Investment Portfolio Management Based on Realistic US's Stock Data with Two Models

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Abstract. Portfolio theory is widely used in the financial field. Let us Suppose we combine the modern investment portfolio theory and diversify the investment portfolio. In that case, we can reduce investment risks and increase the possibility of satisfying all kinds of investors to obtain investment returns. In this article, we mainly consider applying the Markowitz model and the index model in portfolio theory, trying to explore its rate of return in the US market. We found that in the constructed investment portfolio, the portfolio's return and Sharpe ratio constructed by the Markowitz model are consistent with the performance of the index model. This provides investors with a new investment perspective for portfolio construction.

Keywords: investment; stock market; Index model; Markowitz model.

1. Introduction

The investment portfolio management is curial to the final return of the whole investment, and with the advancing economic condition now, an increasing amount of investors were keen on finding the most balanced investment portfolio between the risk and the rate of return [1].

As Dawood H. Sultan [2] first mentioned in his work, the difference between different programs and their various ratios shows that those ratios and the fluctuations of the stock price have positive correlations and use different kinds of stocks from the U.S to prove his hypothesis.

This kind of analysis required a large amount of data collecting and processing [3-5]. Primarily, finding and choosing appropriate stocks from those numerical amounts of stocks from the market was demanding work for the investors for the amount of information it needs and the quality of information required. Commonly, the stocks in the S&P500 were trusted with high quality and low risk. The company that sold those stocks had a relatively reliable operation phase and working capital cycle [6-7]. Moreover, to ensure the quality of the information found, those investors needed to either pay for the collection or have several investigations of the validity of that information [8]. For transaction cost, related research supposes that charges on all transactions equal to a fixed percentage of the amount transacted. It is shown that the optimal buying and selling policies are the local times of the two-dimensional process of bank and stock holdings at the boundaries of a wedge-shaped region which is determined by the solution of a nonlinear free boundary problem [9].

As for the investment analysis, I applied a kind of cohesive considerations which included both the Markowitz model and the index model with taking the Sharpe ratio, the rate of return, and the Standard deviation into consideration. Those ratios were crucial to evaluating the investment portfolio, for they provided the analysis with both the quantitative standard and the qualitative standard. The fluctuation of the stock price provided the former one, and the latter was offered by the detailed information of the companies from Bloomberg. We propose that the Markowitz model's return performance is the same as the Index model based on the US stock market data. It would bring more investment insights to the investors when they establish portfolios based on the Markowitz model.

The paper is organized as follows. In section 2, we conduct data analysis and present many figures to show the price change of different stocks. We present our method in section 3. Then, in section 4, we propose our results analysis. Finally, we conclude our findings in conclusion.

2. Data analysis

2.1 Raw data analysis

For the data gathering, I found the price fluctuation of those stocks on Yahoo Finance.

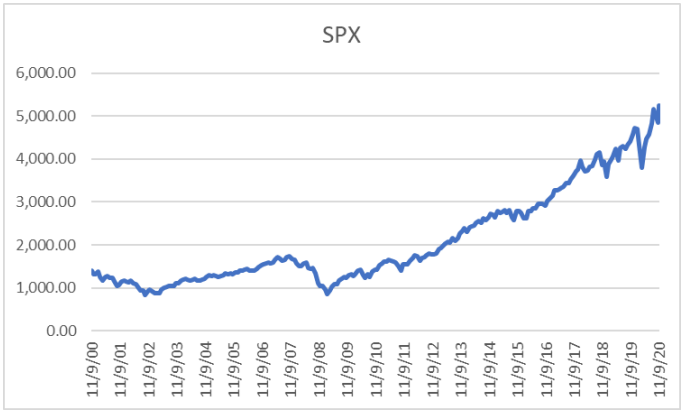

Fig. 1 Price of SPX

The SPX represents the coalition of 500 leading companies in America, which took about 80% of the whole U.S. economy, regarded as the best single gauge of large-cap U.S. equities.

Based on figure 1, from 2000 to 2007, SPX witnessed a slight increase in its price, and then dropped from 1700 to 1500, and then SPX had become increasing gradually from 2009 until 2018, and then faced a severe fluctuation, ranged from 3900 to 5200.

