A Simple Study of the Applicability of the Markowitz Model in the Current Stock Market

Yixin Tian*

Department of Economics, Southwest Minzu University, Chengdu China

*Corresponding author: tianyixin@stu.swun.edu.cn

Abstract. The Markowitz model is widely used in the field of investment. The Markowitz model is a venture capital model proposed by Markowitz in 1952, and it is also called the mean-variance model. In the Markowitz model, the risk is defined as the volatility of the expected rate of return. This is the first time in the history of investment model research that the method of mathematical statistics is applied to the research of portfolio selection. This paper builds a portfolio based on the Markowitz model and studies the performance of the mean-variance model in practical applications by analyzing the process of solving the optimal portfolio problem. Finally, it is concluded that although the mean-variance model can solve investors' investment problems to a certain extent, it also has some shortcomings. For example, the calculation is too complicated, or the application environment is too ideal. Finally, suggestions for improvement are put forward on this basis, and future research directions are explained.

Keywords: Markowitz model; optimal portfolio; efficient frontier; machine learning.

1. Introduction

In the stock market, the future return of an asset is random, and it is also affected by the market environment. The investor cannot simply predict the future rate of return of an asset. Now many researchers have proposed a series of models to help investors make investment decisions. For example, the Fama-French three-factor model and the Markowitz model. These models are widely accepted. Zhang [1] tested the CAPM model and the Fama-French three-factor model, and the results showed that the two models showed relatively effective results in the fitting and applicability of the average return rate. Wen [2] used the Fama-French three-factor model to conduct regression analysis under the GEM market environment and concluded that there is a relatively obvious market premium and scale effect in the Chinese GEM market. But the book-to-market value ratio effect is not obvious. But in practical applications, these models are not necessarily effective. Researchers generally study these models under ideal conditions. However, these models may not necessarily play a role in practical applications [3]. For example, in a quantitative market, many variables are unpredictable. Many models still have room for improvement. This paper discusses the practical application of the Markowitz model.

This paper selects a portfolio of four companies in the US stock market and uses the mean-variance model to solve the problem of the optimal portfolio. At the same time, the advantages and disadvantages of using the mean-variance model are analyzed.

2. Data

2.1 Research objects

The research object of this paper using the Markowitz model includes four companies. The four companies are Apple, Nike, Electronic Arts, and Microsoft. These four companies are involved in four different fields. Beyond that, there is very little correlation between companies.

2.1.1 Apple

Apple Inc. is a multinational technology company from the United States. Its headquarters are located in Cupertino, California, USA. The company is currently involved in technological fields such as mobile phone communications, computer software, and electronic product design. Apple is currently listed on the NASDAQ stock exchange in the United States (Table 1). Its ticker symbol is AAPL. Apple's 2022 net income will be $99,803,000 an operating income of $394,328,000. Apple's 2022 stock price over time chart is shown in figure 1.

