

Portfolio Optimization Project

Introduction

Portfolio optimization is a crucial concept in modern finance, aiming to maximize returns for a given level of risk or minimize risk for a given level of return. This project applies Modern Portfolio Theory (MPT) to construct an optimal portfolio of selected financial assets by analyzing their historical performance and risk metrics. The analysis focuses on two key portfolios:

- The **Maximum Sharpe Ratio Portfolio**, which offers the best risk-adjusted returns.
- The **Minimum Volatility Portfolio**, which minimizes overall risk.

Data Summary

The dataset comprises adjusted closing prices for the following assets: [AAPL, MSFT, GOOG, AMZN]. Historical data spanning from 2021-01-01 to the most recent trading day (2024-12-12) was sourced using the `yfinance` library. Key metrics derived from this data include:

- **Daily Returns:** Percentage change in prices from one day to the next.
- **Annual Returns:** Scaled average daily returns assuming 252 trading days per year.
- **Volatility:** Standard deviation of returns, measured daily and annualized.

Summary Statistics:

- **Annual Returns:**
 - AAPL – 20.5%
 - AMZN – 15.6%
 - GOOGL – 25.7%
 - MSFT – 22.7%
- **Annual Volatility:**
 - AAPL – 26.7%
 - AMZN – 35.4%
 - GOOG – 30.8%
 - MSFT – 26.1%
- **Correlation Matrix:**

Ticker	AAPL	AMZN	GOOG	MSFT
AAPL	1.00	0.561	0.604	0.680
AMZN	0.561	1.00	0.641	0.669
GOOG	0.604	0.641	1.00	0.698
MSFT	0.680	0.669	0.698	1.00

Methodology

- 1. **Data Preparation:** Daily returns were calculated using the percentage change formula.
- 2. **Risk Metrics:** Key metrics such as annual volatility, covariance, and correlation matrices were computed to assess the relationships between assets.
- 3. **Portfolio Optimization:**
 - Random portfolios were generated with varying weights.
 - For each portfolio, expected return, volatility, and Sharpe ratio were calculated.
 - The **Efficient Frontier** was plotted to visualize the risk-return tradeoff for all portfolios.
- 4. **Optimal Portfolios:**
 - The portfolio with the **maximum Sharpe ratio** was identified.
 - The portfolio with the **minimum volatility** was also highlighted.

Results

Efficient Frontier

The Efficient Frontier showcases portfolios with the best risk-return tradeoffs. Key observations include:

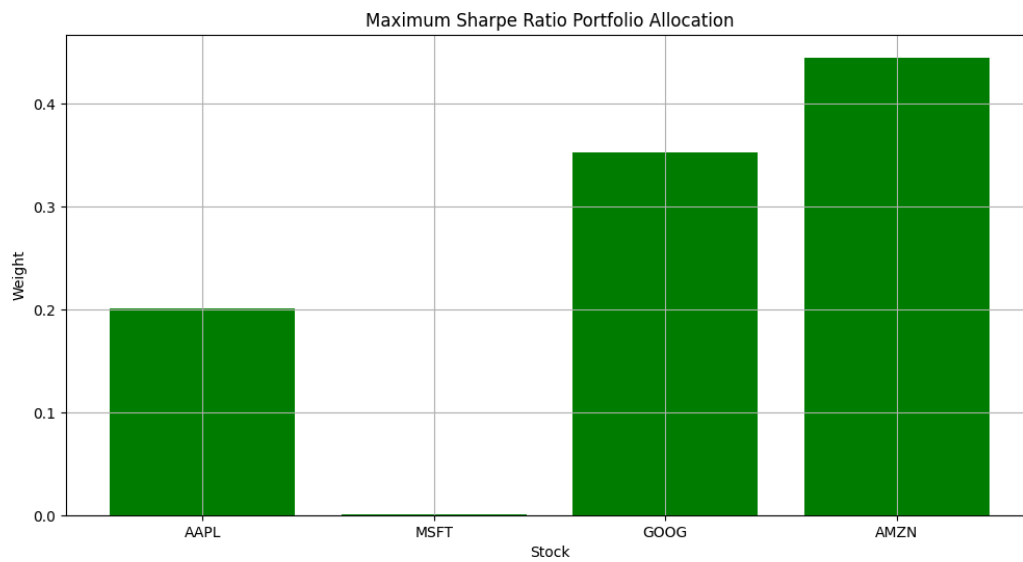
- The **Maximum Sharpe Ratio Portfolio** offers the highest return per unit of risk.
- The **Minimum Volatility Portfolio** minimizes overall portfolio risk.

Optimal Portfolio Metrics:

Portfolio	Expected Return	Volatility (Risk)	Sharpe Ratio
Maximum Sharpe Ratio	23.32%	24.79%	0.86
Minimum Volatility	21.99%	24.07%	0.83