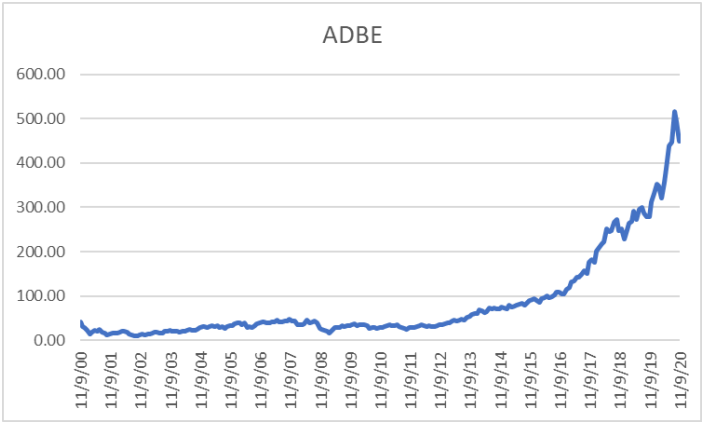

Fig. 2 Price of ADBE

ADBE stands for the price fluctuation of Adobe Inc., which is a multinational computer software company headquartered in San Jose, California. It specialized in software for the creation and publican of a wide range of content, such as graphics, photography, illustration, animation multimedia, etc. According to figure 2, the price of Adobe stayed low from 2000, continued for about 14 years to 2014, and then its price witnessed a substantial increase from about 34 to about 520 in 7 years, and then followed by a steep dropdown.

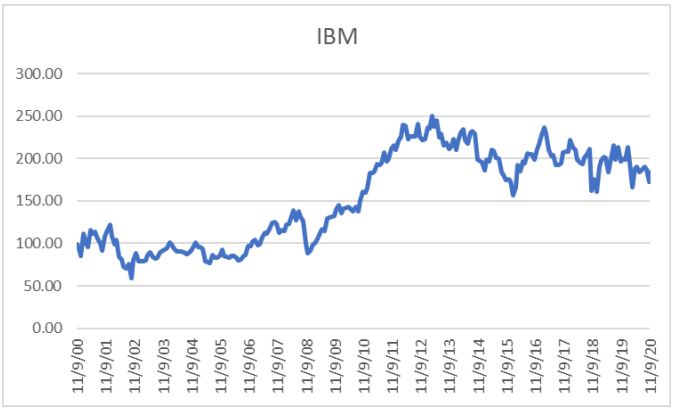

Fig. 3 Price of IBM

IBM stands for International Business Machines Corporation, an American multinational company headquartered in Armonk, New York, with operations in over 170 countries. IBM produced and sold computer software, hardware, and middleware, and consulting services and hosting services were on their list. The stock price of IBM fluctuated a lot during the passing 20 years. At the first stage, which is from 2000 to 2002, IBM stock price witnessed a moderate drop down, from 115 to 58. After the decrease, the stock price increased significantly from 98 to 250 in 4 years. Then IBM experienced a period of oscillation from 2013 to 2020, with several increasing and decreasing, and finally, get a moderate price of about 200.

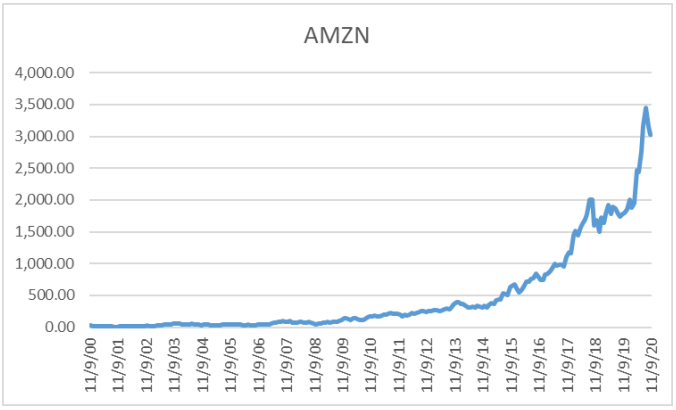

Fig. 4 Price of AMZN

Amazon is an American multinational company focusing on e-commerce, cloud computing, digital streaming, etc. For that this company is one of the big fives in the U.S., it had considerable influence on the U.S. market, and its brand is the most valuable in the U.S. Based on figure 4, the stock price of Amazon stayed quite low from 2000 to 2015, which is from about 0 to approximately 500. After that, AMZN witnessed a sharp increase from 2015 to 2020, from about 500 to 3500, then fell slightly in the last 2020 to 3000.