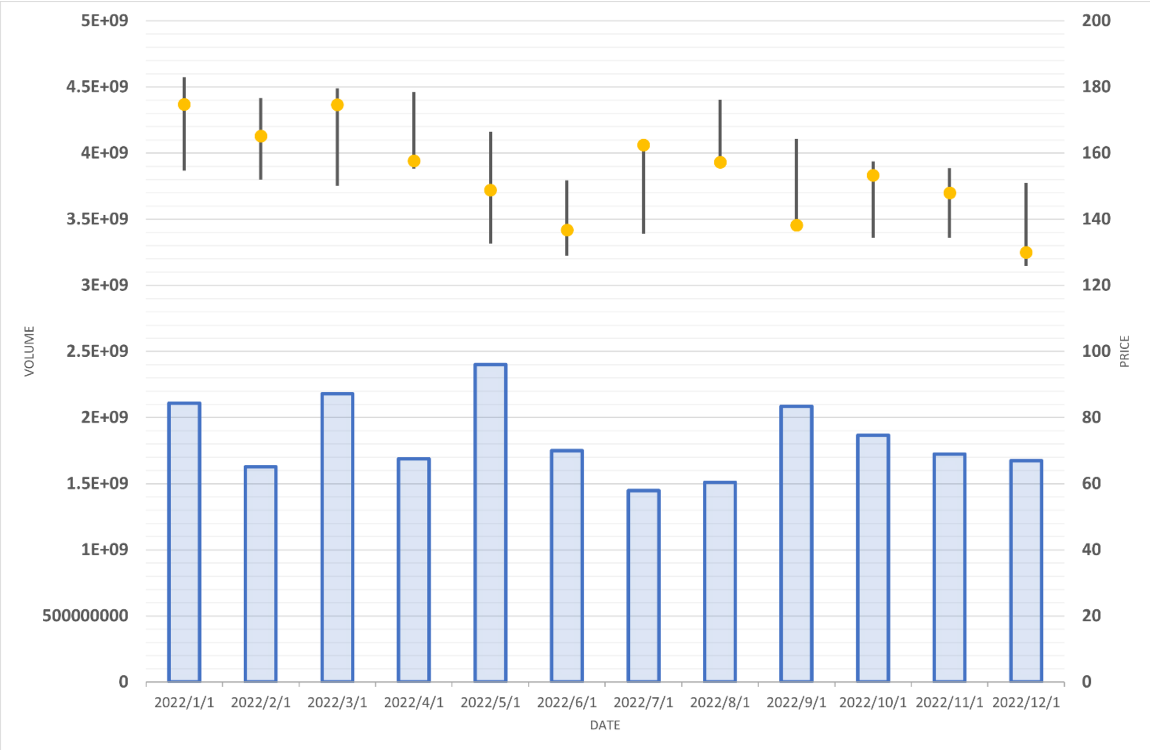

Figure 1. Apple's 2022 stock price and sales volume over time

Table 1. Apple Inc. Monthly Sales Volume, Highest, Lowest, and Closing Prices in 2022

Date	Volume	High	Low	Close
2022/1/1	2108446000	182.940002	154.699997	174.779999
2022/2/1	1627516300	176.649994	152	165.119995
2022/3/1	2180800100	179.610001	150.100006	174.610001
2022/4/1	1687795600	178.490005	155.380005	157.649994
2022/5/1	2401040300	166.479996	132.610001	148.839996
2022/6/1	1749099800	151.740005	129.039993	136.720001
2022/7/1	1447125400	163.630005	135.660004	162.509995
2022/8/1	1510239600	176.149994	157.139999	157.220001
2022/9/1	2084722800	164.259995	138	138.199997
2022/10/1	1868139700	157.5	134.369995	153.339996
2022/11/1	1724847700	155.449997	134.380005	148.029999
2022/12/1	1675657600	150.919998	125.870003	129.929993

2.1.2 Nike

Nike is a company founded in 1967 in Oregon, USA. The company mainly involves the fields of sportswear and sports accessories. is one of the world's largest sellers of athletic shoes and athletic apparel. Nike is currently listed on the NASDAQ stock exchange in the United States (Table 2). Its stock symbol is NKE. Nike's 2022 operating income will be $46,710,000 and its net income will be $6,046,000. The chart of Nike's share price over time in 2022 is shown in figure 2.

