



Instructions

In the group project for Introduction to Financial Engineering, your team acts as stock portfolio managers. An investor has commissioned your team to pick and analyse a portfolio of stocks. Financial data must be chosen, presented, and analysed in a report.

In the following pages, the precise analysis is outlined step by step. BUT the ordering of questions is to illustrate the order in which the questions is naturally addressed when doing the various calculations and analysis. You should write one coherent, self-contained report where you provide the theory, the results from your analysis, and the conclusions summarized and/or presented in graphs and tables.

ANY REPORT REFERRING TO QUESTION "THIS AND THAT" WILL NOT BE APPROVED – it must take the form of a coherent, self-contained report referring to itself and relevant literature.

Along with the report, you must submit a file/folder with code that documents the calculations.

The analysis of returns vs. log returns is up to the students. Please provide arguments for your choice(s) and make sure that your calculations are internally consistent.

The total number of pages is 3, including this front page.

Stock data

Your client would like to invest in USD stocks and wants you to pick a diversified portfolio. You may assume that the risk-free rate of return is 0.02 (2%). Download daily adjusted closing prices from Yahoo! Finance from January 1, 2016, until January 1, 2022, for eight stocks of the S&P 500 Index¹ fulfilling the following characteristics:

- No two stocks must have strongly² correlated returns
- No more than two stocks should represent the same industry groups³
- If one of your stocks exhibits some sort of extreme behavior compared to the rest, it might be a good idea to replace that stock
- IMPORTANT: As soon as you have picked your eight stocks, email nilan@dtu.dk with the chosen tickers! This allows me to see if there is anything odd with your chosen data that might cause confusion or trouble.

Data presentation

After choosing the eight stocks, present the data to your reader. E.g.,

- Which stocks have you picked, and which industries do they belong to?
- How do historical prices/returns look?
- What are the average historical returns (in annualized terms), standard deviation of returns (also in annualized terms), and correlation between returns?
- What does the distribution of returns look like?
- What are the range, skewness and kurtosis of the returns?
- What is the Sharpe Ratio for the stock?

Data analysis

After the initial data presentation, you should carry out relevant data analysis

- How does the auto-correlation and partial auto-correlation of returns look for each of the stocks? For (at least) two stocks, determine the time series component (trend, seasonality, and stationary).
- Determine if the returns of the stocks exhibit volatility clustering.
- For (at least) two assets, choose an appropriate ARIMA/GARCH/ARIMA-GARCH model for returns and estimate the parameters using an appropriate estimation method:
 - If the appropriate model contains both an ARIMA-part and a GARCH-part, the correct approach is to estimate the parameters simultaneously. However, this is not straightforward in Python⁴, so we will accept that you first estimate the ARIMA-part and thereafter estimate the GARCH part on the residuals from the ARIMA-part.
 - In Matlab⁵ and R, it's fairly straightforward to do the joint estimation, so if you are working in any of those programs, you are free to choose between step-wise estimation or joint estimation.

¹Wikipedia seems to have a somewhat updated list of S&P companies including their industry, so if you don't know eight tickers, this is a good source of inspiration

²Here, we define two stocks to be strongly correlated if $|\rho| > 0.7$

³According to the Global Industry Classification Standard, GICS

⁴<https://medium.com/analytics-vidhya/arima-garch-forecasting-with-python-7a3f797de3ff>

⁵<https://se.mathworks.com/help/econ/fit-a-composite-conditional-mean-and-variance-model-to-nasdaq-returns.html>

Portfolio theory

Even though your results from the data analysis show that mean and (co-)variances are not constant over time, this is now assumed. Based on Markowitz' portfolio theory, derive and illustrate the optimal portfolio choices. Identify the following portfolios in terms of weights, return and risk:

- Risky-assets only global minimum variance portfolio
- The tangent portfolio
- Risky-assets only global minimum variance portfolio with no short selling allowed
- The equal weights portfolio
- Risky-assets only minimum variance portfolio, where no more than 20% of the wealth is allocated to each stock and no short selling allowed
- Risky-assets only minimum variance portfolio, where at least 8% of the wealth is allocated to each stock and no short selling allowed⁶

Portfolio performance

Download daily data from Yahoo! Finance from January 1, 2022, until today for your eight stocks.

- Calculate, report, and comment on the performance of each of your six portfolios during 2022. Do the portfolios behave as expected?
- Many of the metrics used to describe data are also suitable for reporting performance, i.e., annualized return and volatility of the portfolios, the minimum and maximum daily returns, and the Sharpe ratio.
- Use your estimated ARIMA/GARCH/ARIMA-GARCH model for the two selected stocks to perform a forecast for the year 2022, like in section 14.13. How does this compare with actually observed returns during 2022?

⁶Hint: For the two final portfolios, you can use the same approach as for the no short selling and add the relevant restriction. But there is not necessarily a solution fulfilling all constraints for all values of $\mu \in [\min\{\mu_i\}, \max\{\mu_i\}]$ as there is in the no short selling case.