risk is one of the hottest subjects, and diversifying your investment portfolio is one of the best ways to do so. When choosing investments, consumers always aim to reduce risk while maintaining a specific rate of return. The risk and return on a portfolio are discussed using mathematical and statistical techniques. It is made clear that there are two types of risk: systematic risk and unsystematic risk, the latter of which can be diversified through a portfolio. Since 2019, the Covid-19 epidemic in the United States has had variable degrees of impact on different businesses. Others have been stimulated while many industries have stagnated. This article examines the effects of the pandemic on the global healthcare industry while concentrating on the medical stock market. Using the investing database, each medical company's data was examined. The Markowitz model is used to study two time periods before and after the outbreak. According to specific real-world circumstances, this conclusion can assist investors in making the best investment choices for risky investment portfolios.

Keywords: Investments, Equities, Markovitz Model, Asset Allocation, Medical Stocks, Covid-19.

1. Introduction

1.1 Background

The Covid-19's devastation has had a catastrophic effect on the world economy. The service sector, industry, and agriculture have all been significantly impacted. First off, there was a lot of volatility on the international financial markets, and numerous times in a short period of time, U.S. equities had a meltdown. The volume of international trade even declined at the same time as the growth rate of international trade was markedly lowered. Thirdly, the Covid-19 has had an effect on the industrial chain, especially in industries that have experienced significant internationalization, such the automotive, electronics, and machinery and equipment industries. Additionally, the outbreak has lowered business profits and confidence, which is unfavorable to international investment. In addition, as the Covid-19 spreads, unemployment rates are increasing. The stability of the economy and society may be impacted by this. The Covid-19 has seen a general reduction in per capita income, which has decreased peoples' purchasing power and inclination to spend. The United States has a huge role in the global economy. Its numerous industries, including the textile and petrochemical sectors, have unavoidably all seen varied degrees of impact. Due to Covid-19's issues running normally, the travel, aviation, catering, and entertainment industries are under a great deal of pressure, which may necessitate layoffs. Furthermore, the rise in unemployment is unquestionably very bad news for the US.

1.2 Related research

When the Markowitz investment model employs a normal distribution to describe investment returns, it would be reasonable to regard higher-than-average returns as Risk of Defects. Zheng and Yang therefore suggested two better versions of the Markowitz investment model [1]. Long and Deng reach two findings after studying Markowitz's investing portfolio. One is that traditional theory's assumption that investors' rationality is static and emotionally indifferent is untrue, and the other is that expected variance cannot accurately characterize asset risk properties because it ignored the fact that different risk levels apply to different groups of people [2].

Yu conducted a feasibility analysis and looked into the two models' actual market value in China. According to YU, China's stock market was slow to grow, the capital market is young, and there are

few market regulations compared to those in developed nations. The model's underlying assumptions should be changed when it is applied to portfolio research. The single-exponential model should be used on the Chinese stock market where systematic risk is much higher than non-systematic risk since it is simpler to use and the assumptions are less stringent, and it should produce better results [3].Yang et al. examined the connection between the mean square error model and the single exponential model. They carried out their studies using a mean-variance model and a single exponential model, respectively. The single index model can, in our opinion, streamline the computation procedure and enable the distinction of investment risks on this foundation [4].

With the exception of funds with negative alpha values, Lu builds a new portfolio using an arbitrarily chosen sample of funds and discovers that it does not outperform the original portfolio. Positive alpha active investing strategies cannot outperform selecting a fund portfolio at random. The key goal for investors, it is suggested, should be to more effectively mimic the investment approach used by the major market index [5]. Through their study of fund portfolios, Tian and Chen discovered that the portfolio investment strategy built by a single index model has a few benefits over other approaches as a benchmark. But there is a small lack of volatility. Information time lag is the main cause of this [6]. The single-exponential model method, according to Li, is an advancement of the direct weighting method and may successfully address the issue of insufficient data in real-world applications. The rule of large numbers states that a single index model can be used to calculate the fitted value of the portfolio return when the portfolio is sufficiently diversified and there is an information time lag [7].

Jiang and Zhao experimented with investment portfolios by adding more assets, and they discovered that as the number of assets increased, the overall risk of the portfolio began to resemble its systematic risk [8].The risk of a portfolio is closely correlated with the amount of different assets, according to research by Wang et al. utilizing a portfolio of securities to study the diversification of portfolio risk. To effectively lower overall investing risk, investors can choose stocks that are negatively linked as investment objectives [9]. Xu investigated the state of the secondary stock market at the time, contrasted the traits of typical investors, examined the macroeconomic environment, and came up with potential investment plans. Buy-and-hold strategy is the first; constant ratio strategy is the second; indexed investment strategy is the third; and portfolio investment strategy is the fourth [10].

