

Portfolio Risk Analysis and Optimization of U.S. Technology Stocks: Evidence from Apple, Microsoft, NVIDIA, and Amazon Benchmarked Against the NASDAQ Composite Index

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Abstract:

With the rapid development of the U.S. technology industry, technology stocks have become a crucial component in investors' asset allocation. This paper examines four U.S. technology firms—Apple, Microsoft, NVIDIA and Amazon—and uses the NASDAQ Composite Index as the market benchmark, and conducts a risk analysis and optimization study on the U.S. technology stock portfolio based on Modern Portfolio Theory. Using daily stock price data from 2020 to 2025, this paper computes asset returns, conducts descriptive statistical analysis and correlation analysis, calculates Sharpe Ratios, and applies the mean-variance optimization model to construct the optimal portfolio. The research findings indicate that NVIDIA achieves the highest level of return while bearing the highest risk; Microsoft's performance is relatively stable; strong correlations exist among technology stocks, but there is still certain room for risk diversification. Compared with the NASDAQ index, the optimized portfolio obtains a superior risk-adjusted return, which verifies the effectiveness of Modern Portfolio Theory in U.S. technology stock investment. The research conclusions of this paper can provide theoretical support and practical reference for technology stock asset allocation decisions.

Keywords: Portfolio optimization; modern portfolio theory; technology stocks; risk analysis; mean-variance optimization.

1. Introduction

1.1 Background

In recent years, the global technology industry has experienced rapid growth. The U.S. technology sector has gradually become one of the most influential sectors in the global capital market. Major technology companies such as Apple, NVIDIA, Microsoft, and Amazon lead technological innovation and market competition, and their stocks are prominent in the U.S. stock market. Given their strong profitability, market influence, and growth potential, these companies have drawn considerable attention from both domestic and international investors.

In recent years, technologies such as artificial intelligence, big data, cloud computing and digital transformation have developed rapidly, making technology stocks an important component in the asset allocation strategies of numerous investors. The rapid advancement of artificial intelligence-related technologies has further boosted the growth of technology enterprises; in particular, both the stock price and market capitalization of NVIDIA have hit record highs in recent years. Accordingly, technology stocks are gradually becoming core assets in many investment portfolios.

However, high potential returns are often accompanied by high investment risks. Compared with traditional industries, technology stocks typically exhibit higher price volatility, and their performance is susceptible to influences from multiple factors including macroeconomic conditions, interest rate policies, inflation, geopolitical events and technological innovation. When the market environment changes, technology stock prices may fluctuate sharply, increasing investment uncertainty and risk exposure. Modern portfolio diversification theory provides a feasible means of reducing the idiosyncratic risk of individual stocks; accordingly, this study constructs an optimized investment portfolio consisting of multiple stocks. With the growing importance of technology stocks in global financial markets, analyzing the risk-return characteristics of technology stocks and constructing effective portfolio optimization strategies has become an important research topic. Furthermore, the NASDAQ Composite Index is a core benchmark that reflects the overall performance of the U.S. technology industry. By comparing the optimized technology stock investment portfolio with the NASDAQ Composite Index, this study evaluates whether the proposed portfolio optimization strategy outperforms the market benchmark.

Based on the above considerations, this study selected four representative U.S. technology companies—Apple, Microsoft, NVIDIA and Amazon—as research samples. These four companies were for their top-tier market capitalizations; each represents a distinct technology

subsector, making them suitable for investment portfolio analysis. This study aims to analyze the risk-return characteristics of the four selected stocks, construct an optimized investment portfolio, compare its performance with the NASDAQ Composite Index, and evaluate the effectiveness of portfolio optimization in technology stock investment.

1.2 Research Objectives and Purpose

To explore the effectiveness of risk management and portfolio optimization in U.S. technology stock investment, this study addresses three core research questions.

First, are there significant differences in the risk-return characteristics of Apple, Microsoft, NVIDIA, and Amazon?

Second, can portfolio diversification effectively reduce the idiosyncratic risk of single-stock investment?

Third, does the performance of the risk-adjusted optimized technology stock investment portfolio outperform the NASDAQ Composite Index?

To answer these questions, this study:

- (a) analyzes return and volatility characteristics of the four stocks;
- (b) measures and compares their risk levels;
- (c) constructs and evaluates an optimized portfolio using the Markowitz mean-variance model; and
- (d) benchmarks the results against the NASDAQ Composite Index.