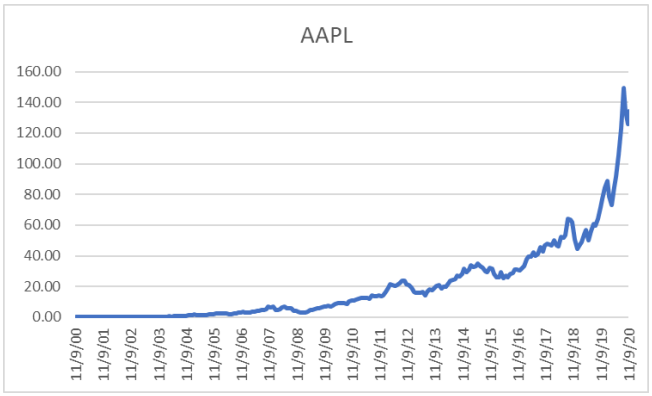

Fig. 5 Price of AAPL

AAPL stands for Apple. Inc, which is an American multinational company headquartered in California. Apple designs, develop and sells consumer electronics, computer software, and online services. Now Apple was one of the most popular smartphones and tablet companies in the world. Based on figure 5, Apple's stock price experienced a stationary period from 2000 to 2011, and from 2012 it is gradually increasing from about 20 to 60 in 2018. After a slight drop-down of its price, Apple's stock price rocketed in 2 years from 60 to 150 and finally witnessed a significant fall to 130.

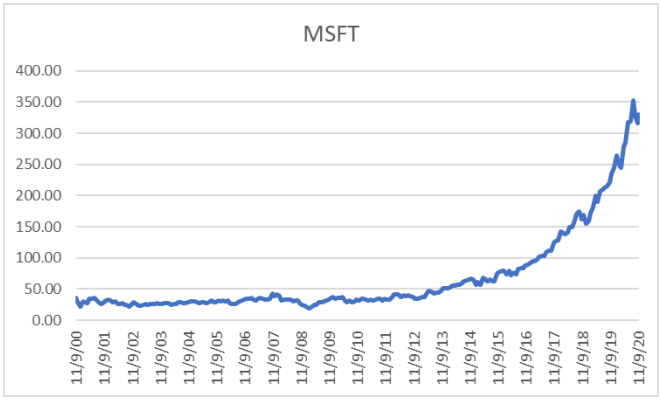

Fig. 6 Price of MSFT

MSFT stands for Microsoft, which is an American multinational technology company with headquarters in Redmond. Like Apple, it developed, Manufactures, licenses, supports, and sells computer software, consumer electronics, personal computers, and related services. It was best known for software products, such as its Windows operating system. According to figure 6, the price of Microsoft stayed low from 2000 to 2016, which did not break through 50. However, in 2017, the stock price skyrocketed to about 350 in 2020 from about 100 in 2017.

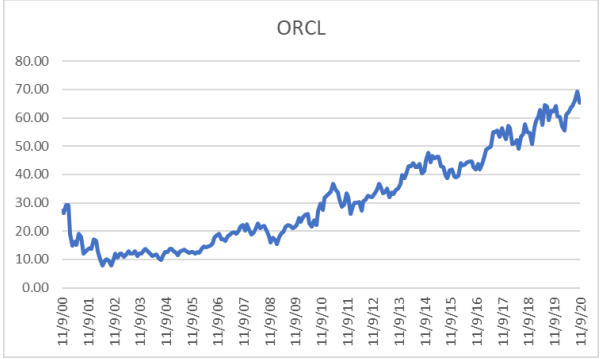

Fig. 7 Price of ORCL

ORCL stands for the Oracle corporation, which is an America technology corporation headquartered in Austin, Texas. The company was formerly headquartered in Redwood Shores, California, until December 2020, when it moved to Texas. The products of this company mainly are database software and technology, cloud engineered systems, and enterprise software products. Based on figure 7, its stock price dropped from 30 to 10 from 2000 to 2002, and then it increased with small scale till 2008, and then ORCL witnessed a significant increase in its price from 2010 to 2020.

