

LVR ON LAYER 2

Empirical Analysis of Loss versus
Rebalancing on Layer 2



CONTENT

WHY LVR MATTERS

HYPOTHESIS

KEY QUESTIONS

METHODOLOGY

ANALYSIS

CONCLUSIONS

LVR - WHY DO
WE CARE ?



A photograph of two women standing in a dark, smoky, industrial setting. They are wearing dark, edgy clothing. The woman on the left is wearing a black jacket and sunglasses, and the woman on the right is wearing a dark hoodie and headphones. The background features a brick wall with two glowing red vertical neon lights and several windows with yellow light coming through.

“CAUSE BABY NOW
WE GOT BAD BLOOD!”

- ANONYMOUS

Why LVR matters

"LVR is the costs incurred by automatic market makers (AMM) liquidity providers (LPs) due to stale prices that are picked off by better informed arbitrageurs."

- Milionis et al., 2022

Why LVR matters

"LVR is the costs incurred by automatic market makers (AMM) liquidity providers (LPs) due to stale prices that are picked off by better informed arbitrageurs."

- Milionis et al., 2022

"LPs live on an isolated remote island, waiting for outsiders to bring them news of the outside world, at the unjustifiably high cost of LVR."

- Elaine Hu, 2024

Key Questions



Key Questions

01

How much LVR is out there?

- On Ethereum, Base, Arbitrum for WETH-USDC
- In UniswapV2 & UniswapV3 type of pools
- In amount of USDC
- In % of pool value

02

How close are theoretical vs. empirical estimates?

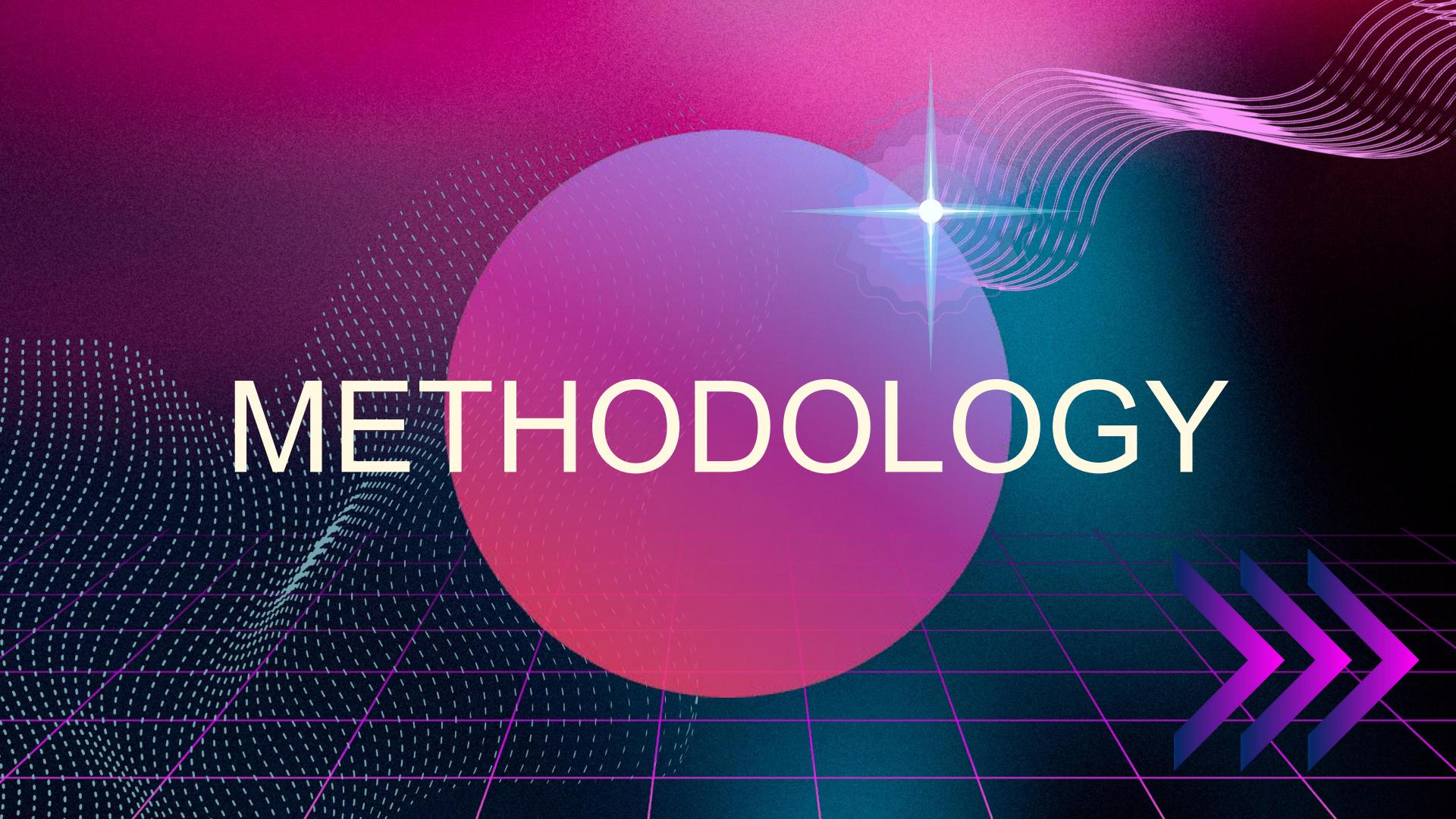
- Empirical number using rebalancing strategy
- Theoretical number using mathematical formula
- Considering trading fees

03

How to reduce LVR?

- Hedging frequency
- CEX vs. Perpetual hedging
- Block time
- FCFS vs. PGA
- Trade/swap volume

METHODOLOGY



METHODOLOGY

Empirical

Theoretical

$$LP \ P\&L_t - RB \ P\&L_t = LP \ FEE_t - LVR_t$$

METHODOLOGY

Empirical

Hedged
LP P&L

$$LP \text{ } P\&L_t - RB \text{ } P\&L_t$$



Theoretical

$$LP \text{ } FEE_t - LVR_t$$



METHODOLOGY

Empirical

Hedged
LP P&L

$$LP \text{ P\&L}_t - RB \text{ P\&L}_t =$$



$$RB \text{ P\&L}_t - LP \text{ P\&L}_t + LP \text{ FEE}_t =$$

Observable onchain data

Theoretical

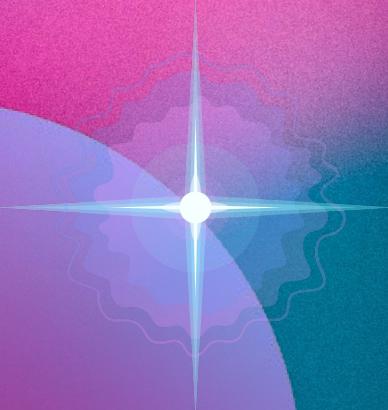
$$LP \text{ FEE}_t - LVR_t$$



$$LVR_t$$

Closed-form
expression i.e.
 $\hat{\sigma}_t^2 \times V_t \times \Delta t$ for
constant product pool

ANALYSIS



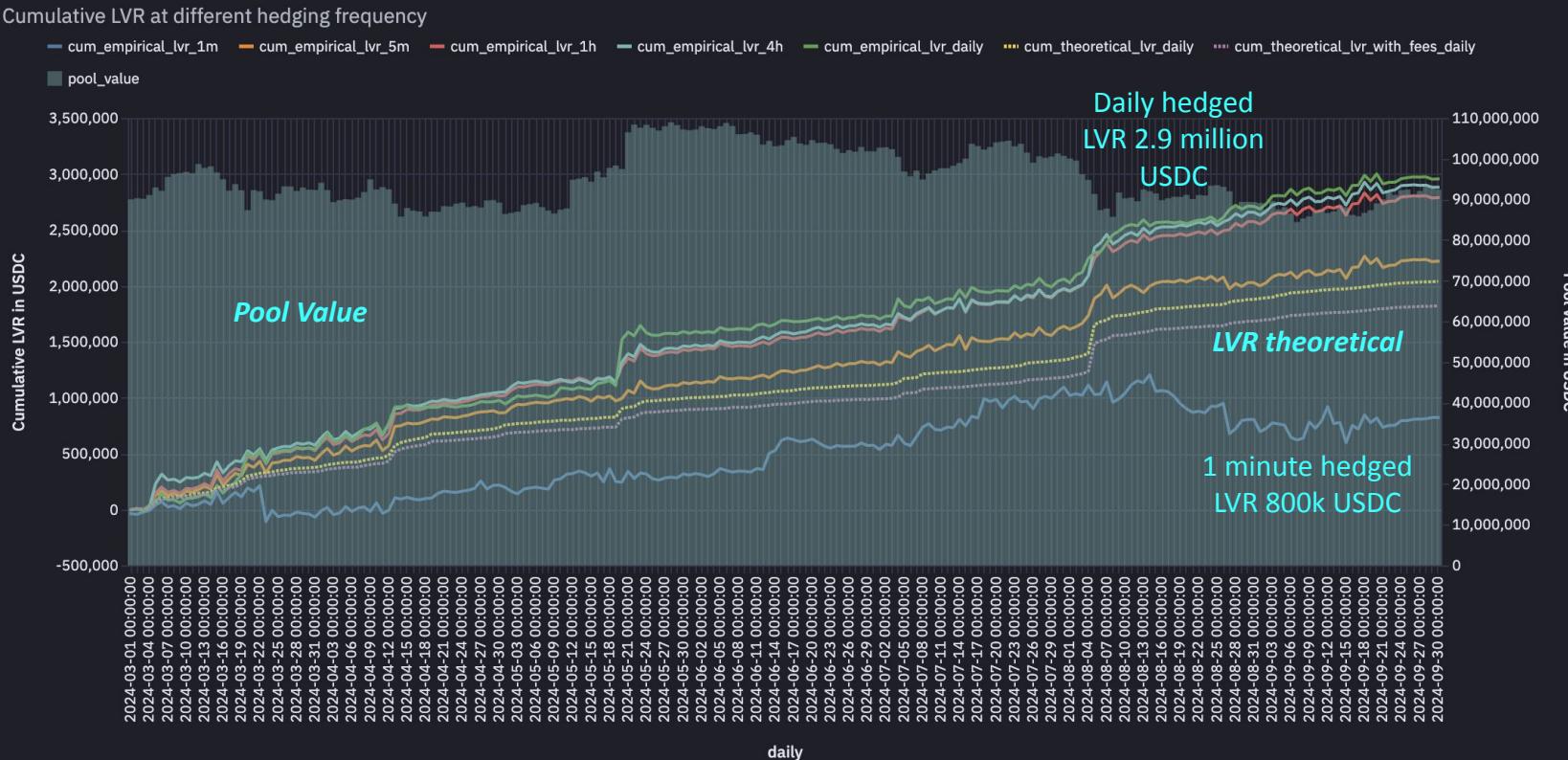
HOW MUCH LVR?