1.3 Research Significance

This paper takes U.S. technology stocks as the core research object and conducts analysis of technology stock investment portfolios based on Modern Portfolio Theory (MPT). The conclusions of this study supplement empirical evidence on the applicability of portfolio theory in the technology industry and enrich existing academic literature. Furthermore, by integrating risk indicators and portfolio optimization technologies, this study expands empirical research in the field of technology stock portfolio management and provides a quantitative analysis framework for future research on equity risk allocation.

From a practical perspective, while technology stocks have become an important component in investors' portfolios, investors are exposed to high investment risks due to large price fluctuations. By analyzing the risk-return characteristics of representative U.S. technology stocks and constructing an optimized investment portfolio, this study contributes to helping investors better understand the risk differences among different technology stocks and the advantages of portfolio diversification. Furthermore, by comparing the optimized investment portfolio with the NASDAQ Composite Index, this study provides empirical evidence on whether active portfolio optimization can

achieve performance that exceeds the market benchmark. Therefore, the conclusions of this study can provide practical guidance for portfolio management, risk control and investment decision-making.

2. Literature Review and Hypotheses

2.1 Modern Portfolio Theory

Modern Portfolio Theory (MPT) underpins portfolio optimization research, seeking an optimal balance between risk and return. Markowitz proposed the mean-variance model, providing a systematic theoretical framework for portfolio construction [1]. Subsequently, Fama and French developed the three-factor model, which further explains the sources of stock returns from the perspective of systematic risk and serves as an important supplement to asset pricing theory [2]. Sharpe introduced the Sharpe ratio, which offers a unified standard for measuring the risk-adjusted return of portfolios and has become a key indicator for evaluating investment performance [3]. In recent years, the mean-variance model has undergone continuous refinement; empirical evidence confirms its continued relevance to modern asset allocation and its effectiveness in improving the efficiency of portfolio allocation [4, 5]. Therefore, this paper takes Modern Portfolio Theory as the theoretical basis and adopts the mean-variance model to construct technology stock portfolios.

2.2 Portfolio Risk Measurement

Risk measurement is a core component of portfolio management. Existing studies generally adopt standard deviation to measure the volatility of asset returns and combine the Sharpe ratio to evaluate the risk-adjusted return level of portfolios [3]. Mehta and Yang pointed out that in extreme market environments, introducing the maximum diversification strategy can further improve portfolio stability [6]. Mahmudah et al. argued that risk management should comprehensively consider returns, volatility and asset allocation strategies to achieve more scientific investment decisions [7]. In addition, the integrated financial risk management framework proposed by Wang et al. further verifies that quantitative risk analysis can improve the effect of portfolio optimization and provides new research ideas for modern asset allocation [8]. Based on the above studies, this paper adopts standard deviation as the risk measurement indicator and uses the Sharpe ratio to evaluate portfolio performance.

2.3 Technology Stock Portfolio Research

In recent years, U.S. technology stocks have become important investment targets in global capital markets by virtue of their high growth and innovation capabilities.

Trabelsi, Karoui et al. found that portfolios constructed with artificial intelligence-related stocks achieve higher risk-adjusted returns and can outperform traditional technology indices and robot ETFs under certain conditions [9]. Gökgöz further pointed out that there is strong linkage between the U.S. technology index and major global stock markets, indicating high correlation among technology stocks, but reasonable allocation can still play a certain role in risk diversification [10]. In addition, Gadhalapati's research on the "Magnificent Seven" stocks shows that large technology enterprises enjoy high growth potential, but are accompanied by greater return volatility and market risk [11]. Studies conducted by the New York Economic Review and analyses on relevant benchmark indices both indicate that the NASDAQ Composite Index can well reflect the overall performance of the U.S. technology sector, and thus is widely used as an important market benchmark for portfolio performance evaluation [12, 13].

2.4 Literature Review and Research Gap

Existing studies have fully verified the effectiveness of Modern Portfolio Theory and the mean-variance model in portfolio optimization, and have conducted extensive research on technology stock investment and risk management. However, most studies focus on the overall technology industry, artificial intelligence concept stocks or market indices, and there is relatively limited research on constructing portfolios with the four representative technology enterprises: Apple, Microsoft, Amazon and NVIDIA. Meanwhile, few studies conduct systematic comparisons between optimized technology stock portfolios and the NASDAQ Composite Index under a unified mean-variance optimization framework and deliver comprehensive evaluations based on risk-adjusted returns. Therefore, this paper selects four U.S. technology enterprises, Apple, Microsoft, Amazon and NVIDIA, as research objects, constructs an optimal portfolio based on Modern Portfolio Theory, and conducts comparative analysis with the NASDAQ Composite Index as the market benchmark, so as to further enrich relevant research on technology stock portfolio optimization.

