Decentralized Finance Navigates Every Route

DefiNER : A Solution Framework for Modeling and Hedging Impermanent Loss and Dynamic Liquidity Provision Using Deep Reinforcement Learning in Uniswap V3 with Concentrated Liquidity

NUS FINTECH SUMMIT 2024
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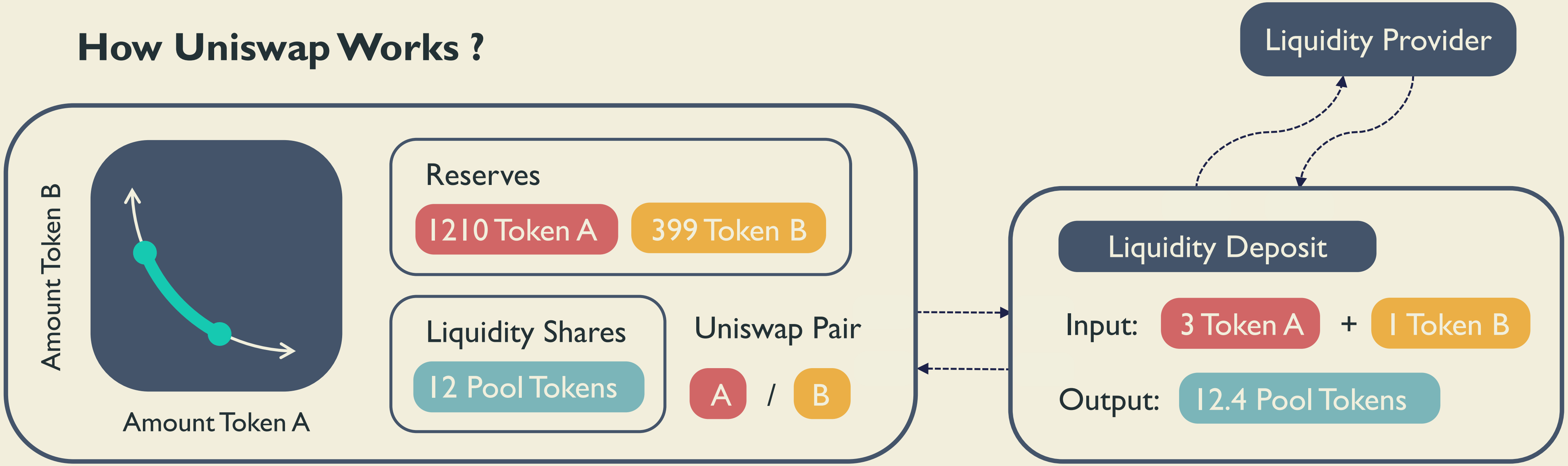
Problem Statement by

TokkaLabs

Background

“ In **Uniswap v3**, LPs can concentrate their capital within **custom price ranges**, providing greater amounts of liquidity at desired prices. In doing so, LPs construct individualized price curves that reflect their own preferences. ”

How Uniswap Works ?

