Is Atomic Execution Enough for Arbitrage Profit Extraction in Shared Sequencers?

Maria Silva and Benjamin Livshits

CAAW - FC

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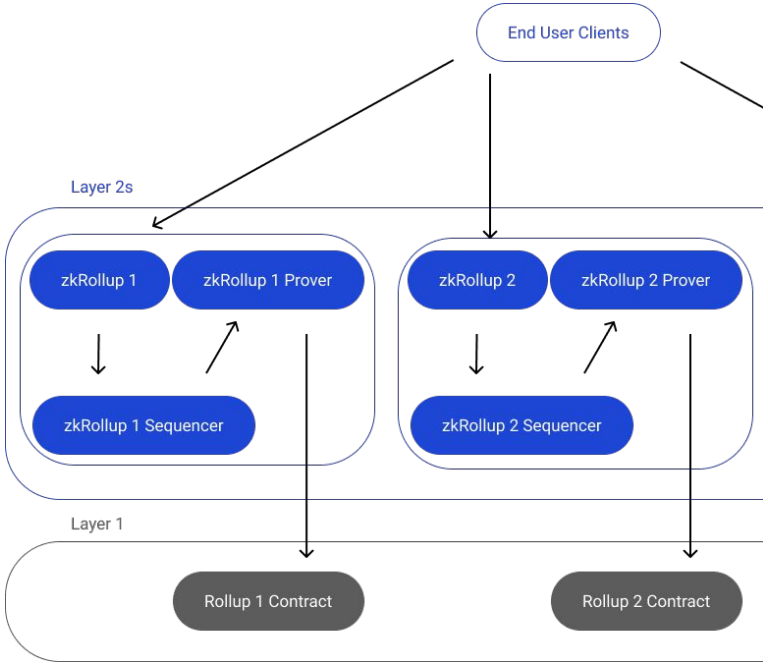
Matter Labs

Imperial College London

NOVA IMS Information Management School

Shared sequencing

- Sequencing = building rollup blocks
- Shared sequencing = same entity sequences transactions from multiple rollups
- Potential advantages:
  - Rollup composability => Better UX for end-users
  - Better MEV extraction => more revenue for rollups



Source: [Espresso Systems]

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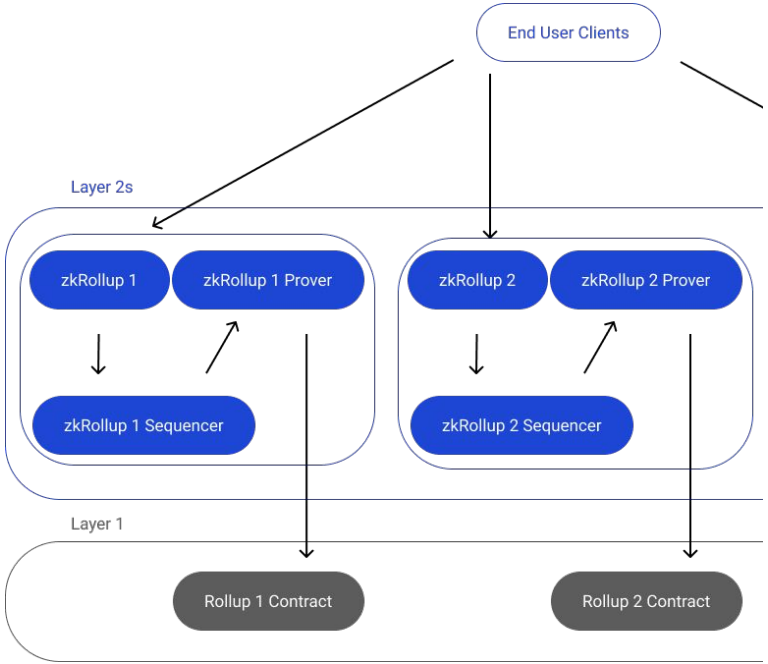
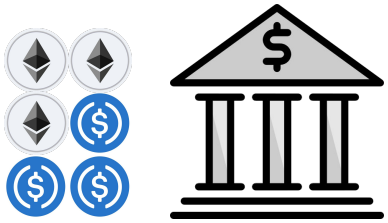
  - **Better MEV extraction => more revenue for rollups ??**



Source: Espresso Systems

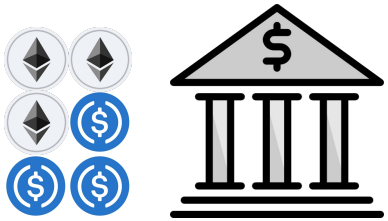
MEV on rollups today

Exchange B



1 ETH = 3200 USDC

Exchange A



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MEV on rollups -> **Arbitrage**

