

Portfolio theory in investment decision making: Evidence from NVIDIA and Costco

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Abstract. Investors always seek to get returns in the financial market. However, due to the risk-averse nature of investors, they wanted to gain the maximum return with the lowest risk. Therefore, many investors diversify their portfolios to mitigate the existing risk. NVDA and COST, from NVIDIA Corporation and Costco Whole Sales Corporation, are two pervasive stocks in the market. This research will construct a tool for investors to balance risk and return through several variables, for example, expected return, standard deviation, and Sharpe ratio, for all possible portfolio combinations so that investors can acknowledge the best outcome at their preferred level of risk or reduce risk while meeting their requirements. In addition, this research will also provide a method to build the most efficient portfolio that includes NVDA and COST, which may become a practical reference for many investors. Modern portfolio theory is selected as the theory base of this article, and the Excel Solver is operated to investigate the portfolio's efficiency. By dealing with the historical data of NVDA and COST between 2014/1/2 and 2023/12/29, a series of calculations, and using the Excel solver, it can be concluded that (23.875%, 76.125%) is the optimal combination of weight of portfolio for investors with the most significant Sharpe ratio.

Keywords: Modern portfolio theory, Sharpe ratio, Efficient portfolio, Risk aversion.

1. Introduction

Investors in the capital market all seek to get returns. However, risks, that is, uncertainties, always accompany returns. Due to the human nature of seeking stability instead of enduring uncertainty, most investors are risk-averse [1]. Nevertheless, investors must balance the risks and returns because of their inverse relationship. As they lower the risks, they expect a considerable level of returns.

In the capital market, investors can invest in many types of securities. Not only bonds and fixed-income securities investors invest in, but also equities. Usually, investors construct their personalized portfolios. One method that investors use to lower the portfolio risks is adjusting the weights of each security within the portfolio [2]. This practice is called diversification [2].

Worldwide investors have widely used diversification. This research aims to use stocks NVIDIA Corporation (hereafter NVDA) and Costco Wholesale Corporation (hereafter COST) as examples, representing the practical use of portfolio theory in the investment.

NVIDIA Corporation (NVDA) is an Artificial intelligence computing company established in January 1993, covering areas of AI and Data Science, Design and Simulation, High-Performance Computing, Gaming and Creating, Automotive, Robotics and Edge Computing, Data Center and Cloud Computing [3]. NVIDIA has many products, including NVIDIA RTX™, NVIDIA Omniverse™, NVIDIA GeForce RTX™, and NVIDIA DRIVE [3]. Its product has a significant worldwide influence. For example, NVIDIA DGX™ AI supercomputer powered a larger language model for AI [3]. ChatGPT reached 100 million users in two months [3].

Costco Wholesale is a membership warehouse club. Costco Wholesale originated in 1976 with the name of Price Club [4]. Then the first Costco warehouse was established in Seattle in 1983 [4]. Costco Wholesale offers a comprehensive and exclusive product category selection, speciality departments, and membership services [4]. As of 2024.2.22, Costco Wholesale owns 875 warehouses in 13 countries [4]. Moreover, up to 2023.11.26, Costco Wholesale has 129.5 million cardholders and 72.0 million householders [4]. Costco Wholesale has a significant influence on the world's retail market [4].

The methodology used in this research is the Markowitz Portfolio Theory [5]. Through the examples of NVIDIA and COST, this research will provide investors with a valuable tool to build their portfolios, reducing risk while meeting investors' requirements.

The rest of the paper will be structured as follows: Section 2 will introduce the methodology used in this research, followed by the introduction of the selected financial assets; Section 3 is the historical data and calculations analysis, a discussion of the result and the research process. Finally is the conclusion of the research.

