How to Invest Money Effectively in Stocks

Leyla Farzaliyeva, Nazrin Abbasli
Istanbul Sehir University
34865 Dragos, Istanbul, Turkey
leylafarzaliyeva2019std.sehir.edu.tr
nazrinabbasli2019std.sehir.edu.tr

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Abstract

This work seeks to develop a portfolio that maximizes the expected returns and minimize the risk as much as possible and determines how one should invest a sum of money when different stocks are available, each with some unpredictability in how their price will fluctuate over time. The Modern Portfolio Theory (MPT, Markowitz Portfolio Theory) is a mathematical framework for analyzing this kind of situation. In this paper, the Monte Carlo Simulation Method has been implemented using Python with the objective to find a portfolio that gives maximum profit or minimum risk. To do so, the portfolio of 4 stocks, be more precise “Apple”, “Amazon”, “Microsoft” and “Netflix” have been considered. In order to get the data of prices of the above-mentioned stocks “Yahoo Finance” platform has been used. From the randomly simulated portfolios, the Efficient Frontier has been created and the Sharpe Ratio has been used for calculating the risk-adjusted return.

1 Introduction

Modern Portfolio Theory (MPT) is an investment strategy introduced and developed by Harry Markowitz, and represented in his paper “Portfolio Selection,” published in the Journal of Finance in 1952. Because of his contribution, he won a Nobel Memorial Prize in 1990 in Economic Sciences.

MPT is a theory on how investors, who are willing to take a risk, can create portfolios to maximize expected return based on a given level of market risk, considering risk as a result of the reward.

On the one hand, higher risk means a higher return, and on the other hand, lower risk means a smaller return. MPT considers that investors are risk-averse. It means that if there are two portfolios with the same expected return, investors are going to take the portfolio with less risk. The investors can choose the portfolio with higher risk if and only if there is a chance to get higher expected returns.

When creating a portfolio diversification factor should be taken into account as well. A diversified portfolio contains a mix of different stocks rather than a single stock, and it yields on reducing the level of risk.

2 Literature Review

According to Markowitz, for each amount of return, there exists only one portfolio that has the lowest risk, and conversely, for each amount of risk, there is a portfolio that has the highest return [1]. These kinds of preferred portfolios lie on the upper boundary of the Markowitz bullet which is called Efficient frontier (Figure 1).

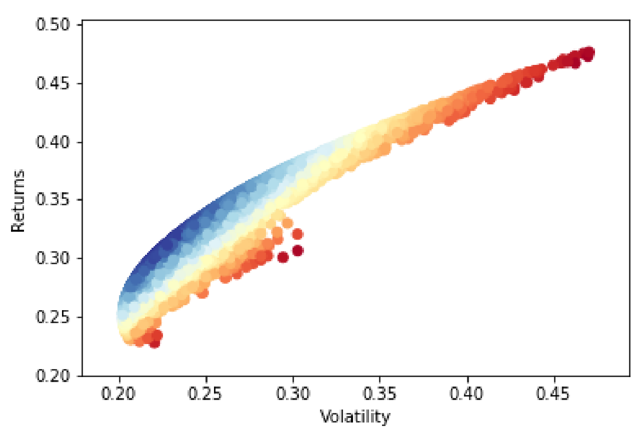

Figure 1: Markowitz bullet.

Every point inside the Markowitz bullet represents a portfolio that can be improved by moving it to the boundary (Efficient frontier). For instance, if we move a point from inside horizontally then we would obtain a portfolio with the same expected return but with less risk [2].

William F. Sharpe has taken the idea even further. He has developed a formula that calculates the risk-adjusted return, and this formula is called The Sharpe Ratio [3].

$$SharpeRatio = \frac{R_p - R_f}{\sigma_p} \quad (1)$$

where:
R_p = Expected return of the portfolio
R_f = Risk free rate
σ_p = Standard deviation of the portfolio

The Sharpe ratio simply measures the efficiency of expected returns, by considering the amount of the risk that required in producing that return. In other words, if two investments have similar returns, the one with a higher standard deviation will have a lower Sharpe ratio. In order to balance the higher standard deviation, a higher return needs to be generated to keep a higher Sharpe ratio. Basically, it indicates the amount of additional return when an investor takes additional risk.

3 Proposed Methodology

The purpose of MPT is to construct an efficient set of portfolios that gives maximum expected return with minimum risk. Therefore, two kinds of objection functions can be set. At first, our objective function was to maximize the expected return. To do so, we created a hypothetical portfolio that is diversified and consists of 4 different stocks (Table 1). We pulled historical price data between the dates 01/01/2010 – 14/12/2019 from Yahoo Finance, in order to estimate portfolio performance using past pricing data. Our purpose is to find the optimal weights for each of the stocks in our portfolio. The total money that is going to be invested in the portfolio is 1(100%). The weight of each stock is a portion of the total investment. Put it differently, the weight of a stock is the money that is invested on that particular stock. Thus, the sum of weights is 1.

