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Research on the Investment Portfolio Optimization Based on Efficient Frontier Model: A Portfolio of AMD, NVIDIA, TXN, LRCX, AVGO, QCOM, INTC and MRVL

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Abstract: Optimal investment portfolio is beneficial for investors to make decisions and construct investment strategy. This paper uses effective frontier methods to build an investment portfolio. This study selects 8 different companies from the USA, which are AMD, MRVL, LRCX, QCOM, INTC, AVGO, and TXN, and collects the data to optimize investment portfolio. The study finds that the optimal portfolio point is (0.1407, 0.0506), the risk is 0.1407, and the return is 0.0506. In this case, for AMD, MRVL, NVIDA, LRCX, INTC, QCOM, AVGO, and TXN, the weights for each company are 0.0502, -0.3867, 0.5289, 0.4367, -0.9987, -0.2805, 1, and 0.6501, respectively. The study allows for short selling and buy mechanisms, since a negative number is actually equivalent to a short sale. As a result, the study has an optimal portfolio that enables investors to make optimal investment decisions for the company the study choose. Through this research, it can help people to increase their life quality, because investment can help with more finance in the daily life, which can let people consume a better goods.

Keywords: portfolio investment, efficient frontier, NVIDIA

1. Introduction

Investment has many benefits for our lives, enabling us to achieve our life goals, such as accumulating enough retirement pension to enjoy the old age, establishing an education fund to consider our children's future, accumulating a certain amount of funds to buy a car or house, or accumulating a sum of funds to travel around the world, and some people even plan to establish their own businesses, etc. The achievement of these goals and investment are conducive to providing a better economic foundation. Moreover, people often encounter unexpected situations in their daily lives, such as illness, injury, death of loved ones, natural disasters, theft, unemployment, etc., which can lead to a decrease in personal wealth. In order to offset these unexpected and disasters, it is necessary to carry out scientific investment planning, reasonably arrange income and expenditure, in order to have sufficient financial support and successfully overcome difficulties in the event of unexpected and disasters; In the absence of unforeseen circumstances or disasters, it is possible to establish a "risk fund" and increase its value, thereby improving the quality of life. The importance of the investment including, firstly, realizing the preservation and appreciation of wealth (resistance to inflation). Secondly, improve family risk resistance. Thirdly, improve the life quality (improve financial

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conditions and meet different levels of consumer demand). Finally, investment is closely related to national economic growth (the basic driving force of economic growth. An increase in investment will cause a K-fold increase in income).

In addition, there are some other researchers doing the similar research, De Bondt and Thaler used empirical evidence from CRSP monthly earnings data and the overreaction hypothesis, the majority of people tend to analyze whether the behavior of "overreacting" to unexpected and dramatic news events will affect stock prices in violation of Bayesian rules, and summarize the substantial forms of weakness under low market efficiency [1]. McGrattann and Prescott studied whether the market was overvalued at a level where the stock value of American companies was close to 1.8 times the US GDP in the first half of 2000, a standard growth model based on the theory of aggregate economy was constructed, and the conclusion was drawn that the market was not overvalued [2]. Guiso and Sapienza et al. studied the impact of a general lack of trust on stock market participation, using micro data from the Netherlands and Italy as well as cross-border data, and found that a lack of consistent evidence of trust is an important factor in explaining the problem of limited participation [3]. Mazur, Dang and Vega used the knowledge of currency circulation and the worst performing 8K and DEF14A file data to analyze the performance of the U.S. stock market during the stock market crash in March 2020 caused by COVID-19, and concluded that natural gas, food, health care and software stocks have achieved high positive returns, while the stock values of oil, real estate, entertainment and hotel industries have declined significantly. Besides, loss-making stocks exhibit extreme asymmetric volatility, which is negatively correlated with stock returns [4].