2. Methodology

To present the combinations of expected return and variance of all the possible portfolios, including NVDA and COST, and find the optimal portfolio. This research adopts the method introduced in the Modern Portfolio Theory suggested by Harry Markowitz to draw the efficient frontier that shows all the possible portfolios in which no better alternative portfolios can bring a higher return level with the same risk level [5]. After acquiring all possible outcomes, the optimal portfolio with the highest Sharpe ratio is expected [6]. Thus, this research finds the tangency (optimal) portfolio by drawing the tangent line between the efficient frontier and the risk-free point. The optimal portfolio with the highest Sharpe Ratio is found in this case [7].

2.1. Modern Portfolio Theory

Modern portfolio theory (hereafter MPT) provides risk-averse investors with an overview of portfolios to maximize the expected return on any desired level of risk. MPT has the following assumptions: 1) investors should maximize expected returns; 2) investors consider expected return a desirable thing; 3) investors are risk-averse; 4) identical information and perfect transaction cost; and 5) investors make decisions solely based on expected returns and risks. Risk Aversion means investors should invest in multiple asset classes or multiple securities, which is diversification [5]. Markowitz demonstrates how investors can use statistical methods to analyze the risk and return characteristics of different assets and construct efficient portfolios that offer the best risk-return trade-offs. Simplify expected return as E , and standard deviation, also called volatility, as V . He states that investors have a choice of multiple combinations of E and V depending on the choice of portfolio. Furthermore, a graph of all (E, V) combinations can be constructed [5]. Then, therefore, investors can select the efficient portfolio with the maximum E for a given V or less.

2.1.1. Rate of Return

The rate of return (R_t) is the percentage change of the security price from time $t - 1$ to time t . It is collected from historical data, representing an investment's gained return (R_t). Below, (1) is the equation of R_t .

$$R_t = \frac{P_t - P_{t-1}}{P_{t-1}} \quad (1)$$

2.1.2. Expected Return

The portfolio's expected return is the average weighted sum of each asset's rate of return. Defining the expected return of a single asset equals μ_i , the average rate of return of an asset, which i is the single asset numbered from 1 to n . (2), below, is the equation of the portfolio's expected return.

$$\mu_i = \frac{\sum_{i=1}^n R_t}{n} \quad (2)$$

After obtaining the expression of μ_i , the portfolio's expected return can be calculated as equation (3).

$$E = \sum_{i=1}^n X_i \mu_i \quad (3)$$

The sum of weight of all assets should be equal to 1.

$$\sum_{i=1}^n X_i = 1 \quad (4)$$

2.1.3. Variance

The variance is calculated using the equation (5) below. r_t^i is the return on asset i in period t .

$$\text{oneVar}(R) = \sigma^2 = \frac{\sum_{t=1}^n (r_t^i - \mu_i)^2}{n-1} \quad (5)$$

The variance is usually used as an indicator of the risk of an asset. There is a positive relationship between the variance and the risk.

The portfolio variance can be calculated through calculating the weighted combination of the individual variances adjusted by their co-variances. In this research, we studied the portfolio with two stocks in it. Thus, when the number of assets equal to 2, below, (6) is the equation of the portfolio variance. w is the portfolio weight of asset, σ^2 is the individual variance, and $Cov_{1,2}$ is the co-variance of the two assets

$$\text{Var}_p = \sigma_p^2 = w_1^2 \sigma_1^2 + w_2^2 \sigma_2^2 + 2w_1 w_2 Cov_{1,2} \quad (6)$$

2.1.4. Covariance and Correlation

Covariance measures how much the two assets vary together. It is essential to select assets with relatively low or negative covariance to include in the portfolio to lower the risk further. The covariance between two assets can be computed using the equation (7).

$$\sigma_{ij} = Cov(r^i, r^j) = \frac{\sum_{t=1}^n (r_t^i - \mu_i)(r_t^j - \mu_j)}{n} \quad (7)$$

2.2. Sharpe Ratio

Sharpe ratio measures an individual investment's risk-adjusted performance, named after American economist William Sharpe [6]. By seeing the Sharpe ratio, investors can acknowledge the asset with the highest return per unit risk [6]. Below, (8) is the equation of Sharpe Ratio.

$$\text{Sharpe Ratio} = \frac{R_x - R_f}{\sqrt{\text{Var}(R_x)}} \quad (8)$$

In (8), R_x is the expected portfolio return, R_f is the risk-free rate of return, and the $\sqrt{\text{Var}(R_x)}$ is equal to the volatility.

