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Construction of Multiple Type Assets Portfolio Based on Stocks, Options, Futures, ETFs, Bonds and Cryptocurrencies

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Abstract: The development of portfolio theory has mainly been through 3 stages to become a mature system contemporarily. This theory is a practical approach in choosing and managing investments to maximize general returns within an acceptable level of risks. The topic in this study is a discussion about the Construction of multiple type assets portfolio based on Stocks, Options, Futures, ETFs, Bonds and Cryptocurrencies. The objective is to find out in what quantities and proportions can these assets be combined to realize the maximum returns. According to the anlaysis, the result suggests that under 3 different optimal situations, the optimal weight of each asset will be different depend on their individual return and variance, based on the application of modern portfolio theory and mean variance model. This study can not only make investors understand how to practice the portfolio theory to enlarge the return for a portfolio, but also fill the gap of investment-related research.

Keywords: Portfolio theory, returns, risks, multiple type assets portfolio.

1. Introduction

From the generation of portfolio theory in the late 1960s to the current ingrained, systematic and practical investment theory framework has not been a very long time [1]. Before the concept of portfolio occurred, the views in The Theory of Investment Value by John Burr Williams in 1938 is the dominator of investment methodology. The book captured the idea of the time: the dividend discount model. The goal of most investors is to find a good stock and buy it at the best price [2].

The pace of portfolio research never stops. There are three historical stages that the development of the portfolio theory has gone through, including Traditional Portfolio Theory (TPT), Modern Portfolio Theory (MPT), and Post-modern Portfolio Theory (PMPT) [3]. Among the 3 stages, TPT is originated from the which focus more on analyzing a single security, which is not systematic, objective, and adequate to form an optimal investment portfolio [3]. Additionally, MPT is created by Markowitz in 1959, which depends more on the feature of the portfolio, especially the assets class and the securities diversification. MPT is considered as a progress in the financial theory and investment practices since it mathematically optimizes the relationship between expected return and risk taking [4]. The development of PMPT is due to the incompatibility of MPT assumptions with market realities. Therefore, PMPT build up a more robust and precise framework for designing an optimal portfolio to correct the existing shortcomings in MPT [5]. The research of portfolio theory is necessary because it can improve the investment guidance in building a portfolio that maximizes

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return and minimizes risk through the measurement of the risk of assets and their correlation to each other [6].

As the core of assets management and wealth allocation, the portfolio theory is the method that the investors and portfolio managers use when providing analysis and selection of securities, to achieve the best returns in line with investment objectives [2]. An assets portfolio is a collection of financial assets that mix different asset classes, which can ensure the overall benefit when one asset performs poorly and reduce the risk taking by investment diversification [7]. In recent years, researchers mainly focus on the improvement of modern portfolio theory and the expansion of its related practice. The MPT suggest that the risk and return characteristics of any given investment should not be viewed in isolation, instead, it should be evaluated in terms of how it affects the risk and return of the overall portfolio [8]. Based on the assets the pitfalls of mean-variance portfolio optimization that investigated by Review of Financial Studies, a new approach, the "Galton" strategy was developed by Sam van de Schootbrugge to correct the changing relationship between Actual (realized) means and assets deviate from forecasts using out-of-sample prediction errors [9]. In practice, modern portfolio theory suggests investors to consider the whole existing portfolio instead of a single stock and encourage the combination of the risk tolerance and return expectations when making investment decisions [10]. Portfolio theory is also found out to be very useful in the U.S. stock market as it is an efficient tool for resource allocation and wealth generation [11].

The motivation of the research is to find out in what way can futures, ETFs, bonds and cryptocurrencies are combined as a portfolio to realize the maximization of the return on investment. This research is expected to provide new insights and progress in financial analysis fields regarding to the portfolio investment and the design of new multi-asset portfolios. Besides, the application of the research method is desired to provide references to the other researchers about how to use these models to solve relevant issues. The results of data analysis can also be their research foundation. This article is divided into four parts that covering four different topics. The Sec. 2 involve the introduction of data collection and the portfolio model. The Sec. 3 are the discussion of the data analysis results, the research limitations and recommendations. The Sec. 4 is a conclusion of the study.