MEV on rollups today

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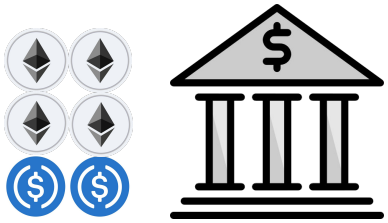

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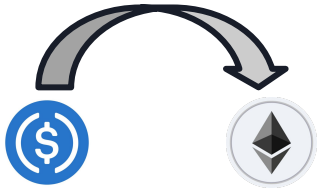

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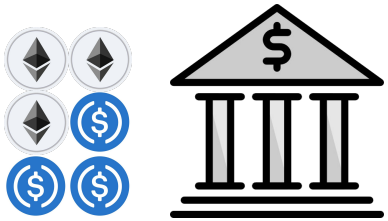

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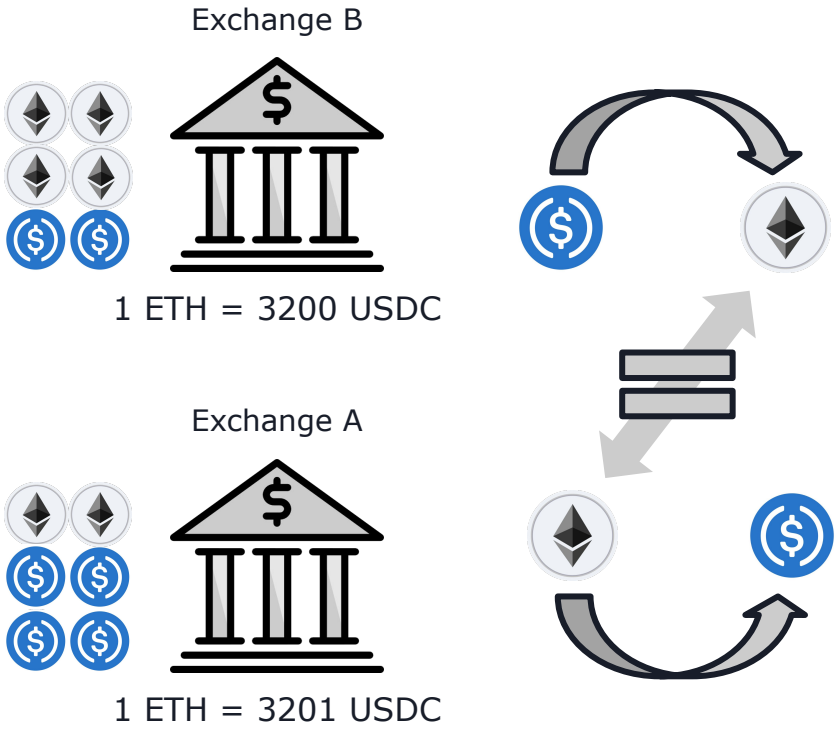
MEV on rollups -> **Arbitrage**

- Exchange B:
  - Pay USDC
  - Buy ETH

MEV on rollups today



MEV on rollups -> **Arbitrage**

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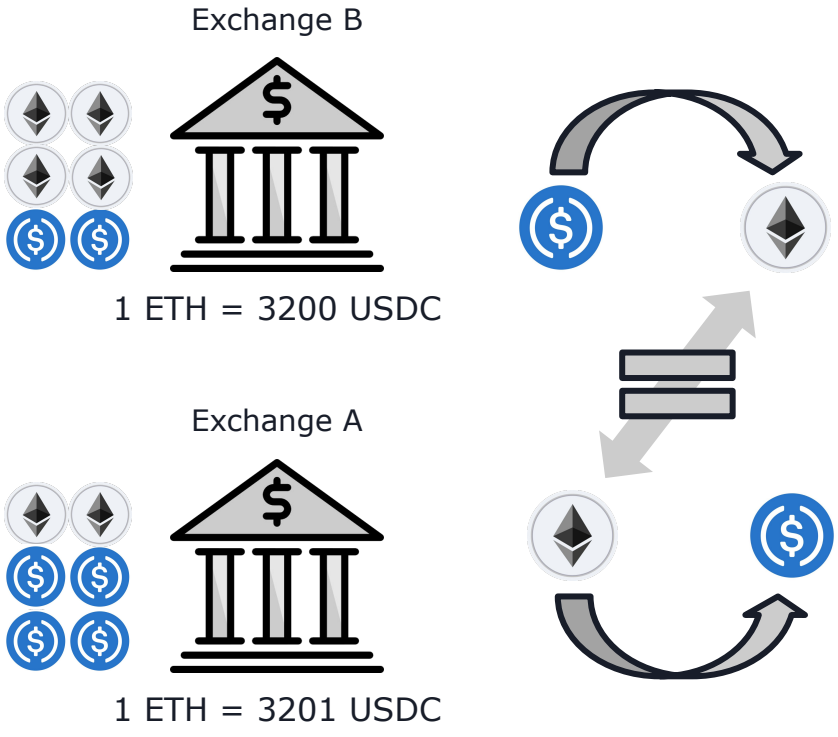
MEV on rollups today