Empirical LVR at different hedging frequencies vs.
theoretical LVR



Empirical LVR at different hedging frequencies

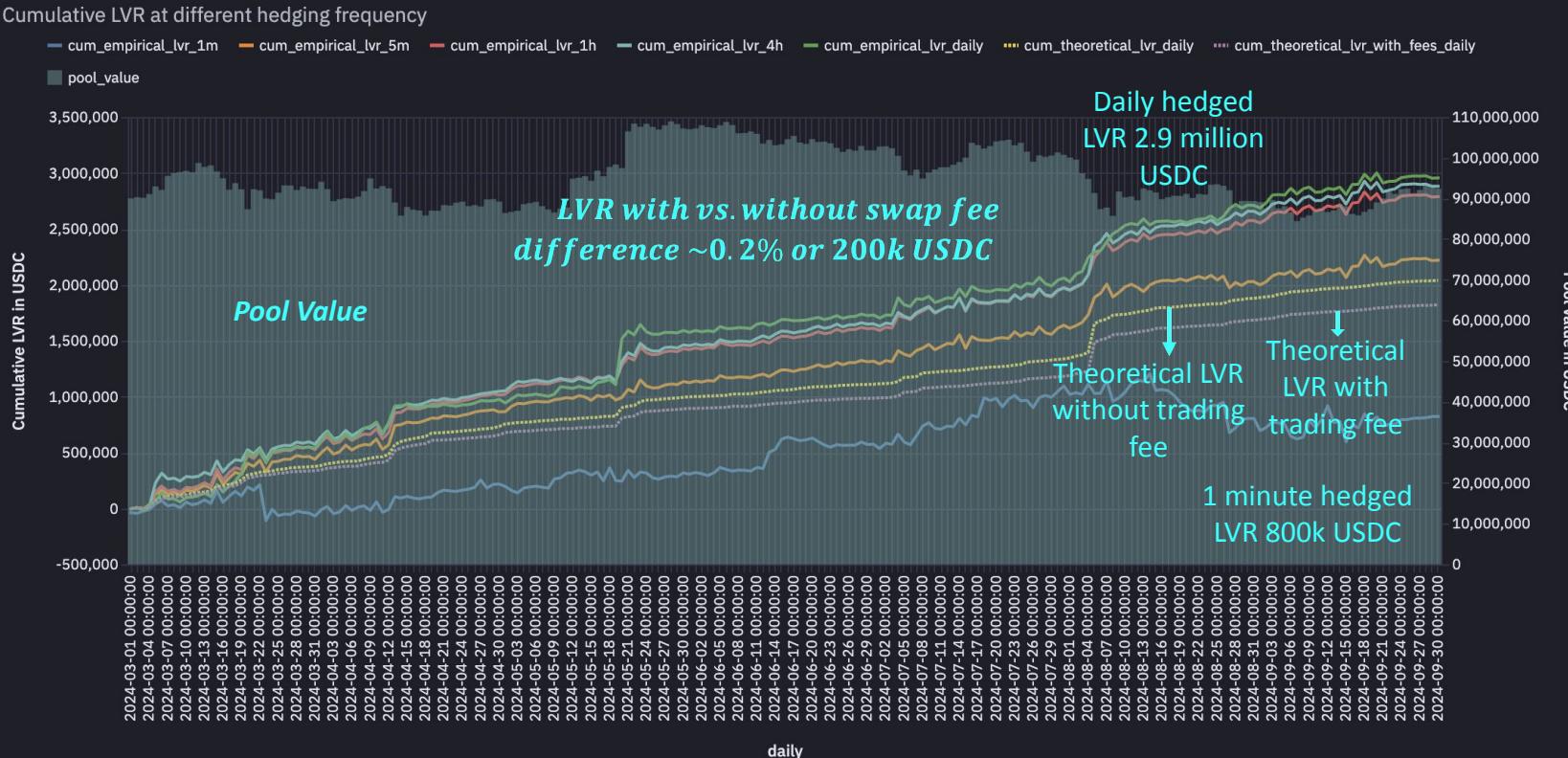
Ethereum



Ethereum Uniswap v2 weth-usdc 0.3% pool

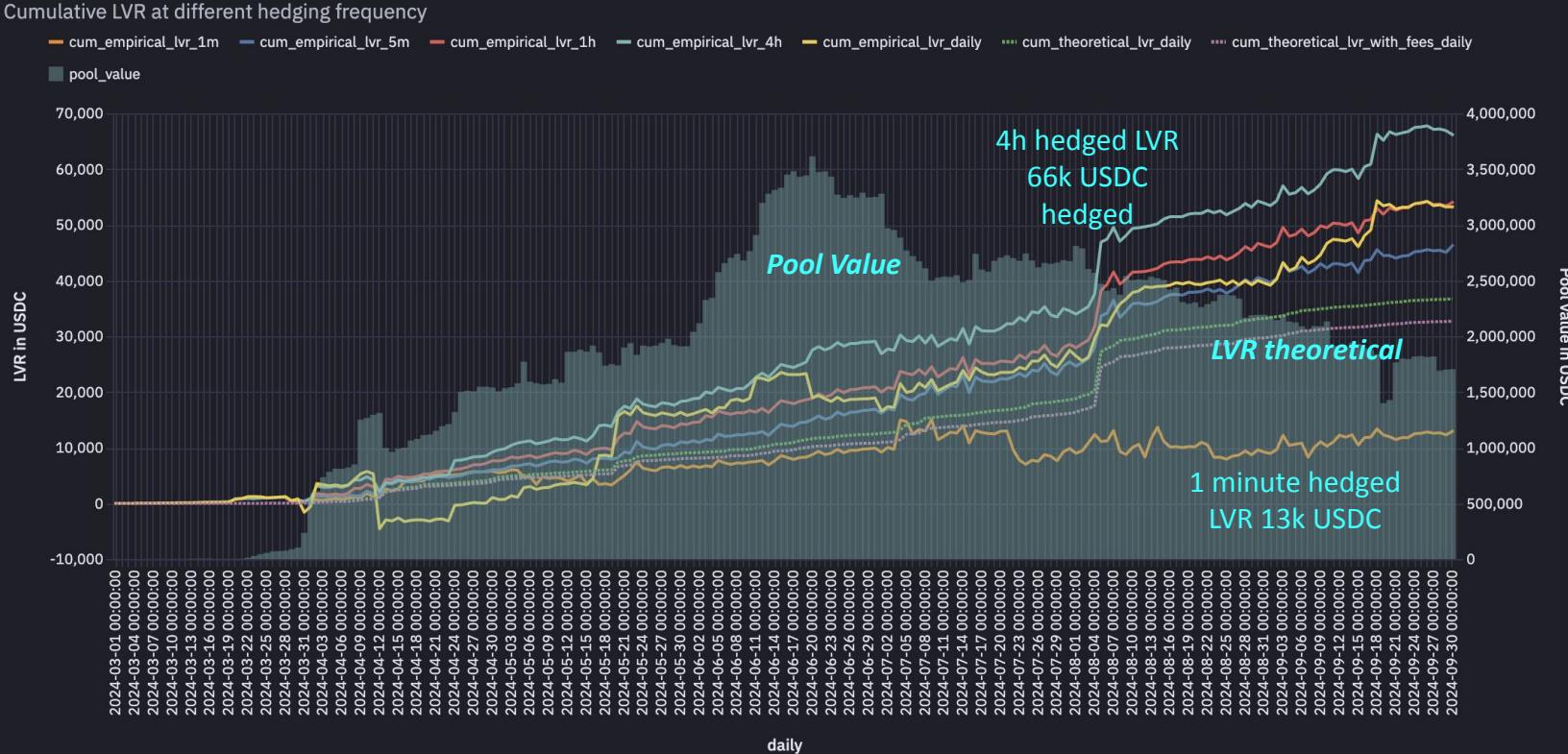
Empirical LVR at different hedging frequencies

