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

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
- $b =$ np.array([1, 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
- $G = -$ np.eye(n) and $h =$ 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 $G = -$ np.eye(n) and $h =$ np.zeros(n)
- Then divide by the sum of weights

Example 2: US, Developed, and Emerging

- Start a new chat.
- 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.

Online Data

- Julius will normally get some online data without complaining.
    - For example, it will get data from Yahoo Finance and Federal Reserve Economic Data (FRED).
- At other times, Julius will say it has no access to external websites and can only advise.
    - In those cases, it will still produce code that you can run elsewhere.
    - But, it will not be available to debug the code for you.
    - This happens, for example, with the SEC's Edgar site.

Yahoo's Adjusted Closing Prices

- Yahoo's adjusted closing prices are adjusted for splits and dividends.
- The percent change in the adjusted closing price is the daily close-to-close return including dividends (on ex-dividend dates).
- If we want returns at a different frequency, for example annual returns, then we can either
    - compound the daily returns, or
    - downsample the adjusted closing prices to annual data and compute the percent change of the downsampled data.

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.