MEV on rollups -> **Arbitrage**

- Exchange B:
  - Pay USDC
  - Buy ETH
- Exchange A:
  - Pay ETH
  - Buy USDC
- Profit = diff in liquidity
  = diff in USDC

Shared sequencing for Arbitrage

“Atomic execution”

Bundle transactions to ensure combined execution

Rollback capability

Shared sequencing for Arbitrage

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Bundle transactions to ensure combined execution

Rollback capability

“Atomic bridging”

Bridge and swap assets in the same transaction

Removes/reduces liquidity requirements

Shared sequencing for Arbitrage

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Bundle transactions to ensure combined execution

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More challenging

Bridge and swap assets in the same transaction

Removes/reduces liquidity requirements

Shared sequencing for Arbitrage

“Atomic execution”

Bundle transactions to ensure combined execution

Ensure arbitrage operations are executed together or not at all

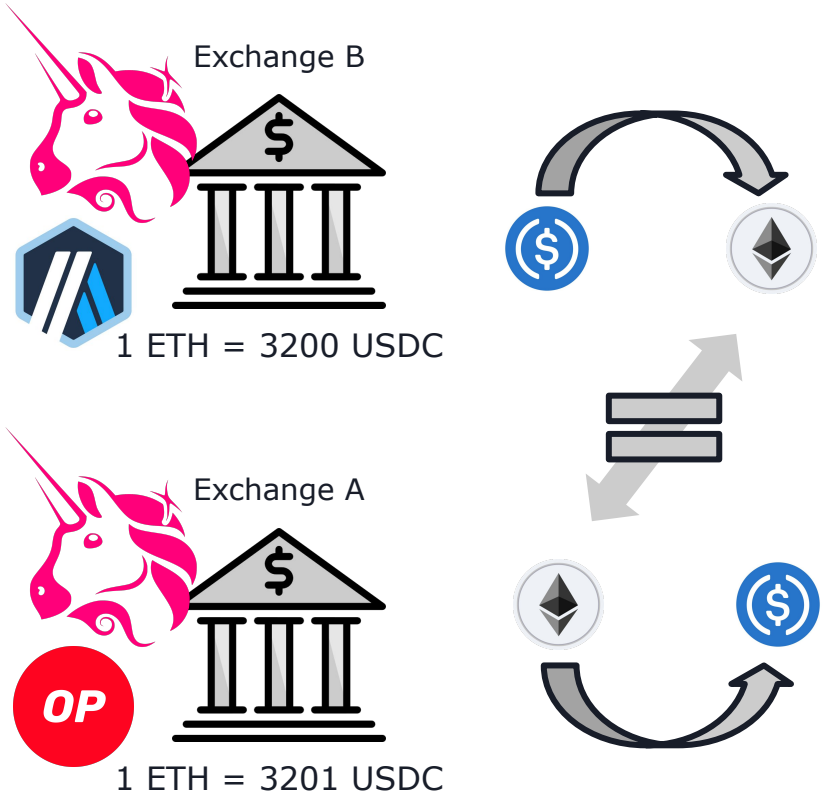
“Atomic bridging”

More challenging

Bridge and swap assets in the same transaction

Removes/reduces liquidity requirements

Atomicity in cross-chain arbitrage



MEV on rollups ->

Cross-chain Arbitrage

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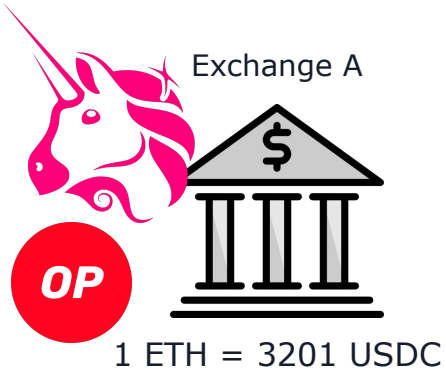
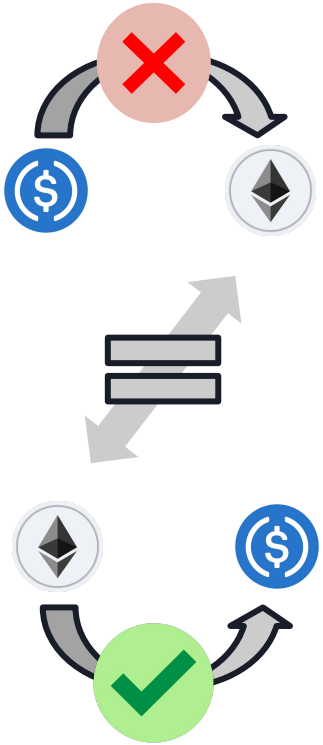
Atomicity in cross-chain arbitrage