Ethereum



Empirical LVR at different hedging frequencies

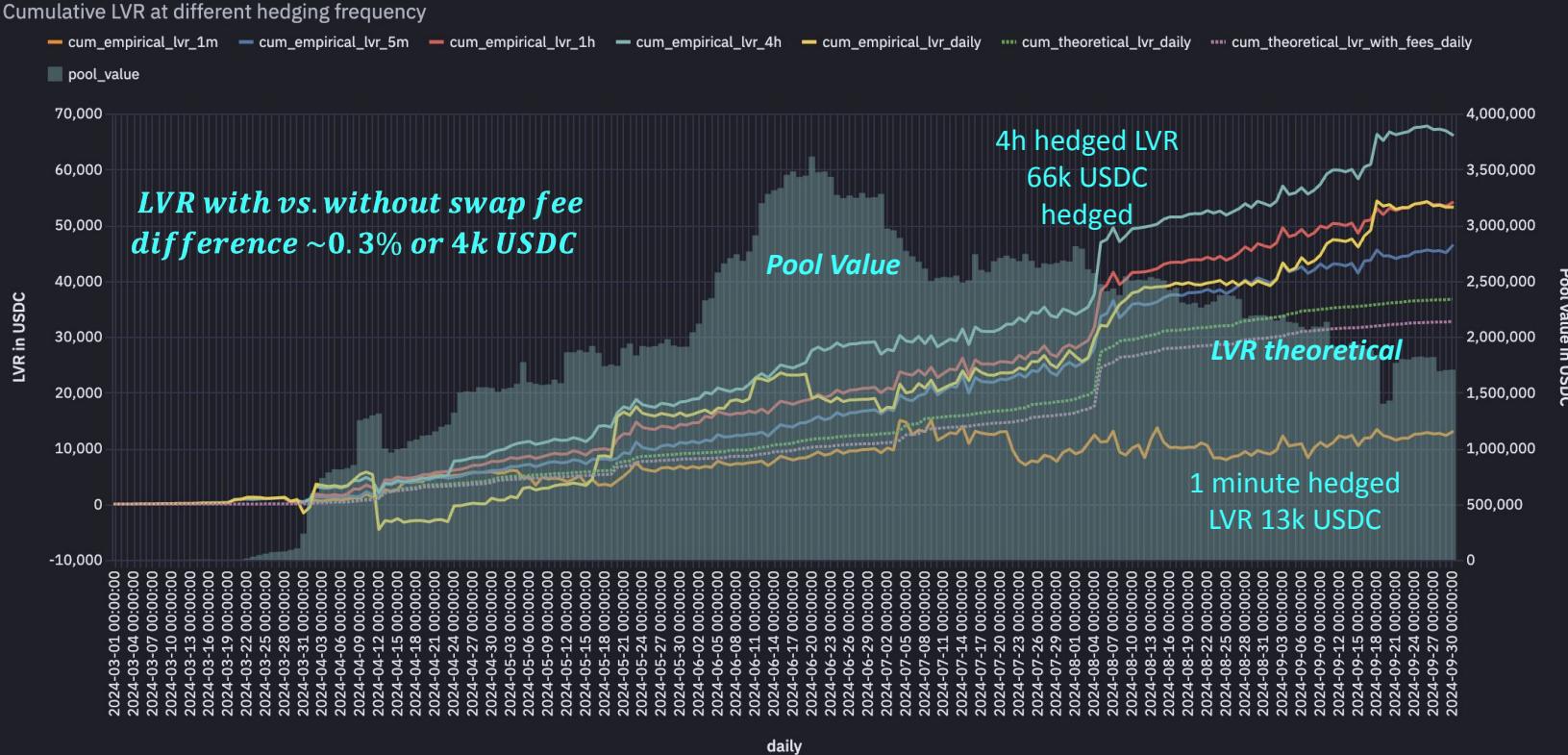
Base



Base Uniswap v2 weth-usdc 0.3% pool

Empirical LVR at different hedging frequencies

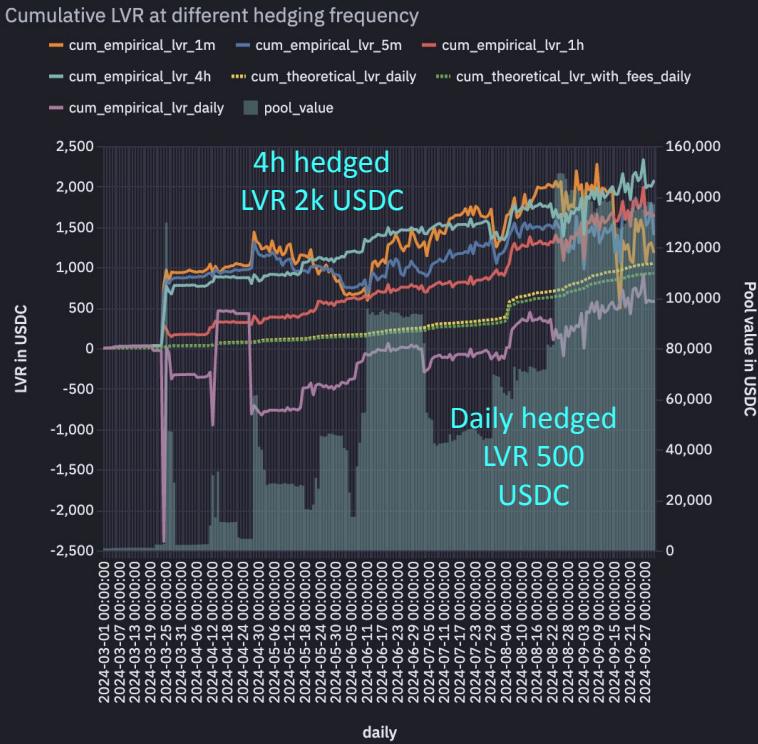
Base



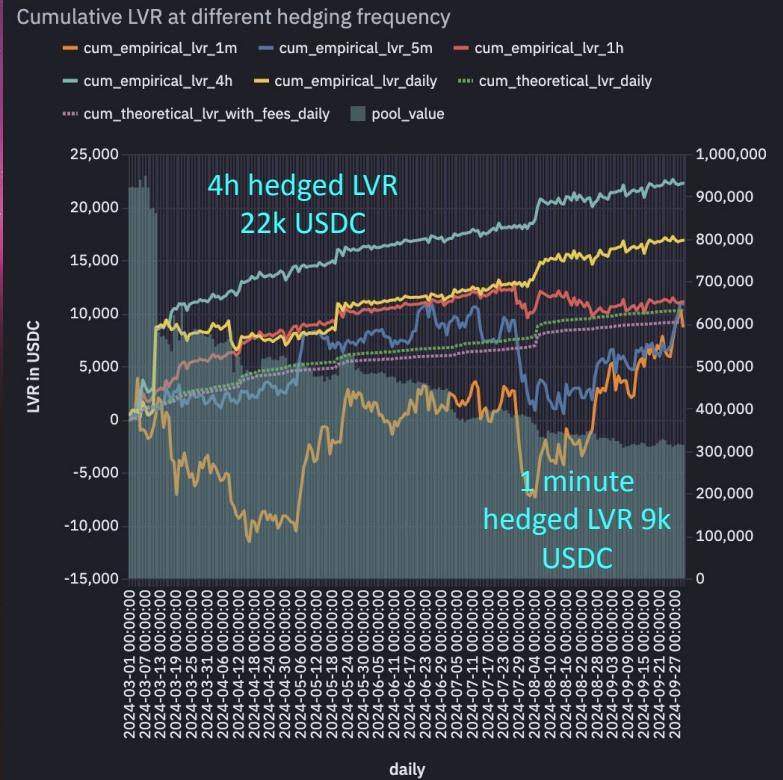
Base Uniswap v2 weth-usdc 0.3% pool

Empirical LVR at different hedging frequencies

Arbitrum



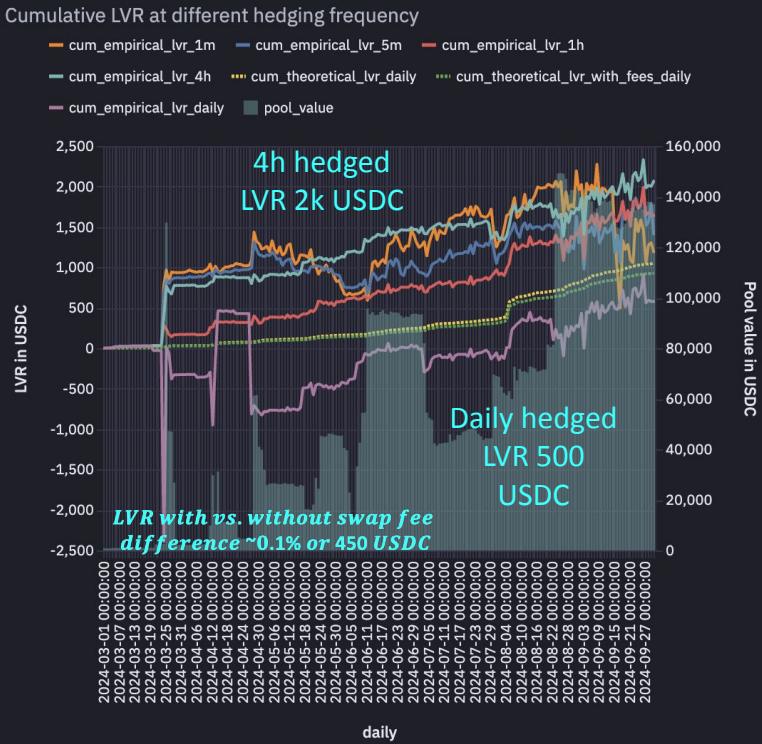
Arbitrum Uniswap v2 weth-usdc 0.3% pool



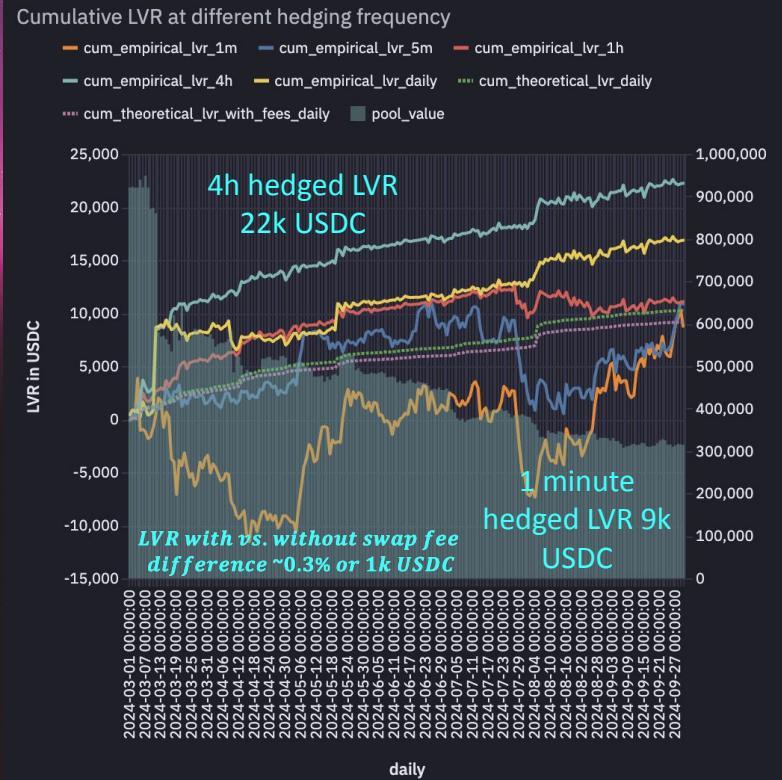
Arbitrum camlot v2 weth-usdc 0.3% pool

Empirical LVR at different hedging frequencies

Arbitrum



Arbitrum Uniswap v2 weth-usdc 0.3% pool



Arbitrum camlot v2 weth-usdc 0.3% pool

CEX vs. PERP

Given the 2 platforms to hedge lp positions, which one is better?

- A. Binance
- B. dYdX



Rebalancing strategy P&L - hedging on CEX vs. Perpetual

Ethereum



* Deducting maker-taker mid-point trading fee 0.035% for dYdX

* Deducting 0.1% trading fee for Binance

Ethereum Uniswap v2 weth-usdc 0.3% pool

Rebalancing strategy P&L - hedging on CEX vs. Perpetual

Base

Rebalancing strategy pnl 1m using Binance vs. dYdX price



Rebalancing strategy pnl daily using Binance vs. dYdX price



* Deducting maker-taker mid-point trading fee 0.035% for dYdX

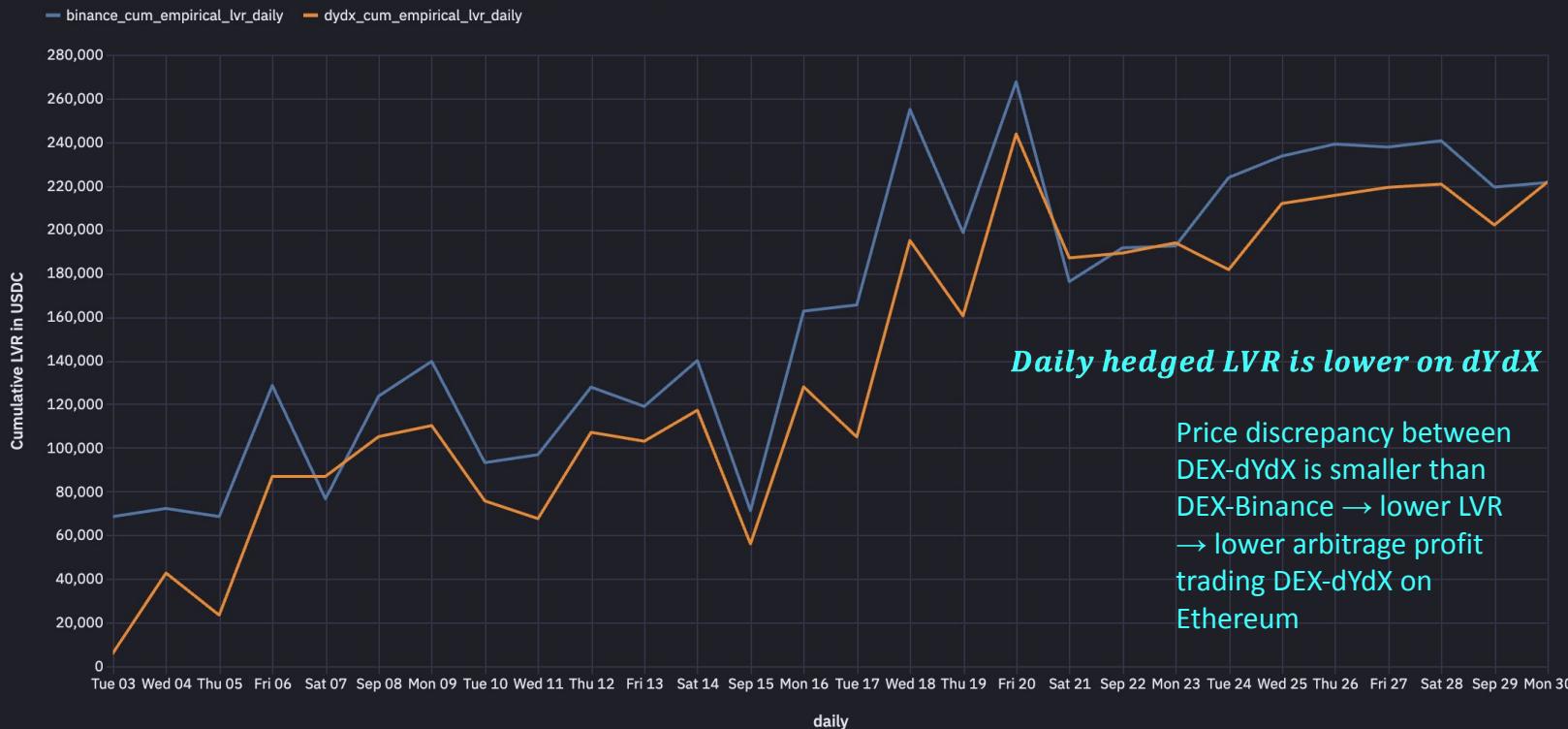
* Deducting 0.1% trading fee for Binance