2. Method and data

2.1 Model

The Makoviz model and the single index model is relatively high in terms of portfolio and risk diversification. This study explores the risk asset allocation through the impact of these two models on the portfolio. The historical data of different stocks are analyzed by the method of multiple regression, and the correlation coefficient and the rate of return of each period are obtained separately. Then, it will be discussed according to various factors of definition and purpose, so as to provide investors with a relatively high investment reference.

In Markovitz portfolio selection model:

$$E(r_p) = \sum_{i=1}^{n} w_i \, E(r_i) \tag{1}$$

$$\sigma_p^2 = \sum_{i=1}^{n} \sum_{j=1}^{n} w_i \, w_j \; Cov(r_i, r_j) \tag{2}$$

Where $E(r_p)$ refers to the expected rate of return, $\sigma_p$means standard deviation, w refers to the internal weights of the combination and $Cov(r_i, r_j)$is their covariance;

In theory, The Markowitz model can divide a portfolio into multiple risky assets and one risk-free asset. Its core idea is that investors can determine a desired return in advance, and through the above formula, the proportion of investors invested in each investment project (such as stocks) (project fund allocation) can be determined, so that the total investment risk is minimized.

With this model, Investors can identify suitable assets in the portfolio, then analyze the expected returns and risks of these assets during the holding period, then establish an effective set of securities to choose from, and finally combine specific investment objectives to determine the optimal portfolio of securities.

In Single-index model：

$$r_i = E(r_i) + \beta_i m + e_i \quad (3)$$

Where r_i is the rate of return, $E(r_i)$ is the expected rate of return, the coefficient of β_i determines the systemic risk of the security i, m indicates the uncertainty of the economy as a whole, and e_i indicates the uncertainty of a particular company. The mean of m is usually 0 because the unintended macroscopic contingency is measured with macro factor m, its standard deviation is σ_m^2, and the mean of e_i is 0, which describes the uncertainty of the return of the security, and its standard deviation is $\sigma^2(e_i)$. It is very important that m and e_i are not related. Thus, the variance of r comes from two separate parts (systems and companies) so：

$$\sigma_i^2 = \sigma_m^2 + \sigma^2(e_i) \quad (4)$$

The systemic risk of securities I is $\beta_i^2\sigma_m^2$, the total risk is:

$$\sigma_i^2 = \beta_i^2\sigma_m^2 + \sigma^2(e_i) \quad (5)$$

Because m and e_i are uncorrelated, the covariance of the two securities i and j is:

$$Cov(r_i, r_j) = Cov(\beta_i m + e_i, \beta_j m + e_j) = \beta_i\beta_j\sigma_m^2 \quad (6)$$

Equation (6) indicates that there is an approximate substitution relationship between companies, and companies with equal β values have the same market risk.

With this model, the last equation greatly reduces the amount of covariance calculated, otherwise, the covariance of the bonds in the portfolio must be calculated in terms of historical returns, and each bond must be calculated separately. Therefore, the single model significantly reduces the amount of computation.

2.2 Data

This study analyzed data from the investment database from a variety of industries, including the globally advanced businesses [Amazon (AZN), Medtronic (MDT), Novartis (NVS), Pfizer (PFE), and Roche (ROG)]. The chosen timeframes, December 2018 through December 2019 and January 2020 through January 2021, respectively, illustrate two distinct scenarios during regular times and during the Covid-19 pandemic. The two tables below show the coefficients that the multiple regression model produced.

Table 1. Various data on healthcare stocks before Covid-19 (2018.12-2019.12)

Financial Ratios	AZN	MDT	NVS	PFE	ROG
Annualized Average Return	-0.77%	-0.98%	-1.08%	-2.55%	-0.90%
Annualized StDev	5.14%	3.67%	3.57%	4.16%	3.13%
Sharpe Ratio	-15.01%	-26.60%	-30.33%	-61.19%	-28.83%
Beta	-0.042	0.622	0.411	0.756	0.756
Alpha	-0.008	-0.004	-0.007	-0.019	-0.008
Residual StDev	0.051	0.033	0.034	0.036	0.031

Table 2. Various data on healthcare stocks DURING Covid-19 (2020.01-2021.01)