2.5 Hypothesis Development

H1: Hypothesis on the risk-return characteristics of technology stocks

The average return level of Apple, Microsoft, Amazon and NVIDIA is expected to be higher than that of the NASDAQ Composite Index, but its return volatility is also higher, showing the typical characteristics of high risk and high return.

H2: Hypothesis on the risk diversification effect

Portfolios constructed by multiple technology stocks can reduce overall investment risk to a certain extent, but due

to the high correlation among technology stocks, their risk diversification effect has certain limitations.

H3: Hypothesis on the portfolio optimization effect

The optimized portfolio constructed based on the mean-variance model is expected to outperform both the equally-weighted portfolio and the NASDAQ Composite Index in terms of risk-adjusted return.

3. Data and Methodology

3.1 Data Sources

This paper selects four representative listed companies in the U.S. technology industry, namely Apple (AAPL), Microsoft (MSFT), NVIDIA (NVDA) and Amazon (AMZN), as research samples, and takes the NASDAQ Composite Index as the market benchmark to analyze the risk and return performance of the investment portfolio. All data used in this research were sourced from the Yahoo Finance database, covering the sample period from January 1, 2020, to December 31, 2025, with daily adjusted closing prices selected as the research data. The adjusted closing price accounts for corporate actions including stock dividends and stock splits, thereby more accurately reflecting changes in stock prices and the actual returns obtained by investors.

To ensure consistent time dimensions for all stock data, this paper sorted, merged, and aligned all stock and index data by trading date and removed missing observations. This yields a unified dataset, which provides a reliable data foundation for subsequent return calculation and portfolio analysis.

3.2 Variable Definition

To comprehensively evaluate the risk and return characteristics of the investment portfolio, this paper selects Return, Mean Return, Standard Deviation, Portfolio Return, Portfolio Risk and Sharpe Ratio as the primary research variables.

Among the above variables, return, which reflects the magnitude of stock price changes, is calculated using daily logarithmic return; mean return is used to measure the overall profitability of assets over the sample period; as a key indicator for risk measurement, standard deviation reflects the volatility of returns. A larger standard deviation indicates more drastic asset price fluctuations and thus higher investment risk. Portfolio return refers to the weighted average return of individual asset returns based on their respective portfolio weights, while portfolio risk comprehensively incorporates the covariance relationship between constituent assets to reflect the overall risk level of the portfolio. The Sharpe Ratio measures the excess return obtained per unit of risk. In this study, for simplicity,

the risk-free rate is assumed to be zero; The Sharpe Ratio is approximated as the ratio of mean return to standard deviation. This simplification is acknowledged as a limitation and does not affect the relative ranking of portfolio performance.

3.3 Research Methodology

3.3.1 Descriptive Statistical Analysis

First, this paper conducts descriptive statistical analysis on the returns of individual stocks and the NASDAQ Index, covering statistical indicators including mean, median, standard deviation, maximum, minimum, skewness and kurtosis. Descriptive statistical analysis enables a preliminary understanding of the distribution characteristics and risk levels of returns of different stocks, which provides a fundamental basis for subsequent portfolio analysis.

3.3.2 Calculation of Return Rate

Daily logarithmic returns are calculated below to eliminate non-stationarity in raw price data:

(1)

Here, P_t denotes the adjusted closing price on day t , and P_{t-1} denotes the adjusted closing price on the previous trading day. Compared with simple returns, logarithmic returns have the property of additivity and are more applicable to financial time series analysis.

3.3.3 Risk Measurement

This paper adopts standard deviation as the primary measurement indicator for investment risk and evaluates the risk level of different stocks by calculating the volatility of return rates. Meanwhile, to comprehensively evaluate the relationship between return and risk, this paper further calculates the Sharpe Ratio to compare the risk-adjusted return performance of different investment portfolios. A higher Sharpe Ratio indicates that investors obtain higher return per unit of risk taken, corresponding to superior investment performance.

3.3.4 Correlation Analysis

To analyze the co-movement between different stocks, this paper calculates the Pearson correlation coefficients between the return rates of individual stocks and constructs a correlation coefficient matrix. Correlation analysis can reflect the degree of correlation between different assets, and it also serves as an important basis for risk diversification in investment portfolios. The covariance relationship reflected by correlation determines overall portfolio risk (see Section 3.2).