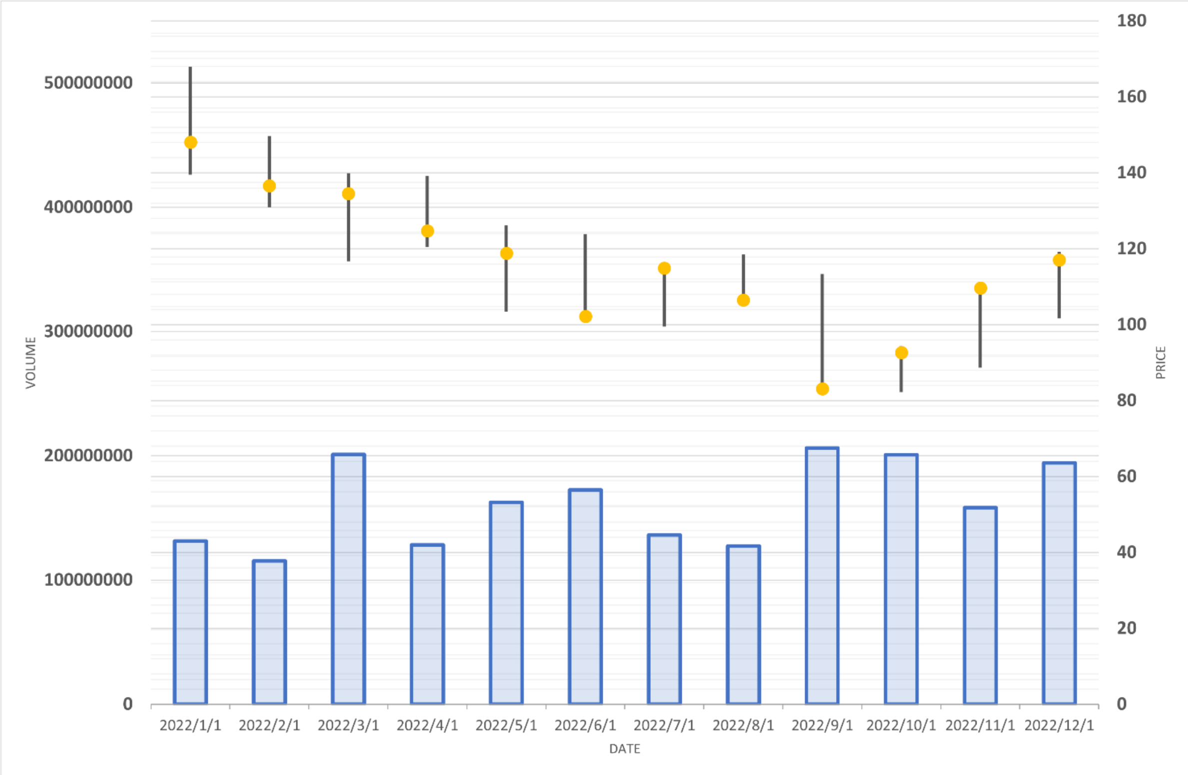

Figure 2. Nike's 2022 stock price and sales volume over time

Table 2. Nike Company 2022 stocks sell for the number, the highest price, lowest price, and closing price for the monthly stock

Date	Volume	High	Low	Close
2022/1/1	131502000	167.910004	139.559998	148.070007
2022/2/1	115406000	149.679993	130.929993	136.550003
2022/3/1	201080600	139.860001	116.75	134.559998
2022/4/1	128180100	139.139999	120.480003	124.699997
2022/5/1	162628900	126.199997	103.459999	118.849998
2022/6/1	172665200	123.82	100.779999	102.199997
2022/7/1	136287300	115.209999	99.529999	114.919998
2022/8/1	127466600	118.470001	105.809998	106.449997
2022/9/1	206296500	113.360001	82.5	83.120003
2022/10/1	200873100	94.349998	82.220001	92.68
2022/11/1	158370900	109.690002	88.720001	109.690002
2022/12/1	194174600	119.18	101.68	117.010002

2.1.3 Electronic Arts

Electronic Arts is a world-renowned interactive entertainment software company, originally established in California, USA in 1982. Electronic Arts are mainly engaged in the development, publishing, and sales of various electronic games. The company often enters into agreements with third-party companies to license its games to third parties to distribute and host its games. Electronic Arts are currently listed on the NASDAQ stock exchange in the United States (Table 3). Its ticker symbol is EA. Electronic Arts' 2022 operating income will be $6,991,000 and its net income will be $789,000. A chart of EA's share price over time in 2022 is shown in Figure 3.