Base Uniswap v2 weth-usdc 0.3% pool

Empirical LVR - hedging on CEX vs. Perpetual

Ethereum

Ethereum cumulative LVR in USDC - using Binance vs. dYdX price to hedge



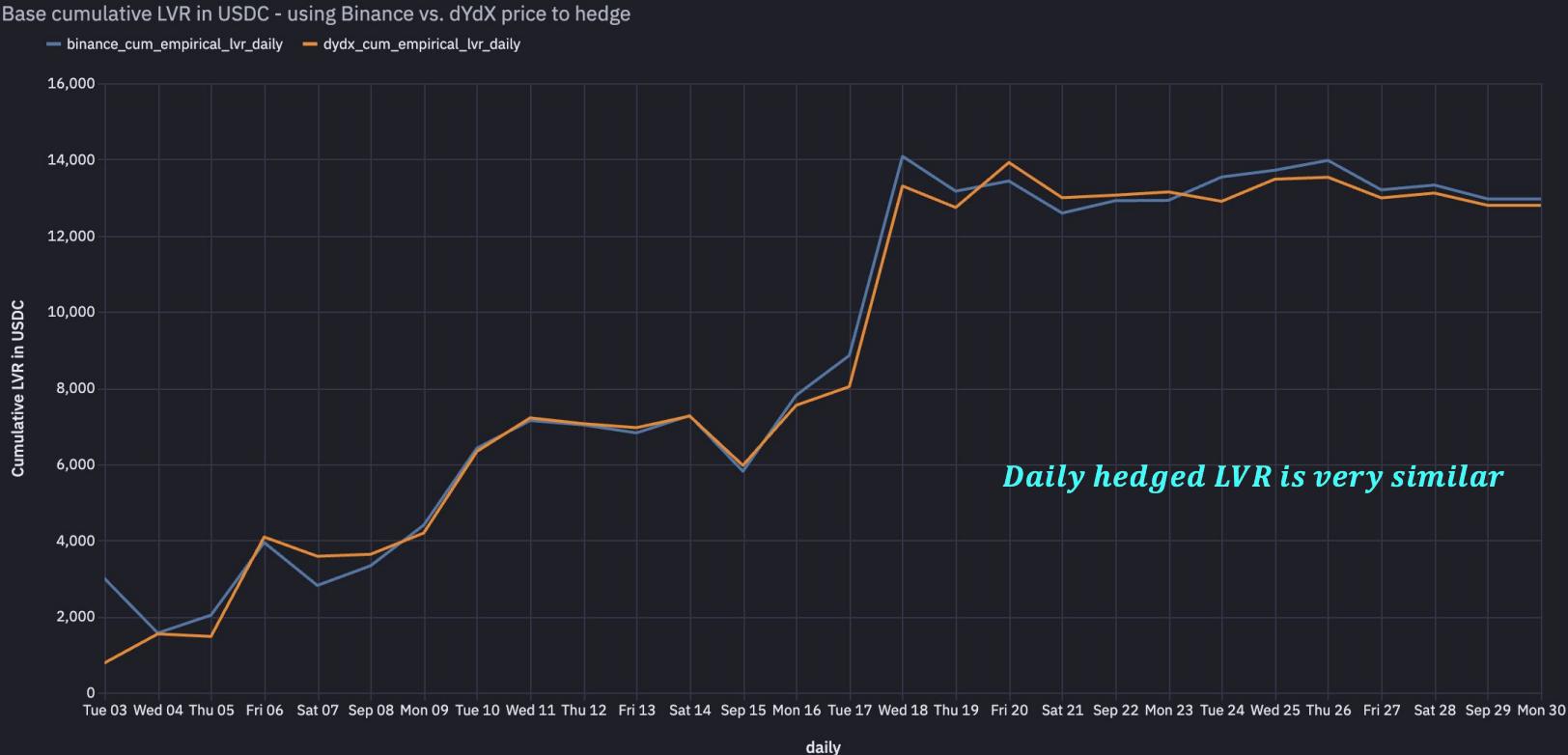
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Ethereum Uniswap v2 weth-usdc 0.3% pool

Empirical LVR - hedging on CEX vs. Perpetual

Base



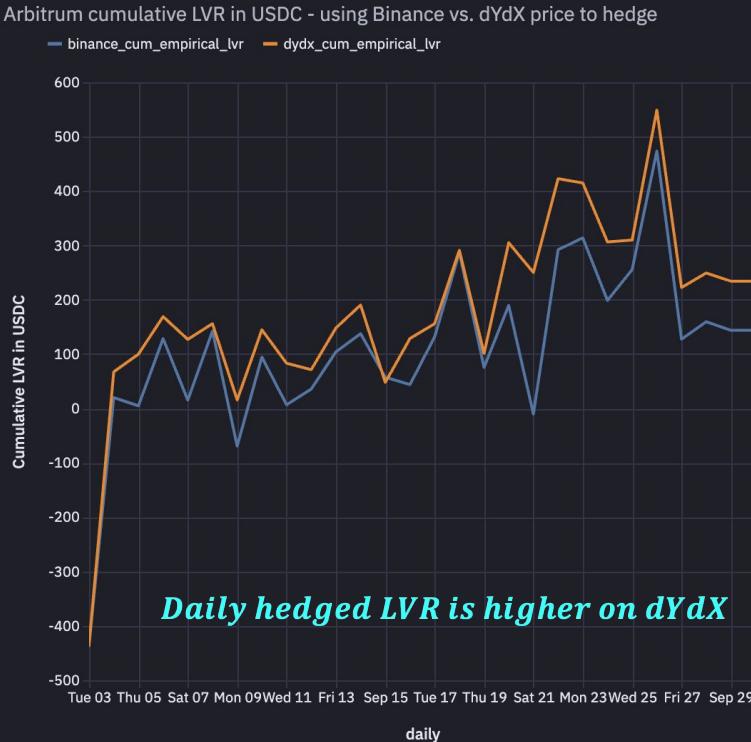
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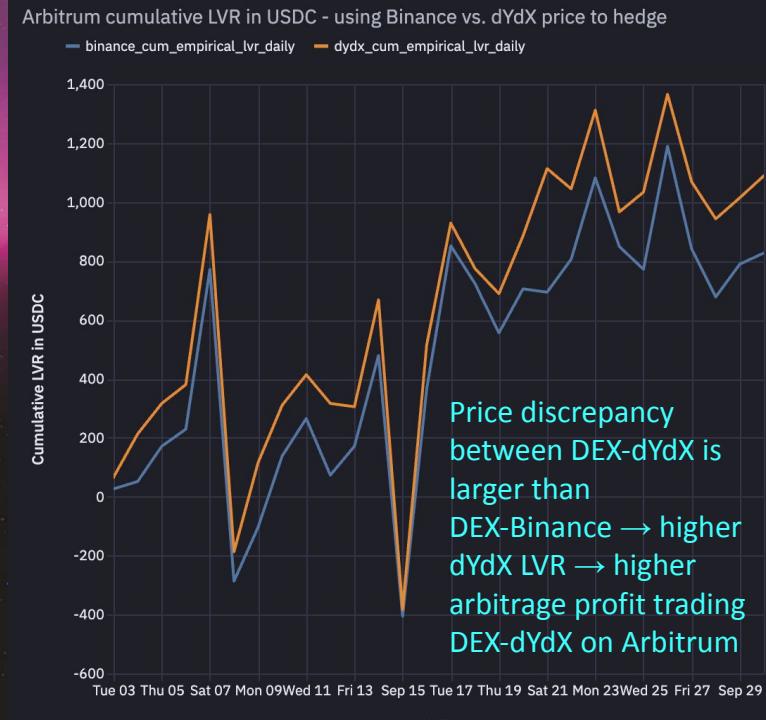
Base Uniswap v2 weth-usdc 0.3% pool

Empirical LVR - hedging on CEX vs. Perpetual

Arbitrum



Arbitrum Uniswap v2 weth-usdc 0.3% pool



Arbitrum camlot v2 weth-usdc 0.3% pool

ALL CHAINS

Which chain has the lowest LVR %
(Uniswap v2 pools 0.3% WETH-USDC)?

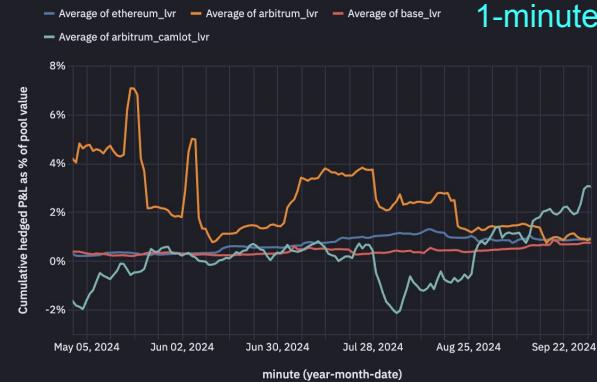
- A. Ethereum
- B. Base
- C. Arbitrum



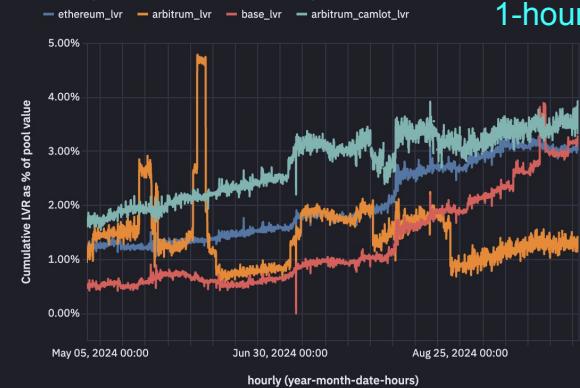
Empirical LVR % – Ethereum vs. Base vs. Arbitrum

All chains

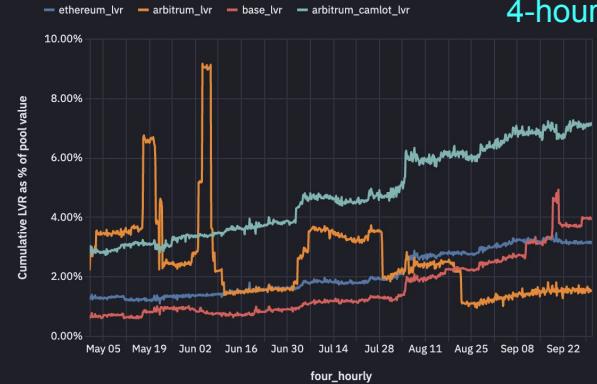
LVR as % of pool value (1m) - filtered from May 1st 2024



LVR as % of pool value (1h) - filtered from May 1st 2024



LVR as % of pool value (4h) - filtered from May 1st 2024



LVR as % of pool value (daily) - filtered from May 1st 2024



- Base LVR % < Ethereum LVR %.
- Shorter block time < lower LVR %.
- Arbitrum's outcomes are inconclusive.
- It could be due to other factors i.e. FCFS, volume and # of swaps in the pool.