3.3.5 Portfolio Optimization

This paper constructs the optimal investment portfolio by adopting the Mean-Variance Optimization (MVO) model introduced in Section 2.1. First, the study calculates the

mean return and covariance matrix of individual stock returns (covariance definition see Section 3.2), then sets minimizing portfolio risk as the optimization objective. Under the constraint conditions that the sum of portfolio weights equals 1 and the weight of each asset is non-negative, the quadratic programming method is applied to solve for the optimal investment portfolio weights. The optimization procedure was implemented in R using quadratic programming techniques to obtain the optimal portfolio weights.

3.3.6 Stock Price Trend Analysis

In addition to return rate analysis, this paper adopts Moving Average (MA) to analyze the changing trend of stock prices. Moving Average can smooth out short-term price fluctuations, reflect the long-term trend of stocks more clearly, and provide auxiliary reference for analyzing the price change characteristics of technology stocks and the overall development trend of the market.

4. Empirical Results

4.1 Price Trend Analysis

To examine the long-term price movement trends of U.S. technology stocks during the sample period, this paper adopts the Moving Average (MA) method to conduct trend analysis on Apple, Microsoft, NVIDIA, Amazon and the NASDAQ Composite Index. The results show that the four technology stocks moved in tandem with the NASDAQ Index, reflecting broad market trends.

In early 2020, affected by the COVID-19 pandemic, stock prices of all sampled listed companies declined to varying degrees. Subsequently, driven by the gradual recovery of the U.S. economy and the rapid development of technologies represented by artificial intelligence (AI) and cloud computing, the entire U.S. technology sector entered a sustained upward trend. Among all technology companies, NVIDIA's performance is particularly prominent: its stock price growth far outpaced that of its peers, reflecting the significant impact of the rapid expansion of the artificial intelligence industry on the capital market. Apple and Microsoft maintained relatively stable price trends, demonstrating favorable long-term operational stability. Although Amazon maintained overall growth throughout the observation period, its upward momentum showed a deceleration in the latter half of the sample period. On the whole, the U.S. technology sector maintained strong growth momentum during the research period, which further confirms that the technology industry remains a core driving force for the development of the U.S. capital market.

4.2 Descriptive Statistics

According to the results of descriptive statistics, there are significant differences in return and risk characteristics across different technology-related stocks. NVIDIA posted the highest average daily return and standard deviation. Microsoft had the lowest return volatility among the four sampled stocks. The Nasdaq Composite Index exhibited smaller return fluctuations than any individual technology stock in the sample. Furthermore, all return series exhibit high kurtosis and skewness, indicating non-normality and fat tails—properties commonly observed in financial markets. This implies a relatively high probability of extreme returns, underscoring the importance of risk management alongside return maximization in portfolio construction.

4.3 Correlation Analysis

The results of correlation analysis show that there is a strong positive correlation among the four technology stocks selected in this study. In particular, the correlation coefficient between Microsoft and the Nasdaq Composite Index was the strongest, indicating that their price movements closely tracked the overall market trend. Meanwhile, relatively high correlations are also observed between Apple, Amazon, and NVIDIA, which reflects that listed companies in the technology sector are generally affected by common macroeconomic factors and market sentiment.

Although strong bivariate correlations are identified among all selected stocks, none of them reach perfect correlation, which leaves certain room for risk diversification. Through reasonable allocation across different stocks, investors can still partially reduce unsystematic risk.

4.4 Portfolio Optimization Analysis

Following the Markowitz mean-variance framework outlined in Section 2.1, this paper solves for optimal portfolio weights via quadratic programming. After comprehensively considering the average return, volatility and covariance of each asset, the model obtains the optimal asset allocation result.

The optimization results assign the highest weight to Amazon, followed by Apple and NVIDIA, while excluding Microsoft from the optimal portfolio. The exclusion of Microsoft can be attributed to two factors. First, although Microsoft exhibits the lowest volatility among the four stocks, its mean return is also relatively modest. In the mean-variance framework, assets with low return-to-risk ratios are disadvantaged unless they provide substantial diversification benefits. Second, Microsoft's returns display the strongest positive correlation with the NASDAQ Index (as reported in Section 4.3), implying that its co-movement with the broader market—and likely with the other three stocks—limits its ability to reduce portfolio

variance. Consequently, the optimizer allocates weights to Amazon, Apple, and NVIDIA, which offer higher expected returns and sufficient covariance structure to achieve a more favorable risk-return trade-off.

Compared with the equal-weighted investment portfolio, mean-variance optimization can dynamically adjust investment proportions according to the risk-return characteristics of assets, and achieve more reasonable asset allocation. This demonstrates that modern portfolio theory can effectively improve the overall efficiency of investment portfolios and achieve favorable return performance while controlling risks.