MEV on rollups ->

Cross-chain Arbitrage

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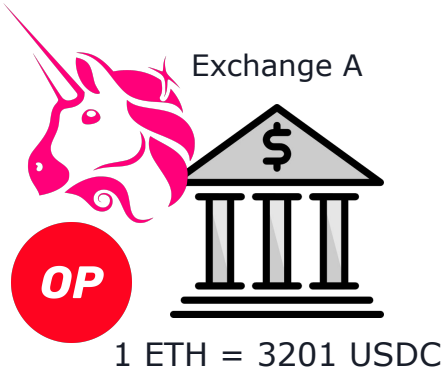
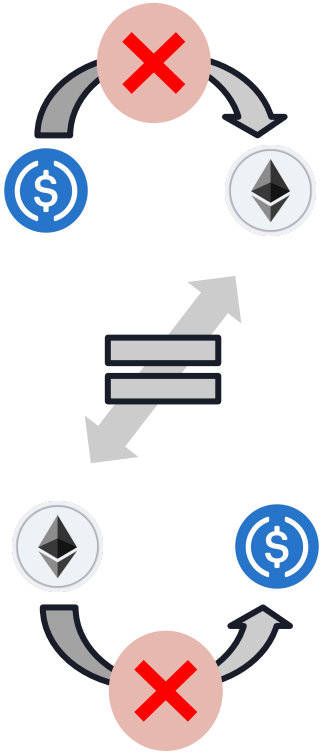
Non-atomicity = Transactions don't depend on each other

Atomicity in cross-chain arbitrage





MEV on rollups ->

Cross-chain Arbitrage

- Exchange B:
  - Pay USDC
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- Exchange A:
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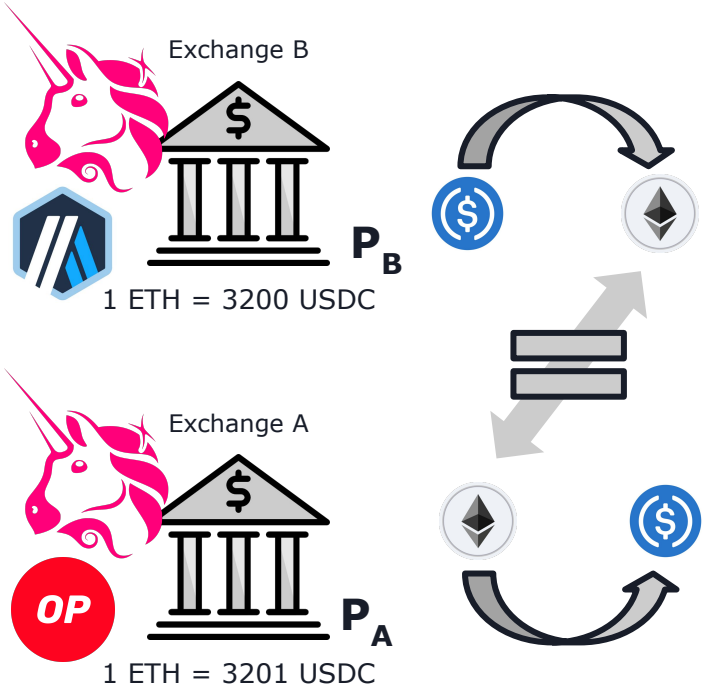
- Profit = diff in USDC

Atomicity = Transactions depend on each other

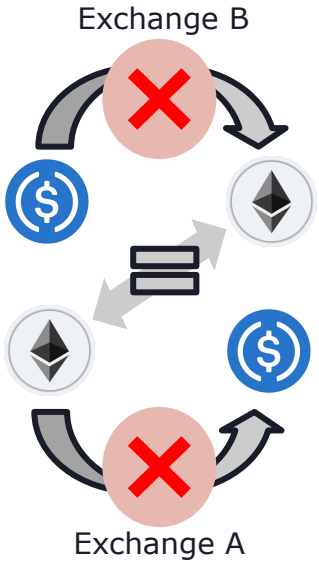
Our model - setup

- Two-token arbitrage, across two similar **CPMM pools** (one in each rollup)
- **Ignore** transaction or sequencing **fees**
- Transaction may fail with prob. $\mathbf{f_A}$ and $\mathbf{f_B}$
- Arbitrageur holds **liquidity** on both rollups and **values it at $\mathbf{P_{ext}}$**

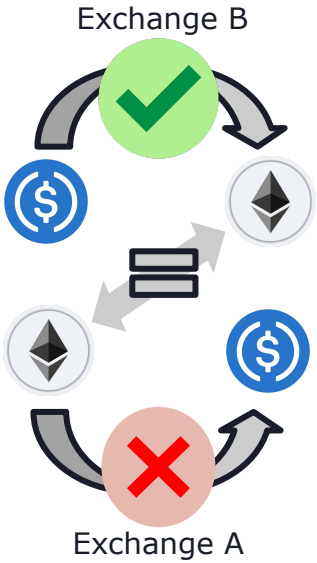


Our Metric = [Expected Profit | atomicity] - [Expected Profit | no atomicity]