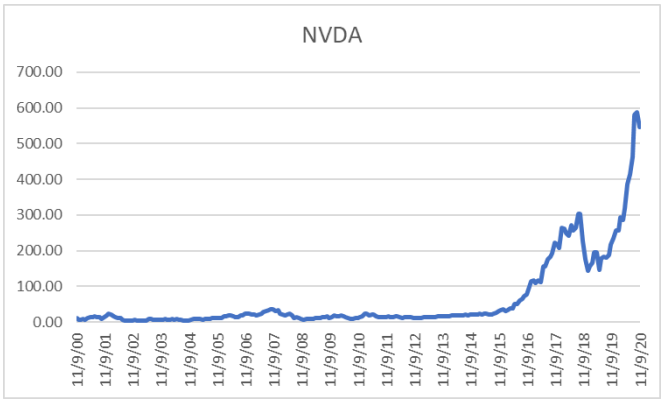

Fig. 8 Price of NVDA

NVDA stands for Nvidia, an American multinational technology company incorporated in Delaware and California. It designs graphics processing units for the gaming and professional markets, as well as system on chip units for mobile computing, and the product of Nvidia was extensively used in architecture, engineering, and construction.

According to figure 8, from 2000 to 2015, the stock price of Nvidia stayed relatively low, which was bout 0 for the whole 5 years. However, its price increased significantly from 2015 to 2018, from 0 to about 300, and witnessed a sharp decrease in 2019, and then skyrocketed to about 600 in 2020.

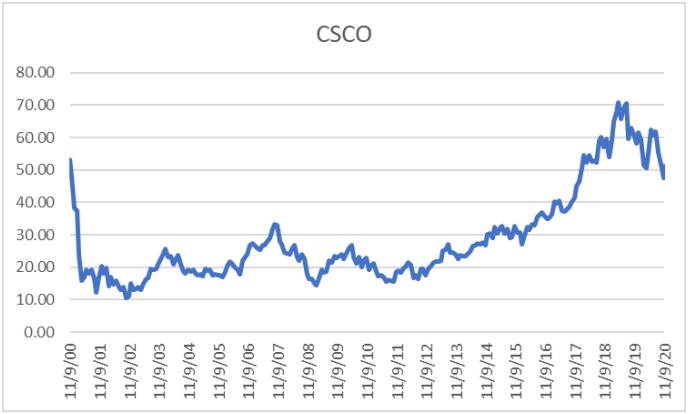

Fig. 9 Price of CSCO

CSCO stands for Cisco system, Inc. It is an American multinational technology conglomerate headquartered in San Jose, California. This firm developed and manufactured networking hardware, software, telecommunications equipment, and specialized products for the internet of things, domain security, and energy management market. In terms of figure 9, the stock price of Cisco initially dropped sharply in 2000, from about 55 to 18, and then fluctuated from 30 to 10 from 2002 to 2013. After that, the stock price rise from about 30 to 70 from 2014 to 2018, then decreased to 50 in 2020.

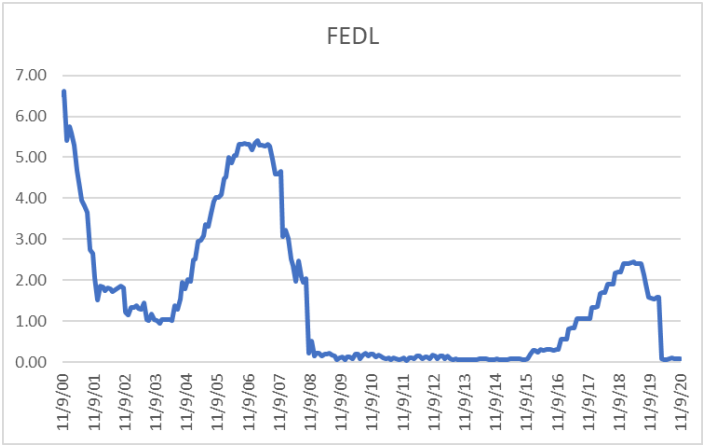

Fig. 10 Fluctuation of FEDL

In terms of figure 9, the number of FEDL dropped from nearly 7 to about 2 in 2001, and then it witnessed a quick boost, and then it dropped down a lot until 2008. After that, it stayed low for several years until 2017, and after a sudden increase from 2017 to 2019, it finally returned to about 0 in 2020.

3. Method

This part mainly illustrates the method I applied in this research, including the constraints set for research and then the models applied in the research, Markowitz model and index model.

3.1 Constraints

I chose three kinds of constraints to cohesively analyze the analysis of the index. The first one is to limit the weight of each stock that each stock would take a certain amount of weight not below zero. The second one is to rule the impact of the SPX out of the total calculation, which made a more specific analysis towards the other stocks.