Table 1: Information of selected assets

Assets Name	Symbol	Asset Types	Industry
Apple Inc.	AAPL	Stock	Electronics Software Services
NVIDIA	NVDA	Option	Computer Hardware
Lean Hogs	HEQ	Futures	Agriculture
Vanguard S&P 500 ETF	VOO	ETF	Assets Management
iShares U.S. Treasury Bond	GOVT	Bond	Finance
Bitcoin	BTC	Cryptocurrency	Telecommunications

2. Data and Method

2.1. Data

The resource of data collected is in stock exchanges including Nasdaq, Trading View and Tip Rank because of their large scale, reliability and availability, and the samples are all in Table 1, they are all top performed assets in each kind of them. The data collected method is simple random sampling. The range of time is from July 2019 to July 2024, in which the weekly data has been collected. The sufficient time span and short statistical period can ensure the accurate reflection of the data trend. The indicator of the market return is 14.61% and the risk-free rate is 4.26%, which is the historical U.S stock market average return in the past 5 years until May 2024. Table 1 includes the information

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of the names and symbols of each type of assets and the industry that they are in. Table 2 is the descriptive analysis of these assets, in which GOVT is the least profitable but most stable, NVDA and BTC have the largest amount of return but also risker than the others.

Table 2: Descriptive Statistics for the Return of All Types of Assets

Descriptive Analysis								
Assets	Observation	Maximum	Minimum	Mean	Standard Deviation	Cumulative Return	Skewness	Kurtosis
AAPL	240	0.147	-0.175	0.006	0.040	1.396	-0.292	2.191
NVDA	240	0.333	-0.238	0.013	0.075	3.112	0.124	1.446
HEQ	240	0.385	-0.312	0.003	0.070	0.768	0.201	5.272
VOO	240	0.121	-0.149	0.003	0.028	0.607	-0.523	5.659
GOVT	240	0.028	-0.024	0.000	0.008	-0.104	0.032	0.697
BTC	240	0.308	-0.420	0.012	0.096	2.951	-0.067	2.509

2.2. Methods

In the previous research, the mean-variance model for portfolio optimization based on Harry Markowitz's "Portfolio Selection" of applying probability theory and solving quadratic programming has been used to solve portfolio problems [12]. Assume that an investor wants to invest in a portfolio of a number of n risky assets, 'r' is the expected return rate of Asset i, then the expected yield is:

$$E(r_p) = \sum_{i=1}^{n} x_i E(r_i \quad (1)$$

Using σ_i^2 to represent the variance of the i-th asset, the equation of variance of the combination of n assets is:

$$\sigma_p^2 = \sum_{i=1}^{n} x_i x_j \, cov(r_i, r_j) = \sum_{i=1}^{n} x_i^2 \, \sigma_i^2 \sum_{i=1}^{n} \sum_{j=1}^{n} x_i x_j \rho_{ij} \sigma_i \sigma_j \quad (2)$$

where i and j stand for different types of assets. ρ_{ij} refers to the coefficient of Asset i and Asset j, which reflects their correlation and can be used to compare the magnitude between them. From this formula, the portfolio risk is affected by the investment weight of each asset, the correlation between different assets and the standard deviation of each asset. So, it is more recommended to choose the assets with smaller variance and correlation coefficient between each of them to reduce risk. The sample mean and the sample variance of the past earnings data can be used to predict the future return and risk in practice. The portfolio volatility is:

$$\sigma_p = \sqrt{(\sum_{i=1}^{n} w_i \sigma_i)^2} \quad (3)$$

where w_i is the proportion of the portfolio invested in Asset i and σ_i is Asset i's standard deviation of return.

If all possible combinations in the portfolio can constitute a feasible set, the shape of this set is similar to a left convex solid area. The feasible set can be equally divided into 2 parts by the center of minimum variance portfolio point that is considered as the frontier or the boundary. Portfolios above the efficient frontier satisfy the highest expected return at a certain level of risk or provide the lowest risk for a given level of expected return, which is below the efficient frontier is considered suboptimal [13].

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The Sharpe ratio is used to measure investment performance by adjusting for risk. The higher the Sharpe ratio, the greater the return on the investment relative to the risk taken, the more optional the investment. This ratio can be used to evaluate individual stocks or investments, or it can be used to evaluate an entire portfolio [14]. Therefore, this ratio is suitable to this research. The formula is:

$$\text{Sharpe Ratio} = \frac{[E\ (R_p) - R_f]}{\sigma_p} \tag{4}$$

where the E (R_p)stands for the expected rate of return for the portfolio, R_f is the risk-free interest rate, and σ_p refers to the standard deviation of the portfolio. To reach a higher Sharpe Ratio, the portfolio should be a combination of assets with larger expected rate of return, smaller risk-free rate and standard variation, so that the investment can consider to be good [15].