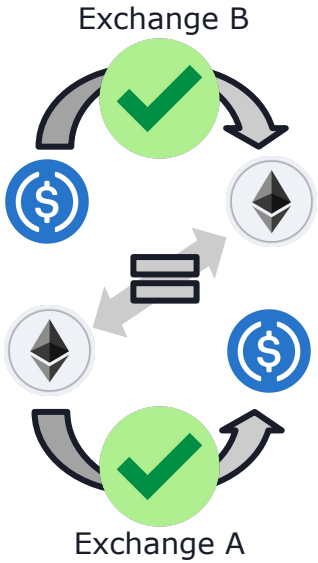
Our model - fail scenarios



$$\text{Profit}_{\text{diff}} = 0$$



$$\text{Profit}_{\text{diff}} =$$
$$= 0 - (\Delta x_B P_{\text{ext}} - \Delta y_B)$$
$$= \Delta y_B - \Delta x_B P_{\text{ext}}$$



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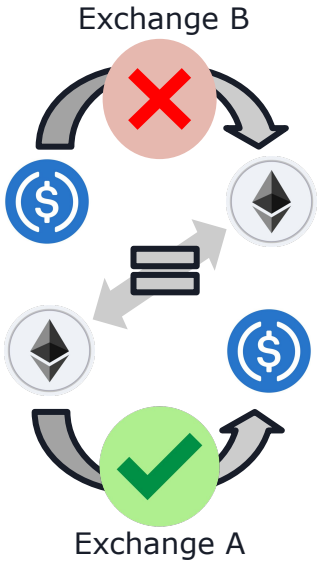

$$\text{Profit}_{\text{diff}} =$$
$$= 0 - (\Delta y_A - \Delta x_A P_{\text{ext}})$$
$$= \Delta x_A P_{\text{ext}} - \Delta y_A$$

Our model - final formula

$$
\begin{aligned}
&\mathbb{E}[\text{Profit}_{\text{diff}}] = \\
&= (\Delta y_B - \Delta x_B P_{\text{ext}}) \cdot P[\mathcal{F}_{S_A} = 1 \cap \mathcal{F}_{S_B} = 0] + \\
&\quad (\Delta x_A P_{\text{ext}} - \Delta y_A) \cdot P[\mathcal{F}_{S_A} = 0 \cap \mathcal{F}_{S_B} = 1] \\
&= (\Delta y_B - \Delta x_B P_{\text{ext}}) \cdot f_A \cdot (1 - f_B) + (\Delta x_B P_{\text{ext}} - \Delta y_A) \cdot (1 - f_A) \cdot f_B \\
&= f_A(\Delta y_B - \Delta x_B P_{\text{ext}}) + f_B(\Delta x_A P_{\text{ext}} - \Delta y_A) + f_A f_B(\Delta y_A - \Delta y_B) \\
&= \Delta x_B \left[f_A(P_B^* - P_{\text{ext}}) + f_B(P_{\text{ext}} - P_A^*) + f_A f_B(P_A^* - P_B^*) \right]
\end{aligned}
$$

Our model - final formula

$$\mathbb{E}[\text{Profit}_{\text{diff}}] =$$

$$(\ldots)$$

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Trade size

Our model - final formula

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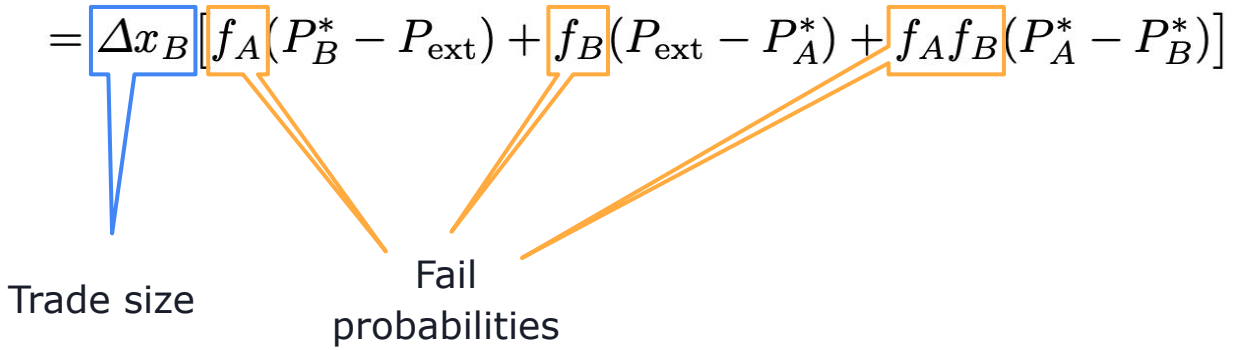