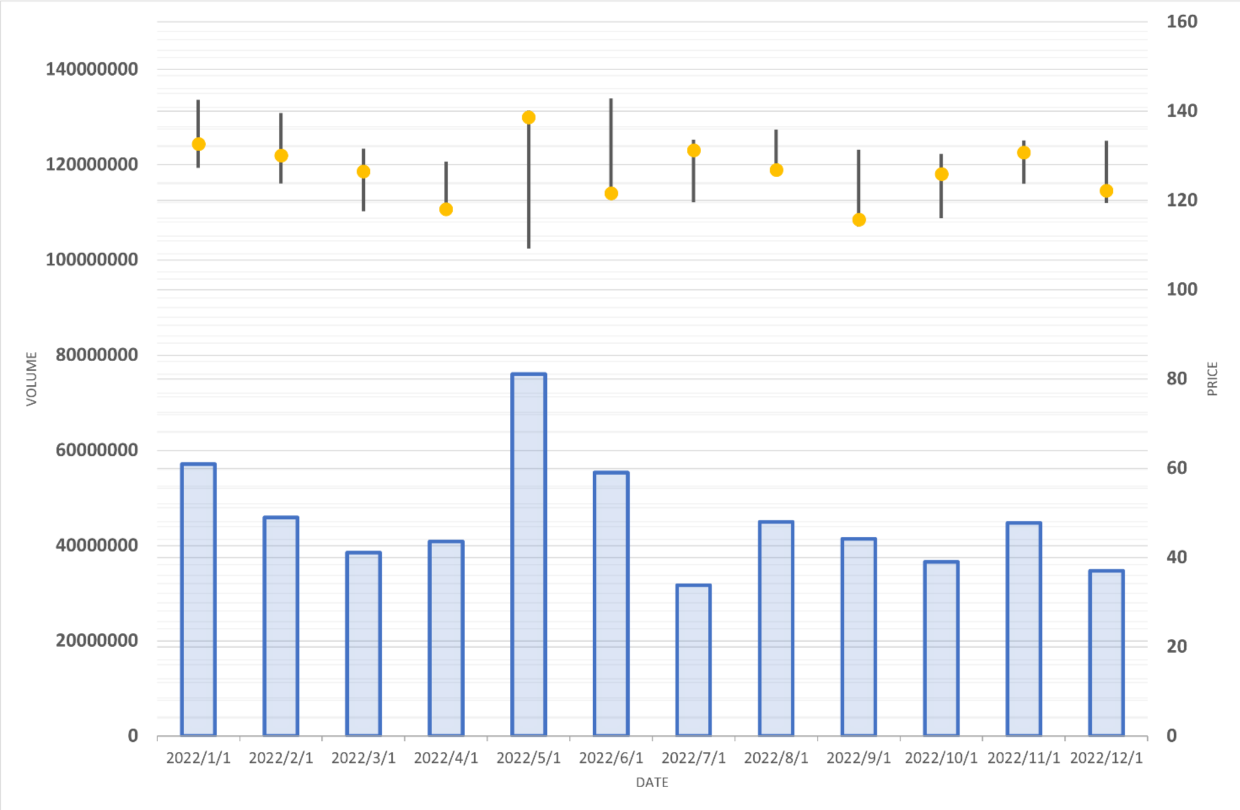

Figure 3. 2022 EA Stock Price and Number Sold Over Time

Table 3. Electronic Arts Inc. Monthly Number of Shares Sold, Highest, Lowest, and Closing Prices in 2022

Date	Volume	High	Low	Close
2022/1/1	57093900	142.550003	127.279999	132.660004
2022/2/1	45920500	139.610001	123.800003	130.089996
2022/3/1	38493200	131.589996	117.580002	126.510002
2022/4/1	40874700	128.729996	117.739998	118.050003
2022/5/1	76034600	140.160004	109.239998	138.649994
2022/6/1	55352200	142.789993	121.07	121.650002
2022/7/1	31702900	133.619995	119.540001	131.229996
2022/8/1	44965900	135.850006	125.370003	126.870003
2022/9/1	41421800	131.399994	114.07	115.709999
2022/10/1	36554300	130.449997	116.010002	125.959999
2022/11/1	44771000	133.399994	123.720001	130.779999
2022/12/1	34714700	133.339996	119.419998	122.18

2.1.4 Microsoft

Microsoft Corporation was founded in 1975 and is headquartered in Washington State. Microsoft is mainly involved in the fields of software development and smart device development. The company provides a range of services, including cloud-based solutions, providing customers with software, services, platforms, and content, and the company provides solution support and consulting services. Microsoft Corporation is currently listed on the NASDAQ stock exchange in the United States (Table 4). Its ticker symbol is MSFT. Microsoft's 2022 operating income will be $198,270,000 and its net income will be $72,738,000. The 2022 share price of Microsoft Corp. over time is shown in figure 4.

