In this post, we discuss modeling assumptions and empirical results from the paper:[2410.10797] MEV Capture Through Time-Advantaged Arbitrage, a joint work with Ed Felten, Robin Frisch, Maria Ines Silva and Ben Livshits.

We look into the Maximal Extractable Value (MEV). Currently, there are four most popular forms of MEV on Ethereum.

1. price arbitrages: to capitalize on price discrepancies between different exchanges,
2. liquidations: collateral from debt repayment in lending protocols can be purchased at a discount,
3. backrunning: similar to price arbitrage, with a difference that the fundamental price on outside markets is not changed,
4. sandwiching: involves wrapping a victim's swap transaction between two new transactions in such a way that provides a worse trade execution to the victim while tracking a small profit.

Effective mechanisms for transaction ordering becomes a key aspect of blockchain design. With arbitrage activity increasing, rollups are considering which policies they should use to include and order transactions. The simplest and natural approach is the first-come-first-serve (FCFS), used in traditional exchanges, and Priority Fees, used in many popular blockchains. In FCFS system, transactions pay the same gas fees determined by the state transition function, and users cannot pay a premium for faster inclusion. Instead, users who value fast transaction inclusion are likely to invest in latency infrastructure in order to improve their latency.

A recent TimeBoost proposal auctions a time advantage for transaction inclusion. The winner of the auction gets its transactions scheduled in FCFS order. Other transactions are also scheduled in FCFS order, but with a fixed time delay. More concretely, users bid for the right to access an "express lane" where transactions are sequenced for execution immediately. This access is sold for a fixed time interval to a single user. The transactions submitted by the remaining users are artificially delayed by the sequencer for a predefined time, which results in the user who purchases the time advantage being able to guarantee that their transactions will be sequenced ahead of its potential competitors. Our paper investigate the impact of this time advantage, focusing on arbitrage opportunities exposed via automated market makers. We analyze the optimal strategy for a time-advantaged arbitrageur and compare it to the profits generated by other MEV extraction approaches.

As expected, the transaction ordering policy significantly influences how the profit from MEV extraction is distributed among participants. For instance, on Ethereum, most profits are paid to validators through MEV-Boost, while on Arbitrum currently, and on FCFS systems more generally, profits stay with MEV extractors and are likely invested in improving their access to sequencers (e.g., through latency improvements). One can argue that avoiding such a latency competition would be favorable and more efficient for the underlying chain. Letting the extractors bid for the opportunity to extract MEV in an auction, allows the rollup protocol redirect proceeds to it.

The emergence of these mechanisms raises the question of how arbitrageurs will react to the design and how much rollups are expected to capture. There is also the question of whether a particular design introduces new opportunities for MEV extraction or increases the magnitude of existing MEV opportunities. Both of these may lead to higher profits for extractors at the expense of other participants. In this paper, we aim to tackle these questions. First, note that time advantage does not create sadnwiching opportunities itself. As long as the sequencer is trusted not to leak transactions before they are sequenced, no party will have the information they would need to sandwich, with or without TimeBoost. Next, given zero (or very low) chain gas fees, backrunning opportunities cannot be efficiently exploited by the time-advantaged arbitrageur, as probabilistic exploitation by any player is still possible. The time-advantage can be efficiently used when exploiting price arbitrages and liquidations. We focus on the former, and leave the latter for future research. Our paper is the first that not only measures the impact on arbitrage profits of changing the block production policy, but also analyses how introducing a time advantage to the sequencing policy impacts arbitrageurs' decisions. Concretely, this work provides five main contributions:

1. A theoretical model to analyze the scenario where a single actor has a time advantage and uses it to perform arbitrage between a liquidity pool in a DEX and an infinitely liquid external market. Another assumption in the theoretical model is that nobody has any information advantage on the outside market, i.e., the race is decided at the DEX.
2. A theoretical derivation of the optimal strategy for when the advantaged arbitrageur submits the extraction transaction under the proposed timeboost model. For this derivation, we assume that prices evolve according to certain distributions (including a geometric Brownian motion) and that the liquidity pool charges no fees.
3. Using dynamic programming and the empirical price distributions of some key liquidity pools, we analyze the optimal strategy for when the advantaged arbitrageur submits the extracting trade. The state in the dynamic programming table is characterized by three parameters: how much time has passed in the 1 minute interval of holding the express lane license, how much time passed in the 200ms advantage since the price difference crossed the threshold where arbitraging is profitable, and the price difference.
4. We simulate the expected profits an arbitrageur could extract in some key liquidity pools under different sequencing regimes: FCFS, fixed time interval arbitraging and Timeboost, estimating the price change over time from the most traded marketplace.
5. We look into an option of letting pools capture some share of the value from the arbitrage opportunity by letting the contract know about Timeboost transaction at the time of execution. This results in a sequential game where the pool

first sets up a fee structure for extracting the value, and then the arbitrageur best responds to it by choosing the price that maximizes its returns. In the equilibrium of this game, the pool obtains 25% and the time-advantaged arbitrageur obtains 50% of the total value.

For details check out the paper. Any feedback is welcome.