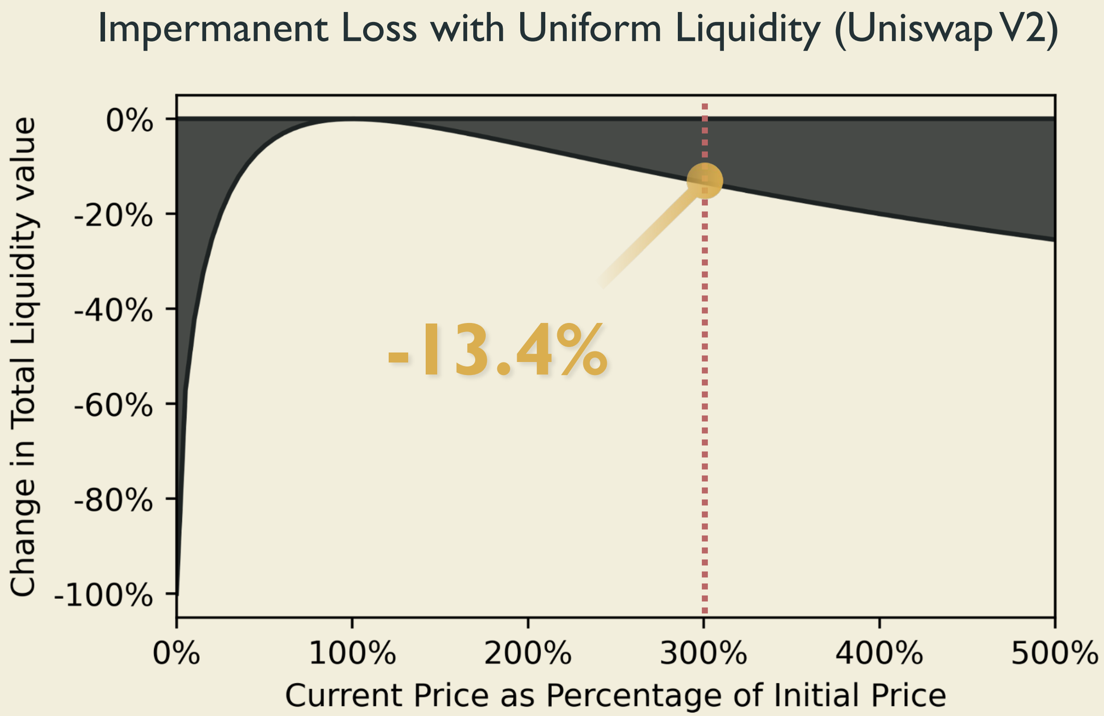


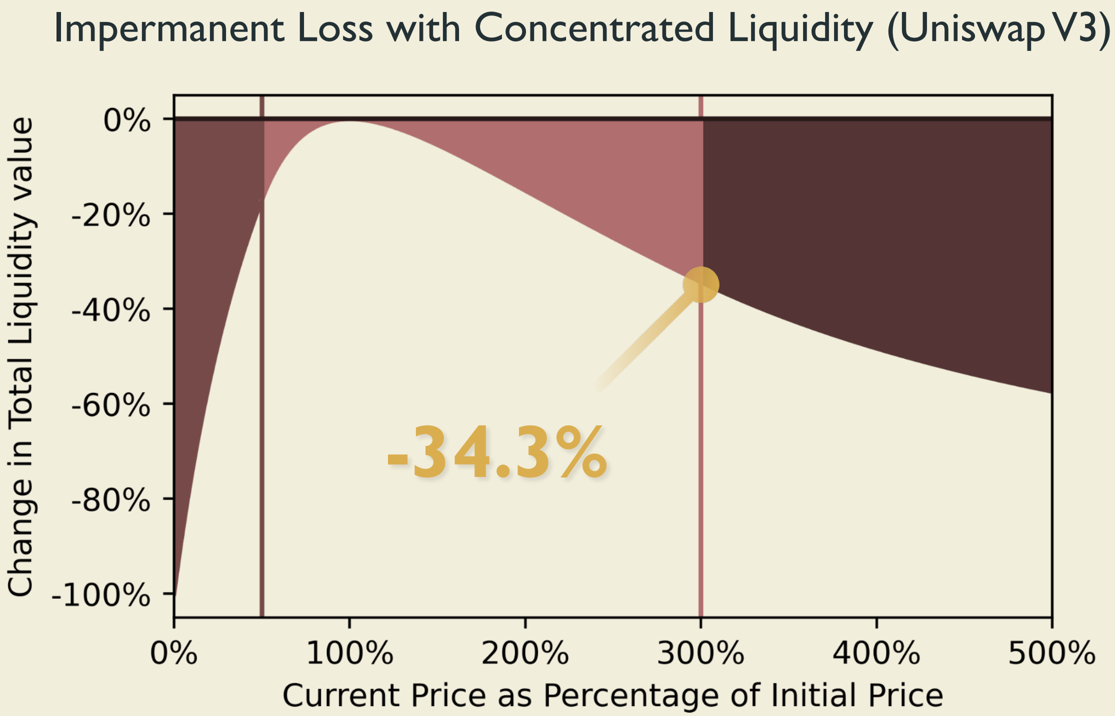
Introducing Uniswap v3. (2021, March 23). Uniswap Protocol. https://blog.uniswap.org/uniswap-v3
How Uniswap works | Uniswap. (n.d.). Retrieved December 31, 2023, from https://docs.uniswap.org/contracts/v2/concepts/protocol-overview/how-uniswap-works

Business Problem 1

Hedging Strategy is required for more pronounced impermanent loss with concentrated liquidity in Uniswap V3

The difference between the value of the liquidity position and the value of holding equal amounts of assets

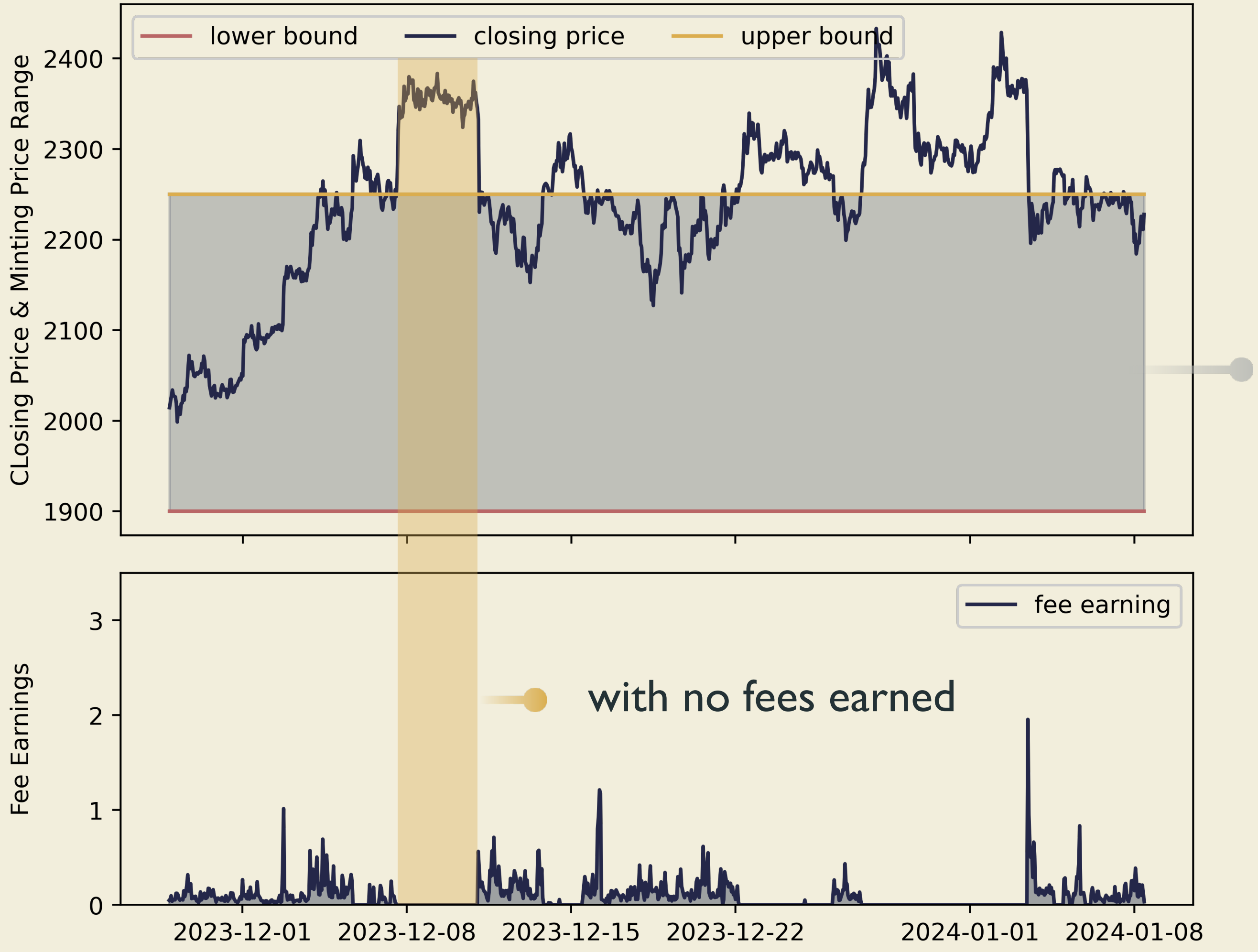




Khakhar, A., & Chen, X. (2022). *Delta Hedging Liquidity Positions on Automated Market Makers* (arXiv:2208.03318). arXiv. https://doi.org/10.48550/arXiv.2208.03318

Schaller, A. J. (2022). *Hedging the Risks of Liquidity Providers* [Bachelor's Thesis]. ETH Zürich.