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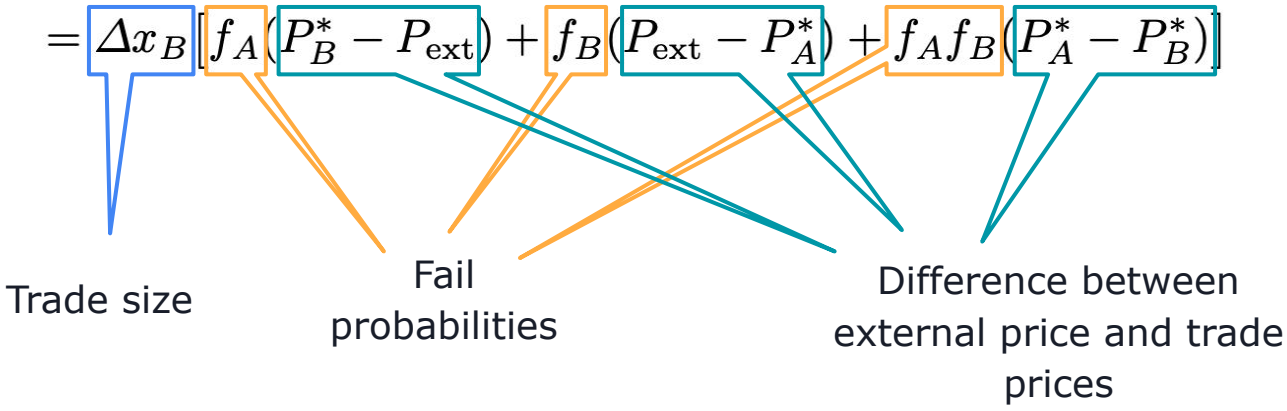
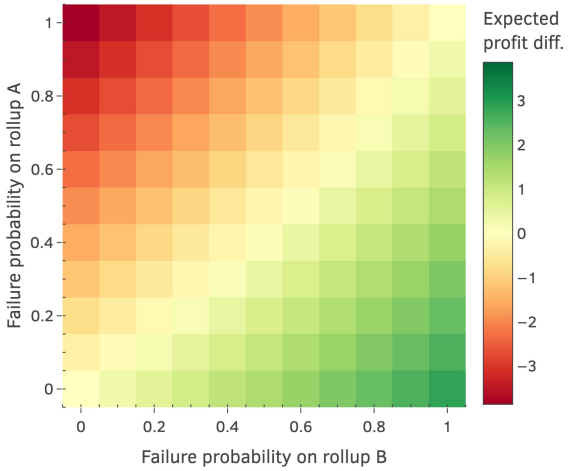
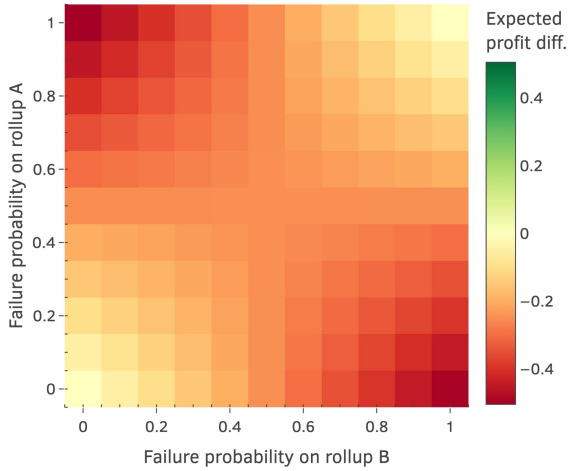


