PROJECT DETAILS

GROUP SIZE: Projects should be in groups of 3-5. You should organize your own groups.

PROJECT TECHNOLOGY: Please use Python and deliver Jupyter Notebooks.

THE PROJECT COMPRISES TWO TASKS:

- **Individual Component –** To be completed individually, you can help each other but remember I will see your code and this should not be copied from one to another.
- **Group Component –** To be completed by the group.

DELIVERABLES:

- Solved notebooks for each individual component. Make use of markdown cells and comments to show you understanding of the code.
- Solved notebook for group component.
- Either:
    - ~10 minute video of the group explaining the workbook for the group component. Demonstrate your understanding of what is happening and why you made the decisions you did. You will likely need to provide a link to this video.
    - Presentation in person of the jupyter notebook with questions from Professor.
- **Please submit via Moodle.**

DUE DATE: JUNE 24th 23:59h

Please contact me with any questions.

INDIVIDUAL TASK: GENERALIZED BLACK-SCHOLES & MONTE CARLO SIMULATION METHODS

You will examine the pricing of options for a stock or index that we will assume follows a log-normal model (geometric Brownian motion), i.e.,

$$\frac{dS_t}{S_t} = \mu dt + \sigma dW_t,$$

where W_t is a Wiener process, μ the constant drift, and $\sigma > 0$ is the diffusion coefficient.

1) Select a stock or index with liquid options in the 1 to 3 month range. Name your stock/Index.
   a) Pick a expiration timeframe T to consider in this range.
   b) Pick the strike price available closest to the current price.
   c) Determine the risk free rate you will apply and find the value.
   d) Estimate volatility for the calculation of options prices.
   e) Consider if you will include a dividend yield and estimate if so.

2) Estimate European Call and Put option prices using you previously decided values with the generalized Black-Scholes formula.
   a) Confirm that the put-call parity holds.
   b) Estimate and analyse the Greeks (e.g., delta, gamma, theta, ….) for both contracts.
   c) Pick a contract and simulate a delta-hedging strategy over the life of the option.

3) Estimate the fair value of the call & put option contracts using Monte Carlo (MC) simulation methods considering 50000 simulations.
   a) Compare price results with those obtained using the Black-Scholes formula. Compare both to actual market results.
   b) Estimate the Greeks (e.g., delta, gamma, theta, ….) using MC simulation for both contracts.

GROUP TASK: OPTION PRICING: CRYPTOCURRENCIES

As an emergent area of finance options on cryptocurrencies are relatively low volume but of growing interest to traders. Opinions differ on the properties of cryptocurrencies for simulation and hedging purposes. Some argue they act as currencies, some say they act as stores of value like gold, while others argue they act as commodities (inputs to other businesses). A few early studies in the literature have shown that options on Cryptocurrencies can be mispriced, and profit-making opportunities might exist.

1) Pick a crypto currency (Bitcoin or Ethereum) you will analyse. Use https://www.deribit.com/ to collect prices[1] for put and call options for your selected cryptocurrency that are near the money (closest strike price to current price) for the different time periods (1 day to 4 Quarters) available. Assume the Cryptocurrency follows a log-normal model (geometric Brownian motion), i.e.,

$$\frac{dS_t}{S_t} = \mu dt + \sigma dW_t,$$

   where W_t is a Wiener process, μ the constant drift, and $\sigma > 0$ is the diffusion coefficient.

   a) Estimate volatility using different historical time series of varying lengths.

   b) Calculate the implied volatility for different option lengths and compare to the historical volatility. What does this tell you?

   c) Use an approach of your choice to value options and compare to traded prices. Do you find any potential opportunities? What might this say about your approach or the market?

One issue with our Black-Scholes approach to pricing is that the main assumptions underlining the Black-Scholes model (constant volatility, Gaussianity and Geometric Brownian Motion processes for returns) may not apply to the cryptocurrencies. Your goal is to improve our estimation of prices compared to a simplistic BSM model.

2) Research and select an alternative model (or multiple alternative models) for cryptocurrency option pricing. It might not surprise you to find a number of different approaches have been tested, take a look in the literature and select the model(s) that you believe are the most

[1] Derbit options are technically inverse options, in that they are settled in cryptocurrency not in USD. However, you can take the quoted prices that are listed in USD as an oversimplification. If you are interested in pricing inverse options see: Alexander, C., & Imeraj, A. (2021). Inverse options in a Black-Scholes world. Available at SSRN 3893037.

promising. For example, you could look at improving the modelling of volatility or using machine learning to estimate prices. You can look at methods from traditional finance or those specific to cryptocurrencies. If you need a starting point, you can take a look at the review paper from Almeida, J., & Gonçalves, T. C. (2022). A systematic literature review of volatility and risk management on cryptocurrency investment: A methodological point of view. Risks, 10(5), 107. **Remember** you don't need to test all the options listed just a few alternatives you believe are promising.

a) Explain your approach and the theoretical advantages over Black-Scholes-Merton.
b) Fit the model(s) and compare your pricing results. How do they compare to the market and those previously derived? Can you draw any insights?