Allocative Inefficiencies in Public Distributed Ledgers

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Introduction

- a model of auctions for blockchain transactions on ethereum
- choice of public vs. private mempool for transactions
- empirical analysis of transaction covering 2020-2021
- partial overlap with introduction of private pool by flashbots (February 11, 2021)
- private pool data ends with July 31, 2021 before introduction of EIP 1559 with new fee mechanism

Main Results

- equilibrium analysis of pool choice by users, arbitrageurs and validators
- bidding equilibrium as part of subgame perfect equilibrium
- welfare analysis of partial vs. full adoption by validators
- empirical support for bidding predictions and welfare implications

Model

- a set of competitive validators
- a user with a frontrunnable transaction and a finite set of non-frontrunnable users
- two arbitrageurs
- transaction venues: private and public pool

Three Periods

period 1:

- validators choose whether to monitor private pool next to public pool
- private pool transaction can only be observed by validators who choose to monitor private pool
- finite adoption rate of private pool

$$\alpha = \frac{M}{N} \in [0, 1],$$

  where N is total number of validators, M is validators accessing private pool
- $1 - \alpha$ is the execution risk: random validator does not have access to private pool

Three Periods

period 2

- users decide on bid fees and submission venues with bid fee

$$f_i$$

- users earn private benefits

$$v_0 > v_1 > ... > v_n > ...$$

  and net utility

$$v_i - f_i - c\mathbb{I}_{\text{frontrun}}$$

- frontrunnable user loses

$$c > 0$$

  if being front-run by arbitrageur

Three Periods

period 3

- arbitrageur creates an order, attaches a fee, and decides which venue to choose, public or private or both
- on public pool order of arbitrageur is broadcast
- arbitrageur who executes a frontrunnable transaction earns

$$c > 0$$

Benchmark: Public Pool Only

- depending on the cost/damage of frontrunning c allocative inefficiency arises due to:

1. high cost $c > c_1$, frontrunnable transaction is not submitted
2. low cost $c < c_1$, frontrunnable transaction is submitted, but attack occurs and lower value transaction fail to included

Equilibrium with Private and Public Pool

- with execution risk $1 - \alpha$, participation of validator has to be sufficiently high for users to enter:

$$\alpha > \lambda$$

- there are two equilibria (the second requiring cost condition $c < c_1$:

1. full private pool adoption equilibrium: no frontrunnable attacks and all users adopt private pool
2. partial adoption equilibrium: frontrunnable user chooses public pool, attacks occur through both pools

Welfare

- a private pool weakly increases aggregate welfare
- full adoption equilibrium is socially efficient, partial adoption equilibrium is not socially efficient

Discussion

- equilibrium analysis is stated in terms of cost condition c
- cost conditions are likely heterogeneous across users
- can you identify sorting and matching patterns across users that match predictions for given cost c
- theory is identifying multiple equilibria in static game, does empirical data suggest specific equilibrium selection or equilibrium transition in dynamic environment?

Discussion: Validator

- what if validator does not have to make the choice of presence on private pool
- validator is simply presented with a complete block from the private pool or selects public pool
- increasing adoption rate of private pool by validators in data
- relay services produce complete block, validator only sees blinded block

Discussion: Private Pool

- private pool modeled as trusted third party
- what about competing private pools rather than trusted private pool
- what about secure hardware solution as trusted third party
- what about a role of private pool to increase the efficiency of the transction by determining the priority of the transactions