Instructor: Dr. Milivoje Davidovic.
Northeastern University: Spring 2023.

FINA 6339: Quantitative Portfolio Management.

HOMEWORK 3.

Deadline: April 13, 2023 (11:59 PM). **Total Points:** 30 pts.

Instructions: Please mark all the questions properly to make the assignment readable. You are supposed to show your work to get full credit. Any overlapping results and Python codes will be subject to additional scrutiny, according to the university policies. Students are supposed to use Python (exclusively) to complete the assignment. The assignment has to be submitted as a single pdf file (Python output (tables and graphs) followed by your comments and interpretations, merged with the Python script exported as a pdf output file), togehter with data sets (as a separate single Excel file) through Canvas (exclusively) by the deadline. The assignment will not be graded if both files (the main pdf file and an Excel file) are not submitted (separately). Late assignments will receive zero points.

PART A: Portfolio Optimization. (15 pts.)

Problem A1.

Download data for any five stocks for any available period of your choice from (YahooFinance). The data set should include at least 252 observation, but there is no upper limit for the number of observation. Also, your data set should remain confidential. Use Python (exclusively) to: (a) find optimal weights for this portfolio (all five stocks) to minimize portfolio variance; (b) to find optimal weights for this portfolio (all five stocks) to maximize portfolio return; (c) to find optimal weights to ensure an equal level of risk contribution for each asset. The Python output and your comments/interpretation should be included in the main pdf file.

Problem A2.

Download data for any five cryptos for any available period of your choice from (CoinMarketCap). The data set should include at least 252 observation, but there is no upper limit for the number of observation. Also, your data set should remain confidential. Use Python (exclusively) to: (a) find optimal weights for this portfolio (all five cryptos) to minimize portfolio variance; (b) to find optimal weights for this portfolio (all five cryptos) to maximize portfolio return; (c) to find optimal weights to ensure an equal level of risk contribution for each asset. The Python output and your comments/interpretation should be included in the main pdf file.

Problem A3.

Use Python to calculate (a) the optimal portfolio returns for each stock market portfolio (3 optimal returns), and plot the distribution of these returns (histogram or kernel density plot); comment on the difference between these three optimal portfolio returns; (b) the optimal portfolio returns for each crypto market portfolio (3 optimal returns), and plot the distribution of these returns (histogram or kernel density plot); comment on the difference between these three optimal portfolio returns; (c) comment on the difference between the distribution of corresponding stock and crypto optimal portfolios (min-var stock vs. min-var crypto; max-return stock vs. max return cryptos; equal risk contribution stock vs. equal risk contribution cryptos).

Problem A4.

An investor aims to maximize his utility by investing in a combined portfolio consisting of a risky asset (say, Bitcoin), and a risk-free asset (say, 3-month T-bill). The payoffs are estimated to be as follows: (a) 30% chance that his investment will be multiplied by a factor of 3; (b) 40% chance that the factor will be 1, and (c) 30% chance to lose his investment. His utility is described by $U(x) = ln(x)$, and there is a comparable option to earn 20% risk-free. Will the investor be better-off by investing only in a risk-free asset? What is the allocation of his wealth given that the investor seeks to maximize his utility?

PART B: Brownian Motion & Bond Portfolio. (15 pts.)

Problem B1.

Use Python (exclusively) to simulate: (a) 1D Brownian motion; (2) 2D Brownian motion; (3) 3D Brownian motion. You can use $N = 5000$ for each simulation. Plot each simulated stochastic process on a separate plot.

Problem B2.

Pick any two cryptos you obtained in Problem A2. Then, use Python (exclusively) to: (a) simulate log returns of the first asset using 1D Brownian motion; (2) simulate log returns of the other asset using 1D Brownian motion; (c) plot both the realized log returns and the simulated log returns on the same plot (two plots, one for each asset) and comment on the dynamics of the realized and the simulated log returns for each asset.

Problem B3.

Use Python to: (a) simulate the Vasicek interest rate model (pick model parameters according to your choice); then, plot the simulated short paths (one plot), and simulated yield curves (another plot); (b) simulate the yield-price relationship for any two bonds; then, interpret the difference between these two simulations (*Hint: assume different maturities, yields, par value, etc. for the two bonds; then, simulate and plot the price-yield curve fro each bond; finally, comment on the difference between these two plots).*

SUBMISSION.

- **Step 1:** Use Python (exclusively) for each problem, export all tables, figures, and computational results to a docx file.
- **Step 2:** Interpret and comment all the results according to the requirements written in each problem.
- **Step 3:** Once the assignment is completed, save the docx file as the main pdf file on your computer.
- **Step 4:** Export Python script as a pdf file (it has to be organized to follow the problems in the assignment), and merge it with the main pdf file (the main file followed by the Python script) to make a single pdf file.
- **Step 5:** Submit the single pdf file, together with a separate Excel file (that includes all data sets in different spreadsheets) exclusively through Canvas (so, you are supposed to submit only two files).

Good luck and have fun!