Discussion on market effectiveness, Samuelson proposed that the stock market is micro efficient, but macro ineffective. It indicates that the efficient market hypothesis has a better effect on individual stocks than on the overall stock market. Therefore, researchers proposed a simple test based on regression and simple scatter plots to prove the authenticity of Samuelson's aphorism about US stock market data since 1926 [5]. In order to study the main indicators of the development of the Pakistani stock market and their possible correlation with actual economic activity during the post liberalization period, Iqbal investigated market liberalization, integration of the market with global markets, and issues on corporate governance, then compared them with a sample of developing and developed markets. The results showed that the size of the Pakistani stock market was relatively small, the sources of capital mobilization are relatively insignificant, and these factors decrease the value of the stock market in promoting economic activity. In addition, due to the influence of noise traders and speculators, the market seems too volatile. From a positive perspective, the market seems to have brought huge returns to investors, compensating for the intensification of market volatility [6]. When managers make decisions, should they follow the signals sent by the market and stock market, even if this may differ from their assessment of fundamentals. In order to find the answer, Blanchard, Rhee and Summers reviewed theoretical arguments and tested empirical evidence. They observed investment behavior during the economic crashes of 1929 and 1987 and concluded that the role of market valuation was limited under fundamental conditions [7].

Scholars used the latest developments in cointegration theory to examine the connections and dynamic interactions between stock market trends. And it was found that before October 1987, there was a strong linkage among stock markets in different countries. After October 1987, the international linkage between stock price indices significantly increased, with the Nikkei Index being the only exception. Moreover, the US stock market had a great impact on the French, German and English Market markets afterwards. The results suggest that the reaction of French, German and English Market markets to the innovation of American stock markets is the same as that of cross-border information efficient stock markets. Lastly, it documented that the performance of the stock market in Japan was not related to the US, France, Germany and the UK stock markets during this period [8]. Wattenberg created a new two-dimensional visualization algorithm that can calculate very detailed

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information. This display method is based on Shneiderman's tree graph technology, while utilizing hierarchical and similarity information, and is highly popular [9]. Zuckerman believed that the value of corporate stock presents the value of a company's productive assets, and used the Standard Model to adjust costs to prove that, and concluded that if assets only include capital goods, not permanent monopoly franchise, then the value of securities measures the value of capital. Moreover, data from American companies indicate that they have formed a significant amount of intangible capital, especially in the past decade [10].

On this basis, the issue in this article is to construct the optimal investment portfolio, which is beneficial for investors to make decisions. To achieve this goal, this paper will adopt effective cutting-edge methods to study what issues have been addressed, and this research will contribute to which of the investment point that investor will choose in the multiple optimal investment portfolio points.

The structure of the remaining of this research is as follows. Section II introduces the background of each company and the changes in returns and stock prices, along with other data information. Section III is about the methods and formulas used in the calculation of the article (Efficient Frontier Model). Section IV explains the calculated results, which are the points of the optimal investment portfolio. And there is also a discussion in this section. Section V summarizes, including the advantages and disadvantages of the used method, research issues, and future improvements.

2. Data

2.1. Introduction of 8 Companies and Its Returns Rate

Among the 8 sample companies, AMD is an American multinational semiconductor company develops computer processors in the field of technology for business and consumer markets. MRVL is an American chip manufacturer specialized in manufacturing chips for storage, communication and consumer electronics. NVIDIA is a Fabless manufacturing that mainly designs and sells graphics processors. LRCX is a Science and technology in the United States company responsible for the production, design and sales of semiconductor products. INTC is the world's second largest semiconductor company. QCOM is a radio communication technology R&D company. AVGO is a Fabless manufacturing in the United States. TXN is an American multinational technology company and it is famous for developing, manufacturing and selling semiconductors and computer technology.

This article visualizes the stock return data of 8 companies from 2018 to 2023, as shown in Figure 1, it can be concluded that the most volatile range for AMD's returns is from August 2018 to February 2019, it experiences the lowest returns amount the 4 companies at around -0.55% in November 2018. Also, there is a large float between May 2022 to May 2023, and located at 0.01% in the end of the period. However, other time periods are comparatively gentle. For the MRVL, the period with significant fluctuations is from February 2022 to June 2023, while the rest of the period is relatively smooth. It peaked at June 2023 at 0.4%. Finally, it located at 0.2%. NVIDIA has the largest fluctuation in the graph, except for relatively stable periods from August 2019 to November 2021, with other periods experiencing significant fluctuations. It has the bottom at -0.4% in May 2022 and float to 0.1% in June 2023. Moreover, LRCX is the almost the most common line in this graph, as it doesn't fluctuate as strongly as other lines. As for the final point it lies, is at around 0% in June 2023. The returns of the INTC fluctuate heavily from February 2020 to May 2023, and it is shown in a blue line in the graph. Its peak is at 0.28% in May 2023 and bottom figures at -0.22% at August 2022. Therefore, QCOM has the largest returns among the 4 companies during 5 years periods at 0.41% in May 2019, also include the lowest returns at -0.25% in August 2019. In this case, its short-term fluctuations are significant, which show as a high risk. The AVGO is almost the slightest within the Figure 1, it fluctuates heavily from November 2021 to June 2023, and peaks at 0.25% in May 2023. At other times, it is comparatively slight than others. In addition, the return of TXN is peaked at 0.25%, that

