

# PORTFOLIO OPTIMIZATION

MGMT 675

AI-Assisted Financial Analysis

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# 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.

# DIGRESSION ON CVXOPT



# 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.

# 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.

**BACK TO EXAMPLE**

# 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

# ANOTHER DIGRESSION ON CVXOPT

# 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.

# 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.

# DATA FROM YAHOO



# 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.