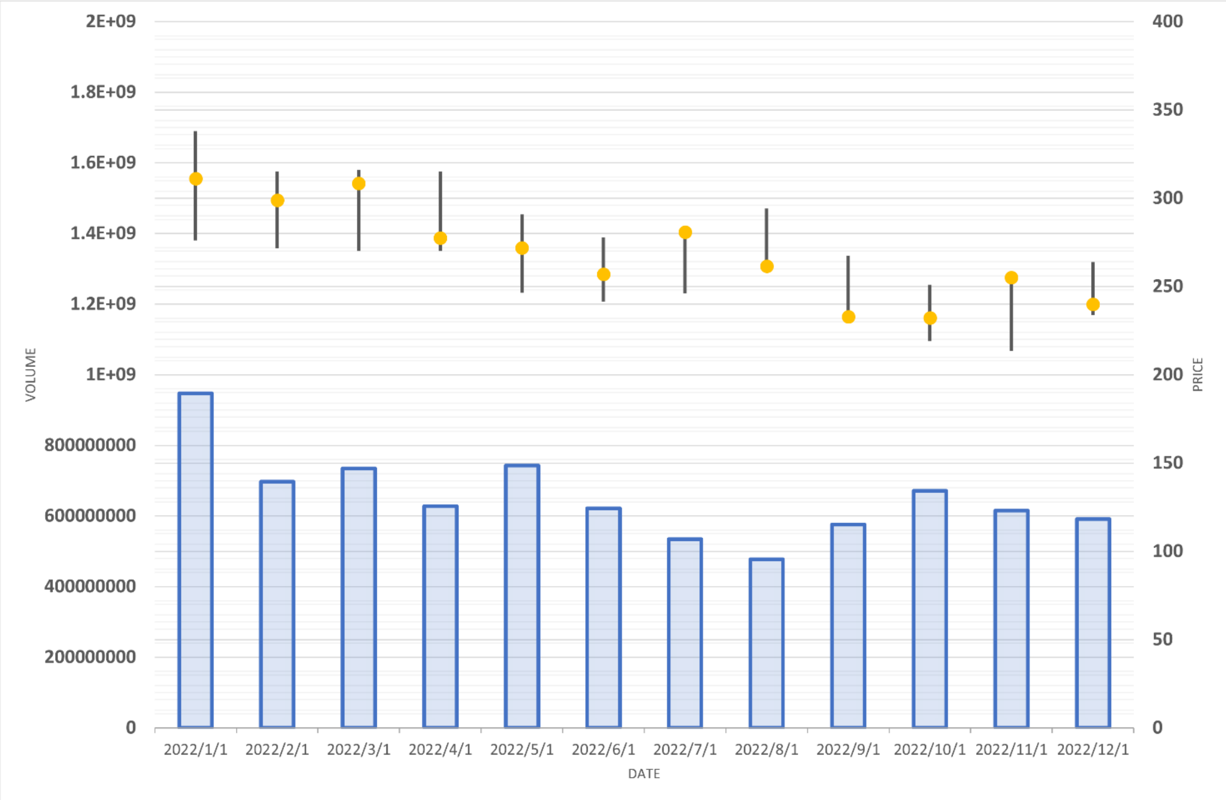

Figure 4. Microsoft's 2022 stock price and sales volume over time

Table 4. Monthly Number of Shares Sold, Highest, Lowest, and Closing Prices for Microsoft Corporation in 2022

Date	Volume	High	Low	Close
2022/1/1	947531400	338	276.049988	310.980011
2022/2/1	697050600	315.119995	271.519989	298.790009
2022/3/1	734334200	315.950012	270	308.309998
2022/4/1	627343400	315.109985	270	277.519989
2022/5/1	742902000	290.880005	246.440002	271.869995
2022/6/1	621372300	277.690002	241.509995	256.829987
2022/7/1	534891800	282	245.940002	280.73999
2022/8/1	477157600	294.179993	260.660004	261.470001
2022/9/1	575586600	267.450012	232.729996	232.899994
2022/10/1	671225100	251.039993	219.130005	232.130005
2022/11/1	615296000	255.330002	213.429993	255.139999
2022/12/1	591351000	263.920013	233.869995	239.820007

2.2 Conformity

Table 5 and Table 6 show the statistical table of stock prices of four companies in 2022 based on historical data. It contains average, standard error, median, mode, standard deviation, variance, kurtosis, skewness, region, minimum, maximum, sum, and number of observations for each company stock price.

Table 5. Four tables of company descriptive statistics

AAPL Price		NKE Price	
average	153.9125	average	115.7333
standard error	4.143779	standard error	5.384308
median	155.28	median	115.965
mode	#N/A	mode	#N/A
standard deviation	14.35447	standard deviation	18.65179
variance	206.0509	variance	347.8893
kurtosis	-0.78332	kurtosis	-0.29736
skewness	-0.1108	skewness	-0.00303
region	44.85001	region	64.95
minimum	129.93	minimum	83.12
maximum	174.78	maximum	148.07
sum	1846.95	sum	1388.8
number of observations	12	number of observations	12
EA Price		**MSFT Price**	
average	126.695	average	268.875
standard error	1.885212	standard error	7.941308
median	126.69	median	266.67
mode	#N/A	mode	#N/A
standard deviation	6.530565	standard deviation	27.5095
variance	42.64828	variance	756.7725
kurtosis	-0.2442	kurtosis	-1.10087
skewness	-0.02783	skewness	0.207725
region	22.94	region	78.85001
minimum	115.71	minimum	232.13
maximum	138.65	maximum	310.98
sum	1520.34	sum	3226.5
number of observations	12	number of observations	12