3. Results and Discussion

3.1. Model Performance and Explanation

According to modern investment theory, companies should use logic and reason to invest, that is, to diversify their portfolios to achieve better overall returns without taking on more risk. To achieve diversification, a portfolio investment weight constraint can be the maximum proportion of one asset is restricted to 30% ($0 \leq w_i \leq 30\%$), where w_i is the weight of each asset, and the optimal weight of each of them will be produced by using Mean-variance portfolio optimization. The 3 optimal condition is considered, including Maximum Sharpe Ratio Portfolio (MSRP), Global Minimum Variance Portfolio (GMVP), and Maximum Return Portfolio (MRP). Under each strategy the distribution of optimal portfolio composition will be different.

Table 3: Correlation of the Assets

	AAPL	NVDA	HEQ	VOO	GOVT	BTC
AAPL	1.000	0.139	0.019	0.069	0.005	0.070
NVDA	0.139	1.000	0.055	-0.051	0.097	-0.134
HEQ	0.019	0.055	1.000	0.003	0.048	-0.047
VOO	0.069	-0.051	0.003	1.000	-0.111	-0.037
GOVT	0.005	0.097	0.048	-0.111	1.000	-0.040
BTC	0.070	-0.134	-0.047	-0.037	-0.040	1.000

Table 4: Covariance Matrix of all assets

	AAPL	NVDA	HEQ	VOO	GOVT	BTC
AAPL	0.002	0.000	0.000	0.000	0.000	0.000
NVDA	0.000	0.006	0.000	0.000	0.000	-0.001
HEQ	0.000	0.000	0.005	0.000	0.000	0.000
VOO	0.000	0.000	0.000	0.001	0.000	0.000
GOVT	0.000	0.000	0.000	0.000	0.000	0.000
BTC	0.000	-0.001	0.000	0.000	0.000	0.009

Table 3 and 4 has shown the correlation and covariance between every two assets, which is used in computing the portfolio variance. Figure 1 is the trend of weekly return of these kinds of assets during July, 2019 to July, 2024, from which the returns of BTC NVDA and HEQ are the most fluctuated especially during the following 3 periods including week 31 to 41, week 71 to 91 and week

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171to 181.And the NVDA and HEQ involve the maximum weekly return in the portfolio and the BTC has the lowest weekly return that appeared in week 34.

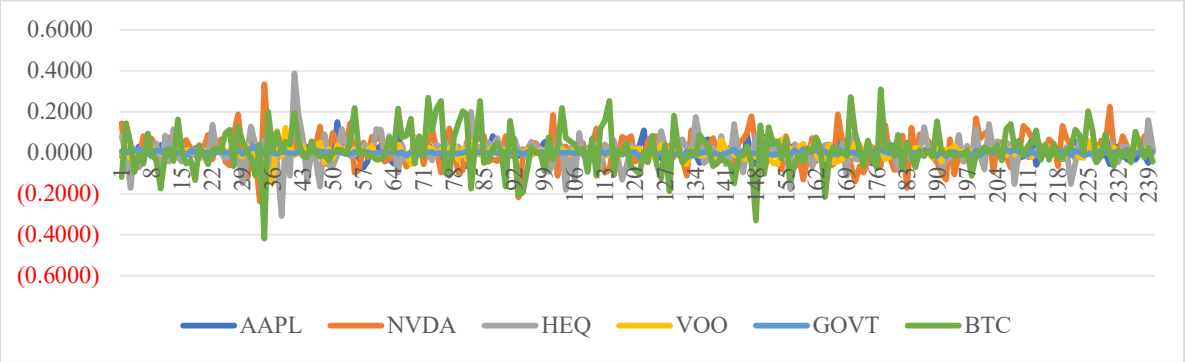

Figure 1: Weekly return trends of 6 kinds of assets for the period Jul.2019 to Jul.2024

