Financial Modelling (BEAM046) Term 1 2022/3

Week 4 Tutorial Case: Value at Risk

You are a risk management analyst for an investment bank. Your manager wants you to compute VaR at a range of confidence levels between 50% and 100% for a position in call options on Apple (ticker symbol AAPL) with a maturity of closest to two months and a strike price of about 90% of the stock price (the use of 90% is simply to identify an option whose strike price is slightly below the stock price, and hence reasonably liquid). The VaR horizon is the maturity of the option contract. She would also like youto compute the VaR for the underlying stock.

You decide to estimate VaR using Monte Carlo simulation. Monte Carlo simulation proceeds by generating simulated price paths for the underlying asset, valuing the option portfolio at the VaR horizon for each of these simulated price paths, and using the distribution of portfolio values across all the simulated price paths to estimate the portfolio VaR.

1. Assume *today is 14/10/2022*. Obtain the option price, associated underlying stock price and time to expiry from www.cboe.com (go to 'Data' then 'Quotes Dashboard' and enter the ticker symbol in the search box; Choose 'Options', change the Options Range to 'All' and select the appropriate Expiration, then press 'View Chain').
2. The template provides you with one year of daily data on the adjusted close price for the underlying stock from finance.yahoo.com. Use this to calculate daily log returns and estimate daily volatility.
3. To simulate the stock price on day t, P_t, we will assume that daily log returns, $r_t = \ln(P_t / P_{t-1})$, are normally distributed with a zero mean and a variance of σ^2. From the definition of the log return, we can write:

   $$\ln P_t = \ln P_{t-1} + r_t = \ln P_{t-1} + \sigma\varepsilon_t$$

   , where σ is the standard deviation of daily log returns and ε is a standard normal variable (i.e. a normally distributed variable with a zero mean and unit variance).

   We can therefore simulate the stock price each day by generating a series of standard normal variables, and applying the above formula, using our estimate of daily volatility from Step 2. Use the random number generator in Excel (Data/Data Analysis/Random Number Generation) to generate 1000 realizations of a standard normal random number for each day.

4. Using the simulated values of ε, the today's stock price, P_0, and your estimate of daily volatility, σ, compute the series for lnP for each realization. Compute also the series P_t.

5. Using the simulated value of P_t (the price of the share at the expiry date of the option), compute the value of the option, C_T, at expiry.
6. Using the simulated values of P_T and C_T, compute the simple return on the stock and the option over the life of the option (i.e. from day 0 to day T), for each realization. Plot the distributions of the simulated stock and option returns. Use the simulated returns to compute the VaR for the stock and the option.
7. Conduct sensitivity analysis for volatility. Allow volatility to range from 1.5% to 2.5% in increments of 0.1%. How do the MCS estimates for the 95% VaR change with volatility?