Investors expect a high Sharpe ratio to get more excess returns due to their risk aversion. Risk aversion represents a way for investors to react to uncertainty while investing. Risk-averse investors, thus, tend to select a portfolio with low, acceptable risk.

Generally, the security is performing poorly when its Sharpe ratio is less than 1; within the range 1 to 2, the security is performing adequately; if the Sharpe ratio is between 2 and 3, the security is performing very well; finally, when the security has a Sharpe ratio greater than 3, it is performing excellently. Therefore, investors commonly want their portfolio to have a Sharpe ratio as high as possible. So does this research.

Thus, to find the maximum-Sharpe ratio portfolio, investors can see this portfolio, also called an efficient or tangency portfolio, by drawing the tangent line from the risk-free rate to the efficient frontier taps. The point of tangency is the efficient portfolio. Then, investors can calculate the Sharpe ratio of the efficient portfolio [8].

3. Analysis and Discussion

3.1. Fundamental information on NVDA and COST

3.1.1. Fundamental information about NVDA

NVDA belongs to NVIDIA Corporation. NVIDIA Corporation belongs to the technology sector, the semiconductors industry. It provides graphics and Compute & Networking solutions in plenty of regions. According to the 2023-Annual-Report-1 released by NVIDIA, its revenue is \$27.0 billion, which is flat year on year, and its gross profit is 44,301,000 in thousands, increased by 88.493% compared to 2022 [9].

3.1.2. Fundamental information of COST

COST belongs to Costco Wholesale Corporation. Costco Wholesale Corporation belongs to the Consumer Defensive sector, the Discount Stores industry. It offers branded and private label products through the membership warehouses in many regions. According to the cost-annual-report-final released by Costco Wholesale, its revenue is \$242,290 million, which has increased by 6.757% compared to 2022, And its gross profit is 29,704,000 in thousands, increased by 7.733% compared to 2022 [10].

3.2. Research Analysis

In this research, to present the combinations of expected return and variance of all the possible portfolios, including NVDA and COST, and find the optimal portfolio, here are several steps; all data used is collected from the historical data between 2014/1/2 to 2023/12/29: 1) calculate the expected return and standard deviation of NVDA and COST respectively. 2) calculate the covariance and correlation between NVDA and COST. 3) construct the graph with different weight combinations. 4) use Excel Solver to acquire an efficient portfolio (combination of weight with the highest Sharpe ratio) [11]. 5) calculate this portfolio's expected return, standard deviation and Sharpe ratio [11].

3.2.1. Results of expected return and standard deviation

The result is that NVDA has an expected return of 30.833%, a standard deviation of 56.733%; COST has an expected return of 9.900%, a standard deviation of 14.586%. (Table 1 & Table 2) Expected return signifies the profit or loss an investor can anticipate from an investment. Thus, based on the historical data within ten years (2014/1/2-2023/12/29), people could say that over a long time of buying NVDA, they can expect an average profit of 30.833%. Similarly, people could say that over a long time of buying COST, they can expect an average profit of 9.900%. The higher the expected return, the greater the possibility of a higher profit by buying this stock. Therefore, investors who prefer a higher return might want to include more NVDA in their portfolio. Standard deviation also rises with the rising expected return, however. Standard deviation represents the degree of fluctuation of a set of data, which is the average distance of data to the mean. In finance, a high standard deviation represents that the fluctuation in stock price is violent, and the stock's risk is high. Risk-averse investors do not desire it, for it may bring a potential loss.

NVDA, corresponding to its relatively high expected return, has a standard deviation of 56.7333%, more significant than the standard deviation of COST, 14.586%. COST, hence, might be more attractive for risk-averse investors.