Business Problem 2



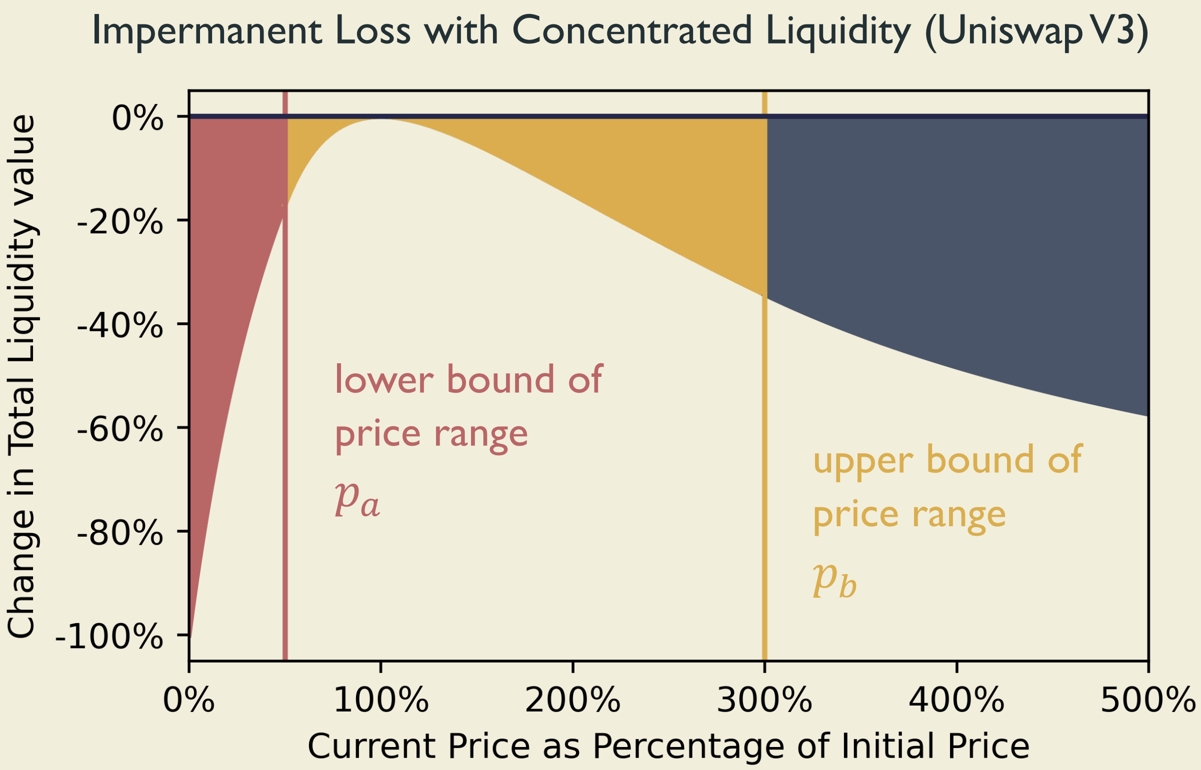
Minting Strategy is required for effective and dynamic liquidity provision to make use of liquidity reallocations

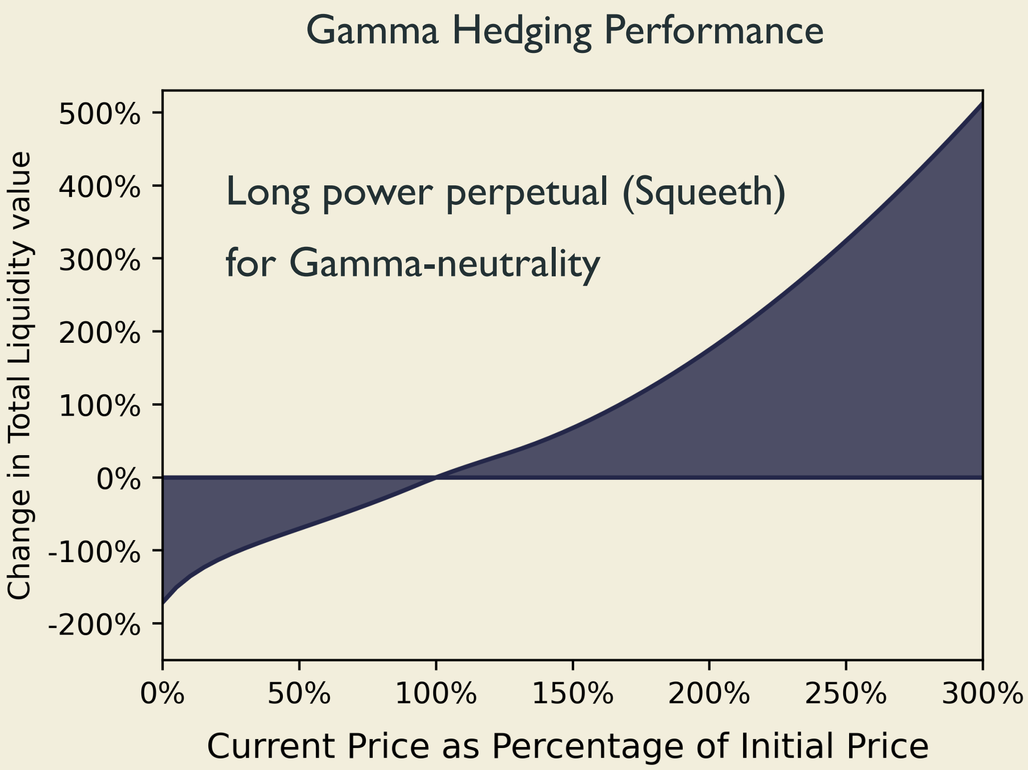
Fee earning affected by:

- liquidity allocation range
- current price of token
- total fee growth in pool

Source code of the modeling and back-testing results can be found in GitHub repository:
[jiaxiang-cheng/definer: By DeFiNER, Decentralized Finance Navigates Every Route. Fintech-As-A-Service: Hackathon of NUS Fintech Summit 2024. (github.com)]