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there are two time periods reach this percentage, they are May 2020 and August 2022. However, it is the slightest one whose risk is also lowest. It only has a bottom at -0.15%, which may larger than other lines in this case.

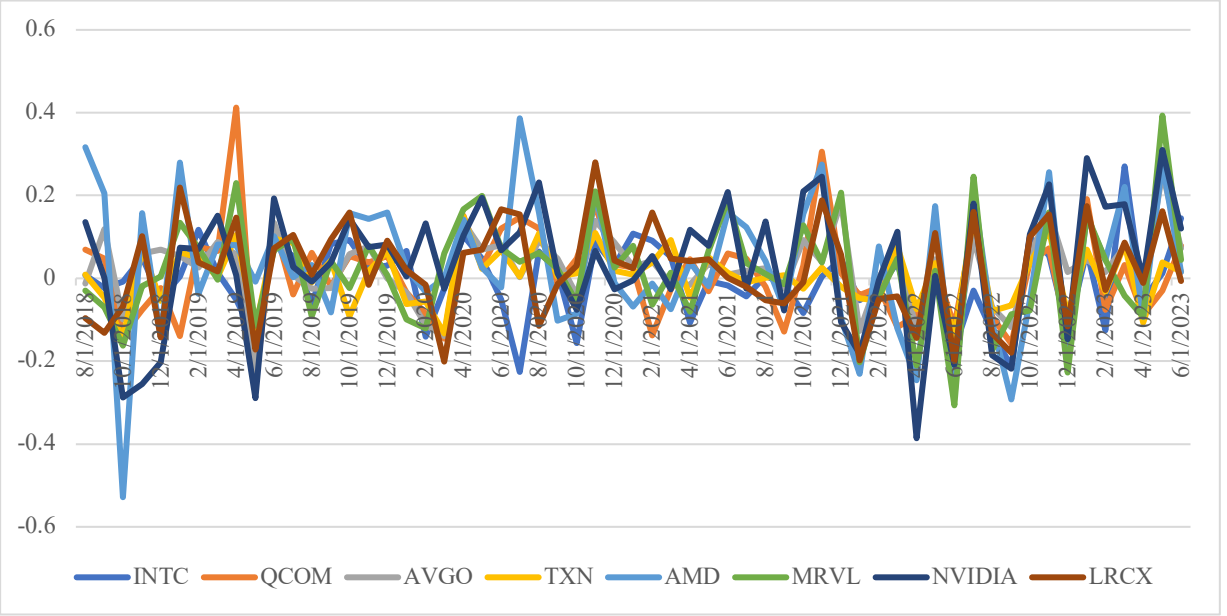

Figure 1: Returns of 8 companies.

This article conducts descriptive statistics on the stock return indicators of 8 enterprises, and the results are summarized in Table 1, the information on the average values, median, standard deviation, minimum and maximum values of each stock shows that, INTC has the smallest mean value of -0.0047, and the mean values of the other 7 companies are all positive. AMD has the smallest minimum return of -0.5285, and it is also the most volatile stock as it has the largest standard deviation of 0.1681. From the maximum return, QCOM is the largest and the value is 0.4123.

Table 1: Returns rate data information.