Table 1. Historical stock prices for NVDA and COST from 2014/1/2 to 2023/12/29

NVDA	Stock price	COST	Stock Price
2014/1/2	15.86	2014/1/2	117.81
2014/6/30	18.54	2014/6/30	115.16
2014/12/31	20.05	2014/12/31	141.75
2015/6/30	20.11	2015/6/30	135.06
2015/12/31	32.96	2015/12/31	161.51
2016/6/30	47.01	2016/6/30	157.04
2016/12/30	106.74	2016/12/30	160.11
2017/6/30	144.56	2017/6/30	159.93
2017/12/29	193.5	2017/12/29	186.12
2018/6/29	236.9	2018/6/29	208.98
2018/12/31	133.5	2018/12/31	203.71
2019/6/28	164.23	2019/6/28	264.26
2019/12/31	235.3	2019/12/31	293.92
2020/6/30	379.91	2020/6/30	303.21
2020/12/31	522.2	2020/12/31	376.78
2021/6/30	800.1	2021/6/30	395.67
2021/12/31	294.11	2021/12/31	567.7
2022/6/30	151.59	2022/6/30	479.28
2022/12/30	146.14	2022/12/30	456.5
2023/6/30	423.02	2023/6/30	538.38
2023/12/29	495.22	2023/12/29	660.08

Table 2. Expected return and standard deviation of NVDA and COST

Expected return of NVDA	Standard deviation of NVDA	Expected return of COST	Standard deviation of COST
0.308	0.567	0.099	0.146

3.2.2. Results of covariance and correlation

The covariance between NVDA and COST is 0.004, and the correlation of them is 0.045.

Covariance measures how much do the two assets vary together. Positive covariance shows that the two assets are moving in the same direction; High absolute value of covariance represents a large degree of change in asset price, led by the change in another asset. If stock A 's price increased by 1%, another stock B which they have a covariance of 1.56, stock B's price will also increase by 1.56%.

With the covariance between NVDA and COST equals to 0.004, this number means that these two stocks are varying in the same direction, but in a very small extent, which they have a very weak relationship. This is desirable and ideal, for low relationship leads to a more effective diversification (greatly lowering the overall risk of the portfolio).

Correlation is the related level of two variables, expressed by a linear relationship. Correlation identifies both the direction and the strength of relationship. For NVDA and COST have a correlation of 0.045, they have a weak relationship, even they tend to move in the same direction. (Table 3) Therefore, similarly, conclude assets that have low correlation such as NVDA and COST is an effective act of lowering risk.

Table 3. Covariance and Correlation between NVDA and COST

Covariance	Correlation
0.004	0.045

3.2.3. Graph

The graph showing all possible weight combination portfolios is obtained using different (E, V) as the point coordinates and then Excel to create a fitting curve closest to these scatter points [5].

The researcher changed the weight combination (weight of NVDA, weight of COST) from (0%, 100%) to (100%,0%). Then, in each combination, calculate the expected return of the portfolio and the standard deviation. After that, composing all the point's coordinates into one scatter plot and adopting these points into a fitting curve, the graph becomes the following:

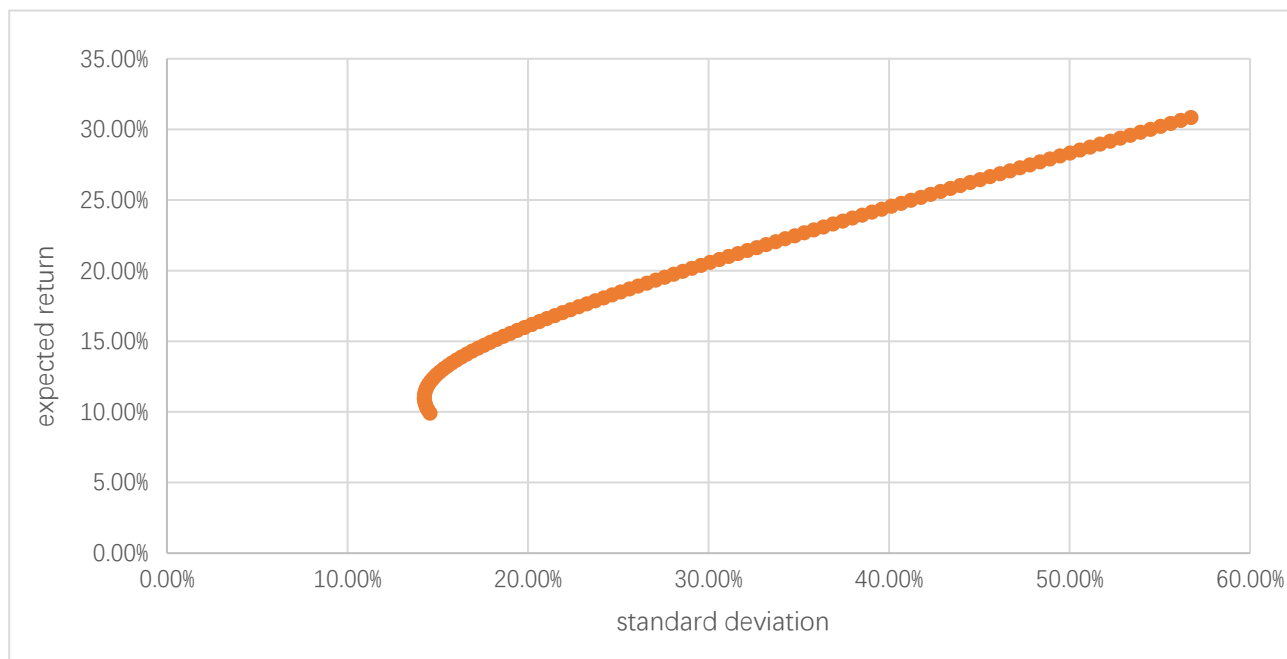


Fig. 1 Efficient frontier of aim portfolio

This graph provides risk-averse investors with an overview of portfolios to maximize the expected return on any desired level of risk, referred to as MPT [5]. (Figure 1& Figure 2) On each level of risk (standard deviation), the corresponding point on the curve represents the best-expected return investors could get.

Furthermore, to find the tangency portfolio, a point needs to be added on the y-axis of the graph, the risk-free rate. The risk-free rate is the rate of expected return that investors could get in zero-risk conditions. This research selects the US 10-year treasury bill as the risk-free rate. According to Bloomberg, 4.25% is the exact value used in this case [14].

A tangent point is obtained after plotting this point on the graph and drawing its tangent to the curve (as shown in the figure below). This tangent point is the efficient portfolio being sought to find.

