PORTFOLIO OPTIMIZATION

MGMT 675
AI-Assisted Financial Analysis
Kerry Back

RICE | BUSINESS
Jones Graduate School of Business

OBJECTIVES

- Frontier portfolios of risky assets (minimize risk subject to achieving a target expected return)
- Tangency portfolio (maximize Sharpe ratio)
- Estimate means, standard deviations, and correlations from historical returns
- Download adjusted closing prices from Yahoo Finance and compute returns

GOAL SEEK IN PYTHON

- There are several choices in python for optimizing functions.
- The qp function from cvxopt is a very good choice for portfolio optimization.
  - cvxopt = convex optimization
  - qp = quadratic programming

EXAMPLES

- From Applied:
  - U.S., U.K., France, Germany, Japan
  - U.S., Developed, Emerging
- ETFs from Yahoo Finance

U.S., U.K., FRANCE, GERMANY, AND JAPAN

- Download international.xlsx and international_corrs.xlsx from the course website.
- Upload the files 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.

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.

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.

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

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.

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.
  - 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.

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.