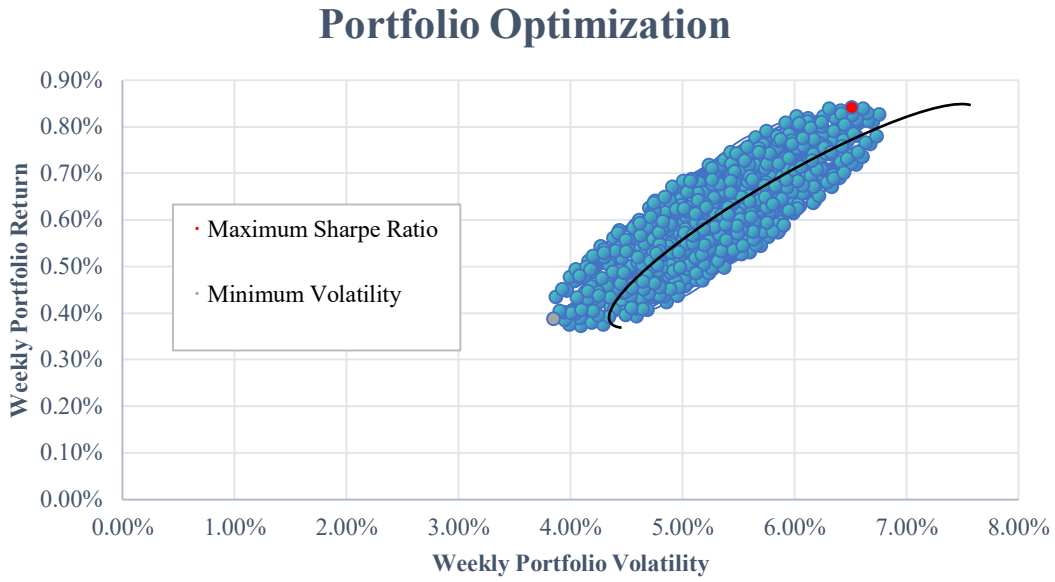

Figure 2: Portfolio Optimization based on Efficient Frontier

Table 5: Optimal Portfolio Composition under 3 Different Optimal Situation

Profile Constitute	Optimal Composition in Maximum Sharpe Ratio Portfolio (MSRP) (%)	Optimal Composition in Global Minimum Variance Portfolio (GMVP) (%)	Optimal Composition in Maximum Return Portfolio (MRP) (%)
AAPL	19.0%	23.8%	30%
NVDA	28.6%	9.5%	30%
HEQ	14.3%	14.3%	0%
VOO	9.5%	19.0%	0%
GOVT	4.8%	28.6%	0%
BTC	23.8%	4.8%	30%

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The result got from the application of mean-variance model is in Table 5 and the point of all weekly portfolio return and volatility has formed the scatter diagram in Figure 2, in which the efficient frontier, MSRP point and GMVP points are highlighted. In Table5, under the Maximum Sharpe Ratio situation, NVDA, AAPL and BTC have the largest optimal portion of 28.6% ,23.8% and 19.0%, and the VOO and GOVT has the least percentage of 9.5% and 4.8% because their outstanding profitability while their risk is also relatively high. Under the Minimum Volatility situating has the largest weight in the portfolio because of its minimum variance, BTC has the smallest portion because it is the most fluctuated one among all six assets. To reach the Maximum Return condition, the most profitable assets should take the highest proportion, including APPL, NVDA and BTC. Since the maximum of weight of each kind of assets is 30%, so this weight will be given to these 3 assets.

According to the Figure 1, it shows how to construct a portfolio with the goal of maximizing the expected return under certain risk level and connects the MSRP and GMVP points. The GMVP point (3.90%, 0.40%) contain the optimal portfolio that satisfy the lowest volatility, and the points above it are more profitable but riskier, and the point below it are riskier and less profitable portfolios than itself. The MSRP point (6.51%, 0.84%) is the asset combination that realizes the best trade-off of return and risk, the points in its left side are alternatives that are have less risk but also smaller return, and the points on the right side are alternatives are not only less profitable but also riskier. The results can help investors to analyze the potential risks and benefits, so as to choose the best investment strategy. Decision depends on whether the investor is more profit-oriented or risk-averse.