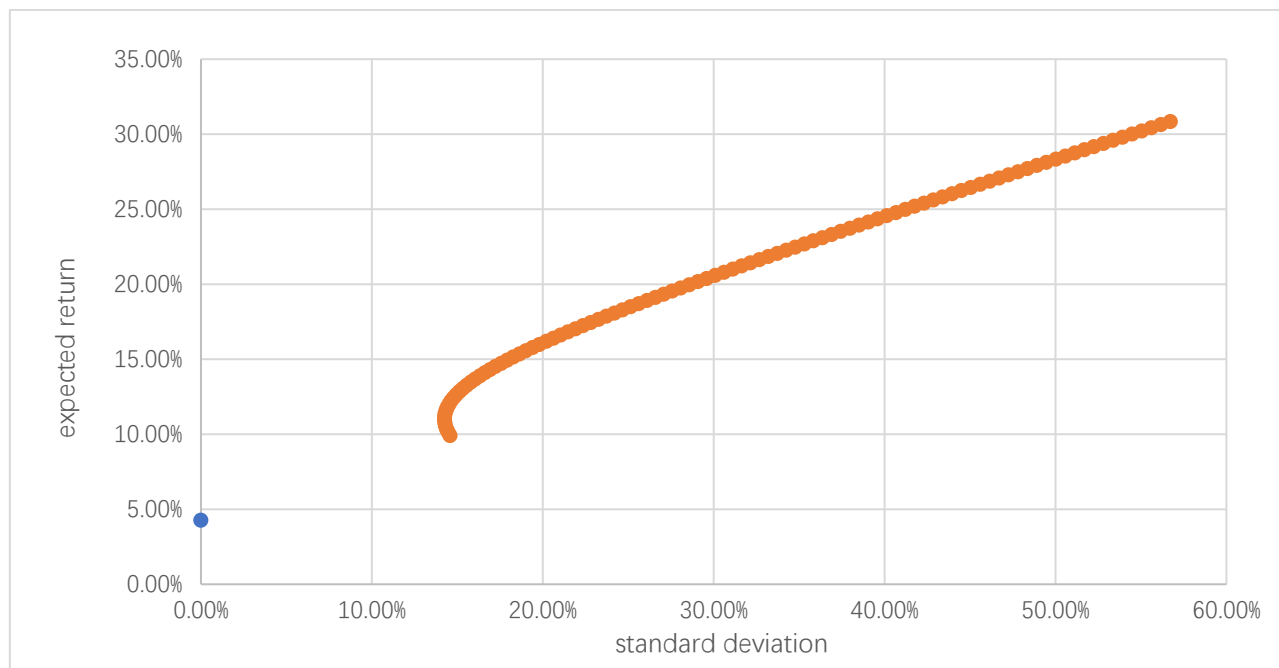


Fig. 2 Efficient frontier of aim portfolio with the risk-free point

3.2.4. Tangency Portfolio

However, finding the tangency portfolio by drawing the tangent line by hand is inaccurate. Thus, this research uses Excel Solver to help solve the problem. First, the Sharpe ratio is set as the objective cell (Max). Then, let the weight of NVDA and COST be variable cells. Moreover, a constraint should be added that ensures the sum of the weight of NVDA and COST is equal to 1. Finally, the solver found a solution with the most significant Sharpe ratio. In this case, the weight of NVDA is 23.875%, and the weight of COST is 76.125%. Therefore, an efficient portfolio is generated, containing 23.875% of NVDA and 76.125% of COST.

Now, the tangent line can be drawn in Figure 3.