Solution to Problem 1 : Delta-Gamma Hedging Strategy





$$V = 2L\sqrt{p} - L\sqrt{p_a} - p\frac{L}{\sqrt{p_b}}$$

$$Gamma = \frac{d^2V}{dp^2} = \frac{1}{2}Lp^{-\frac{3}{2}}$$

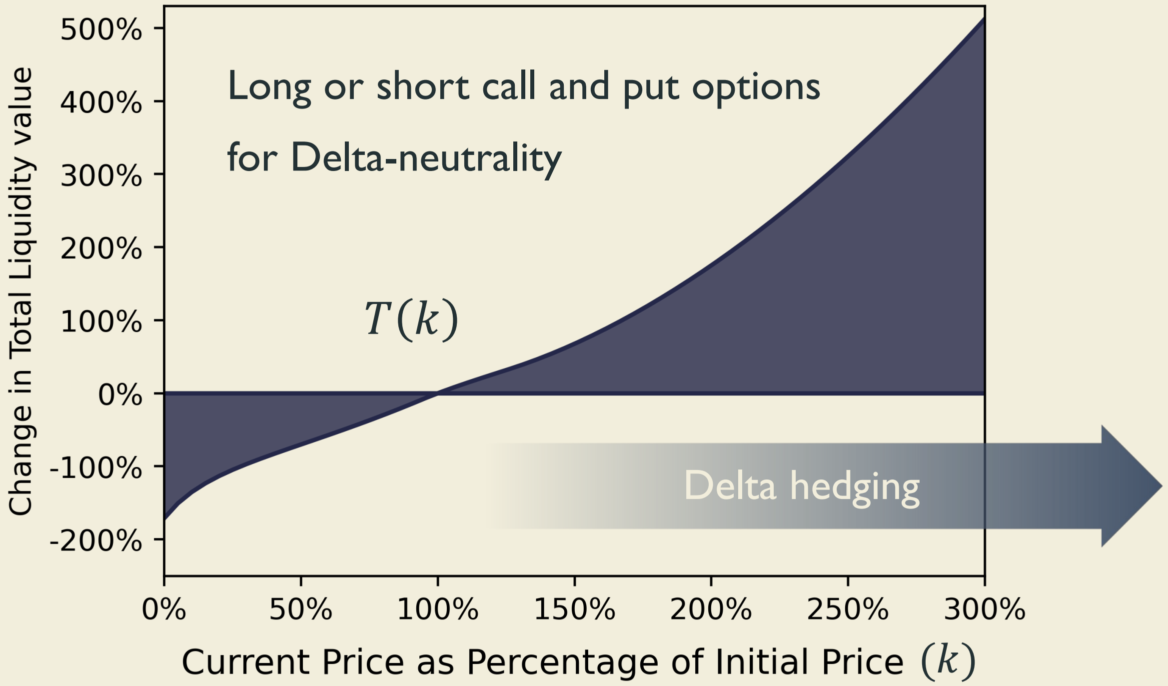
Squeeth

$$Gamma = \frac{d^2V}{dp^2} \approx 2$$

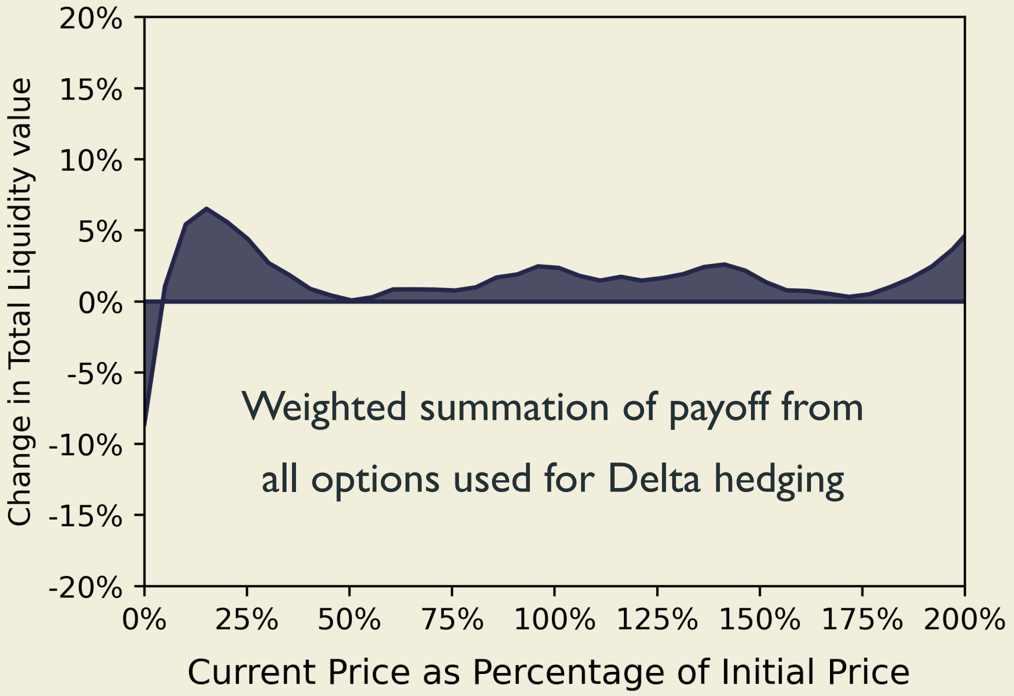
Prospere, W. (2022, May 19). Squeeth Primer: A guide to understanding Opyn's implementation of Squeeth. *Opyn*. https://medium.com/opyn/squeeth-primer-a-guide-to-understanding-opyns-implementation-of-squeeth-a0f5e8b95684

Solution to Problem 1 : Delta-Gamma Hedging Strategy

Gamma Hedging Performance



Delta-Gamma Hedging Performance



options

long call	long put
short call	short put

$$L(\theta) = \frac{1}{2}\sum_k (T(k) + R(options, k))^2$$

$$R(options, k) = \sum_i \theta_i \cdot R(option\ i, k)$$

stochastic gradient descent
to minimize $L(\theta)$

$\boldsymbol{\theta_i}$

Khakhar, A., & Chen, X. (2022). *Delta Hedging Liquidity Positions on Automated Market Makers* (arXiv:2208.03318). arXiv. https://doi.org/10.48550/arXiv.2208.03318

