Required: Complete the following tasks by providing a report with your answers to all questions in a Word or PDF file and your code in a single Python file for the submission.

Case Study 1

1.1 Download the following data from Yahoo! Finance and extract the month-end data (e.g., 1981-01-31, 1981-02-28, 1981-03-31, etc.):

- S&P 500 Index (^SPX): Represents the price values of the S&P 500 Index.
- NASDAQ Composite (^IXIC): Represents the price values of the NASDAQ Composite Index.
- CBOE Volatility Index (^VIX): Measures the market's expectation of 30-day volatility.
- 13-Week Treasury Bill (^IRX): Represents the 13-Week Treasury Bill Yield (in percentage points). Yahoo Finance presents this data in a format similar to stocks, which can include columns like Adjusted Close (Adj Close), Close, Open, High, and Low. For example, "Adj Close" refers to the adjusted yield at the end of the trading day.

Consider the differences among the various types of data columns (e.g., Adjusted Close, Close, Open, High, and Low) and select the most appropriate data type for the S&P 500 Index to estimate and generate the following returns, covering the period from December 2004 to November 2024:

- Monthly Return: Calculate the periodic return for each month (print out the first 5 and last 5 records).
- 20-Year Compounded Return: Compute the total compounded return over the specified 20-year period.
- Annualized Return: Use the natural logarithm method to calculate the average annualized rate of return for the entire period.

Note: The natural logarithm method is commonly used for annualizing returns, estimating the average annualized rate of return based on logarithmic (or continuously compounded) returns. The formula is:

$$Annualized\ Return = \frac{ln\ (Compounded\ Return)}{Number\ of\ Years}$$

Where ln is the natural logarithm function and *Compounded Return* refers to the total return achieved over the entire period, expressed as the accumulated product of periodic growth factors.

[12 marks]

1.2 Generated the moving average of NASDAQ Composite with window sizes of 3 months and 36 months, respectively. Plot the stock price along with the moving average lines on the same graph. In your own words, explain how moving averages are used in stock market analysis to help investors make informed decisions, as well as discuss their potential limitations.

[10 marks]

1.3 How could a spike in the VIX affect short-term interest rates (IRX), considering factors such as investor behaviour, market liquidity, and the role of safe-haven assets during periods of heightened market stress? Use your own words to explain, incorporating historical examples to support your arguments.

[12 marks]

1.4 Based on the data outlined above (i.e., ^SPX, ^IXIC, ^VIX, and ^IRX), discuss how machine learning models could be applied to the following:

- Analysing tail risks: For instance, detecting regime shifts[1] between implied volatility and realized volatility.

[1] The term “regime shifts” refers to significant changes or transitions in the behaviour, structure, or relationship between variables - such as implied and realized volatility - that often correspond to changes in underlying market conditions.

- Predict market trends: For example, forecasting annualized returns for the S&P 500 Index or NASDAQ Composite Index.

You are not required to implement these models in code. Instead, explain in your own words how you would design models to address these problems. Discuss which machine learning algorithms would be most suitable for each task and identify potential features that could enhance predictive accuracy. Justify your choices, including features derived from the above dataset sources (e.g., moving averages) and/or external economic indicators.

[16 marks]
[Total: 50 marks]

Case Study 2

As a financial analyst, you are tasked with evaluating the effectiveness of hedging strategies using options. Your team aims to understand how to construct and analyze option spreads. Use Python to create visualizations for the following strategies, based on the selection of parameters below:

Stock Price Range: S from $[50,55,\dots,150]$
Options:
Strike Prices: $K_1 = 90, K_2 = 100, K_3 = 110$
Time to Maturity: $T = 1$ (in years)
Risk-Free Rate: $r = 0.05$
Volatility: $\sigma = 0.25$
Others:
Inflation rate: $i = 0.03$

3.1 Construct the following option spreads:

- Bull Call Spread: Buy a call with K_1, sell a call with K_2.
- Bear Put Spread: Sell a put with K_2, buy a put with K_3.
- Straddle: Buy a call and a put with K_2.

For each strategy, plot the payoff and profit/loss at expiration for the given range of stock prices and discuss the breakeven points and maximum profit/loss.

[16 marks]

3.2 In your own words, explain the objectives and risks of each strategy and discuss their performance in high-volatility versus low-volatility markets.

[12 marks]

3.3 Further analyze and discuss how dividends on the underlying stock (assume a dividend yield of q) would influence the payoff and profit/loss of these strategies.

[10 marks]

3.4 Compare the use of option spreads (such as straddles), to protect against tail risks (e.g., Black Swan events) versus an alternative instrument (such as swaps or CDS). Use your own words to discuss the advantages and limitations of each approach.

[12 marks]
[Total: 50 marks]

Deadline: Wednesday, 8th January 2025, 14:00 GMT