	Mean	Median	Std.	Min	Max
AMD	0.0313	0.0313	0.1681	-0.5285	0.3865
MRVL	0.0176	0.0209	0.1279	-0.3066	0.3931
NVIDIA	0.0324	0.0606	0.1532	-0.3861	0.31
LRCX	0.0195	0.0221	0.1148	-0.201	0.2801
INTC	-0.0047	0.0052	0.0929	-0.2259	0.2704
QCOM	0.0108	0.0252	0.1142	-0.2539	0.4123
AVGO	0.0227	0.0316	0.0881	-0.2353	0.2544
TXN	0.0077	0.0111	0.0719	-0.1448	0.1521
TREASURY BOND	0.0016	0.0014	0.001	0.0002	0.0035

This article conducted a correlation analysis on the stock return of 8 enterprises, and the results are shown in Table 2. Each of the companies can control their returns in 100%, which can completely influence their own returns and the coefficient is shown as 1 in the table. Therefore, for the INTC, apart from its own influence, AVGO has the greatest impact on it (coefficient is 0.5430). As for the

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QCOM, TXN has the greatest impact on it (coefficient is 0.5720). As for VGO, the greatest impact is brought by MRVL, with the correlation coefficient of 0.7246. For the TXN, the LRCX influences its returns the most, and the correlation coefficient reach at 0.6704. In this case, the biggest impact on returns of AMD is from NVIDIA, and the coefficient is 0.6936. The largest positive correlation coefficient is from AVGO to MRVL, with the coefficient of 0.7246, except MRVL itself. As for the NVIDIA, the largest positive correlation relationship is with AMD, and the coefficient is 0.6936. Finally, the largest positive correlation coefficient for the LRCX is 0.6704, which is brought by TXN.

Table 2: Correlation coefficient of returns rate.

	INTC	QCO	AVGO	TXN	AMD	MRVL	NVIDIA	LRCX
INTC	1	0.2743	0.5430	0.5380	0.2685	0.3851	0.4171	0.4433
QCOM	0.2743	1	0.5164	0.5720	0.5279	0.5006	0.5381	0.5423
AVGO	0.5430	0.5164	1	0.6504	0.5442	0.7246	0.6086	0.60812
TXN	0.5380	0.5720	0.6504	1	0.5266	0.6623	0.5480	0.6704
AMD	0.2685	0.5279	0.5442	0.5266	1	0.5697	0.6936	0.5610
MRVL	0.3851	0.5006	0.7246	0.6623	0.5697	1	0.6278	0.6137
NVIDIA	0.4171	0.5381	0.6086	0.5480	0.6936	0.6278	1	0.5595
LRCX	0.4433	0.5423	0.6081	0.6704	0.5610	0.6137	0.5595	1

3. Method

The effective frontier refers to rational investors who are risk averse and prefers returns. For the given risk level, the investors will select a combination that can obtain the maximum return. For the given expected return rate, the investors will select the combination with the minimum risk. The investment portfolio that can simultaneously meet these two conditions is the effective set (also known as the effective boundary or effective frontier). The combination on the effective boundary becomes the effective portfolio [11].

Markowitz portfolio theory refers to a widely used theoretical model in the investment field, aimed at helping investors optimize the balance between risk and return.

4. Results and Discussion

This paper uses the mean and the variance formulars, which is provided in eq. (1) – (4) to build functions in order to find the variance in each company. In addition, expected returns are obtained by using the limits portfolio risk. And further set the portfolio risk from 0.25 to 0.0566, and get the expected returns as table 3.

$$max_r Ep(r) = \sum_{i=n}^{n} w_e \times Ep(r_e) \tag{1}$$

$$s.d.\sigma = \sqrt{\sum_{i=n}^{n}\sum_{i=n}^{n} w_e + w_k \ Cov(r_e, r_k)} = M \tag{2}$$

$$s.d.\sum_{i=n}^{n} w_e = 1 \tag{3}$$

$$max_r SR = \frac{Ep(r) - r_f}{\sigma} \tag{4}$$

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Table 3: Expected return.