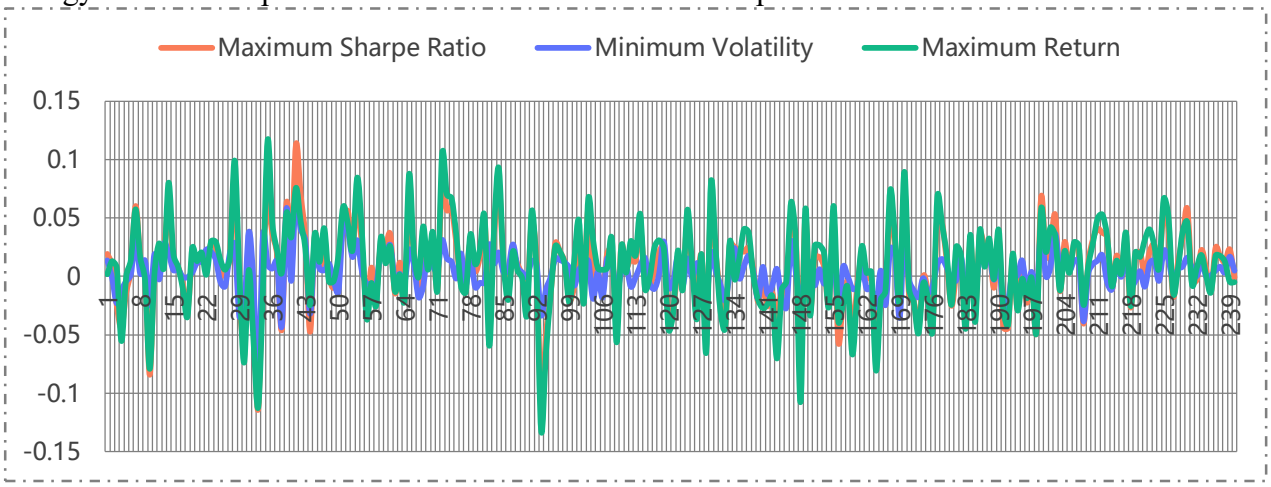

Figure 3: Weekly Portfolio Return Trend under Different Optimal Situation

The weekly portfolio return trend during July,2019 to July,2024 under 3 optimal situations: MSRP, GMVP and MRP is shown in Figure 3. According to the trends, it can be suggested that investors those who have a strong risk-taking ability and are committed to pursuing high returns can choose the maximum return strategy. Investors who are willing to take a certain risk and seek a certain return can choose the maximum Sharpe ratio strategy. The minimum volatility investment strategy is more suitable to the investors having relatively weak risk tolerance, and pay more attention to the long-term benefits of investment. Therefore, these strategies cannot be defined as better or worse, only suitable or not to the investment goal and desire.

3.2. Limitation and Prospects

Although this study explores the optimal portfolio multi-assets investment and make some valuable discoveries, but the result still exist some limitations that should be considered. First, the study did not adequately control some potential variables like the price level of each kind of assets. The prices

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of all these assets are not at the same level and have a large difference between each other, which lead to the failure in providing the graph to make comparison of the price trend of each asset during July, 2019 to July, 2024. Second, the universality of results cannot be ensured since the sample amount is relatively small as only one target was selected for each kind of asset, and the research scope is only restricted in the U.S. So, it may exist some difficulty in generalizing findings from one study to other settings. Based on the above limitations, future research can be improved and expanded from the following aspects. Firstly, future studies should focus more on controlling and exploring potential confounding variables by choosing assets that have smaller price to ease the comparison and analysis, and it can also pay attention to the effect of industry, market capitalization and the asset's nature. And this can be done through designing more rigorous experimental studies, or by using advanced statistical methods. In addition, the future study can widen the research scope to study more countries' situation and selected more samples for different assets to enhance the generalization of the consequence.

4. Conclusion

This paper studies the modern portfolio theory and its application to multi-asset portfolios, where 6 common trading assets, i.e., stocks, options, futures, ETFs, bonds, and cryptocurrencies are considered and analysed. The result shows that MPT is a practical tool of portfolio selection, either for investors who pursue high return and for those who mitigate risk when investing. Besides, under different optimal situation involving maximum Sharpe ratio, minimum volatility and the maximum return, the optimal weight of each asset is different, which depended on the asset's return rate, their correlation, covariance and variance. Based on this finding, the investors can choose among the alternatives to reach their investment goal. The future study is expected to expand the research scope, pay more attention to the control variables and even use more advanced statistical methods. The study is expected to provide investors a better understanding of how to practice the portfolio theory to enlarge the return for a portfolio at a certain risk level some reference to future study.

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