First assignment Quantitative Financial Risk Management
Market Risk

The purpose of this assignment is to set up a functioning VaR system for a portfolio, and to evaluate various methods of VaR and ES forecasts.

Your portfolio must be a combination of stocks or stock/commodity indices and bonds or loans.

For stocks, choose three to five assets. These can be individual stocks, but better these should be market indices and / or ETFs (S&P500, NIKKEI, Emerging market indices, commodity indices, sector ETFs, bitcoin or anything you like). Make sure that your assets are NOT denominated in the same currency, so you should have some FX exposure. You can have long and short positions in your portfolio, but long only is fine too.

Regarding bonds/loans: you must have some interest rate exposure in your portfolio, so either it should be leveraged, i.e., contain a loan against some floating rate such as LIBOR or EURIBOR (plus some credit spread) or it has to contain a "cash" account which receives a floating interest.

For all methods, VaR and ES should be calculated at confidence levels 0.975 and 0.99, and for the time horizon of 1 trading day, unless stated otherwise.

You have complete freedom to choose your implementation tools. You can use Python, Matlab, R, or another algorithmic computer language. Note that Excel will not be enough.

- Download 8 to 10 years of daily data (for your portfolio), from e.g. Yahoo Finance or DataStream, and synchronize the data, deleting or inserting mock quotes for days when there is no trading in at least one of the portfolio constituents.

- Implement and backtest VaR and ES for the two abovementioned confidence levels and 1-day horizon using the following methods:

    - Variance-Covariance method based on the multivariate normal distribution. Investigate the sensitivity of your results to the length of the estimation period, i.e., estimate the variance-covariance matrix based on different past periods and compare the resulting VaR and ES estimates. Especially investigate the differences when you do and do not include stressed periods. Use historical returns on your assets and historical portfolio returns to assess the validity of the normal approximation, by e.g. comparing the histograms to the densities of the normal distribution and/or by a QQ-plot.

- A version of Variance-Covariance method, where you use Student-t distribution with 3, 4, 5 and 6 degrees of freedom instead of the Normal distribution. Again, check Student-t assumption with QQ plots.

- Historical simulation method. Again, use different number of years for your historical simulation (e.g. 5 and 10 years) and compare the VaR and ES estimates.

- Constant Conditional Correlation method, where you estimate and use GARCH(1,1) model with normal innovations applied to each risk factor, together with constant correlation matrix.

- Filtered Historical Simulation method with EWMA for each risk factor.

- Backtest your VaR systems outlined above, by comparing the expected and the actual number of VaR violations per year and the average discrepancy between these two over all years. Also compare the expected shortfalls with average (per year) shortfalls. Plot the VaR violations against the time to investigate whether VaR violations occurred in clusters (indicating dependency between violations) or were evenly spread out in time.

- Compute empirical 5- and 10-days VaRs using historical simulation method (use non-overlapping data!), compare them to the VaRs obtained from the one-day VaR with the square root of time rule and assess the adequacy of this rule applied to your portfolio.

- Complement your VaR system with stress testing, where you let extreme scenarios happen to your main risk factors. Use the following guidelines to generate extreme scenarios (use separate scenarios for risk factors, so not combinations of these):
  - Equity index values or stock prices changing by +/- 20% and +/- 40% of the current values.
  - Currencies moving by +/- 10% for major currencies and +/- 20% for other currencies.
  - Commodity prices changing by +/- 20% and +/-40% of the current values.
  - Interest rates shifting by +/- 2% and +/- 3%.

Write a concise report containing your findings, illustrated by graphs (where necessary and/or appropriate) and tables of results, both similar to that in Section 9.3.4 of the new QRM book (see e.g. Tables 9.1, 9.2 and Figures 9.5, 9.6).

Put yourself in a role of a risk analyst/external risk consultant hired by a financial institution, to help them decide which approach to VaR modeling they should implement for their specific portfolio. Include your conclusions and recommendations.