Arbitrum (high-activity pool)

Ethereum

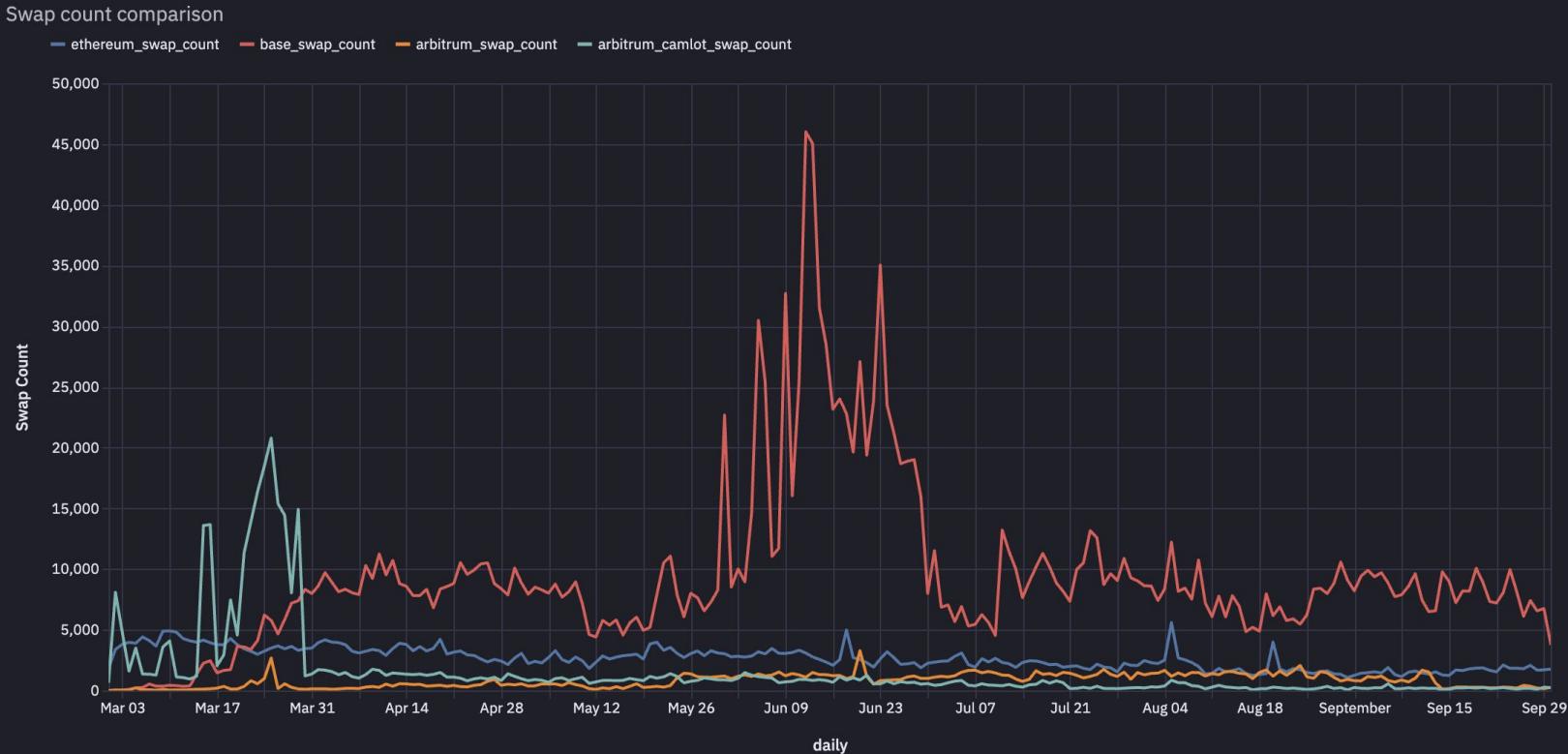
Base

Arbitrum (low-activity pool)

Uniswap v2 weth-usdc 0.3% pool

Swap count – Ethereum vs. Base vs. Arbitrum

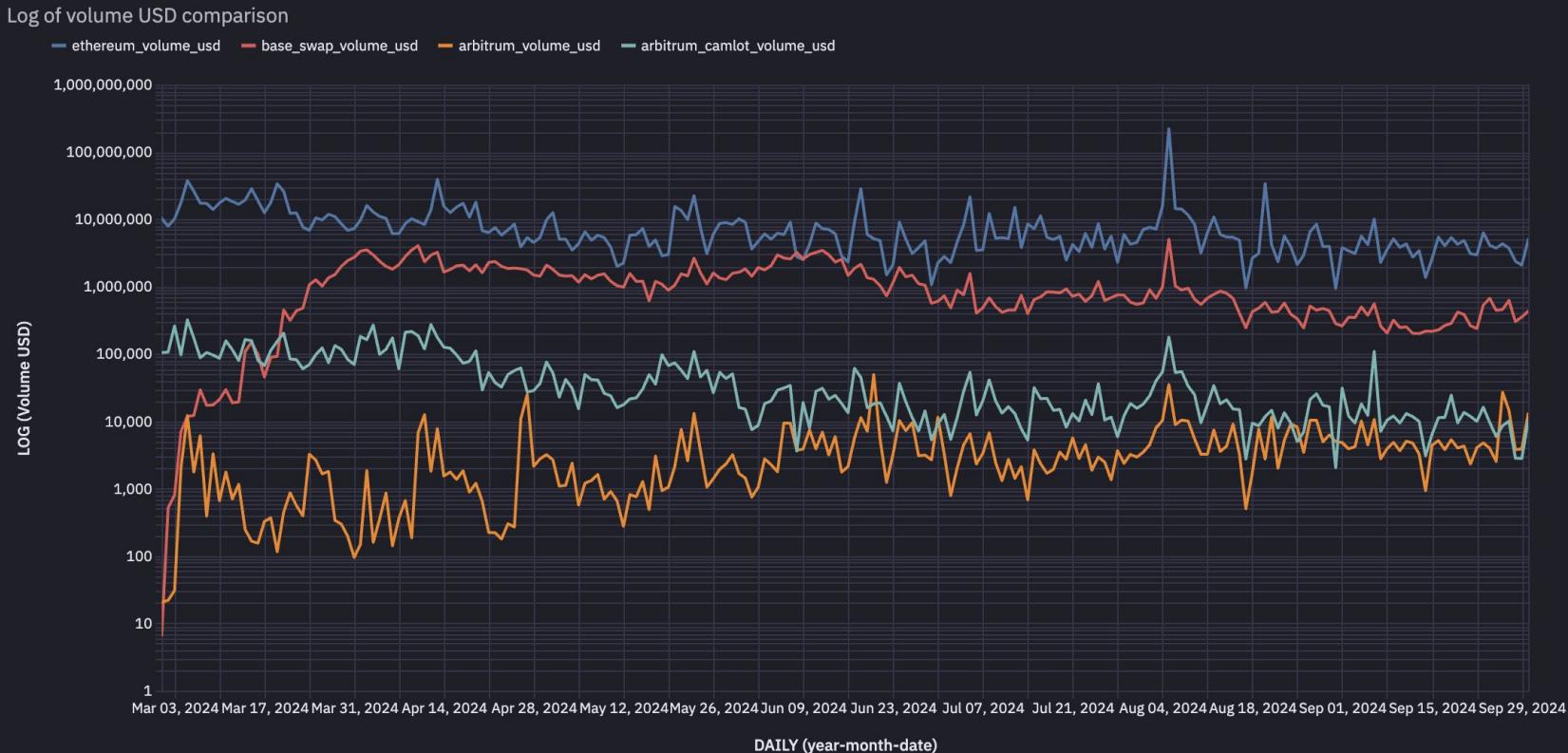
All chains



Uniswap v2 weth-usdc 0.3% pool

Volume USD (log scale) – Ethereum vs. Base vs. Arbitrum

All chains



Uniswap v2 weth-usdc 0.3% pool

Always has been.

Wait it's all LVR?

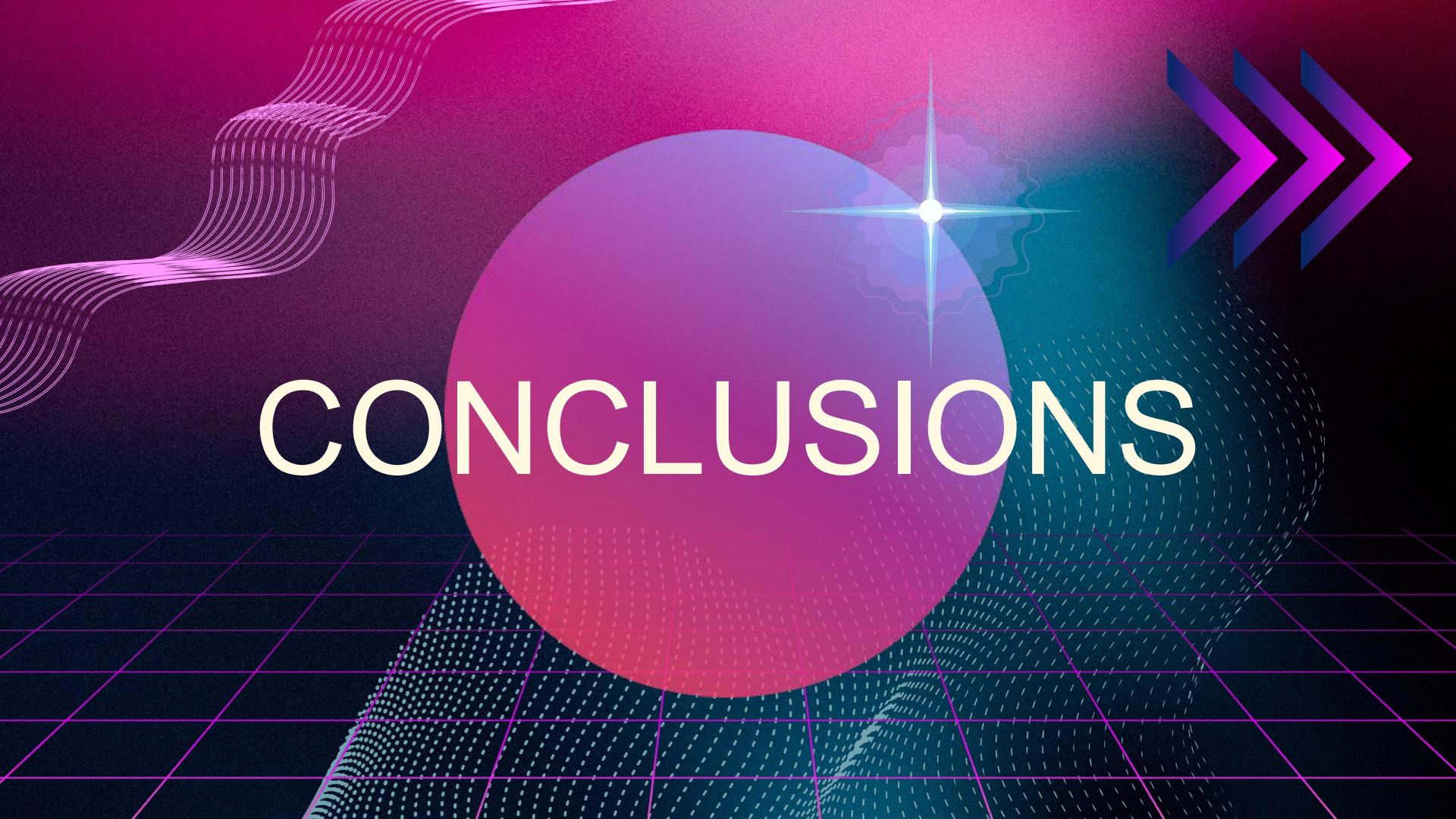


Arbitrum
\$22,000

Base
\$ 66,000

Ethereum
\$2,900,000

CONCLUSIONS



Higher or lower
LVR ?

