TimeBoost: Do Ahead-of-Time Auctions Work?

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January 27, 2026; SNS DeFi

Motivation

Blockchains use auctions as part of their transaction ordering mechanism

In Ethereum *Proposer Builder Separation (PBS)*:

- a builder auction where specialized parties *block builders* bid for the right to determine the content of the next proposed block

In most rollups, transactions are sorted in decreasing priority fees per gas:

- *Priority Gas Auction (PGA)* – an auction for earlier execution

JIT

These auction formats have one commonality: "Just-in-Time" (JIT):

- bidders can bid in it just until immediately before the content of the block is determined

Significant differences:

- in Ethereum builders bid on the right to order the whole block
- in rollups the auction is on the relative ordering of individual transactions by the sequencer
- Ethereum has a public mempool, rollups do not

Ahead-of-Time Auction

Alternative to JIT: "Ahead-of-Time" (AOT) auctions

- sizable time gap between the auction and the order of transactions

In Ethereum, these auctions have been discussed under "slot auctions":

- the builder only bids on the right to propose the next block
- no commitment to any specific block content at the time of bidding
- determine block content only (12 seconds) later

Or "execution tickets"

- lottery tickets allowing block proposal will be sold AOT

In rollups, TimeBoost has an AOT component as part of its design

AOT vs. JIT

In JIT auctions, the performance is just a question of competition:

- if enough bidders compete, paid bids should be close to the value thay get

For AOT auctions, besides competition, there is a problem of prediction

To compare the relative performance of AOT and JIT auctions:

- how well bids match the value that bidders get from the right they acquire

Prediction

Bidders need to predict the future value that they will get:

- if they are able to predict it well (and there is sufficient competition), the auction will yield efficient outcomes
- if they do not, the auction will generally be more inefficient than a JIT auction

First empirical analysis of an AOT auction in the context of blockchains

TimeBoost

On Arbitrum rollup since April 17th, 2025:

- a protocol sells a time advantage in the FCFS policy to one party
- permissionless, sealed-bid second-price auction
- bids are denominated in ETH, a reserve price of 0.001 ETH
- if no bidder bids more than the reserve price, transaction ordering policy remains pure FCFS
- if only one bidder bids more than the reserve price, it pays the reserve price
- if at least two bidders bid more than the reserve price, then the winner is the highest bidder and it pays the second highest bid
- the time advantage equals 200ms and it lasts 1 minute for the winner

TimeBoost: cont.

The auction for the next minute starts at 0s and lasts until 45s:

- 15 second time window for the bidders to predict next minute's value

Time window needed to allow the auction settlement on-chain

The ordering rule is enforced by a designated party, the sequencer:

- executes regular transactions with a 200ms delay
- transactions coming from the TimeBoost winner are executed on their arrival, without delay

In effect, the sequencer merges these two FCFS queues into each other

Outline of Insights

Compare cumulative fixed time markouts to bids for the fast lane:

- markout is not fast lane value, but the best measure we can observe

Observations:

- correlation between winning bids and markouts is weak across bidders
- correlation slightly improves when comparing paid bids (the second highest bid or a reserve price) to markouts
  - the auction is more of a common value type

Further Insights

Bids are a noisy predictor of extracted value

1. the auction ends 15 seconds before the round even starts, increasing the uncertainty of the value in the next minute
2. estimating the future value over 1 minute is difficult

In all settings, two things remain the same:

- the relative order of the most frequent bidder performance
- their absolute profits

Bids and markouts over long time intervals exhibit much higher correlation

- bidders detect trends much better than identify when the high arbitrage value is exactly available

Empirical Approach

Check all transactions winners submit through a fast lane to DEXs

Calculate the hypothetical profit that the party would make

- sell assets they bought a few (5) seconds later, on an external market
- a profit referred to as a markout

The methodology likely leads to an overestimation:

- average prices taken at CEXes may not reflect the real prices auction participants execute their trades at

However, we treat all players in this regard in the same way

Transactions

Filtered data (August):

- 3,006,396 transactions
- an estimated trading volume of 6.65 billion USD

Total numbers:

- TimeBoosted transactions about 4.1M
- the total volume 7.9 billion USD

Only transactions containing single DEX swaps were considered:

- it is easy to check that these swaps are not cyclic arbitrage

Types of Transactions

Two types of profit statistics:

1. aggregate all transaction markouts
2. aggregate markouts by excluding potential negative profits

Some fast lane users are market makers trading on different platforms:

- idiosyncratic reasons for fast lane usage
- some transactions are not for the purpose of arbitrage extraction
- sometimes they trade because they are re-balancing their portfolios
- this is done as part of their overall risk management strategy

Estimated performance improves significantly by excluding losses:

- a further motivation for such filtration

Out of total 3.006M txs, around 2.3M txs result in positive markouts

Empirical Results

Estimated profits from the fast lane transactions are highly variable:

- few high volatility days (and minutes) contribute disproportionally to overall profits

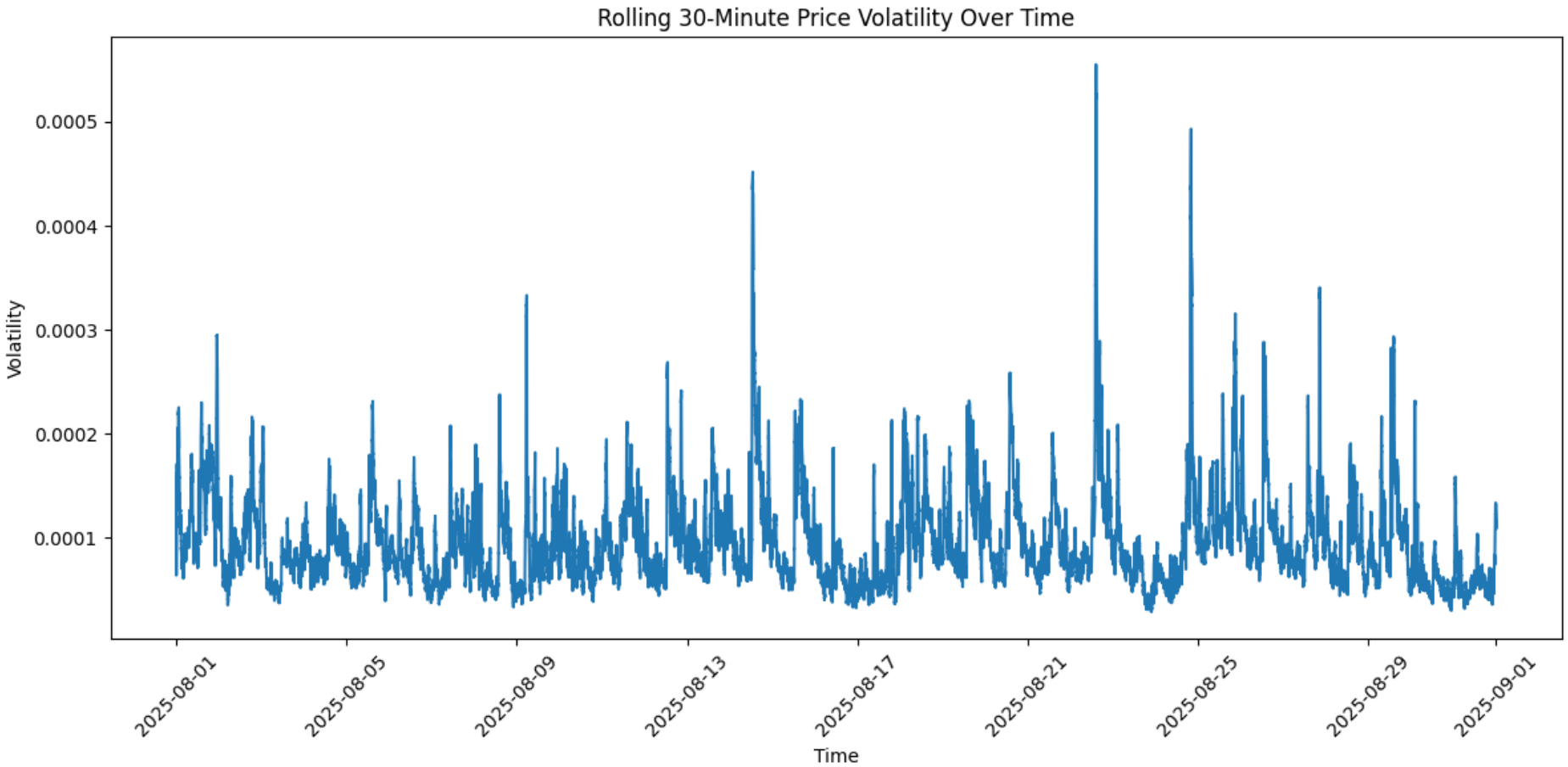

Figure: Price Volatility

Profits

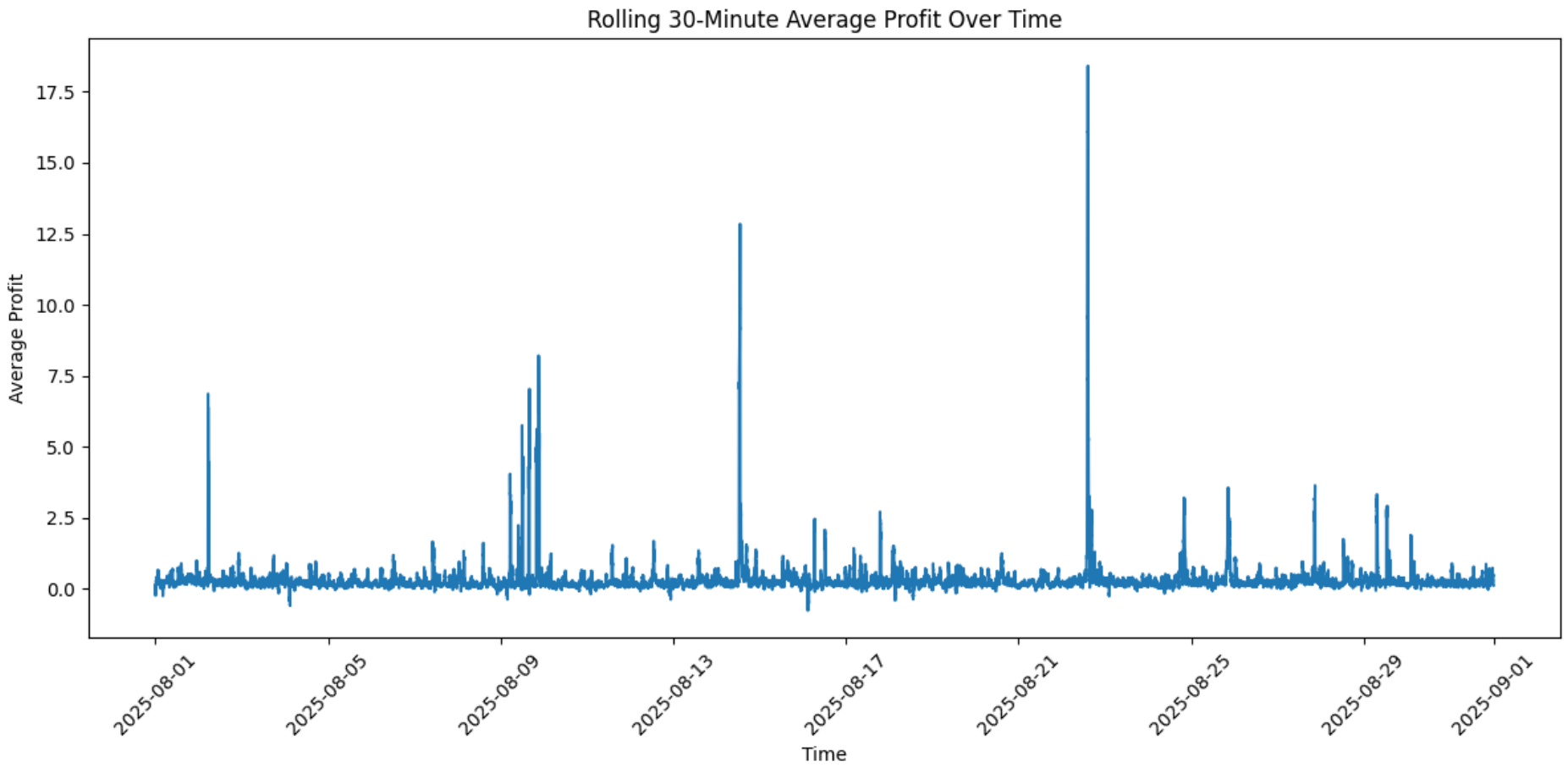

Figure: Arbitrage Profits

Aggregates

Different usage of the fast lane among the three auction participants:

- Wintermute and Selini actively use the fast lane
- Wintermute exhibiting higher transaction frequency

Winner	Total Txs	Rounds	Avg. Txs	Total Gas	Tot. Gas Fees
Wintermute	2.262M	21237	106.5	3.88e+11	43563
Selini	855K	20831	41	1.32e+11	15803
Kairos	4.1K	1180	3.5	5.72e+8	47

Gas fees are denominated in USD, as well as profits/markouts

Different Participants

After subtracting paid bids from the minute markouts, the profits are positive and significant for Wintermute and Selini

- in absolute terms
- on average per auction

Wintermute is able to extract more profit from the system

Kairos is an outlier, by hardly trading actively and making a loss on chain

Winner	Unfilt. Markouts	Filt. Markouts	Total Paid	Total Bid
Wintermute	578K	1.275M	342K	656K
Selini	496K	865K	237K	376K
Kairos	1.1K	1.5K	20K	39K

Long Intervals

Bids are a good predictor of longer run arbitrage profits:

Bid type	5 minutes	10 minutes	15 minutes	30 minutes	1h
Highest	0.62	0.77	0.78	0.83	0.877
Paid	0.6	0.78	0.8	0.82	0.884

Explanation

A simple bidding strategy players seem to exhibit:

- the next bid is based on the previous minute profits the player (or its competitor) makes through fast lane usage

Correlate bids with previous minute profits, current minute profits and future minute profits (aggregated over players)

The correlation is highest with previous profits, worst with future profits:

bid	Pearson		Spearman	
	filtered	unfiltered	filtered	unfiltered
next period	0.50	0.4	0.52	0.43
current period	0.27	0.25	0.35	0.35
previous period	0.22	0.20	0.31	0.35

Autorocorrelations

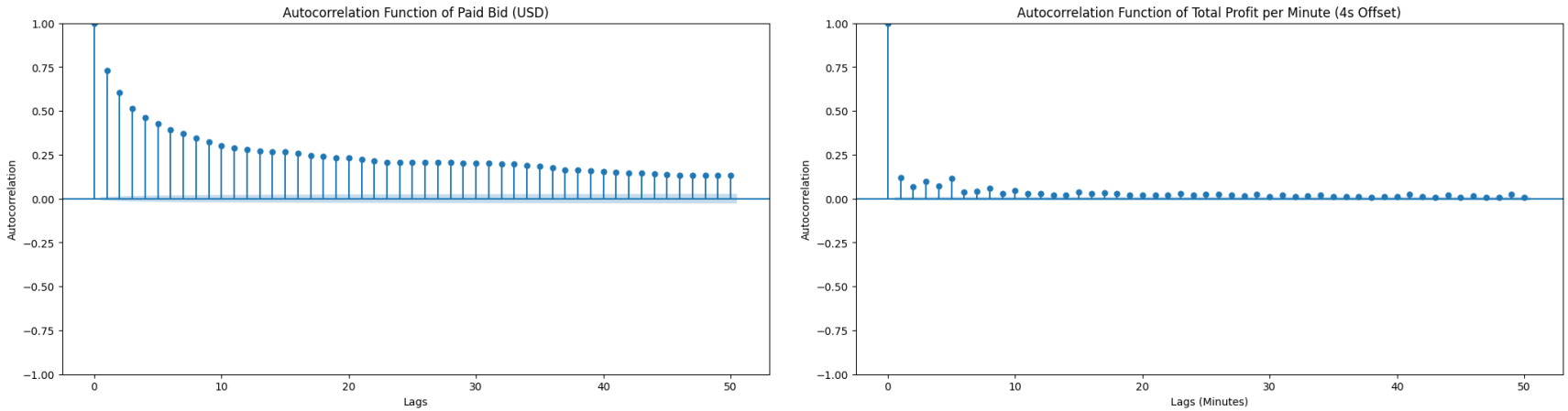

Figure: Autocorrelation of paid bid and of markouts per minute

The autocorrelation of the highest or paid bids is significant

- expected as there are long trends in bidding behavior, corresponding to market sentiment

On the other hand, autocorrelation between markouts is quite low

Future Work

Only scratched the surface of TimeBoost fast lane usage and auction

It is interesting to check how TimeBoost affects:

- liquidity providers
- the performance of other searchers that do not compete in the TimeBoost auction

Thank You!

Questions?