Stock	Company Name
AAPL	Apple Inc.
AMZN	Amazon.com, Inc.
MSFT	Microsoft Corporation
NFLX	Netflix, Inc.

Table 1: Selected stocks.

In this work, we have used the Monte Carlo simulation method in order to optimize a portfolio. Monte Carlo simulation method based on repeated random sampling to get numerical results. The fundamental idea behind it is using randomness for solving problems that may be deterministic in principle. By applying Monte Carlo Simulation we have created 25000 random portfolios with different weights.

The next step was to visualize our data and to find out the best portfolios. Therefore, the efficient frontier for our 25000 portfolios was plotted with different colors according to their Sharpe ratio level, and the portfolios with minimum variance (volatility) and the highest Sharpe ratio were marked with green and red stars respectively (Figure 2).

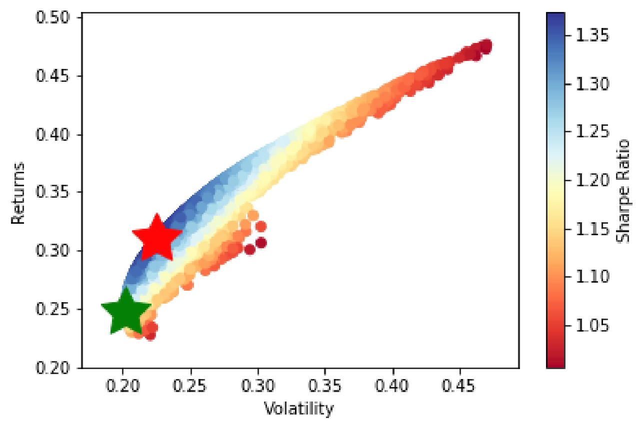

Figure 2: Markowitz Bullet with Sharpe ratio level.

Maximum Sharpe Ratio Portfolio	
Returns	0.308393
Standard deviation	0.224593
Sharpe ratio	1.373118
AAPL	0.411558
AMZN	0.192220
MSFT	0.208385
NFLX	0.187836
Minimum Variance Portfolio	
Returns	0.249389
Standard deviation	0.202275
Sharpe ratio	1.232921
AAPL	0.352159
AMZN	0.109631
MSFT	0.513881
NFLX	0.024330

Table 2: Optimized portfolios

From Table 2 it is obvious that more than half of the budget is assigned to Microsoft in minimum risk portfolio since it is the least risky stock. To get a higher return as a reward of higher risk, one should go for the portfolio with the highest Sharpe ratio that offers the best risk-adjusted return.

Taking one step further, we set an objective function for minimizing risk and created an efficient frontier of our optimized portfolios, and calculated annual risk and return for each individual stock by using the SciPy library in Python (Figure 3).

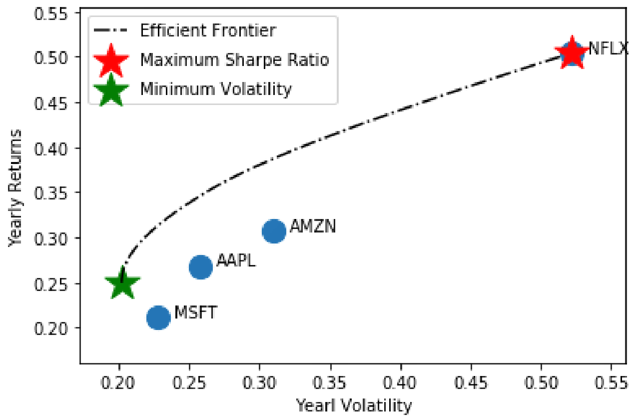

Figure 3: Portfolio Optimization with individual stocks.

It is clear from Figure 3 that, the riskiest stock is Microsoft with an annual risk of 0.23. However, applying portfolio optimization, we can find a portfolio with even lower annual risk (green star) and still get a higher return than Microsoft. This is the evidence of the great power of diversification that Markowitz was trying to reveal.

4 Conclusion

Although it has been more than six decades that Markowitz developed his theory, its main concepts are still essential, and still are being used in more portfolio management companies.
Markowitz Portfolio Theory considers the past performance of stocks as an indicator of future returns. Thus, in this work using the Monte Carlo simulation, we created random portfolios based on the stock data from 01/01/2010 till 14/12/2019. We considered the mean-variance technique including the best possible union of risk and return and constructed optimized portfolios through the use of efficient frontier.

References

[1] H. Markowitz, "Portfolio selection," *The Journal of Finance*, vol. 7, pp. 77–91, 1952.

[2] M. K. Tam, *Lecture notes in Operations Research*. University of Goettingen, 2019.

[3] W. F. Sharpe, "The sharpe ratio," vol. 21, pp. 49–58, 1994.