

DeFi Under the Microscope: A Mathematical Perspective on Data Science

Shen-Ning Tung

National Tsing Hua University

tung@math.nthu.edu.tw

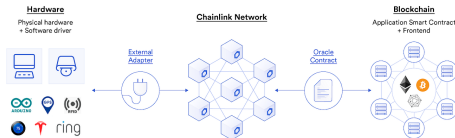
August 29, 2024

DeFi: A New Financial Paradigm

- Decentralized Finance (DeFi): Financial services on open blockchain protocols
- Key Foundations:
 - Smart Contracts: Self-executing contracts with the terms directly written into code
 - Game Theory: Incentive mechanisms for trustless, decentralized systems
 - Cryptography: Secure, tamper-proof transactions and data
- Data Science Opportunities in DeFi
 - On-Chain Data Analysis: Extracting insights from transparent, real-time blockchain data
 - Advanced Risk Modeling: Quantifying and managing risks in complex DeFi systems

Chainlink: Decentralized Oracle Networks

- Role: Securely connecting off-chain data to on-chain smart contracts
- Data Aggregation: Median of multiple oracle reports for accuracy
- Game Theory in Incentives:
 - Staking: Oracles deposit stake as collateral for honest reporting
 - Stake is slashed if oracle reports incorrect data
- Key Applications: Price feeds, Proof of Reserve, Verifiable Randomness



What Is a Blockchain Oracle?

The Graph: Efficient Blockchain Data Indexing

- Indexing Protocol: Transforms blockchain data into easily queryable subgraphs
- Key Features:
 - GraphQL: Utilizes a powerful and flexible query language
 - Subgraphs: Customizable APIs tailored to specific data needs
- Wide Adoption: Powers data for many top DeFi projects and applications

The GRAPH - Google Of Blockchains?

Dune Analytics: Collaborative On-Chain Data Exploration

- Community-Driven Platform: Users create, share, and explore SQL queries and dashboards
- Key Features:
 - Customizable Queries: Tailored SQL queries for specific research questions
 - Open and Transparent: All data and analysis are publicly verifiable
 - Collaborative Learning: Learn from and contribute to the community's work
- Mathematical Applications:
 - Data Visualization: Communicating complex on-chain data patterns
 - Statistical Analysis: Identifying trends and anomalies in DeFi activity

crvUSD dashboard DeFi Savings Rate Dashboard

Gauntlet: DeFi Risk Management Solutions

- Providing risk management services for DeFi protocols
- Key Offerings:
 - Stress Testing: Identifying vulnerabilities
 - Parameter Optimization: Tuning for risk mitigation
 - Smart Contract Auditing: Addressing security risks
- Mathematical Techniques:
 - Agent-Based Modeling: Simulating market behavior
 - Numerical Optimization: Efficient parameter tuning

How Gauntlet manages risk for top DeFi protocols

Simtopia: Open-Source DeFi Simulation Platform

- Flexible, modular platform for simulating DeFi ecosystems
- Key Mathematical Techniques:
 - Agent-Based Modeling: Simulate complex, emergent behaviors
 - Game Theory: Study strategic interactions and incentives
 - Stochastic Processes: Model uncertainty and randomness
- Research Applications:
 - Stress Testing: Evaluate protocol resilience
 - Mechanism Design: Optimize incentives and parameters
 - Market Dynamics: Study emergent phenomena

Simtopia Github Repos

Case Study 1: Optimizing Lending Protocol Risk Management

- Objective: Reveal hidden risk patterns in lending platforms using data science
- Key Techniques:
 - Interest Rate Modeling: Capture interest rate dynamics under market conditions
 - Collateral Risk Modeling: Assess collateral value and liquidation risk
 - User Segmentation: Identify user behavior patterns using clustering algorithms
- Real-World Application: Gauntlet's Aave Market Risk Assessment
 - Evaluated collateral risks and optimized risk parameters
 - Improved platform resilience and stability

Aave Mega Dashboard

Gauntlet's Aave Risk Assessment

Case Study 2: Balancing LP Profits and Market Stability

- Problem: Fixed fees in CPMs can lead to LP losses in volatile markets
- Question: Can dynamic fees balance LP profits and market stability?
- Approach:
 - Model CPM dynamics under different fee structures
 - Simulate market behaviors and LP outcomes
- Insight: Dynamic fees based on market volatility can:
 - Maintain LP profits by compensating for risk
 - Stabilize markets by reducing price impact
- Recommendation: Implement volatility-based fee adjustment via governance

CFM simulations

The Future of DeFi and Data Science

- Advancement in Mathematical Risk Monitoring and Management:
 - Real-time, on-chain risk tracking and mitigation
 - Dynamic, self-adjusting risk parameters
- Innovation in Predictive Modeling and Simulation:
 - Improved market forecasting with machine learning
 - Realistic, high-fidelity simulations of DeFi ecosystems
- Call to Action for Applied Mathematicians:
 - Develop new mathematical models and techniques for DeFi
 - Collaborate with DeFi practitioners to solve real-world challenges