Profit difference simulation



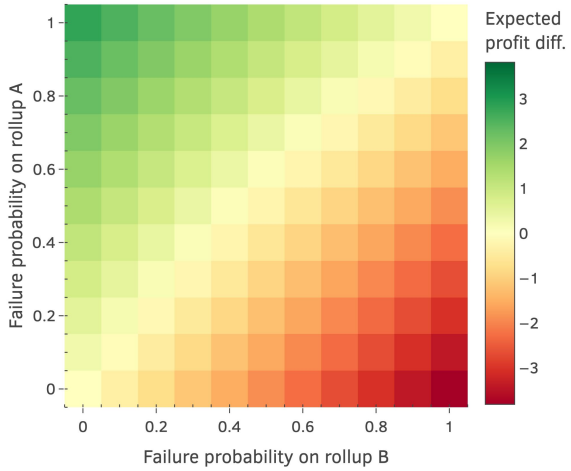
Larger price

$P^*_B < P^*_A < P_{ext}$



Middle price

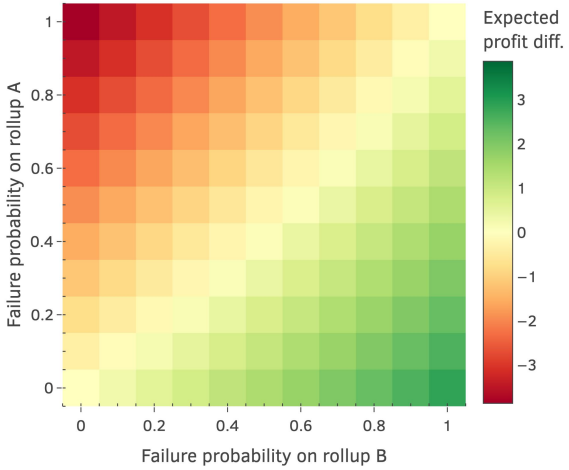
$P^*_B < P_{ext} < P^*_A$



Smaller price

$P_{ext} < P^*_B < P^*_A$

Profit difference simulation - larger price example



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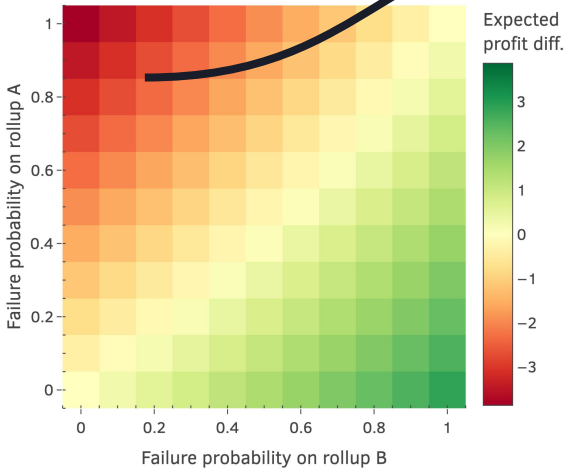

Larger price

$P^*_B < P^*_A < P_{ext}$

Rollup A fails **more** on average than rollup B

No atomicity => **swap B** executes more often

Arbitrageur **buys ETH** on Rollup B at a **better price**

Better to **execute** the swap

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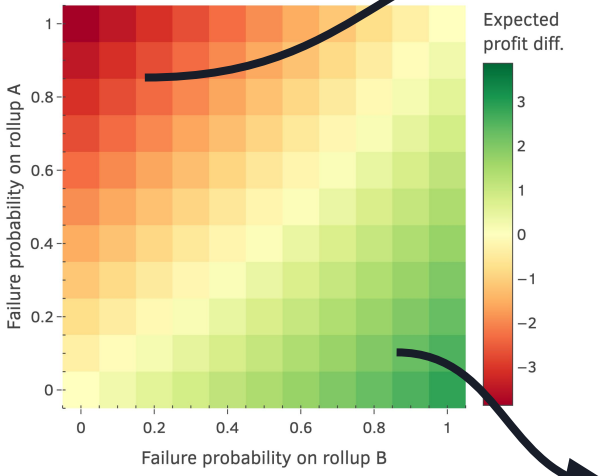

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Rollup A fails **less** on average than rollup B

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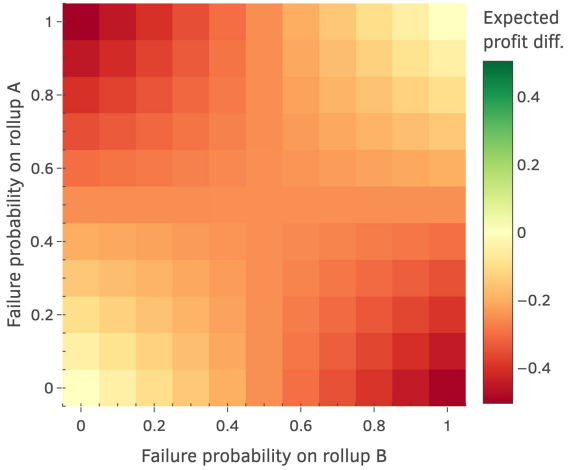
Arbitrageur **sells ETH** on Rollup A at a **worse price**

Better to **not execute** the swap

Profit difference simulation - middle price example



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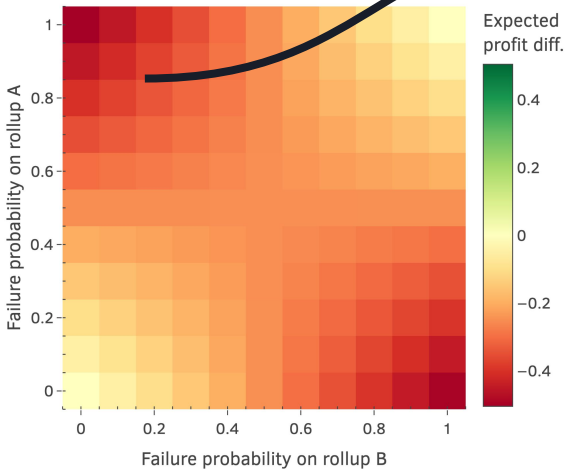