CONCLUSIONS

Empirical

With trading fee

Shorter block time

High hedging frequency

Perpetual

FCFS

High volume / # of swaps

Uniswap v2

Theoretical

No trading fee

Longer block time

Low hedging frequency

Cex

PGA

Low volume / # of swaps

Uniswap v3

Higher or lower
LVR ?

CONCLUSIONS

Empirical

With trading fee

Shorter block time

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High volume / # of swaps

Uniswap v2



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Uniswap v3

Higher or lower
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CONCLUSIONS

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With trading fee

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High volume / # of swaps

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No trading fee

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Low hedging frequency

Cex

PGA

Low volume / # of swaps

Uniswap v3

Higher or lower
LVR ?

CONCLUSIONS

Empirical

With trading fee

Shorter block time

High hedging frequency

Perpetual

FCFS

High volume / # of swaps

Uniswap v2



Theoretical

No trading fee

Longer block time

Low hedging frequency

Cex

PGA

Low volume / # of swaps

Uniswap v3

CONCLUSIONS

How to reduce LVR?

LPs

- Hedge risky assets more frequently
- Provide liquidity on chains with shorter block time and more activities

Protocol Designer

- Internalize LVR and redistribute back to LPs
- Improve the real-time-ness of DEX price update, i.e. bring in oracle updates to DEX, dynamic fees

Blockchain Architect

- Consider faster block time (Flashblocks 250ms)
- FCFS vs. PGA transaction ordering design to increase the opportunity cost of the arbitrageurs

CREDITS

Special thanks to:

Christoph Schlegel @flashbots

Facundo Carrillo @flashbots

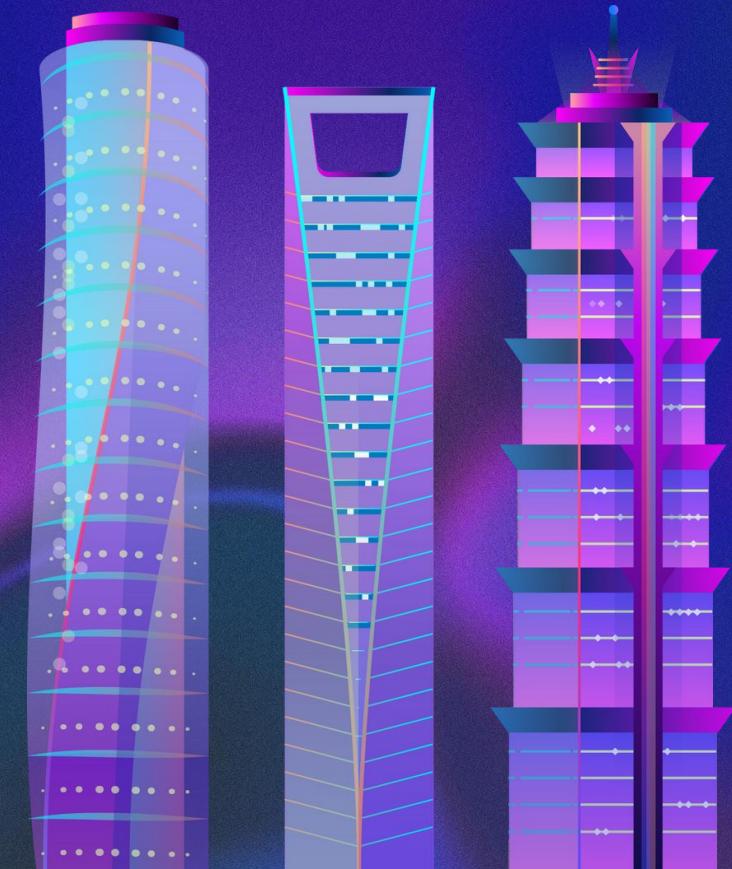
Ciamac C. Moallemi @Columbia University

Tesa Ho @Flashbots

Chenghan Lee @AlliumLabs for the dex pool data
ccdata.io for the cex and perpetual data



Thank you!





THANK

YOU!

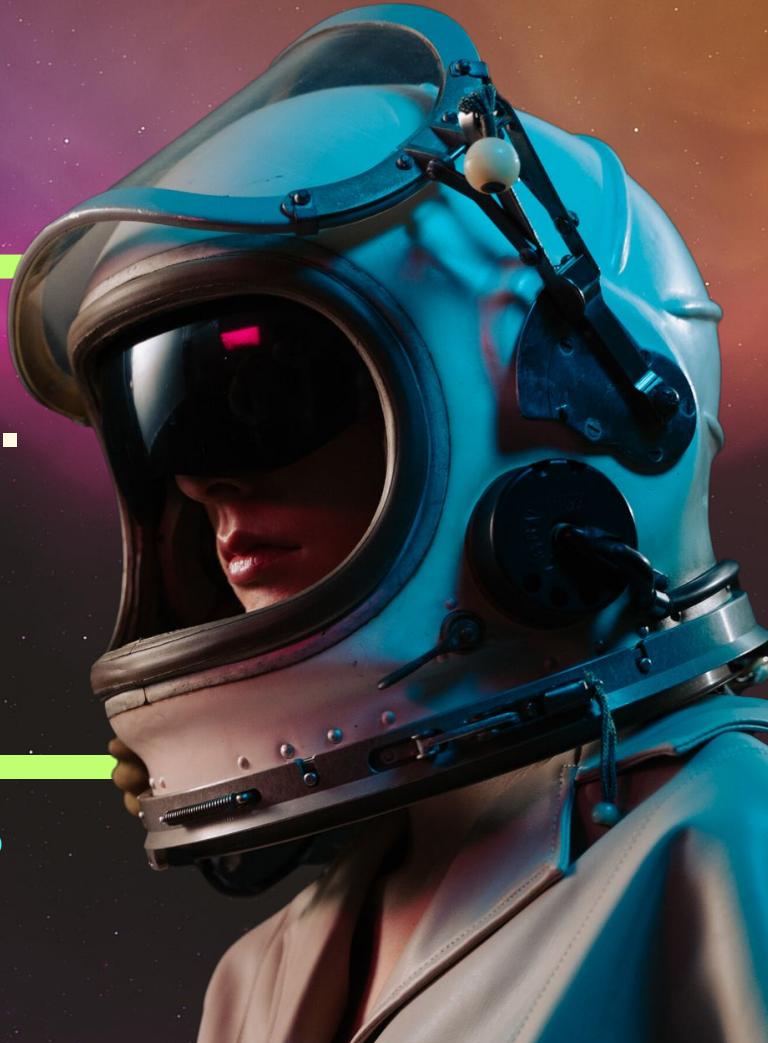
APPENDIX

BIBLIOGRAPHY

- Empirical Analysis of Cross Domain CEX <>> DEX Arbitrage on Ethereum
- Automated Market Making and Arbitrage Profits in the Presence of Fees
- Automated market making and loss-versus-rebalancing
- Anatomy of cex dex arbitrage
- Quantifying Price Improvement in Order Flow Auctions
- The Cost Of Swapping on Decentralised Exchange
- Measuring Arbitrage Losses and Profitability of AMM Liquidity
- Cross-Rollup MEV: Non-Atomic Arbitrage Across L2 Blockchains

UNISWAP V2 vs. UNISWAP V3

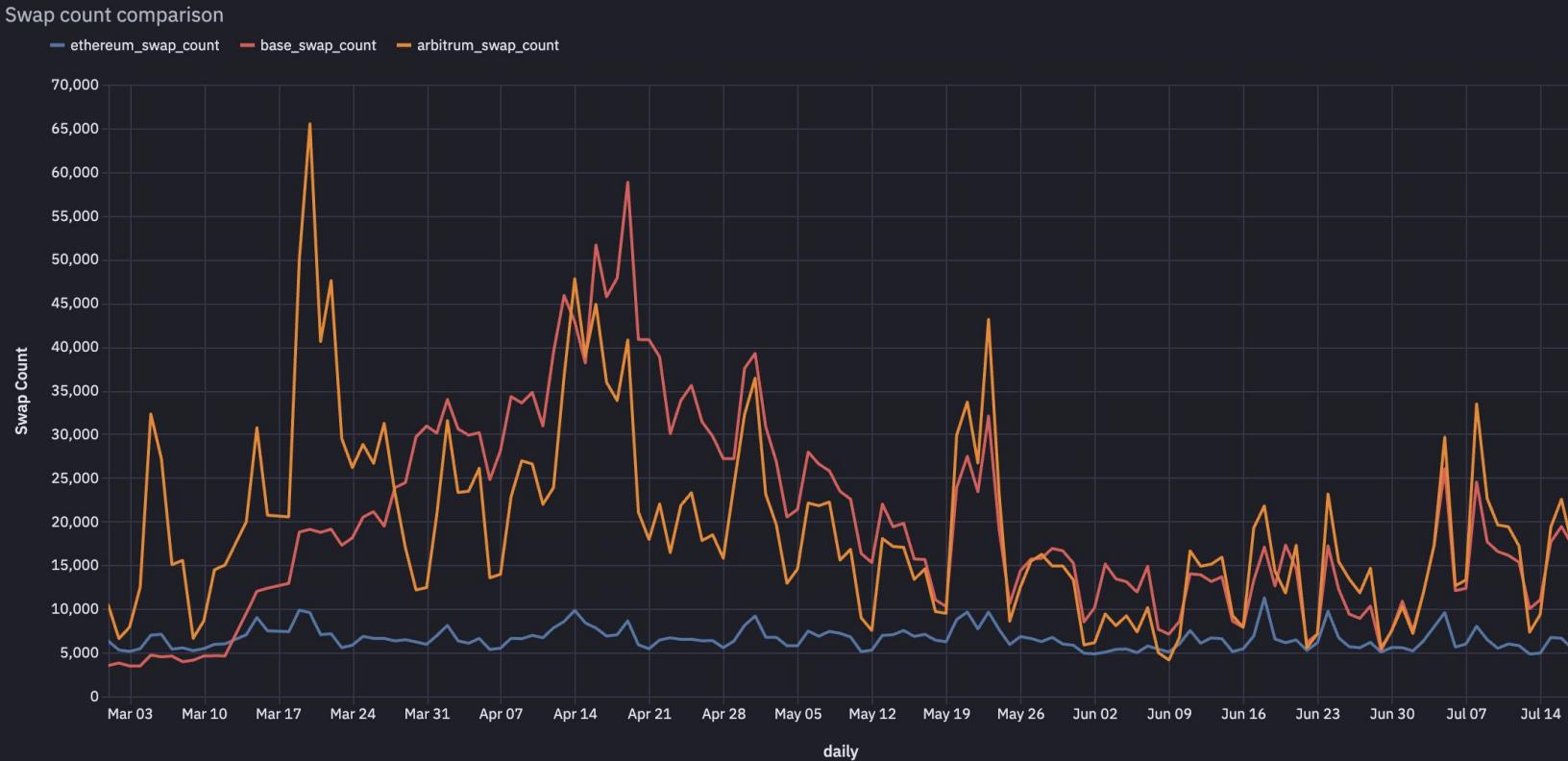
LVR comparison across between Uniswap v2 0.3%
pool & Uniswap v3 0.05% pool



