MCP261 Exercise 1 **January 10, 2024**

Monte Carlo Simulation + Nonlinear Optimization

Due date: 11:59 PM Sunday, January 14, 2024

Submission Instructions

Submit the scripts on MS Teams in a zip file. The zip file must contain a single Python script (no Jupyter notebooks) for each question. Your script must provide the answer to the question upon execution; therefore, ensure that output is presented in a readable format. The script just be easy to read: all variables and key quantities of interest must be clearly named, all computations must be commented, all assumptions must be very clearly stated, and finally, you may even add a short (commented) explanation of your approach to the problem at the beginning of the script. File naming conventions: EntryNum_Name_ExerciseNum.zip (with the script inside named as EntryNum_Name_QuestionNum.py. Submissions that do not follow the above convention will not under any circumstances be entertained. Note that submission folder must contain the attached Excel file with the data also, and your code should be written such that it pulls and processes the data from the local folder where the Excel file is also stored.

For all questions below, use a random number seed of 1234 (i.e., numpy.random.seed(1234) at the beginning of your code). Use the NumPy and SciPy packages only for this assignment.

1. (6 marks) Historical stock data for 5 stocks is available in the attached Excel file. Using this data, perform Monte Carlo simulation (10, 100, 1000, 10000, 100000 and 500000 replications) and find the best performing portfolio from each case. The Markowitz portfolio optimization formulation is given below.
$$\begin{aligned} &\max w^T\mu - \gamma w^T \Sigma w \\ &s.t.\ w^T\mathbf{1} = 1 \\ &\quad\quad w \geq 0 \end{aligned}$$
Here $w \in R^n$ are the decision variables (proportion of the budget to be invested in each stock), μ is a vector of means of the stock price values, Σ is the covariance matrix of the stock prices, and γ is the risk tolerance parameter. Use a value of 0.2 for γ.
2. (4 marks) Solve the Markowitz formulation using a *scipy.optimize* method and print the optimal solution. Then plot the absolute value of the percentage difference between the optimal solution and the Monte Carlo solution against the number of replications (use the set of results from the above question).