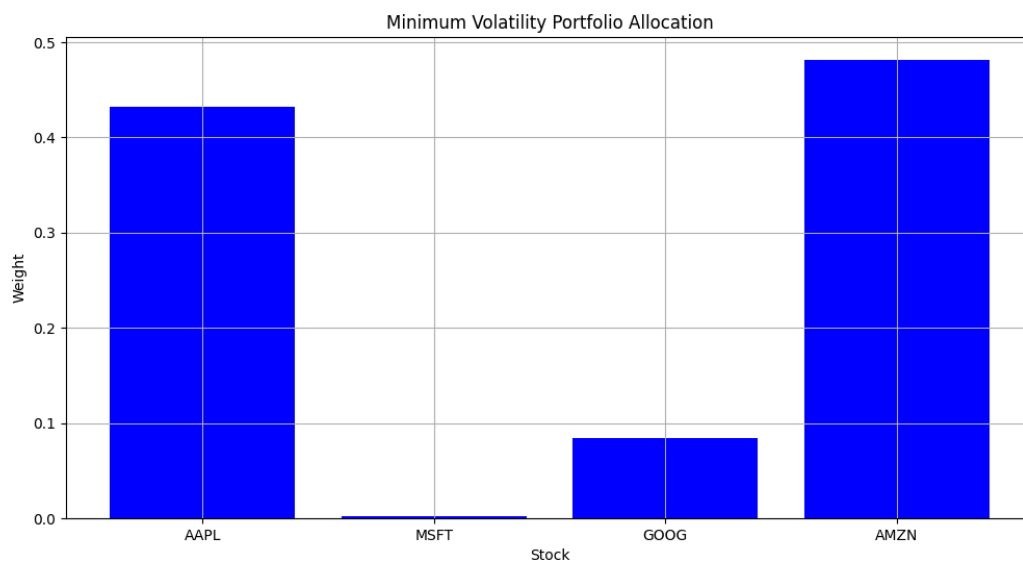
Portfolio Allocations:

- **Maximum Sharpe Ratio Portfolio:**
 - AAPL – 20.1%
 - AMZN – 0.096%
 - GOOG – 35.3%
 - MSFT – 44.5%



- **Minimum Volatility Portfolio:**

- AAPL – 43.2%
- AMZN – 0.270%
- GOOG – 8.41%
- MSFT – 48.1%



Conclusion

This analysis demonstrates the power of Modern Portfolio Theory in constructing optimized portfolios. Key insights include:

- Diversification reduces risk through the inclusion of assets with low or negative correlations.
- The Maximum Sharpe Ratio Portfolio is ideal for investors seeking the highest risk-adjusted returns.
- The Minimum Volatility Portfolio suits risk-averse investors.

Recommendations for Future Work

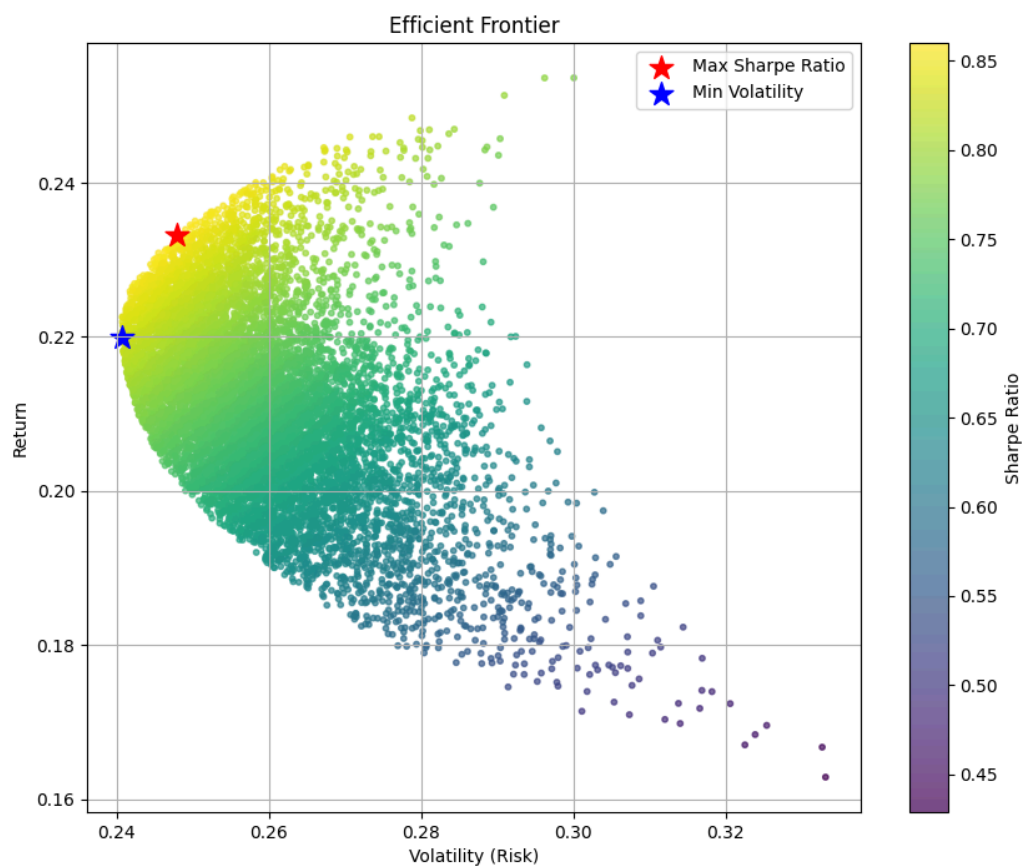
1. Incorporate additional asset classes (e.g., bonds, commodities) for a more diversified portfolio.
2. Apply constraints (e.g., sector caps, no short selling) to reflect realistic investment scenarios.
3. Backtest the portfolios using out-of-sample data to validate performance.
4. Explore dynamic portfolio allocation using rolling windows or machine learning models.

Appendix

- **Correlation Heatmap:**



- **Efficient Frontier Plot:**



- **Code Repository:** [Insert link if applicable]

This report provides a comprehensive foundation for portfolio optimization, showcasing essential data science techniques applied to financial analysis.