

Portfolio Optimization

MGMT 675, AI-Assisted Financial Analysis

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Outline for Today

- Download international.xlsx, international_corrs.xlsx, and us_developed_emerging_rets.xlsx from the Datasets link.
- Examples for frontier and tangency portfolios
 - US, Japan, Germany, France, UK (from Applied Finance)
 - US, Developed, & Emerging (from Applied Finance)
 - ETFs from Yahoo Finance
- We will also see how to save code to Google Colab and Google Drive



Procedure

- Data
 - Upload means, standard deviations, and correlations
 - Or upload returns and calculate historical statistics
 - Or get data online, compute returns, and calculate historical statistics
- Frontier of risky assets
 - Use cvxopt to minimize variance subject to achieving target expected return
- Tangency portfolio
 - Use cvxopt to minimize variance minus risk premium
 - Divide by sum of weights to get tangency portfolio
- Can exclude short sales when using cvxopt for frontier and tangency portfolio
- Can plot assets, frontier, and capital allocation line



Example 1: Frontier of Risky Assets

- Upload international.xlsx and international_corrs.xlsx to Julius. Ask Julius to read them.
- Ask Julius to convert the means, standard deviations, and correlation matrix into numpy arrays.
- Ask Julius to compute the covariance matrix as a numpy array.
- Ask Julius to use cvxopt to minimize variance subject to achieving a target expected return.
 - If allowing short sales, tell Julius there are no inequality constraints.
 - If excluding short sales, tell Julius to not allow short sales.
- Ask Julius to repeat for a range of target expected returns and to plot the expected returns and standard deviations.
- Ask Julius to include the expected returns and standard deviations of the country returns in the plot and to label them.



cvxopt for Frontier Portfolios Allowing Short Sales

- minimize $(1/2)x'Px$ subject to $Ax = b$
- P = covariance matrix
 - $x'Px$ is portfolio variance
- A = array with two rows
 - first row = `np.ones(n)`
 - second row = asset expected returns
- $b = \text{np.array}([1, \text{targ}])$
 - $Ax = b$ means weights sum to 1 and expected return = targ.
- Julius should figure all of this out. But, Julius might assume you want to exclude short sales.

cvxopt for Frontier Portfolios Excluding Short Sales

- minimize $(1/2)x'Px$ subject to $Ax = b$ and $Gx \leq h$
- P , A , and b as before
- $G = -\text{np.eye}(n)$ and $h = \text{np.zeros}(n)$
 - $Gx \leq h$ means weights are nonnegative (no shorts)
- Again, Julius should figure this out.

Example 1: Tangency Portfolio

- Give Julius a number for the risk-free rate.
- Ask Julius to minimize the variance minus the risk premium.
 - If allowing short sales, tell Julius there are no inequality constraints.
 - If excluding short sales, tell Julius to not allow short sales.
- Ask Julius to divide by the sum of the weights to compute the tangency portfolio.
- Ask Julius to include the tangency portfolio and the capital market line on the previous plot.



cvxopt for Tangency Portfolio

- Minimize $x'Px - q'x$
 - $P = 2$ times covariance matrix (but the 2 is not important)
 - $q =$ risk premia
- No equality constraints
- If no short sales, then $G = -\text{np.eye}(n)$ and $h = \text{np.zeros}(n)$
- Then divide by the sum of weights



Example 2: US, Developed, and Emerging

- Upload `us_developed_emerging_rets.xlsx` and ask Julius to read it.
- Ask Julius to compute the sample means, sample standard deviations and sample correlation matrix as numpy arrays.
- Repeat the frontier and tangency portfolio calculations.



Google Colab

- Go to <https://colab.research.google.com/> and sign in.
- Open a new notebook.
- Copy and paste code from Julius into the notebook cells.
- Run the notebook.
- Save the notebook to your Google Drive.



Example 3: ETFs from Yahoo

- Example: ask Julius to use yfinance to get Yahoo adjusted closing prices for
 - SPY = S&P 500
 - VBR = Vanguard small-cap value
 - IEF = Treasury bonds
 - UUP = U.S. dollar bullish
- Ask Julius to downsample prices to end-of-month and compute monthly returns as percent changes in the downsampled prices.
- Ask Julius to compute means, standard deviations, and correlation matrix as numpy arrays.
- Ask Julius to find frontier of risky assets and tangency portfolio as before.