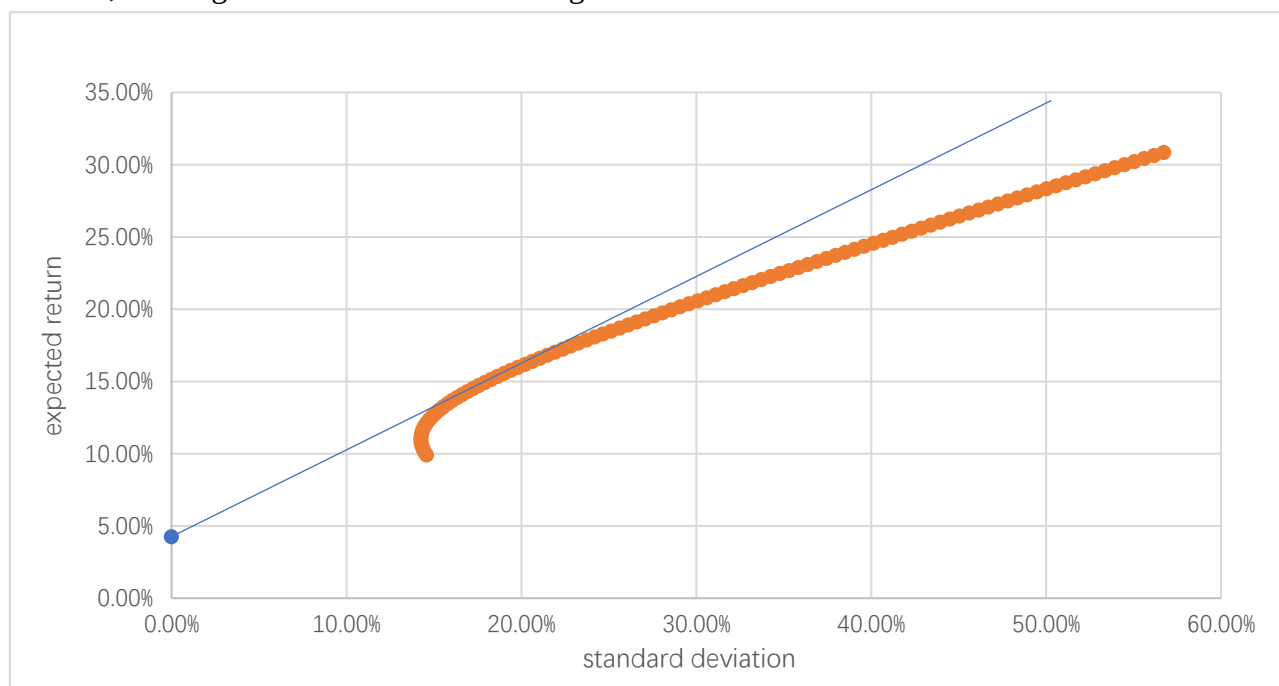


Fig. 3 Efficient frontier of aim portfolio with the tangent line

3.2.5. Calculation of the Efficient Portfolio

By calculating the formula, the expected return of the efficient portfolio is 14.897%; the standard deviation is 17.697%, and the Sharpe ratio is 60.164.

3.3. Summarize

Constructing the portfolio containing NVDA and COST (23.875%, 76.125%) is the optimal combination of portfolio weight for investors, generating the most significant return per unit risk.

4. Conclusion

Investors seek to find the portfolio that could generate the highest return with the lowest risk. The trade-off between return and risk puts all investors in a state of decision-making. Moreover, since most risk-averse investors want to hedge the risk as much as possible, they use diversification, including multiple types of assets in their portfolio and adjusting the weight of each security, to mitigate the diversifiable risk as much as possible. NVIDIA Corporation and Costco Wholesale Corporation are two representative and leading corporations in their industry. Their stocks NVDA and COST are also popular in the stock market. Thus, this research objective is to offer investors a reference of the optimal weight combination (an efficient portfolio with the highest Sharpe ratio) for whose portfolio includes NVDA and COST and provide a practical tool for them to reduce the risk and simultaneously meet their requirements. This research follows the idea of the Modern Portfolio Theory and the Sharpe ratio to construct an overview of all possible portfolios and find an efficient portfolio. Specifically, the research has five steps (all data collected from the historical data between 2014/1/2 to 2023/12/29): 1) calculate the expected return and standard deviation of NVDA and COST, respectively. 2) calculate the covariance and correlation between NVDA and COST. 3) construct the graph with different weight combinations. 4) use Excel Solver to acquire an efficient portfolio (combination of weight with the highest Sharpe ratio). 5) calculate this portfolio's expected return, standard deviation and Sharpe ratio. The expected return and standard deviation of NVDA and COST are calculated. The result is that NVDA has an expected return of 30.833%, a standard deviation of 56.733%; COST has an expected return of 9.900%, a standard deviation of 14.586%. The covariance and correlation: the covariance between NVDA and COST is 0.0035391, and their correlation is 0.04501843. After acquiring these data, the graph of different weight combination portfolios is drawn by constructing a scatter plot (E, V) as the point coordinate. Finally, the tangency portfolio, with the weight combination (23.875%, 76.125%), is found using the Excel solver. Then, the article concludes that constructing a portfolio containing NVDA and COST (23.875%, 76.125%) is the optimal combination of weight of the portfolio for investors that generates the most significant return with per unit risk. This research might contribute to future research and investors' investment decision-making. Because this research is only theoretical, future researchers can adopt the result of this research in reality, to check if the virtual inferences fit with reality.

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