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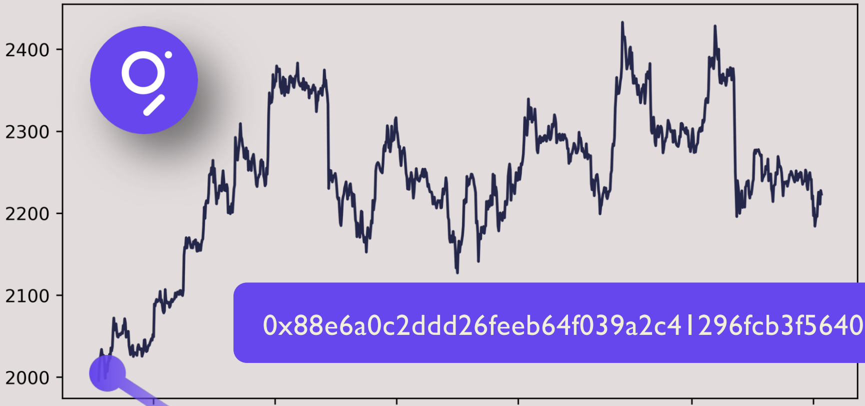
Back-Testing : Data Collection

USDC-ETH 0.05% Uniswap V3 Pool



0x88e6a0c2ddd26feeb64f039a2c41296fcb3f5640

Starting Price : 1995.85

Historical ETH price in terms of USDC from 2023-11-27 to 2024-01-08

Extracted a total of 1000 hourly data using The GraphiQL poolHourDatas

Deribit

Extracted a total of 684 valid and unique options from Deribit on 2024-01-08

To simulate options for back-testing:

- Roll back expiring date 1000 hours earlier (relative date to 2023-11-27);
- Pricing options with **Black-Scholes** model (clipping with min of 0.0001 and max of 3 ETH worth).

Squeeth

Opyn Squeeth **oSQTH**

Bitget

historical oSQTH price from 2023-11-27 to 2024-01-08

[Opyn Squeeth (OSQTH) Price, Charts, and News | Bitget]

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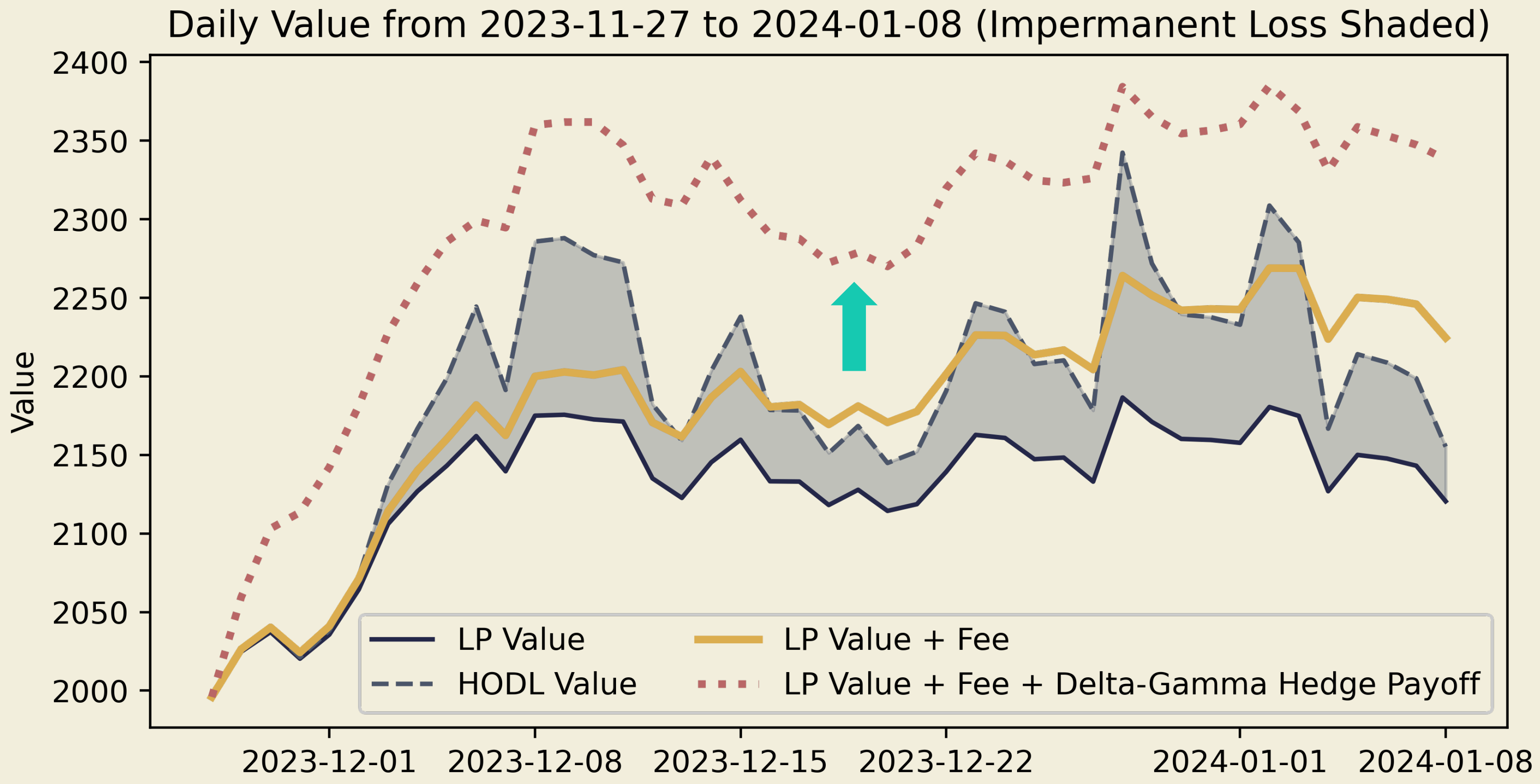
Back-Testing : Delta-Gamma Hedging Strategy