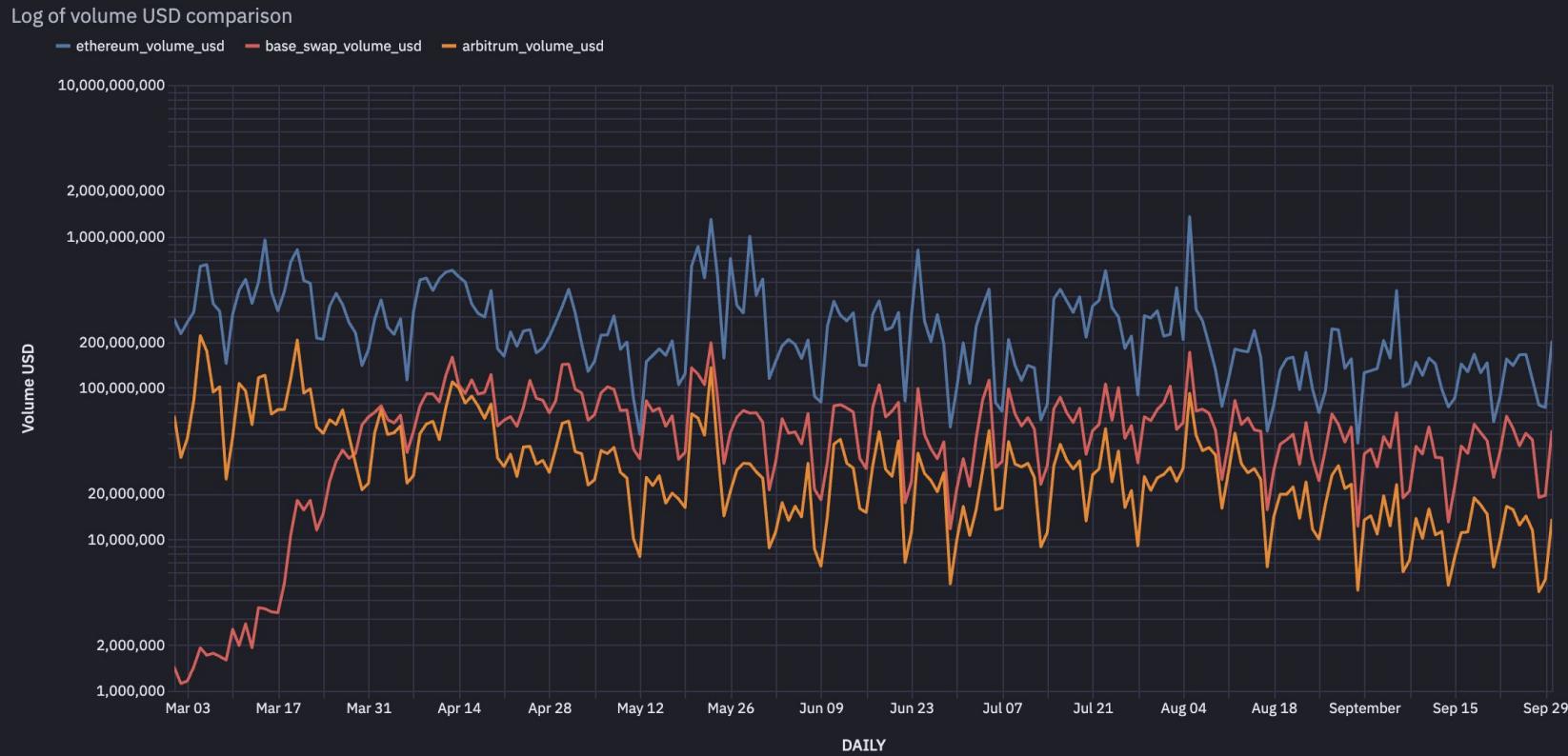
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Swap count – Ethereum vs. Base vs. Arbitrum