	AZN	MDT	NVS	PFE	ROG
Annualized Average Return	-0.34%	0.09%	-0.24%	-0.15%	-0.35%
Annualized StDev	7.08%	9.02%	6.47%	7.87%	5.95%
Sharpe Ratio	-4.77%	0.97%	-3.71%	-1.94%	-5.93%
Beta	0.071	0.960	0.652	0.684	0.065
Alpha	-0.004	-0.004	-0.006	-0.005	-0.004
Residual StDev	0.071	0.054	0.042	0.059	0.059

Before Covid-19, as can be seen in Tables 1 and 2, all of these firms' Sharpe ratios were negative, meaning that they had no reference importance. Additionally, all of these companies had generally negative annualized average returns, with PFE having the lowest return, and other corporations. Since the yields are comparable, investors must allocate assets and manage risks in a flexible manner to create the ideal investment portfolio. The yields changed according to the epidemic situation, and its StDev became larger, indicating that during the epidemic The data fluctuates greatly. The yields of all companies increased during the epidemic, indicating that affected by the epidemic, medical-related listed companies were favored by the market. Additionally, Tables 3 and 4 display the correlation coefficients among the companies.

Table 3. Table of correlation coefficients between companies before Covid-19 (2018.12-2019.12)

Correlation	SPX	AZN	MDT	NVS	PFE	ROG
SPX	100.00%	-2.20%	46.16%	31.36%	49.43%	11.17%
AZN	-2.20%	100.00%	7.08%	10.14%	4.76%	20.21%
MDT	46.16%	7.08%	100.00%	38.95%	35.16%	8.48%
NVS	31.36%	10.14%	38.95%	100.00%	41.98%	30.54%
PFE	49.43%	4.76%	35.16%	41.98%	100.00%	13.67%
ROG	11.17%	20.21%	8.48%	30.54%	13.67%	100.00%

Table 4. Table of correlation coefficients between companies during Covid-19 (2020.01-2021.01)

Correlation	SPX	AZN	MDT	NVS	PFE	ROG
SPX	100.00%	7.61%	80.31%	76.07%	65.56%	8.26%
AZN	7.61%	100.00%	7.83%	13.41%	-2.07%	48.59%
MDT	80.31%	7.83%	100.00%	62.81%	56.45%	4.63%
NVS	76.07%	13.41%	62.81%	100.00%	60.23%	16.19%
PFE	65.56%	-2.07%	56.45%	60.23%	100.00%	11.08%
ROG	8.26%	48.59%	4.63%	16.19%	11.08%	100.00%

The correlation coefficients of MDT, NVS, ROG and other companies are positive before and during the epidemic, indicating that the portfolio between them has less offset risk. The companies that represent them are similar in nature, whereas the correlation coefficient between AZN and PFE during the epidemic was negative, indicating that the portfolios between them have more offset risks.

3. Result and Discussion

The returns must be set to the dummy variable for constraints that allow users to declare upper and lower limitations on asset weights. The lowest value is set to -0.04, the maximum value is set to 0.06, and the increment is set to 0.0005. The author then calculates the data prior to the covid-19 and runs the solver table first. The valid and invalid epidemic boundaries can be found by clicking the highest and minimum values in Solver. Using the same approach as before, calculate the data during the COVID-19 by running the solver table with the min set to -0.02, max set to 0.03, and increment set to 0.005. The same is true of legal and illegal boundaries in a pandemic.