Liquidity Provision on 2023-11-27

1995.85 USD worth

≈ 1 ETH w.r.t. starting price

Delta-Gamma Hedging Strategy

1 (Amount) *

≈ 0.055 ETH w.r.t. starting price

2142 (Amount) *

≈ 0.28 ETH w.r.t. starting price

124 unique options

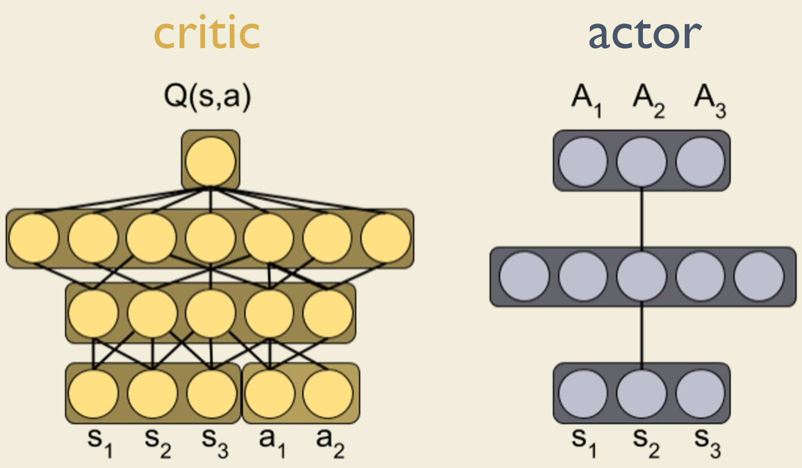
* Amounts adjusted as 1/10 of originals

By 2024-01-08, the total payoff from the hedging strategy is 84.31 USD + 29.18 USD

For options, the payoff is only counted and calculated for options with expiring date reached.

Source code of the modeling and back-testing results can be found in GitHub repository definer/3.3 Back-testing Delta-Gamma Hedge.ipynb at main · jiaxiang-cheng/definer (github.com) from jiaxiang-cheng/definer: By DeFiNER, Decentralized Finance Navigates Every Route. Fintech-As-A-Service: Hackathon of NUS Fintech Summit 2024. (github.com)

Solution to Problem 2 : Dynamic Liquidity Provision Strategy



Deep Deterministic Policy Gradient

Train a deep reinforcement learning model (deep deterministic policy gradient, DDPG) as agent for decision-making:

GIVEN (s_1 s_2)

current market price

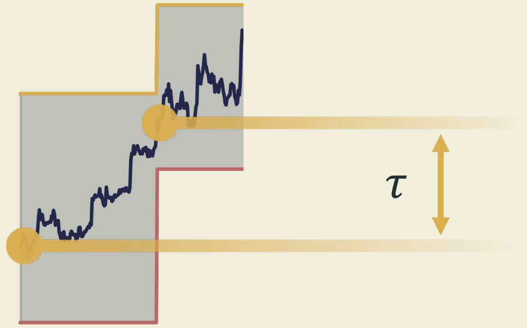
current liquidity position value

DECIDE (A_1 A_2)

price range (upper and lower bounds) for liquidity allocation

+

τ-Reset Strategy



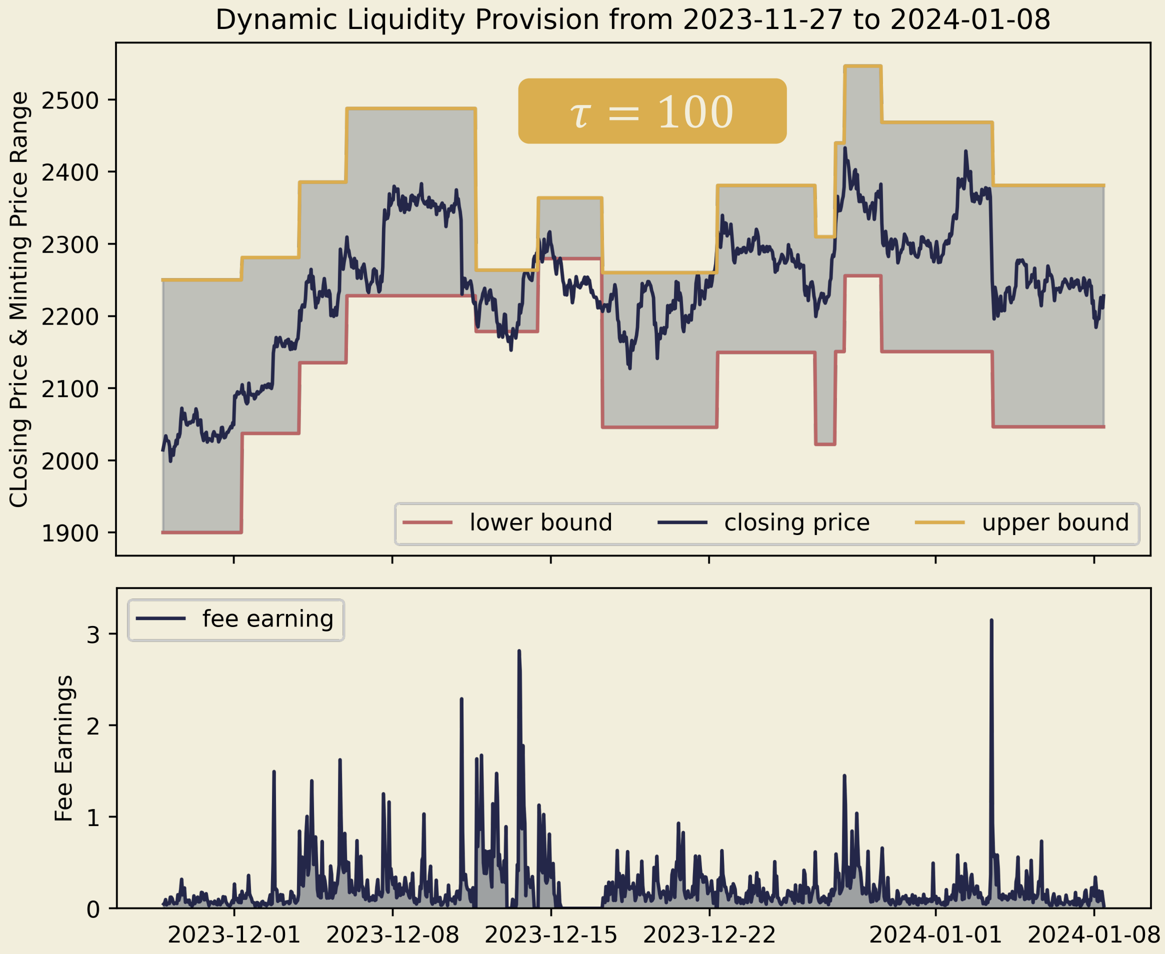
Reallocation of liquidity can only be triggered and suggested by agent when the price has changed over a threshold τ