All chains



Volume USD (log scale) – Ethereum vs. Base vs. Arbitrum

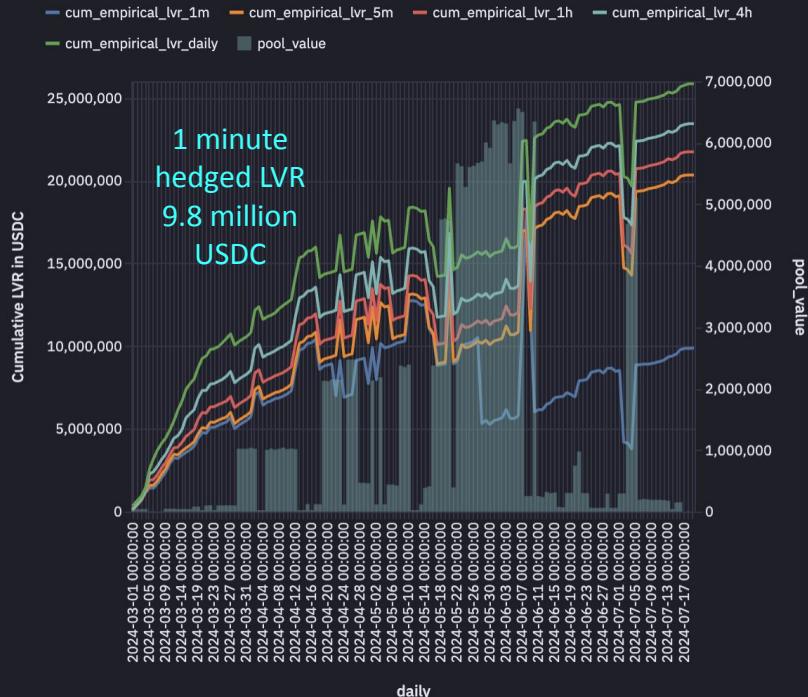
All chains

Uniswap v3 weth-usdc 0.05% pool

Empirical LVR – Uniswap v2 vs. Uniswap v3

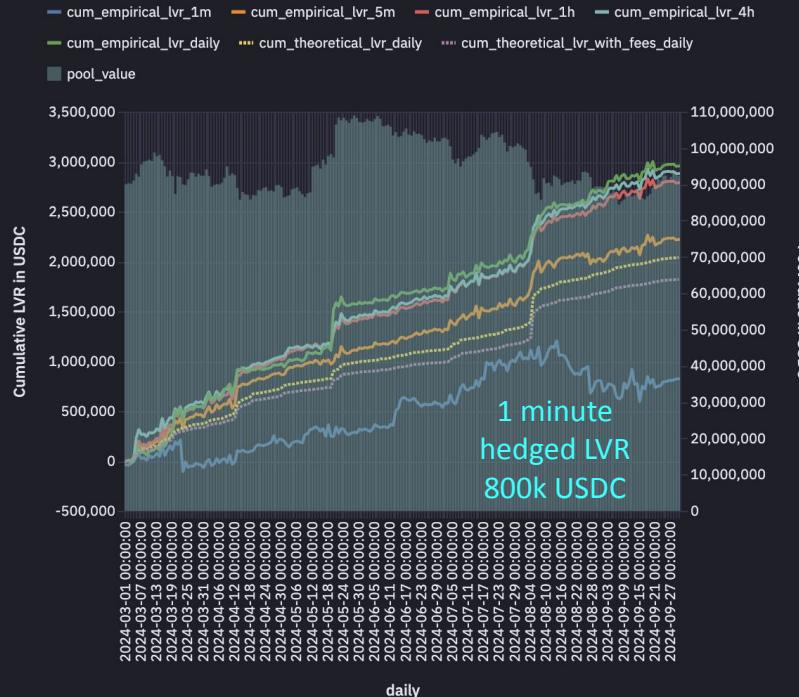
Ethereum

Cumulative LVR at different hedging frequency



1 minute
hedged LVR
9.8 million
USDC

Cumulative LVR at different hedging frequency



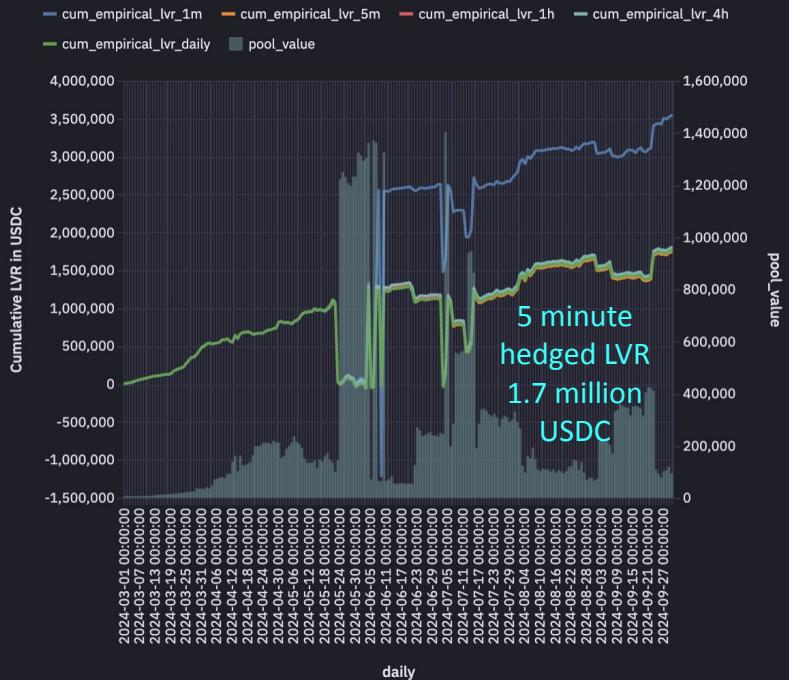
Ethereum uniswap v2 weth-usdc 0.3% pool

Ethereum Uniswap v3 weth-usdc 0.05% pool

Empirical LVR – Uniswap v2 vs. Uniswap v3

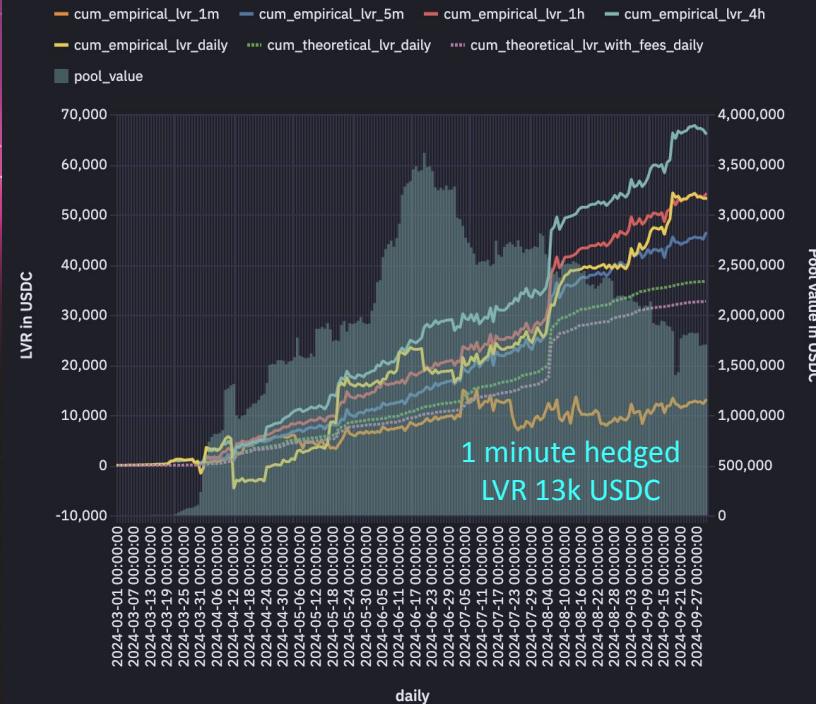
Base

Cumulative LVR at different hedging frequency



Base Uniswap v3 weth-usdc 0.05% pool

Cumulative LVR at different hedging frequency

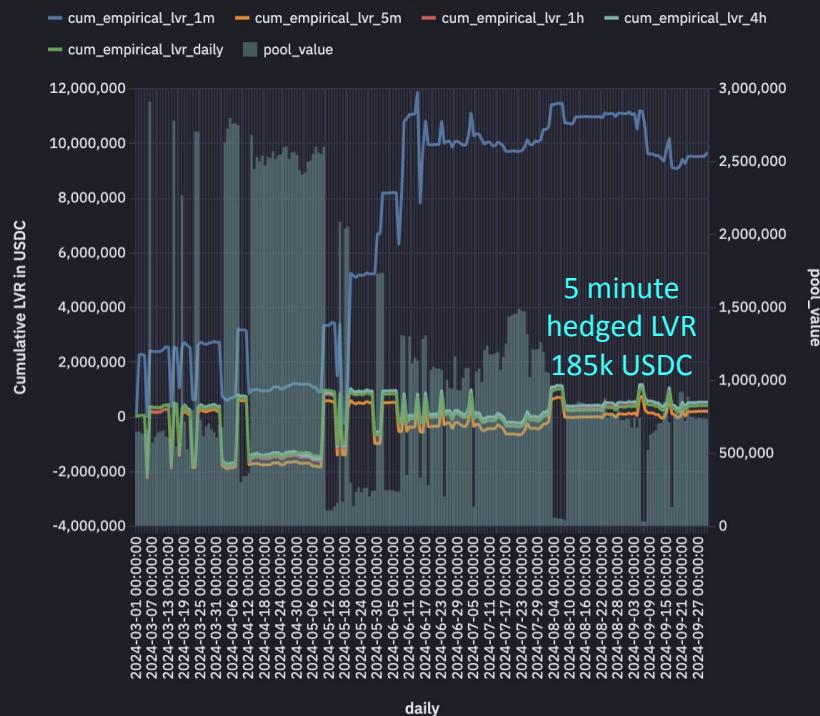


Base camlot v2 weth-usdc 0.3% pool

Empirical LVR – Uniswap v2 vs. Uniswap v3

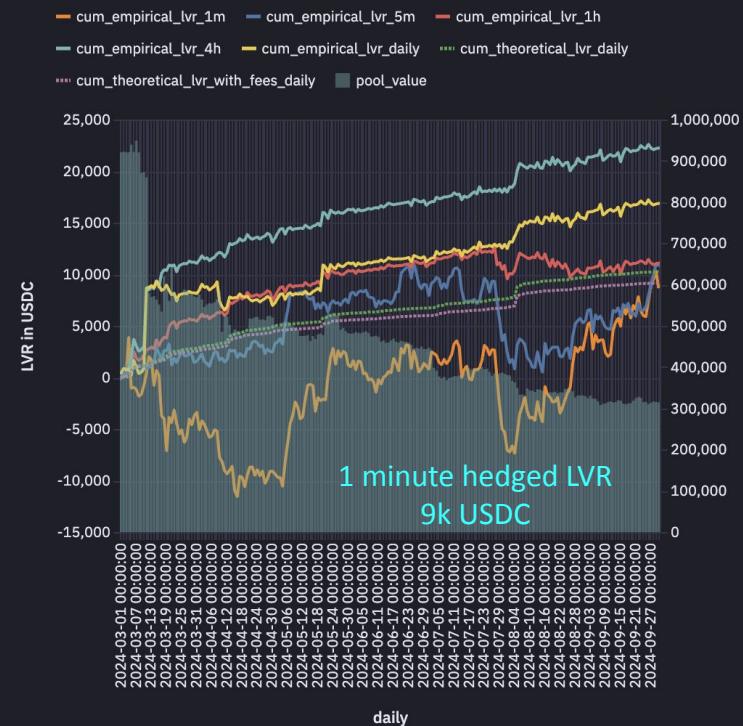
Arbitrum

Cumulative LVR at different hedging frequency



Arbitrum Uniswap v3 weth-usdc 0.05% pool

Cumulative LVR at different hedging frequency



Arbitrum camlot v2 weth-usdc 0.3% pool

HOW MUCH P&L ?

CUMULATIVE HEDGED VS. UNHEDGED P&L IN USDC



CUMULATIVE HEDGED VS. UNHEDGED P&L IN USDC

ETHEREUM

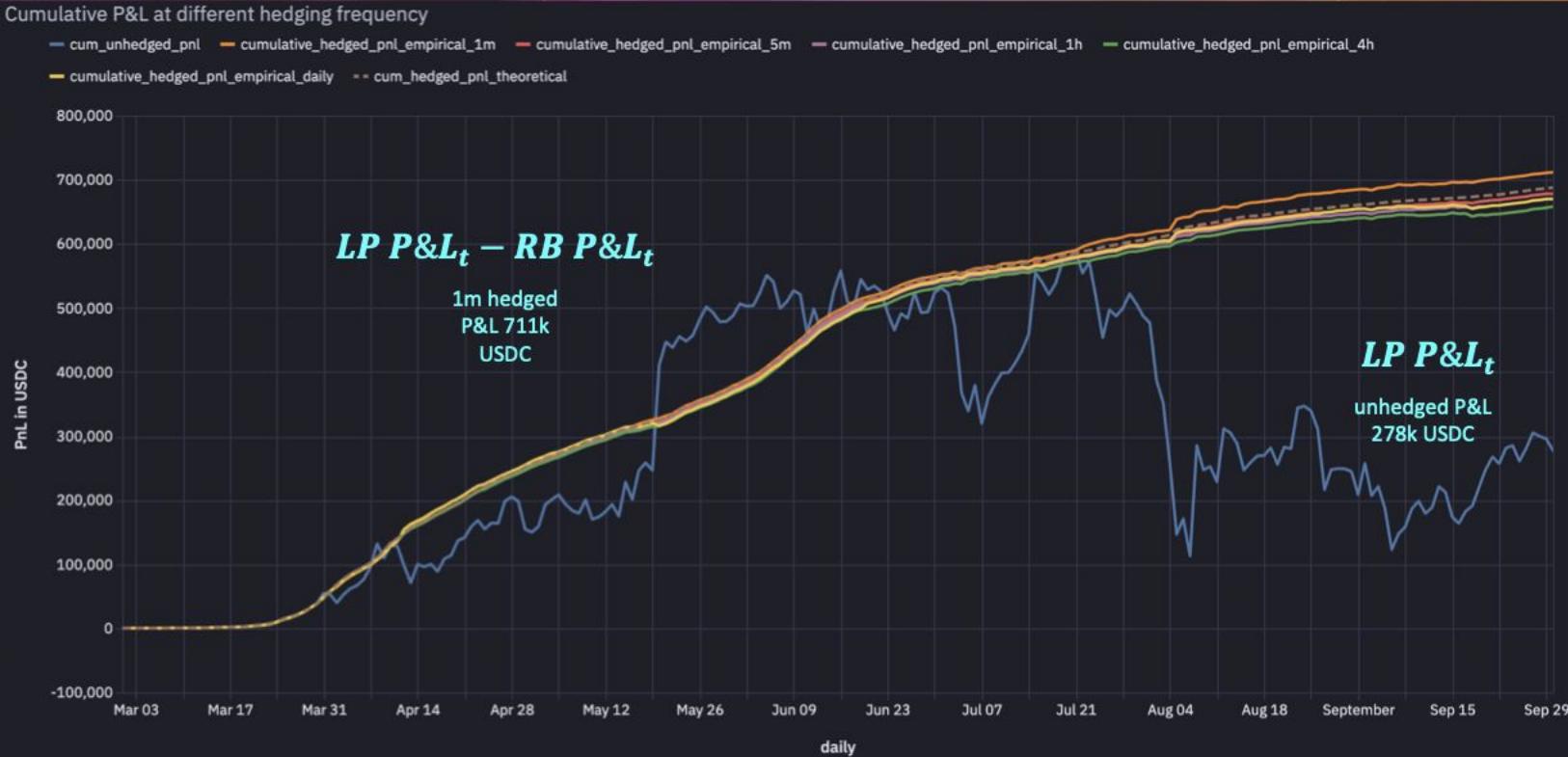
Cumulative P&L at different hedging frequency



ETHEREUM UNISWAP V2 WETH-USDC 0.3% POOL

CUMULATIVE HEDGED VS. UNHEDGED P&L IN USDC

BASE

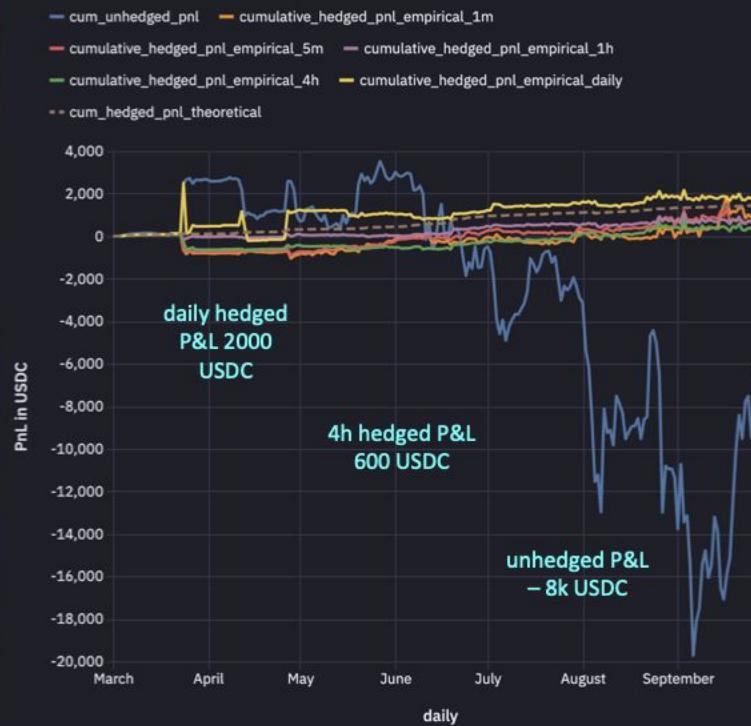


BASE UNISWAP V2 WETH-USDC 0.3% POOL

CUMULATIVE HEDGED VS. UNHEDGED P&L IN USDC

ARBITRUM

Cumulative P&L at different hedging frequency



ARBITRUM UNISWAP V2 WETH-USDC 0.3% POOL

ELAINE HU ⚡🤖

Cumulative P&L at different hedging frequency



ARBITRUM CAMLOT V2 WETH-USDC 0.3% POOL