3.2 Markowitz model

This model is used to find out the weight of each stock that should be applied in the portfolio, which will bring the investor the most profit with undertaking an acceptable amount of risk [9-10]. In my analysis, the Sharpe ratio is also included to show the ratio of the risk and return, enabling the investor to find the best portfolio through calculation

3.3 Index model

This research mainly focused on the two models to establish our investment portfolio, including two extremes [11]. The first one is to construct the portfolio with the largest Sharpe ratio. The other one is to use the least standard deviation to evaluate the advantages and disadvantages of the two models. The following is the Index model.

$$R - r_f = \alpha + \beta(R_M - r_f) \quad (1)$$

We could know that R means the return of the portfolio. r_f is the interest rate of risk-free assets. We usually consider it is the treasure bond rate. R_M is the return of the market portfolio. We use this model to calculate the portfolio's return. And to find the best investment portfolio.

4. Result analysis

With appropriate use of the two models, which are the Markowitz and Index model, I applied two constraints, and the first one is to let a stock to weighted zero, and another one is to prevent any of

the stock from having zero on their weight. And thus, I can compare the different outcomes originated from the constraints by calculating the return ratio, the standard deviation, and the Sharpe ratio.

4.1 Result analysis based on Markowitz model

We obtained the detailed results of the weights of different assets and summarized them in Table 1. We could find that the CSCO owes the highest weights compared to other assets. The weight of this asset is 0.2. Then, we also could find that the other assets' weight is the same. They are all equal to 0.1 in the investment portfolio.

Table 1. Weights of different assets portfolio based on Markowitz model

SPX	ADBE	IBM	AMZN	AAPL	MSFT	ORCL	NVDA	CSCO
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2

When applied to the Markowitz model, with constraint 1, the returning ratio turned out to be about 15.632%, and the standard deviation was 24.445%, with the Sharpe Ratio of 0.639. Those statistics indicate that this portfolio had a relatively mild range of variance and return. The related result is in Table 2.

Table 2. The information of investment portfolio based on Markowitz model

Return	StDev	Sharpe
15.632%	24.445%	0.639

4.2 Result analysis of Index model

We use the Index model in this section to establish our investment portfolio. The result is showed in Table 3. We could find that the Index model's result is the same as the result of the Markowitz model. The CSCO owes the highest weights compared to other assets. If we have 1 billion dollars, we need to invest 0.2 billion to CSCO. Besides, we also could find that the other assets' weight is the same. We need to invest 0.1 billion dollars in other assets based on our model's results.

Table 3. Weights of different assets portfolio based on Index model

SPX	ADBE	IBM	AMZN	AAPL	MSFT	ORCL	NVDA	CSCO
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2

Then, we also give the investment information of our investment portfolio as follows (Table 4).

Table 4. The information of investment portfolio based on Index model

Return	StDev	Sharpe
15.632%	24.445%	0.639

We could find that the results are the same as that of the Markowitz model. The returning ratio is about 15.632%, and standard deviation equals 24.445%, and the Sharpe ratio is 0.639. it means that the one risk would bring a 0.639 return.

According to the above analysis, we learn that the results of the two different models are the same. In this case, we present that there is no difference when we consider the investment portfolio based on the Markowitz model and Index model in the US's stock market from 2000.11.09 to 2020.11.09. Thus, there is the same result of considering the Markowitz model and Index model to establish the optimal investment portfolio.

5. Conclusion

To evaluate the investment portfolio, I choose the comparison between the index model and the Markowitz model, showing the difference of their standard deviation, Sharpe ratio, and the rate of return. This combination of the comparison of those limiting factors, correlating to their ratios, can clearly show the pro and cons of the investment portfolio. And the result I found out through the cohesive analysis of those portfolios showing that the different constraints correlated to different signals were crucial to the fluctuation of the ratios applied with the models, indicating that the constraints based on the different situations of the market will guide the change of the investment portfolio. However, some errors may appear in the result analysis. It is possible some inaccurate information about the stock price and the company's situation, resulting in the mistakes created after ensuring the other factors of the research. Therefore, I planned to find my sources from different kinds of websites and organizations, preventing any mistakes created by wrong information.

In this paper, it has some limitation. I did not collect more market data to investigate different impacts on different industries. In the future, I would research the detailed impacts based on different industries, such as retails, a finance firm, and other industries.

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