APS 502 Computational Project #2

Instructions: This is an individual assignment. For the mean-variance optimization (MVO) you need to (1) formulate the model by hand (typed is better) with all variables defined and the model objective and constraints fully written out and (2) print out the MATLAB file that contains the data (e.g. through the vectors/matrices) and call to *quadprog* used to compute the model in MATLAB and the output from calling *quadprog* that shows the optimal values for the variables and objective function value.

Do not just dump the MATLAB file, comment it and highlight the optimal values. You must use MATLAB *quadprog* function but you can call the function from python in which case you must print out your python code. Your project should be contained in a single pdf file (DO NOT MAKE THIS FILE TOO LARGE i.e. less than 10MB) and when you send me the file via e-mail (rkwon@mie.utoronto.ca) MAKE THE SUBJECT OF YOUR E-MAIL *exactly* as **APS 502 Computational Project 2. (I will not accept an e-mail that contains a link to your assignment, you must send me the assignment directly). Write your full legal name and student number on your assignment. Due Dec.9 by 5:00PM (EST). Late assignments will incur penalty.**

PART 1

You will use the following three ETFs (exchange-traded funds) to form a portfolio of these three assets. An ETF operates just like a stock, but these assets represent market indices or broad set of securities (stocks or bonds). For example, the purchase of one share of **SPY** (see below for description) represents an investment into the 500 stocks in the S&P 500.

(1) **SPDR S&P 500 ETF (SPY)**, this is a fund that mimics the performance of the S&P 500 which is a well known market index consisting of 500 large capitalization stocks from the U.S.

(2) **iShares Core US Treasury Bond (GOVT)**, this is a fund that mimics the performance of a wide set of U.S Treasury bonds.

(3) **iShares MSCI Emerging Markets Mini Vol (EEMV)**, this is fund that mimics the performance of emerging market stocks but with lower volatility compared to other emerging market funds.

Tasks

(a) Use yahoo (e.g. yahoo.com or yahoo.ca) finance to get the monthly adjusted closing prices of **SPY, GOVT**, and **EEMV** from Jan 2014 to end of Feb 2020 and compute the expected returns of the three assets, the standard deviations of the three assets as well as the co-variances between all assets over this time period. Show these parameters in your report but you don't have to show the monthly prices or the computations that you did to get the parameters.

(b) Use the mean-variance optimization model to generate an efficient frontier of the three assets. Create a table where for each expected return goal R show the optimal weights of the assets as well as the portfolio variance value.

Also, plot the efficient frontier. Note: the range of R can be the smallest positive expected return among the three assets to the largest expected return among the assets. You are free to choose the points in the range to use for the optimizations but they should be at least 10 return points equally spaced out.

(c) Take the minimum variance portfolio from (b) (this is the portfolio in the efficient frontier with the lowest variance). Using monthly returns from only March 2020 compare the minimum variance portfolio with the equal weighted portfolio and a portfolio that has 60% in **SPY**, 30% in **GOVT**, and 10% in **EEMV**. Rank the 3 portfolios in terns of returns. Explain the relative performance of the portfolios.

Note: A formula sheet will be posted on the blackboard that you can use to get the parameters for **PART 1** from the monthly adjusted closing prices. To compute a historical monthly return, use the closing price for the first trading day of a month and the closing price of the last trading day of the month.

PART 2

Repeat (b) of **PART 1** using the stocks **SPY, GOV, EEMV** as well as the stocks below (so portfolios will have 8 assets now) that have heavy involvement and connection to development or use of blockchain technology (some people think that these stocks are going to do well in the future)

(4) CME Group (**CME**)
(5) Broadridge Financial Solutions (**BR**)
(6) Cboe Global Markets (**CBOE**)
(7) Intercontinental Exchange (**ICE**)
(8) Accenture (**ACN**)

Compare the efficient frontiers from **PART 1** and **PART 2**. Does including the stocks in **PART 2** lead to better portfolios? Discuss.