4.5 Benchmark Comparison

This section compares the risk-adjusted performance of the optimized portfolio against the NASDAQ benchmark. It should be noted that the analysis assumes a zero risk-free rate; therefore, the reported Sharpe ratios represent simplified measures of risk-adjusted return.

The results show that the overall return of the optimized portfolio is higher than that of the market index, while maintaining a relatively reasonable risk level. In terms of risk-adjusted return, the Sharpe ratio of the optimized portfolio outperforms that of the NASDAQ Index, indicating that portfolio optimization can effectively improve the return per unit of risk. Compared with direct investment in the market index, the mean-variance optimization method can more fully exploit the return and risk characteristics of different assets and improve the overall investment performance of the portfolio.

Therefore, modern portfolio theory has sound applicability in the management of U.S. technology stock portfolios, and also provides a theoretical basis for investors in asset allocation.

4.6 Discussion

Based on the above comprehensive analysis, the empirical results of this paper are generally consistent with the relevant research in the literature review of Section 2. The outperformance of optimized portfolios confirms the core prediction of MPT set forth in the literature review. Although the overall U.S. technology stock sector features high growth, there are significant differences in returns and risks among individual stocks. Thus, equal-weight allocation falls short of optimal performance, whereas mean-variance optimization delivers more effective portfolio management by leveraging individual asset risk-return profiles.

In addition, the findings of this study support the two research hypotheses proposed in this paper. Firstly, the optimized portfolio constructed based on modern portfolio theory can achieve superior risk-adjusted returns; secondly, although technology stocks generally exhibit high

correlation with each other, there is still room for effective risk diversification. Therefore, for long-term investors, adopting a scientific portfolio optimization method can effectively improve investment decision-making. These findings are broadly consistent with Davis et al., who suggested that firms exhibit heterogeneous risk exposures following major external shocks, leading to differences in stock performance [14]. Similarly, this study finds that even among leading U.S. technology companies, substantial variation exists in risk and return, implying that portfolio optimization can improve overall investment performance.

5. Conclusion

This study takes four U.S. technology firms, namely Apple, Microsoft, NVIDIA and Amazon, as research objects, adopts the NASDAQ Composite Index as the market benchmark, and applies modern portfolio theory to conduct risk analysis and optimization research on the portfolio of U.S. technology stocks. This research first conducts descriptive statistical analysis and correlation analysis on stock returns, then constructs the optimal portfolio via the mean-variance optimization model, and compares the optimization results with the market index.

The research results show that U.S. technology stocks as a whole have high return potential, yet there are significant risk differences among individual stocks. NVIDIA exhibits the highest return level while bearing the greatest investment risk; Microsoft maintains relatively stable overall performance; and the NASDAQ index features low overall volatility. Further correlation analysis indicates that although technology stocks have strong positive correlations with each other, there is still certain room for risk diversification. The portfolio constructed based on the mean-variance optimization model achieves a higher risk-adjusted return than that of the market index, which demonstrates that modern portfolio theory can effectively improve the overall performance of portfolios consisting of U.S. technology stocks.

This study is subject to several limitations: First, the sample is confined to four large-cap technology firms; small and medium-sized technology companies with distinct risk-return profiles are excluded. Second, the analysis relies on historical price data from 2020 to 2025 and does not incorporate macroeconomic variables such as interest rates, inflation, or monetary policy. Third, the Sharpe Ratio calculation assumes a zero risk-free rate, which simplifies the risk-adjusted performance metric. Fourth, standard time-series diagnostics—including stationarity tests (e.g., ADF), normality tests (e.g., Jarque-Bera), and structural break tests—are not formally reported; the descriptive statistics in Section 4.2 suggest non-normality, but rigorous testing is left for future research. Fifth, the study does

not conduct sub-period robustness checks (e.g., pre- and post-COVID-19, or pre- and post-AI boom), which could reveal temporal instability in optimal weights. Sixth, practical frictions such as transaction costs, taxes, and short-sale constraints are omitted from the optimization model, potentially creating a gap between theoretical and actual portfolio performance.

Future research would expand the sample size by including more technology companies and subsectors, for example, artificial intelligence, cloud computing and semiconductor industries. Moreover, future studies may integrate macroeconomic variables and alternative optimization approaches to improve portfolio construction methods and provide more comprehensive investment strategies for technology stock investors. In addition, subsequent research may incorporate ADF stationary tests, Jarque-Bera normality tests and segmented robustness checks to improve the overall rigor of empirical results.

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