ISYE 6227
Professor S. Deng

Midterm Project

Portfolio construction and optimization

Consider the problem of investing a total of $1,000,000 in 21 stocks in the U.S. stock market. The tickers of the 21 stocks are: CVS, KO, PG, DWDP, GE, COP, CVX, MSFT, CSCO, CAH, MCK, JPM, BAC, VLO, TGT, HD, ADM, BA, F, VZ, KR.

1. Use the monthly adjusted close prices of the 21 stocks over the time period of Jan. 1999 to May 2019 to compute the expected annualized net-returns and the corresponding standard deviations (as explained in lecture).
    a. (2 points) Plot the 21 pairs of (σ, r) on the r-σ diagram.
    b. (4 points) Plot the (σ, r) of 500 randomly generated portfolios consisting of these 21 stocks and the feasible region of investment possibility. Use two-fund theorem and two particular solutions to the mean-variance optimal portfolio problem to plot the mean-variance efficient set. (Note: a portfolio is a weight vector of 21 components adding up to 1. One can generate 21 uniform (-10,10) random samples and then normalize them to numbers of sum 1.)
    c. (6 points) Generate the investment feasible region for portfolios consisting of non-negative weights and compare it with the region obtained in b). (Hint: solve the mean-variance optimal portfolio problem to get two particular solutions and plot the mean-variance efficient set).
2. Write a computer program (using Matlab, Python, or VBA) to obtain the mean-variance optimal portfolio $x = (x_1, x_2, \ldots, x_{21})$, where x denotes the non-negative portfolio weight vector, for any given target mean rate of return r using data file over the period from Jan. 1999 to Dec. 2014. Suppose you decide to invest $1,000,000.00 in the 21 stocks according to the mean-variance efficient portfolio weight x obtained in Dec. 2014. The investment horizon is from Jan. 2015 to May 2019. Compute the expected net return and the volatility of the net returns of this portfolio over the period of Jan. 2015 to May 2019. For example: the net-return of the portfolio x in Jan. 2015 is equal to the portfolio weight vector x multiplying the net-return vector of the 21 stocks in Jan. 2015, the net-return of the portfolio x in Feb. 2015 is equal to the portfolio weight vector x multiplying the net-return vector of the 21 stocks in Feb. 2015, and so

on so forth. Also, consider the equal-weight portfolio y = (1/21, 1/21, … , 1/21) and compute the 53 monthly returns of the portfolio y over the period of Jan. 2015 to May 2019.

a. (8 points) Compute the mean value and the standard deviation of the 53 monthly returns of portfolios x and y, respectively.
b. (5 points) Comment on which one of the portfolios x and y is the better performing one and why?

3. You now select 10 stocks out of the 21 stocks in Dec. 2014 based on the following criterion.

- Criterion: Computing M-score for each stock i:
  Pick a value from {1, 2, 3, 4, 5, 6} for n and a value from {3, 4, 5, 6, 7, 8, 9} for m. Say, n = 2, m = 7.

  Let C_t denote the price of stock i in month t (for example, t = Dec 2014)
  Ratio 1: $\ln(C_{t-1}/C_{t-n})$; (n = 2). The meaning of the time index (t-n) is n months before t. For example, if t = Jan. 2015, n = 2, then (t-2) is Nov. 2014 and C_{t-n} refers to the stock price in Nov. 2014. As the value of t changes, C_t and C_{t-n} refer to the stock prices in the respective months t and (t-n).
  Ratio 2: $\ln (C_{t-m}/C_{t-1})$; (m = 7)
  Define weights: b_1 = 1/2, b_2 = 1/2
  for stock i = 1, 2, ..., N
  compute ratios R(1, t), R(2, t)
  compute M_i = b_1*R(1,t) + b_2*R(2,t)
  End i-loop

  Now sort the M-scores of all stocks in the month of Dec. 2014 from largest to smallest and pick the 10 stocks with the highest M-scores.

  Prepare a data input file consisting of the monthly returns of the 10 chosen stocks for the time period of Jan. 1999 to Dec. 2014. Use your program to obtain the mean-variance efficient portfolio x_s in Dec. 2014. Compute the mean and the standard deviation of the net returns of portfolio x_s over the time period of Jan. 2015 to May 2019. Next, compute the mean and standard deviation of the net returns of the equal weight portfolio y_s = (1/10, 1/10, … , 1/10) over the same time period of Jan. 2015 to May 2019.

  - (10 points) Try different values for (n, m) and find the best performing mean-variance efficient portfolio x_s and the corresponding performance

of equal-weighting portfolio y_s.

- (5 points) Which one of x_s and y_s in a) performs better? Provide your explanation.

Project deliverables:

1. Ready-to-run codes with a README file containing explanations on how to run the codes or an Excel file containing all functions for answering questions posted in the project description.

2. A project report which contains the following components:
   1. Problem addressed by the project and the model(s) used in the project
   2. Outcome of the model implementation and discussion on whether the obtained results fully address questions posted in project description.