Portfolio risk	Expected Return
0.2500	0.0808
0.2250	0.0747
0.2000	0.0682
0.1750	0.0613
0.1500	0.0537
0.1250	0.0450
0.1100	0.0393
0.1000	0.0351
0.0566	0.0060

Thus, the investment portfolio is shown in figure 2. It indicates that the optimal investment portfolio point is (0.1407,0.0506), where the risk is 0.1407, and the return rate is 0.0506. In this case, the weight in each company is 0.0502, -0.3867, 0.5289, 0.4367, -0.9987, -0.2804, 1, 0.6502 for AMD, MRVL, NVIDA, LRCX, INTC, QCOM, AVGO, TXN, respectively. As a result, the investors put largest percent of money into the AVGO, and do not invest in MRVL, INTC and QCOM. Because they are negative in the weight. The study also allows mechanisms for buying and selling short, as negative numbers are equivalent to selling short, and the weight 1 may means buying short. Therefore, this study has obtained an optimal investment portfolio that is conducive to investors making optimal investment decisions for the companies selected in this study.

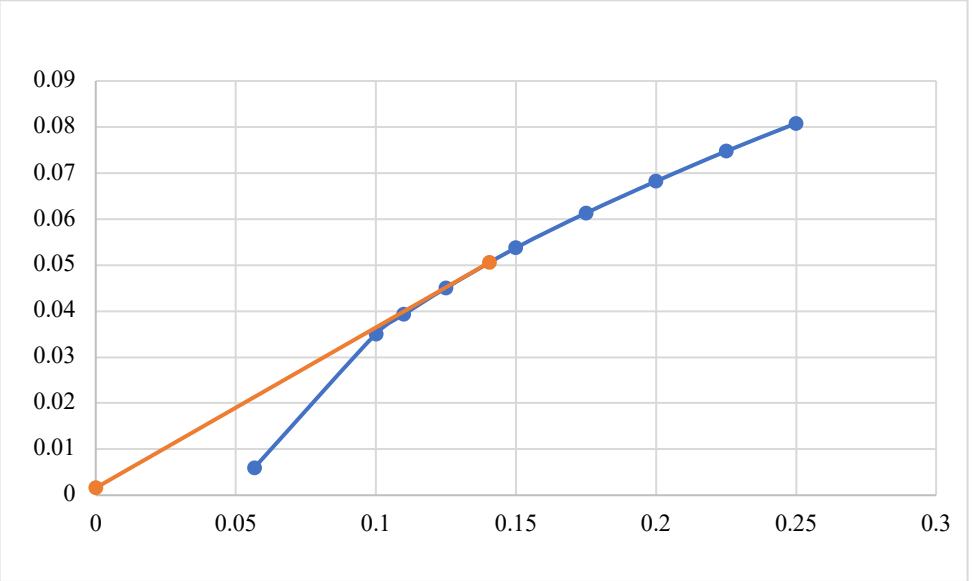

Figure 2: Investment portfolio.

5. Conclusion

This article uses effective frontier methods to study the optimal investment portfolio, the research finds that the optimal investment portfolio point is (0.1407, 0.0506), with a risk of 0.1407 and a return of 0.0506. In this case, for AMD, MRVL, NVIDA, LRCX, INTC, QCOM, AVGO, and TXN, the weights of each company are 0.0502, -0.3867, 0.5289, 0.4367, -0.9987, -0.2805, and 0.6502, respectively. Therefore, the investors invest the maximum percentage of their funds in AVGO instead

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of MRVL, INTC, and QCOM, since the weights of MRVL, INTC, and QCOM are negative. The study also allows short selling and buying mechanisms, as negative numbers of the weights are equivalent to short selling, and a weight of 1 may mean short selling. Therefore, this study has obtained an optimal investment portfolio that is conducive to investors making the optimal investment decisions for the companies chosen in this research.

The conclusion of this study contributes to help investors better build an investment portfolio and give them some valuable investment advice. Building an investment portfolio is of great benefits for investors. Firstly, it is conducive to risk diversification. An investment portfolio involves dispersing funds into different types of assets, thereby reducing investment risks. Thus, when one asset performs poorly, losses can be balanced by the appreciation of other assets. Secondly, the diversified investment portfolios can help the investors to earn the certain returns by investing different assets. As the financial goal and timing of each investor differs, different investment strategies are required. The investment portfolios derived from effective frontier method adopted in this study can be tailored to the needs of different investors.

However, this article has limitations, for example, the paper does not use other models to construct the portfolio and make the comparisons, including in-depth Mathematical analysis model, Fama-French factor model, machine learning model. In the future study, those models should be paid more attention and further discussed.

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