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 and answer the discussion questions. Please provide csv files (or excel) so that your code is recreate-able.
- Solved notebook for group component and a ~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.
- **Please submit via Moodle.**

DUE DATE: APRIL 21st 23:59h

Please contact me with any questions.

INDIVIDUAL TASK: OPTIONS STRATEGIES

Imagine you are an investor that has decided they are extremely risk adverse and wants to invest in such a way as to remove as much risk as possible.

In this assignment, you will construct a **box spread** using real-world market data, analyze the potential returns, and critically evaluate the risk-return profile of this strategy. Your aim is to examine this strategy in detail.

1) Select a stock or index with liquid options in the 1 to 12 month range. Name your stock/Index.
    a) Pick an expiration timeframe within the next 12 weeks.
    b) Select the options you would use to create a box spread.
    c) Price the options with Black Scholes Merton approach to pricing.
    d) Price the options with real quote data, make sure you use the correct data assuming that you are actually going to construct this strategy.
    e) Save the quote data to csv so that the following work can be recreated.
    f) Report the payoff at expiration, the profit, and the return.
    g) Determine the "Greeks" for your strategy.
    h) Comment on what you have found, is this value what you would expect? Will this strategy provide this return risk free? How will it react to different market changes? What would a trader need to take into account?
2) Expand your analysis to try to find the range of returns possible to achieve in the market with a box spread. You want to find both the best possible return, the worst possible return, and try to understand the range of values. Consider different underlying, options, timeframes etc. Remember this should be a box spread that is attempting to be "risk free" or have a certain payoff.
    a) You are going to need many options prices for this part of the project. Please save these all to csv (and load them in) in such a way as that you results could be re-creatable.
    b) Report what you find in terms of possible returns.
    c) Discuss what you found, were there any differences? Why? How did you determine best or worst?

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 BTC, Ethereum ETH, Binance BNB, Solana SOL, or Ripple XRP) 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) Download the options and historical prices to csv that you will use so that all analysis can be recreated.

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

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

   d) Explore the market implied volatility (volatility surfaces) what do you find? What does it tell you about crypto currency?

   e) How would you use the available options to achieve the following, calculate exactly what you would buy and plot the expected payoff of the entire portfolio:

      i) Insure against downside risk on an existing portfolio of the underlying with a value of €10 million but retain upside exposure.

      ii) Achieve the above insurance against downside risk in a cheaper manner by giving up upside exposure.

[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.

iii) Profit from the belief that volatility in the future will be higher than currently priced by the marked.

f) Use an approach of your choice to value options and compare to traded prices (assuming underlying follows GBM). 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 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 and why it is more appropriate for cryptocurrency.
   b) Fit the model(s) and compare your pricing results, how do they compare to the previously calculated values in questions 1?
   c) Use Monte Carlos Simulation to compare the distribution of potential payoffs between your approach and an approach that uses the BSM model/assumptions.
   d) Calculate or estimate the Greeks and compare to an approach that uses the BSM model/assumptions.
   e) What do you find? How do results compare to the market and to BSM? Can you draw any insights?