

Portfolio Analysis and Optimization Project

This project conducts a comprehensive analysis and optimization of a diversified portfolio, utilizing both Python and Excel. We retrieve historical price data, calculate log returns, analyze cumulative returns, and ultimately optimize portfolio allocation to maximize the Sharpe Ratio, a measure of risk-adjusted return.

1. Steps in Python: Data Retrieval and Analysis

We begin by preparing data in Python. Here's a step-by-step guide to data retrieval and initial analysis.

Libraries and Setup

1. Import Libraries

Import essential libraries, including `pandas` and `numpy` for data handling, and `yfinance` for retrieving historical data.

2. Define Date Range

Set a start date and an end date for the data analysis, typically 5 years back from the current date.

3. Select Assets (Tickers)

Define a list of asset tickers to include in the portfolio:

- **TLH**: iShares 10-20 Year Treasury Bond ETF
- **SPY**: SPDR S&P 500 ETF Trust
- **LQD**: iShares iBoxx \$ Investment Grade Corporate Bond ETF
- **VNQ**: Vanguard Real Estate ETF
- **XLV**: Health Care Select Sector SPDR Fund
- **GOLD**: SPDR Gold Shares
- **DBC**: Invesco DB Commodity Index Tracking Fund
- **EQT**: EQT Corporation
- **QQQ**: Invesco QQQ Trust
- **BTC-USD**: Bitcoin

4. Download Data

Use `yfinance` to download the historical adjusted close prices for the selected assets.

5. Calculate Daily Log Returns

Calculate the daily log returns to assess asset performance using:

$$\text{Log Return} = \ln\left(\frac{\text{Price Today}}{\text{Price Yesterday}}\right)$$

6. Analyze Cumulative Returns

Compute cumulative returns by taking the cumulative sum of daily log returns, then plot to visualize the growth trends.

7. Export Data to Excel

Save the retrieved data and calculated metrics to an Excel file, making it accessible for further analysis.

2. Steps in Excel: Sharpe Ratio Calculation and Optimization

After preparing the data in Python, we move to Excel to finalize the analysis and optimize the portfolio. Follow these steps in Excel to calculate the Sharpe Ratio and find the optimal asset allocation.

Instructions for Calculating the Sharpe Ratio and Finding the Optimal Portfolio in Excel

1. Input Data Preparation

- Import the historical data prepared in Python into an Excel sheet, focusing on adjusted close prices.

2. Calculate Daily Log Returns

- Calculate the daily log returns using Excel formulas for each asset.

3. Annualize Returns

- Calculate the annualized returns by taking the average daily return and multiplying by 252, representing the number of trading days in a year:

$$\text{Annual Return} = (1 + \text{Average Daily Return})^{252} - 1$$

4. Calculate Standard Deviation of Returns

- Use Excel's variance and standard deviation functions to compute the annualized volatility for each asset.

5. Set Minimum and Maximum Weights for Each Asset

- Define a minimum and maximum weight for each asset to control its allocation in the portfolio. Start with a minimum of 10% and a maximum of 40%.

6. Create a Covariance Matrix

- Generate a covariance matrix to understand the relationship between asset returns, essential for calculating overall portfolio risk.

7. Portfolio Standard Deviation Calculation

- Use matrix algebra in Excel to compute the portfolio's overall standard deviation with the formula:

$$\text{Portfolio Standard Deviation} = \sqrt{\text{Weights}^T \times \text{Covariance Matrix} \times \text{Weights}}$$

- To calculate the portfolio's overall standard deviation (risk) in Excel, we use matrix algebra to combine the asset weights and covariance matrix. This formula calculates the portfolio standard deviation based on the individual asset volatilities and their correlations.

In Excel, use the following formula:

excel

```
=SQRT(MMULT(MMULT(C7:L7, C25:L34), TRANSPOSE(C7:L7) * 252))
```

- **Explanation:**

- C7:L7 represents the row of asset weights for each asset in the portfolio.
- C25:L34 is the covariance matrix of daily returns for the assets.
- TRANSPOSE(C7:L7) transposes the weights to align with the matrix multiplication.
- * 252 adjusts for annualization, based on 252 trading days in a year.
- SQRT calculates the square root, converting variance to standard deviation.

8. Calculate Expected Portfolio Return

- Calculate the portfolio's expected return using a weighted average of each asset's annualized return.

9. Determine the Risk-Free Rate

- Input the current risk-free rate, such as the 10-year U.S. Treasury yield, necessary for calculating the Sharpe Ratio.

10. Calculate the Sharpe Ratio

- Use the formula:

$$\text{Sharpe Ratio} = \frac{\text{Expected Portfolio Return} - \text{Risk-Free Rate}}{\text{Portfolio Standard Deviation}}$$

- This measures the portfolio's risk-adjusted return.

11. Optimize Weights with Solver

- Use Excel's Solver to maximize the Sharpe Ratio by adjusting asset weights within defined constraints.

12. Refine and Reoptimize

- Adjust minimum and maximum weight constraints to explore how they impact the Sharpe Ratio, rerunning Solver for optimal results.