rebalancing cost

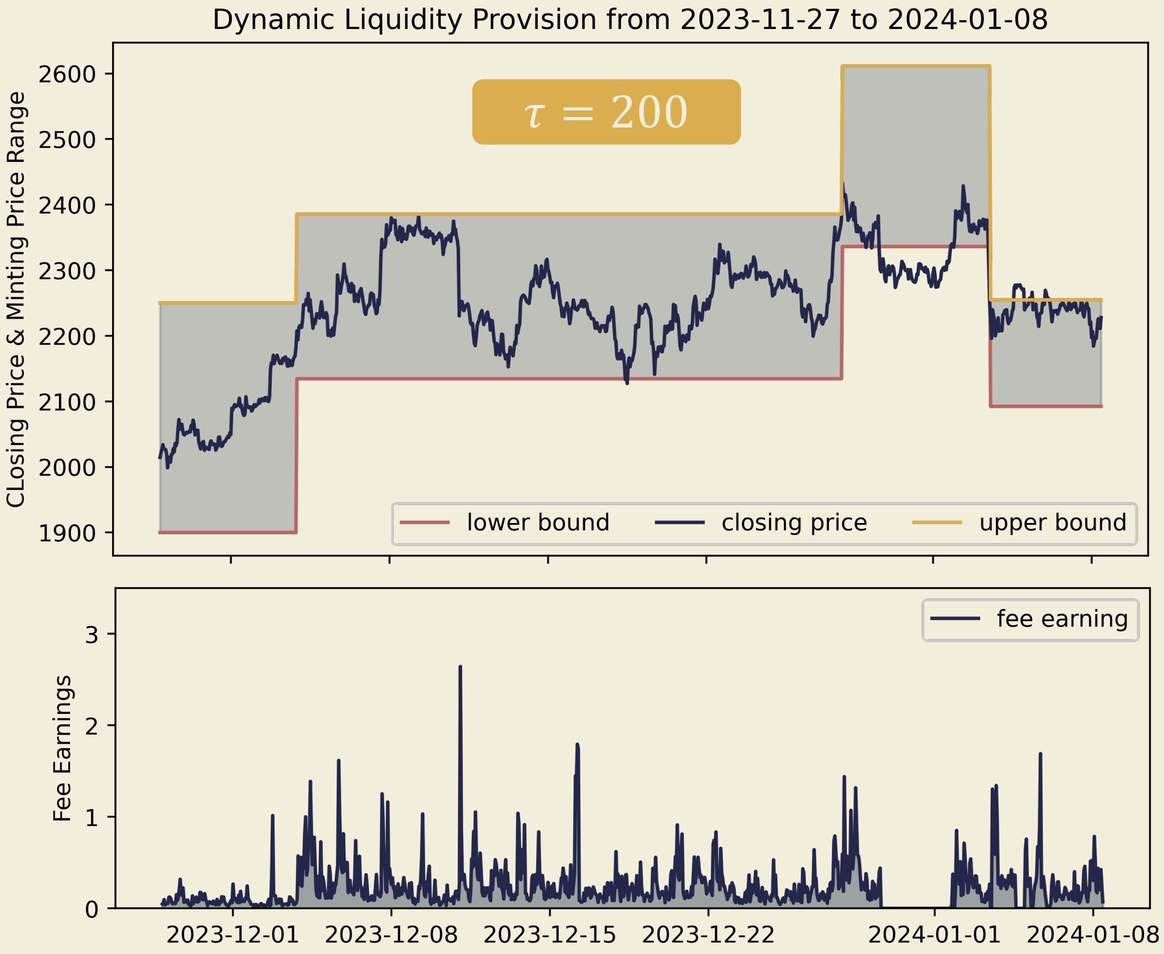
minting cost (gas fee, 0.01)

Silver, D., Lever, G., Heess, N., Degris, T., Wierstra, D., & Riedmiller, M. (2014). Deterministic Policy Gradient Algorithms. *Proceedings of the 31st International Conference on Machine Learning*, 387–395. https://proceedings.mlr.press/v32/silver14.html