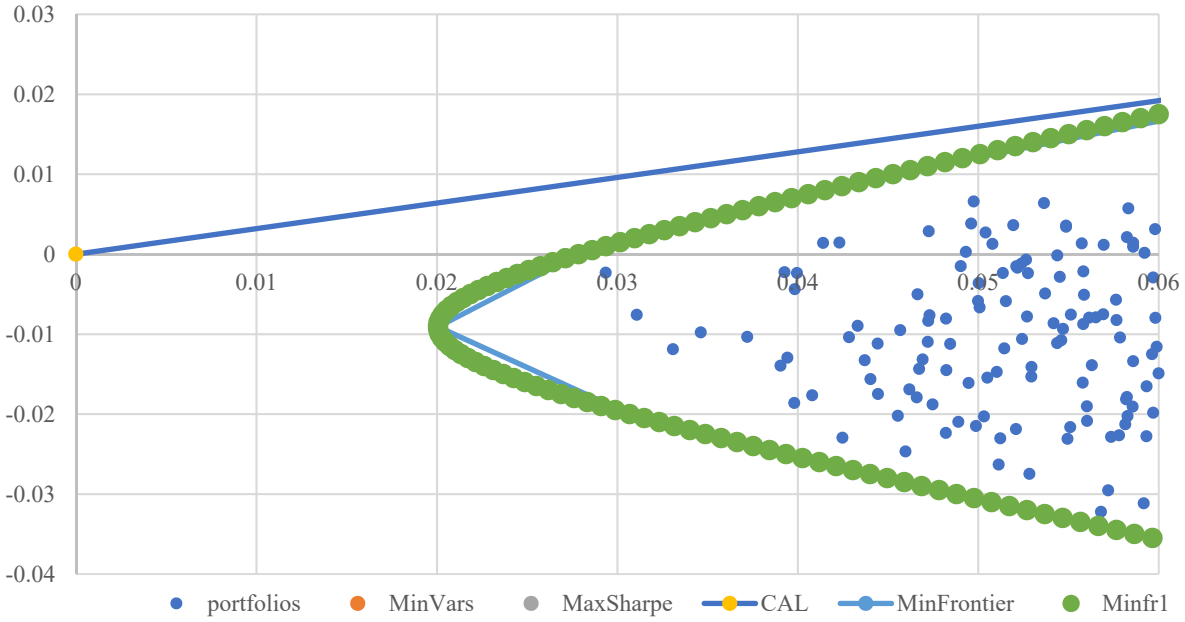

Fig. 1. Graph of the model of Markowitz before Covid-19 (2018.12-2019.12)

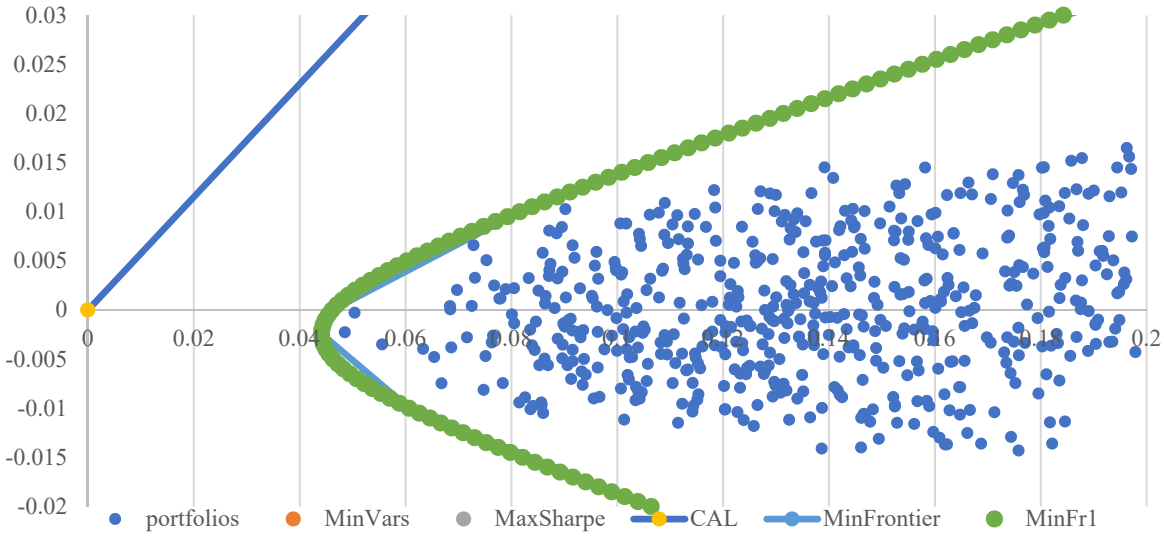

Fig. 2 Graph of the model of Markowitz DURING Covid-19 (2020.01-2021.01)

4. Conclusion

Investment risk refers to the unpredictability of future investment returns, and it includes the possibility of income loss as well as principle investment loss. Reasonable steps must be taken to control investment risks in order to reduce the effect of investment risks on investors during the investing process. Unsystematic risk can be mitigated by risk management and portfolio optimization, lowering risk and raising returns at the same time.

Markowitz's primary insight is that by pooling several hazardous assets together, part of the risk can be mitigated without lowering the average projected rate of return. One of the most efficient strategies to lower risk is to diversify your investments. Systematic and unsystematic risk are two categories of risk. Through an investing portfolio, the former can be spread out and removed.The correlation coefficient between the diversification research assets of each portfolio risk and the risk of the investment portfolio is directly related to each other. We should endeavor to select securities that are negatively linked as investments within the established yield limit when making investment decisions. to successfully lower the overall investment risk. The portfolio of securities efficiently diversifies investment risk, as shown by empirical investigation.

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