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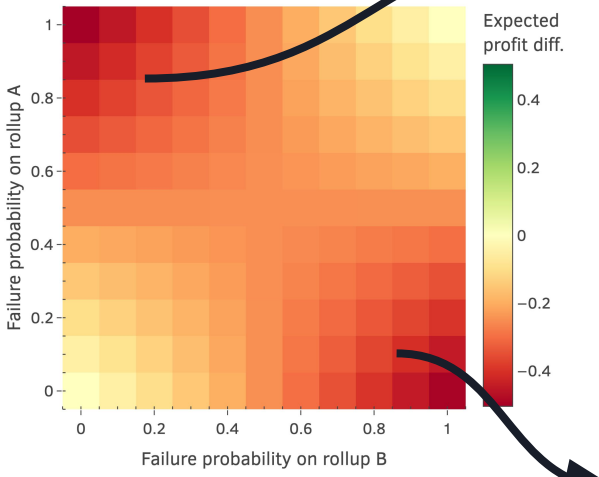

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Arbitrageur **sells ETH** on Rollup A at a **better price**

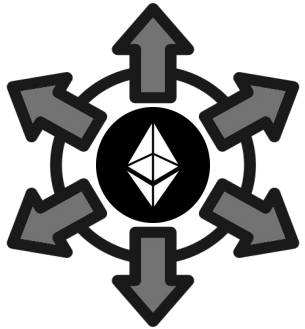
Better to **execute** the swap

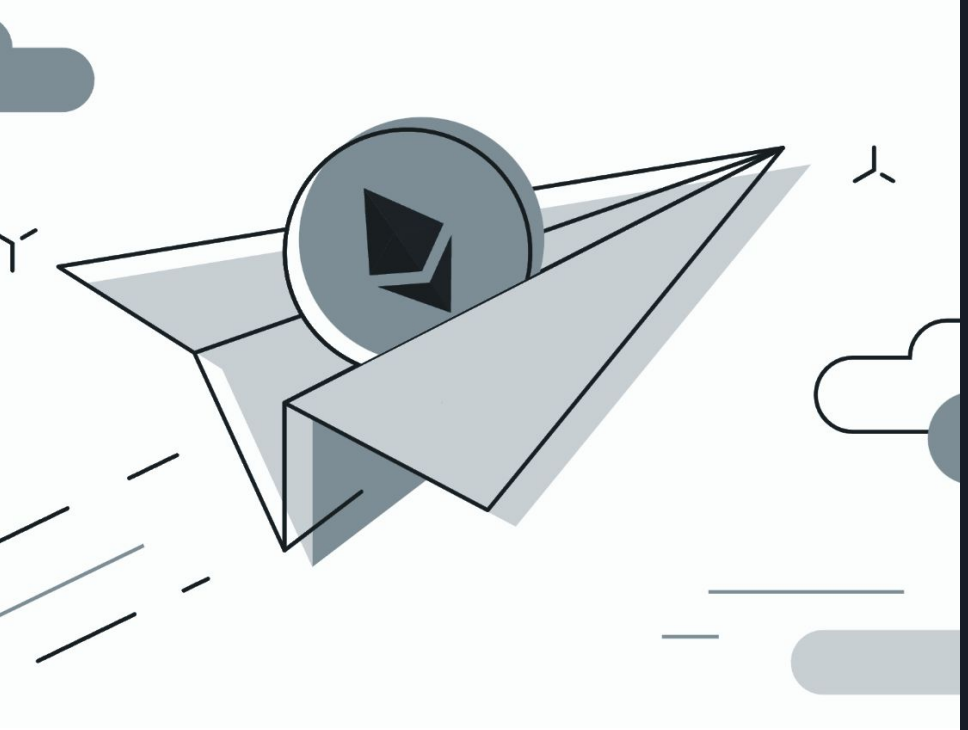
Key takeaways

- Atomic execution **does not always lead to a profit** in cross-chain arbitrage.
- A net gain depends on:
  - The failure probabilities on each rollup
  - The price of the arbitrageur, relative to the pool prices
- Thus, **atomicity is likely not enough** to convince arbitrageurs and rollups to switch -> liquidity is the biggest problem

Possible Extensions

- What happens when we **introduce transaction** and sequencing fees?
- What if the arbitrageur **values their liquidity using a stable token** (e.g. USDC)?
- How prevalent are the **scenarios** in which **atomic execution is not beneficial**?
- Can we use a similar analysis to investigate the **net gain from atomic bridging**?





Thank you!

Maria is currently looking for new projects and collaborations.

You can connect with her on:

LinkedIn

Telegram

@MISILVA73

You can read the full paper on arxiv (2410.11552)