Research Lead Assignment

C11 Labs

Assignment overview As part of this assignment, you are tasked with solving at least two challenges spanning from DeFi Math, Market Making and Project Discovery. You will be expected to demonstrate a structured approach to tackling uncertainty, a critical aspect of the Research Lead role. Documenting your methodologies, assumptions, and steps will be as important as arriving at the correct solution. We encourage the use of any resources or tools that help you achieve your goals.

Instructions

- You will have 14 days from the date of receiving this assignment to complete it.
- You must solve **AT LEAST TWO CHALLENGES** from the list below. Of course, you are welcome to solve more than two.
- You are not expected to know everything immediately. The task is designed to assess your approach to handling uncertainty.
- Provide a clear explanation of the methodologies used, including documentation of your thought process, research, assumptions, and testing strategies.

1 Challenge: Project Discovery

In this challenge you are expected to demonstrate your ability to discover and evaluate potential long tail-alpha opportunities in decentralized protocols. **You are not expected to leak any alpha**, but just a creative challenge to demonstrate your research attitude. Ideally, this would help us assessing how do you find new projects and what are your protocol-microstructure analysis skills when dealing with new protocols.

Deliverables: A pdf report including the following information:

- The project you choose and why you chose it (e.g., inefficiencies, mispricings, statistical arbitrage, flaws, ...)
- Explain how you found the project (e.g., through friends, Twitter, observing other bots, ...).
- Technical Breakdown: Describe the project's core functionality, protocols, or smart contracts. Reverse-engineer or dive into the documentation.

2 Challenge: Long Tail Alpha

Consider the following old contract on Ethereum mainnet (click here to show on Etherscan).

- What is the purpose of this contract? Is it part of a broader protocol? If so, what is the protocol mechanism and how does it work?
- Do you think that there used to be a risk-free arbitrage opportunity in this contract? If so, how would you have implemented it to outperform your competitors?

Deliverables: A pdf document containing the answers to the questions above. You can use any tools or resources you find necessary to answer the questions. If there is any code involved, please provide it as a separate file attached to the mail.

3 Challenge: DeFi Math

This challeng involves DeFi math and coding. You are expected to provide a solution to the first two tasks, including the derivation of formulas. The last task is optional.

Deliverables: A pdf document containing the solutions to both parts, including the derivation of formulas and any code (if used) to solve the problems. The use of desmos charts or any other visualization tools is encouraged.

Scenario: You are dealing with a DeFi pool involving two assets (USDC and ETH), and the pool follows the invariant function (mapping reserves to a certain liquidity level). The invariant function is given by the formula:

$$L(x, y) = x^2y + y^2x$$

3.1 Task A: Determining reserves

Problem Statement: Given that the current liquidity level is $L_0 = 10$ and that the USDC reserves are $x_0 = 42$, determine the ETH reserves, y_0.

Expected Output: Derive the expression for y_0 in terms of x_0 and L_0.

3.2 Task B: Swap Scenario - Exchanging ETH for USDC

Problem Statement: Assuming no swap fees, and given the computed reserves (x_0, y_0) from Task A, calculate the USDC expected amount d_x you would receive in exchange for selling $d_y = 5$ units of ETH.

Expected Output: Derive the expression for d_x in terms of x_0, y_0, d_y and L_0. If an analytical solution is not feasible, develop a numerical approach and document the algorithm and steps used to calculate d_x.

3.3 Task C: Arbitrage

Problem Statement: Suppose that you have the chance of buying or selling from your rich degen friend any amount of ETH you want at the price of 10 USDC per ETH. Given the computed reserves (x_0, y_0) from Task A, would you find convenient to perform a trade with the pool and then selling the proceeds to your friend? If so, what would be your profit?

Expected Output: Assess if it is convenient to interact with the pool. If so, specify which asset you would like to buy from the pool and which asset you would like to sell to the pool, with the associated amounts. Also, specify the profit you would make from the arbitrage by selling the proceeds to your friend.

4 Challenge: Walkthrough of the `rbuilder` repo

Provide an informative walkthrough of the rbuilder crate from the Flashbots repository

`https://github.com/flashbots/rbuilder/tree/develop`

You have **complete freedom in deciding the level of granularity**—your approach can be high-level or low-level as long as it provides a clear understanding of the system. We are not only looking for a descriptive analysis but are also interested in your research approach: how you choose to structure your exploration, prioritize certain areas, and uncover the architecture of the crate.

- Identify the key modules, describe their functionality. Bonus points if you can highlight any design patterns used (e.g., "Gang of Four" patterns or other innovative patterns) if present.
- Additionally, create a flowchart (using tools like draw.io, lucidchart or other) that illustrates the relationships between the core modules to give a clear overview of the workflow.

Deliverables:

- A pdf document containing the walkthrough of the repo describing the key modules and their roles.
- A flowchart that illustrates the relationships between the core modules to give a clear overview of the workflow.

5 Challenge: Market Making

You are tasked with building a basic market-making algorithm. You **can choose one** between two types of algorithms based on your preference:

- **Market-Making Around a Predictive Fair Value**: Design an algorithm that provides quotes around a predictive fair value, which you will need to develop.
- **Market-Making With Risk Management**: Design an algorithm that manages market-making risk, including handling inventory and adverse selection.

You will be provided with the following data

1. **Order Book Data**: Available in JSON format, covering all order books for a token over a specific period.
2. **Trade Data**: Available in CSV format, covering all trades for the token over the same period.

Once you have made your choice, analyse the data and provide a function or class that outputs quotes given certain states or inputs. Do not simulate the strategy.

While a Jupyter notebook (.ipynb) is preferable, you can do the analysis and code in the language you prefer. Please provide the logical steps you followed in a notebook, a presentation or a document, including:

- The rationale behind your choice of algorithm.
- The full derivation of the algorithm, including the mathematical model and assumptions.
- The possible risks and limitations of the algorithm.
- The expected output of the algorithm.