Portfolio Optimization of Volatile Assets

This project demonstrates the principles of modern portfolio theory (MPT) to construct an optimal portfolio of volatile assets. We use Python with libraries like `pandas`, `numpy`, `matplotlib`, and `scipy` to fetch financial data, perform calculations, and visualize the results.

Table of Contents

**1. Introduction to Portfolio Optimization**

What is a portfolio? A collection of financial investments like stocks, bonds, and cash.

**Assets, Returns, and Risk:** Understanding the fundamental concepts of investment. Assets are what you own, returns are your profit, and risk is the possibility of losing money.

**Modern Portfolio Theory (MPT):** A theory on how risk-averse investors can construct portfolios to maximize expected return for a given level of market risk. The key is diversification.

**Efficient Frontier:** A graph representing a set of optimal portfolios that offer the highest expected return for a defined level of risk or the lowest risk for a given level of expected return.

**2. Data Acquisition and Preparation**

**Data Pull:** We use the `yfinance` library to download historical stock price data for our chosen assets (Apple, Nike, Google, and Amazon).

**Data Cleaning:** We focus on the 'Adj Close' price, which is adjusted for dividends and stock splits, providing a more accurate representation of the stock's value.

**Log of Percentage Change:** We calculate the log of daily returns. This is a standard practice in financial analysis as it makes the returns time-additive and helps in normalizing the data.

**3. Statistical Analysis**

**Variance and Volatility:** We calculate the variance and volatility (annualized standard deviation) of each asset. Volatility is a measure of risk; higher volatility means higher risk.

**Covariance and Correlation Matrix:** We compute the covariance and correlation matrix of the assets. This is crucial for understanding how the assets move in relation to each other. A negative correlation is desirable for diversification as it means the assets tend to move in opposite directions, reducing overall portfolio risk.

**4. Portfolio Construction and the Efficient Frontier**

**Portfolio Expected Returns:** We calculate the expected return of a portfolio, which is the weighted average of the individual asset returns.

**Portfolio Variance:** We calculate the portfolio variance, which is a measure of the portfolio's overall risk. It's calculated using the covariance matrix and the weights of the assets.

**Generating Random Portfolios:** We generate thousands of random portfolios with different asset weights to simulate a wide range of possible investment combinations.

**Plotting the Efficient Frontier:** By plotting the returns and volatility of these random portfolios, we can visualize the efficient frontier. The efficient frontier represents the set of portfolios that offer the highest expected return for a given level of risk.

**5. Finding Optimal Portfolios**

**Minimum Volatility Portfolio:** We identify the portfolio on the efficient frontier with the lowest volatility. This is the ideal portfolio for a highly risk-averse investor.

**Optimal Risky Portfolio (Highest Sharpe Ratio):** We calculate the Sharpe ratio for each portfolio, which measures the risk-adjusted return. The portfolio with the highest Sharpe ratio is the optimal risky portfolio. It provides the best return for the amount of risk taken.

**Numerical Optimization:** We use `scipy.optimize.minimize` to find the precise weights for the optimal risky portfolio by maximizing the Sharpe ratio. This is a more accurate method than relying on random generation.

**6. The Capital Allocation Line (CAL)**

**Combining Risky and Risk-Free Assets:** The CAL represents the risk-return trade-off of combining the optimal risky portfolio with a risk-free asset (like a government bond).

**Superior Investment Opportunities:** The CAL shows that by combining the optimal risky portfolio with a risk-free asset, an investor can achieve a better risk-return profile than by holding any other portfolio on the efficient frontier.

**Conclusion and Results**

The problem was to find the optimal allocation of investments among a set of volatile assets (Apple, Nike, Google, and Amazon) to maximize returns while minimizing risk. By applying Modern Portfolio Theory, we have successfully addressed this problem.

Our analysis has yielded the following key results:

**Minimum Volatility Portfolio:** We identified a portfolio with the lowest possible risk. The weights for this portfolio are approximately:

Apple (AAPL): 26.7%

Amazon (AMZN): 4.1%

Google (GOOGL): 28.9%

Nike (NKE): 40.3%

This portfolio is suitable for investors who prioritize capital preservation above all else.

**Optimal Risky Portfolio:** By maximizing the Sharpe ratio, we found the optimal risky portfolio with the best risk-adjusted return. The weights for this portfolio are approximately:

Apple (AAPL): 74.3%

Amazon (AMZN): 19.8%

Google (GOOGL): 0%

Nike (NKE): 5.9%

This portfolio is the ideal choice for an investor who wants to maximize their returns for a given level of risk.

**The Power of Diversification:** Our analysis demonstrates that by combining assets with different risk-return characteristics and correlations, we can construct a portfolio with a better risk-return profile than any single asset.

**The Capital Allocation Line (CAL):** We have shown that by combining the optimal risky portfolio with a risk-free asset, an investor can achieve an even better risk-return trade-off, further optimizing their investment strategy.

In conclusion, this project provides a comprehensive, step-by-step guide to portfolio optimization. The final graph, which includes the efficient frontier, the minimum volatility portfolio, the optimal risky portfolio, and the Capital Allocation Line, serves as a powerful visual tool for making informed investment decisions. It provides a clear roadmap for constructing a portfolio that aligns with an investor's specific risk tolerance and return objectives.