Table 6. Monthly returns for four companies in 2022

Date	AAPL Return	NKE Return	EA Return	MSFT Return
2022/1/1				
2022/2/1	-0.055269505	-0.077801063	-0.019372893	-0.039198667
2022/3/1	0.057473391	-0.014573453	-0.027519364	0.031861805
2022/4/1	-0.097130788	-0.073275871	-0.066872175	-0.099867047
2022/5/1	-0.055883275	-0.046912583	0.174502249	-0.020358872
2022/6/1	-0.081429692	-0.140092564	-0.122610838	-0.055320588
2022/7/1	0.188633659	0.124461853	0.078750463	0.093096617
2022/8/1	-0.032551807	-0.073703456	-0.033224058	-0.068639986
2022/9/1	-0.120977	-0.219163877	-0.087964087	-0.109266864
2022/10/1	0.10955137	0.115014397	0.088583529	-0.003306093
2022/11/1	-0.034628911	0.183534765	0.038266117	0.099125462
2022/12/1	-0.122272554	0.066733521	-0.065759283	-0.060045434
Average	-0.022225919	-0.014161667	-0.003929122	-0.021083606

3. Method

3.1 Markowitz model

Portfolio theory can be understood in a narrow sense as to how investors choose the best portfolio and the number of securities to achieve the highest returns under certain investment risks. Among them, the Markowitz model is one of the most representative ones. In stock investing, the future is unknown to investors. Because the trend of stock prices is usually unpredictable, it is difficult for investors to guarantee the maximum benefit in a certain risk.

In Markowitz's portfolio theory assumption, investors only use expected return and risk to determine the price of securities [4]. Investors need to know the expected value of the expected rate of return and the variance or standard deviation of the expected rate of return. Among them, the expected value of the expected rate of return represents the expected return, and the variance or standard deviation of the expected rate of return represents the risk. Choose several different stocks and calculate the returns of different stocks through historical data to predict the future.

3.2 Build an optimal portfolio

This paper uses the Markowitz model to analyze the historical data of the above four companies (this paper uses the US 2022 ten-year daily Treasury bond coupon yield curve interest rate) and calculates the optimal weight. Other data obtained through calculation are shown in Table 7. Draw all the calculated data into a scatter plot, and get Table 8.

Table 7. The optimal weight obtained

	Weight	**ER**	**W*ER**
APPL	0	-0.022225919	0
NKE	1	-0.014161667	-0.014161667
EA	0	-0.003929122	0
MSFT	0	-0.021083606	0
sum of weight	1		

Table 8. Some data obtained by calculation

Portfolio risk	**ER**
0.1	-0.011394794
0.095	-0.010421881
0.09	-0.009256919
0.085	-0.007559395
0.08	-0.005864854
0.075	-0.008029934
0.07	-0.010708619
0.065	-0.016105956

