Worksheets “AMZN”, “GM”, “JPM” contain monthly data of US stocks Amazon.com, Inc., General Motors Company, and JPMorgan Chase & Co. from December 2012 to December 2022. Data are downloaded from Yahoo!Finance.

Worksheet “FF5 Factors” contains monthly returns data of Fama-French 5 factors (market factor “Mkt-RF”, size factor “SMB”, book-to-market factor “HML”, operating profitability factor “RMW”, and investment factor “CMA”), as well as monthly risk-free rate “RF”. Data are downloaded from Kenneth R. French’s website.

RMW (Robust Minus Weak) is the average return on the two robust operating profitability portfolios minus the average return on the two weak operating profitability portfolios.

CMA (Conservative Minus Aggressive) is the average return on the two conservative investment portfolios minus the average return on the two aggressive investment portfolios.

Use these data to answer Question 1.

You can add worksheets in Excel and modules in VBA whenever necessary.

Question 1. Go to Worksheet “Q1”.

You can use Excel functions or your own VBA function/sub procedures to do calculations.

(1) Calculate monthly log returns of three stocks from January 2013 to December 2022. Report the results in highlighted range in columns C:E.

(2) Estimate the input parameters, including expected monthly returns, standard deviation of monthly returns, sample variance-covariance matrix and sample correlation matrix of monthly returns of three stocks. Report the results in highlighted ranges in columns H:J.

(3) We will construct an equal-weight portfolio with the three stocks (AMZN, GM, JPM) and simulate the portfolio value after 1 year.

At the beginning of 2023, the investor constructs an equal-weight portfolio (1/3 of total wealth in each stock) with AMZN, GM, and JPM. The initial investment is $100,000.

Assume that stock returns of three stocks follow Geometric Brownian motion (GBM). At the end of each month, the investor will **rebalance the portfolio** such that the proportion of total wealth invested in each stock is still 1/3. Assume that this is a self-financing portfolio.

Simulate portfolio value at the end of each month from January 2023 to December 2023.

Note: VBA function `Cholesky` *is given in Module “Cholesky_fn”.*

(4) Use **Data Table function** to repeatedly simulate the portfolio value at the end of December 2023 for 20 times.

Please include all the calculations in the indicated area in Worksheet “Q1”. You may use Excel functions or VBA codes to generate results. You may add rows and columns in this worksheet whenever necessary.

Question 2. Go to Worksheet "Q2".

In this question we use Monte Carlo simulation method to price an Asian option. We assume that the underlying stock follows geometric Brownian motion (GBM) under the risk-neutral measure:

$$\frac{dS}{S} = (r - q)dt + \sigma\varepsilon\sqrt{dt}$$

Then the stock price at time *T* is given by

$$S_T = S_0 \exp\left(\left(r - q - \frac{\sigma^2}{2}\right)T + \sigma\varepsilon\sqrt{T}\right)$$

where S_0 is the current stock price, *T* is time to maturity, *r* is the continuously compounded risk-free rate, *q* is the continuous dividend yield, and σ is the volatility of the underlying stock.

Asian option is an example of a path-dependent option, which means that the value of the option at expiration depends upon the path by which the stock arrived at its final price. There are numerous kinds of Asian options. In this question, we value an "**arithmetic average price**" put option. Its terminal payoff at expiration date is

$$V(T) = \max(K - A(S,T), 0)$$
$$A(S,T) = \frac{1}{n}\sum_{i=1}^{n} S_{i\Delta t}$$

where $\Delta t = \frac{T}{n}$ is the time step in GBM model. That is, we equally divide time interval $[0, T]$ into n subintervals. $A(S,T)$ is arithmetic average of underlying stock price at time $\Delta t, 2\Delta t, \dots, n\Delta t\ (= T)$.

Then option price is calculated as the expected payoff at maturity *T*, discounted by risk-free rate over the same period, that is e^{-rT}.

Worksheet "Q2" gives the information of an arithmetic average price put option. It will expire in 6 months. $A(S,T)$ should be calculated as the average of stock price after 1, 2, …, 6 months. Therefore, time step $\Delta t = \frac{0.5 \text{ year}}{6} = 0.0833 \text{ year} = 1 \text{ month}$.

(1) In VBA Module "Q2", write a sub procedure called **`MCMAsian`** that takes the following actions:

- Read the input parameters into the sub procedure.
- Simulate a time path of stock prices month by month from today until 6 months later (expiration date).
- Calculate arithmetic average of stock price from the simulated time path and calculate the terminal payoff of this Asian option $V(T)$.
- Repeat the simulation for 100 times.
- Write 100 simulations of the terminal payoff of the Asian option in range B20:B119.

(2) In cell B16, calculate the Asian option value based on these 100 simulations (using risk-neutral valuation).