Back-Testing : Dynamic Liquidity Provision Strategy



Total Fee = 226.99 USD



Total Fee = 231.07 USD

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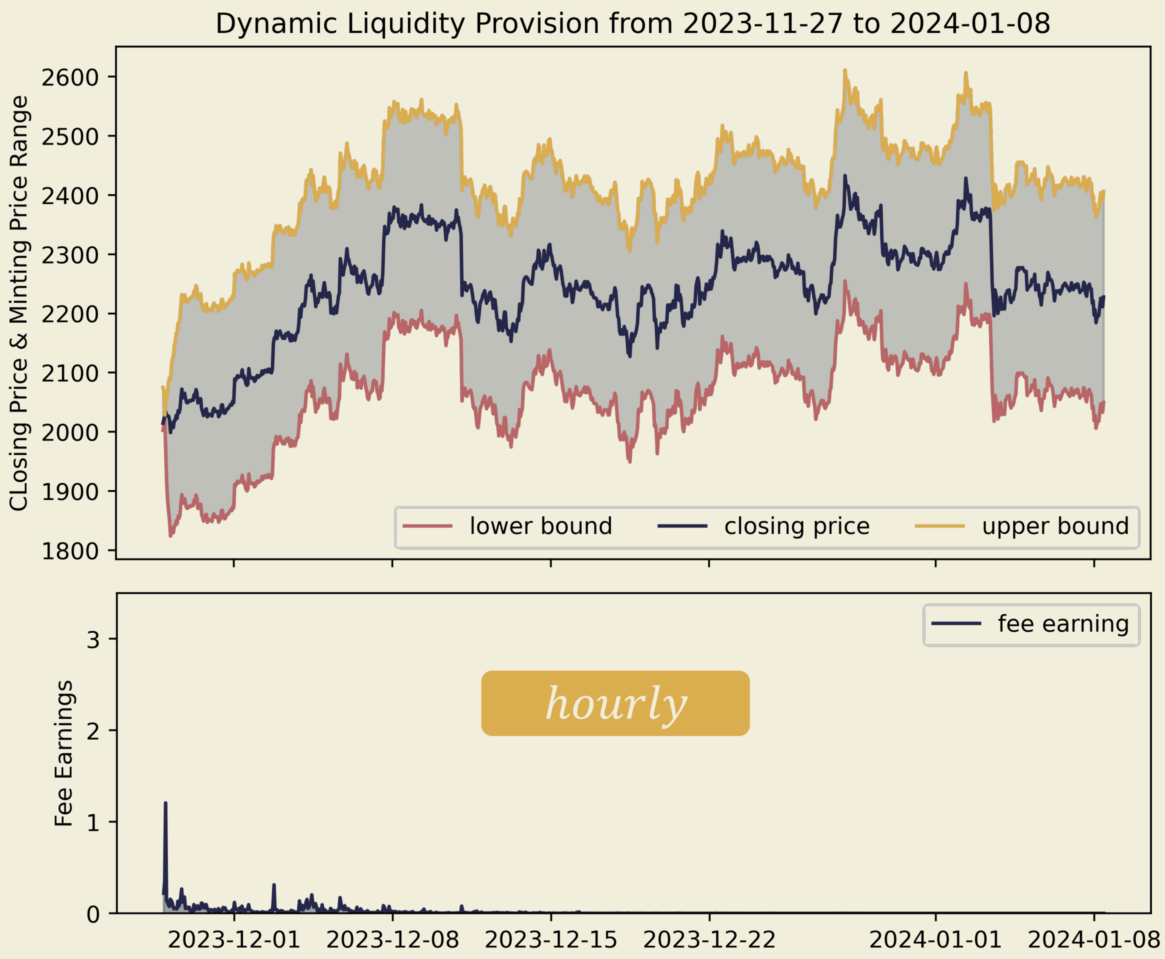
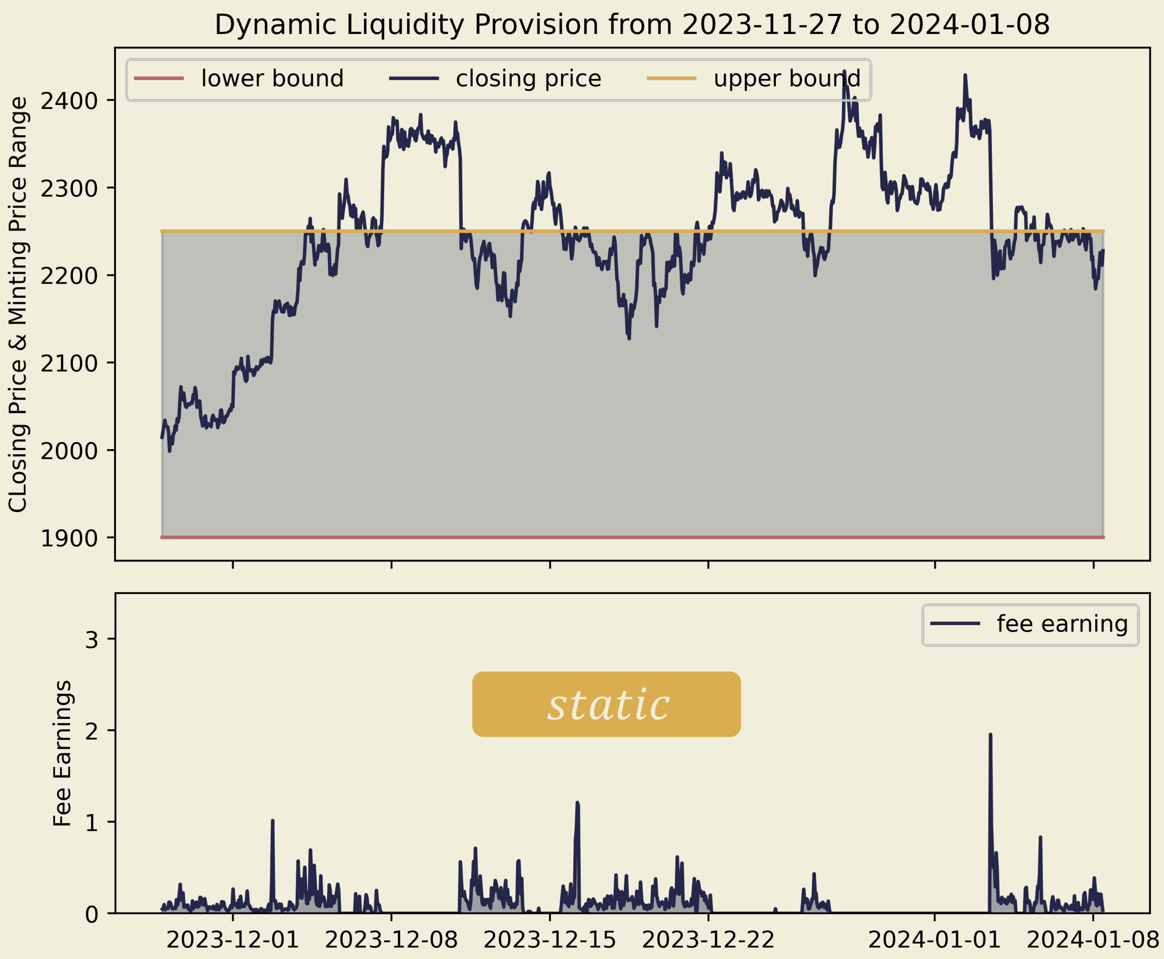
Back-Testing : Dynamic Liquidity Provision Strategy (Extreme Cases)



Total Fee = 14.46 USD



Total Fee = 89.16 USD

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Summary

Delta-Gamma Hedging Strategy

Using Squeeth for Gamma hedging and options from Deribit for Delta hedging weighted with stochastic gradient descent

Dynamic Liquidity Provision Strategy

Using deep reinforcement learning model and τ-Reset Strategy for dynamic minting considering both fee return and reallocation cost

Innovative Contributions

- Accelerated Stochastic Gradient Descent
- Hedging with Power Perpetual and Options
- Deep Deterministic Policy Gradient Application
- …

Next Steps

- Back-testing with different historical cases
- Improve the hedging strategy regarding return versus cost (optimize weights of options)
- API development for easier development and evaluation
- Potentially archive work with academic value to preprints for publicity
- …

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Our Team

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