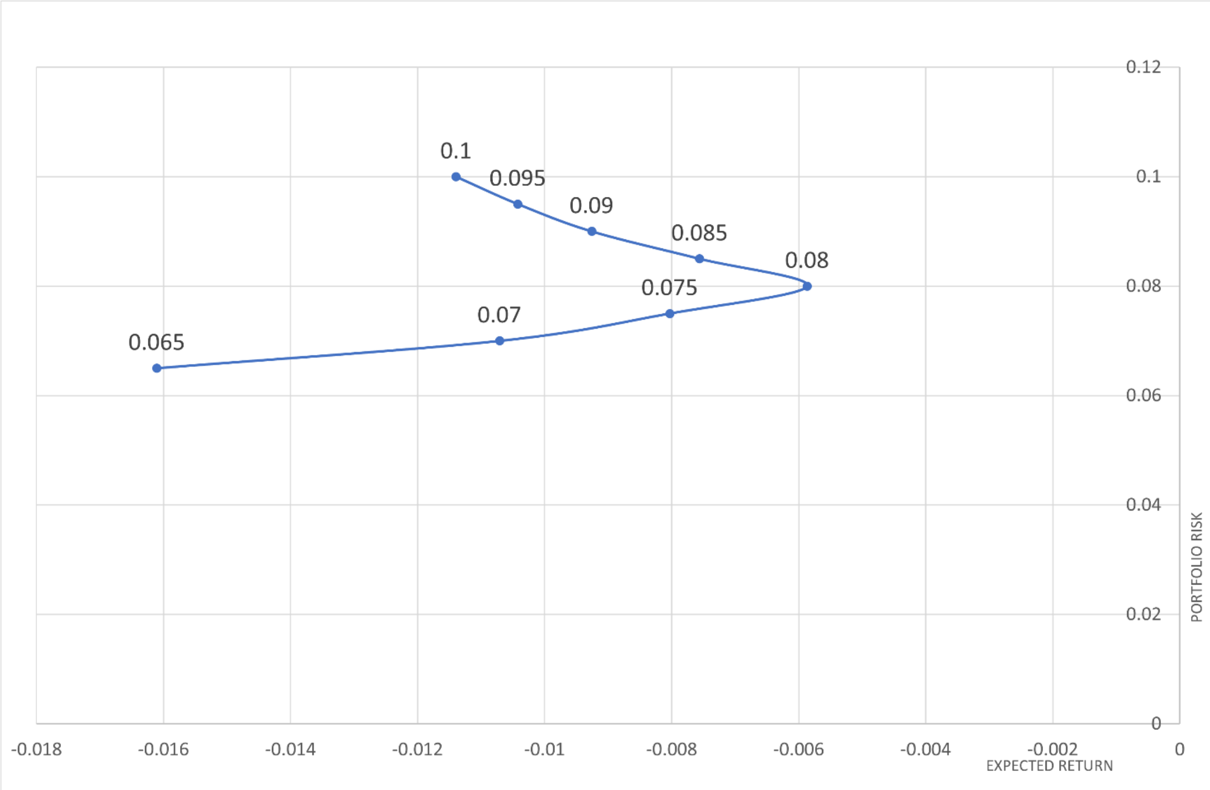

Figure 5. Portfolio Scatterplot

Based on the historical data of four companies in the past year, this paper uses their monthly average stock prices to calculate the monthly rate of return. Then calculate the expected rate of return and the standard deviation of the expected rate of return. Finally, the effective frontier is represented by drawing a scatter diagram.

From Table 8, we can get that among the four companies, Apple has a weight of 0, Nike has a weight of 1, Electronic Arts has a weight of 0, and Microsoft has a weight of 0. The Sharpe ratio is the highest. From Figure 5. We can get the efficient frontier of this set of portfolios.

4. Discuss

4.1 Advantages

The first advantage of Markowitz's theory is that Markowitz's theory simplifies the difficulty of investment analysis to a certain extent. Investors only need to master the expected return and variance of the selected portfolio to analyze the stock price trend to a certain extent. The Markowitz model allows investors to better analyze future stock price trends based on historical data. The second advantage is that the Markowitz model also proves that diversified investment can effectively reduce the unsystematic risk of the portfolio. Qi [5] believes that this model can clearly display the mean and variance of the portfolio under different scenarios, allowing investors to have a clearer understanding of their portfolio.

Guo and Fu [6] compared the efficient frontiers of 30 stock samples calculated by comparing the Shanghai and Shenzhen stock markets based on the sample data from June 1998 to June 2001. Finally, it is concluded that the Markowitz efficient portfolio is superior to the underlying securities in nature. It also outperforms random simple equal-weight combinations.

4.2 Disadvantages

The Markowitz model also exposed its shortcomings in the process of using it. The first is that the calculation is too complicated for ordinary investors to do. If investors want to use the Markowitz model, investors must draw an efficient frontier, and investors need to draw a feasible set if they want to obtain an efficient frontier. If investors want to obtain a feasible set, they need to use some algorithms, such as MATLAB and Monte Carlo simulation. This is why the Markowitz model is more difficult to implement in practice. The second is derailment from reality. Markowitz's theory can indeed help people to solve the expectations of the future to a certain extent, but it does not take the whole situation into account. Guo and Fu [6] believed that the implementation of the Markowitz model should be based on a series of strict assumptions. For example, the rate of return must obey the normal distribution [7], but now more and more studies have found that this is not the case. Second, the Markowitz model also does not take into account short selling. In this paper, according to the formula, the stock weight must be greater than or equal to 0, and short selling is not considered. This may not hold true in the U.S. stock market. The Markowitz model also does not take into account risk-free assets [8], and investors cannot borrow money to invest at risk-free rates. To sum up, the Markowitz model is too idealistic and to some extent divorced from reality.

4.3 Optimization

The traditional Markowitz model is too idealized to a certain extent and is bound by data. In the actual stock market, the rate of return can change at any time. Li [7] added the rate of change ΔR on the basis of the traditional Markowitz model to deal with changes in the rate of return.

4.4 Other methods

Now, more and more researchers have put forward more model theories so that investors can make better investment profits. Zhang, Dang, and Huang [9] proposed a two-step diversified investment portfolio optimization model based on machine learning on the basis of considering transaction costs and upper and lower bound constraints. The model is mainly divided into two steps: step 1 selects stocks with higher predicted returns through machine learning, and evaluates and selects the model; step 2 selects stocks with higher predicted returns according to step 1, and uses the MSV model, MV model, and 1/N model to determine the investment ratio of the selected stocks [9]. This method based on the fusion of machine learning and portfolio construction provides a more comprehensive and flexible analysis of the stock market. This is a more advanced theoretical model.

Aljanabi [10] believes that the portfolio optimization method based on machine learning is superior to the standard Markowitz mean-variance model in the selection of the optimal portfolio and the determination of the coherent portfolio of the portfolio manager. The empirical results persist across the commodity market sample period and are robust across other investment horizons and asset management dynamic positions.

5. Conclusion

In order to discuss the advantages and disadvantages of the mean-variance model in practical application, this paper uses Markowitz's portfolio theory to conduct a series of analyses through the research on the portfolio mentioned in the text.

In the process of searching for data, this article found that the amount of calculation when applying data is too complicated, which is not suitable for ordinary investors. But it can still help investors make decisions to a certain extent. In this article, the historical data of the four companies are calculated on a monthly basis. On this basis, we can find the optimal investment ratio of this portfolio by applying the model. Calculated according to the historical data of the four companies given in this article, no matter how the weight is changed, the income will be negative in the future. Although people would not choose this investment portfolio under normal circumstances, based on model calculations, we can find out the investment point with the lowest loss. This is where the mean-variance model comes into play.

The shortcoming of this article in the research process is that the data used are not accurate enough. In this paper, when constructing the optimal investment portfolio, the data used are calculated on a monthly basis. It would be more accurate to calculate the result according to the daily data, but at the same time, it would also greatly increase the amount of calculation. In the future, the author will study the connection between Markowitz's investment theory and the construction of investment portfolios based on machine learning, and further study how to better help investors solve investment problems.

References

[1] Zhang, L.S. (2022). *An Empirical Study on my country's Shanghai 50 Index Constituents——Based* on *the CAPM Model and the Fama-French Three-Factor Model. Economic Research Guide* (26), 78 - 80.

[2] Wen, Y. (2019). Validity *Test of Fama-French Three-Factor Improved Model* (Master's Thesis, Hunan Normal University) https://kns-cnki-net-443.webvpn.swun.edu.cn/ KCMS/detail/detail.aspx?dbname=CMFD201902&filename=1019671862.nh.

[3] Moeini Najafabadi, Z., Bijari, M. and Khashei, M. (2020), "*Making investment decisions in stock markets using a forecasting-Markowitz based decision-making approaches*", *Journal of Modelling in Management*, Vol. 15 No. 2, pp. 647 - 659. https: //doi.org/10.1108/JM2-12 - 2018- 0217.

[4] Markowitz, H. (1952). *Portfolio Selection*. *The Journal of Finance*, 7 (1), 77 – 91. https://doi.org/10.2307/2975974.

[5] Qi, G. (2022, April). *Review of Research on Markowitz Model in Portfolios*. In *2022 7th International Conference on Social Sciences and Economic Development (ICSSED 2022)* (pp. 786-790). Atlantis Press.

[6] Guo, S.H., and Fu, Q.H. (2003). *An Empirical Analysis of the Efficient Frontier of my country's Stock Market——Validation of the Markowitz Model. Thought Front* (01), 23 - 28.

[7] Li, S.L. (2020). *Research on the Markowitz Portfolio Model of Mean and Variance Changes. Bohai Rim Economic Outlook* (02), 185 - 186. doi: 10.16457/j.cnki.hbhjjlw.2020.02.138.

[8] Zola. (2021). *Research on Portfolio Strategy Based on Mean-Variance Model. Research in Financial Theory* (05), 9 - 16. doi: 10.13894/j.cnki.jfet.2021.05.002.

[9] Zhang, P., Dang, S.L., and Huang M.Y. (2022). *Two-step M-SV Portfolio Optimization Based on Machine Learning Forecasting Stock Returns. Chinese Management Science* (07),. doi: 10.16381/j.cnki.issn1003-207x.2021.2308.

[10] Najafabadi, Z. M., Bijari, M., and Khashei, M. (2019). *Making investment decisions in stock markets using a forecasting-Markowitz based decision-making approaches*. *Journal of Modelling in Management*, *15* (2), 647 - 659.