Discussion of: Miner Collusion and the BitCoin Protocol
by Alfred Lehar and Christine A. Parlour

Asani Sarkar
Federal Reserve Bank of New York

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Friction in Bitcoin Ecosystem

• Why friction matters:
  • Bitcoin as asset: matters to investors
  • Bitcoin as medium of exchange: affects exchange rate with fiat currency

• Sources of friction:
  • Bitcoin-fiat money exchange: Costs and delays
  • Complexity of bitcoin ecosystem

• Issues: Capacity constraints, mining and transactions fees
Bitcoin: Interface with Traditional Finance

**Bitcoin as a Value Transfer System with Exchanges**

1. Deposit currency
2. Withdraw bitcoin
3. Transfer bitcoin
4. Deposit bitcoin
5. Withdraw currency

Note: “Exchange” here can also refer to a dealer such as a company running a “Bitcoin ATM.”
Two Views on Bitcoin Capacity Constraints

- Bitcoin protocol push miners’ block rewards (in new coins) to zero
  - Transactions fees (paid by users) reward miners when arrival rates are high

- Fixed protocol and high transactions demand: bitcoin may be non-viable
  - Competitive, price-taking miners earn zero expected profits; users determine fees
  - High demand: congestion queuing: transaction fees>0; waiting times in equilibrium
  - Fees too low & mining non-viable (Huberman, Leshno, Moallemi 2017) or too high & discourage user participation (Easley O’Hara Basu 2019)
  - Users migrate to traditional payments system (Hinzen, John, Saleh 2019)

- This paper:
  - Capacity endogenous: Unused even with fees
  - Miners act as if they price discriminate
  - Competitive mining, but mining pools act collectively
  - Undermine decentralization + security of a blockchain (“selfish mining. Eyal and Sirer (2014) and Eyal (2015))
Rising importance of transaction fees

Easley, O’hara and Basu 2019

Panel B: Percent of miner revenue derived from transaction fees

Fig. 1. Total bitcoin transaction fees. This figure gives yearly data on the level of transaction fees (measured both in US dollars and in bitcoins (BTC)) and on the relative importance of transaction fees for overall miner revenue.
Outline of Discussion

• Summary of paper

• Dynamics of mining pools

• Incentives to collude in mining ecosystem

• Empirical results

• Conclusion
Summary: Model

• Empirical observations
  • Capacity is not constrained: excess capacity even on worst day
  • Not due to lack of demand or empty mempool
  • Miners choose to “leave money on the table”

• Model: this behavior is optimal if miners price discriminate
  • All orders executed by price priority; full capacity
  • Miners execute orders by price priority; ration strategically

• Rationing equilibrium:
  • If servicer commits to execution probabilities for certain bids, then can induce higher bids from those with greater immediacy
  • Servicer executes high bid with prob. 1 and all other bids with prob. < 1

• Sustain collusion by punishing deviation: full capacity mining forever
  • Unique equilibrium?
Dynamics of Mining Pools

Cong, He, Li 2019: mining pools have close to 100% share of hash rates since 2015

- Pool shares appear to mean-revert
- Empirically, larger pools charge higher fees but grow slower
- Price discrimination by any one pool possible, but may be temporary
- Other limits to pool size: no increasing returns to scale in cryptography
  - Individual miners belong to multiple pools: can “undo” power of pools
Mining Pools’ Incentive to Collude

• Mining pools:
  • Offer differentiated (wrt software, payment method etc.) services
  • Most important: sell insurance to individual miners (as high upfront costs)
  • Benefits of risk sharing increase with aggregate mining activity

• Aggregate hash activity increased with growth of mining pools: consistent with rationing?

• Pool managers decide which blocks to mine
• Mining pool combines hash rates of many miners to solve single cryptographic puzzle
• Pool’s mining rewards (including transaction fees) shared with between miners & pool owners in proportion to hash rate contributions
• Pools have incentive to price discriminate to increase profits

• Pools often owned by specialized mining equipment manufacturers (e.g. Bitmain Technologies)
  • Make most money from selling or renting equipments
  • Incentive to set low transaction fees to maximize revenues from equipments (Ferreira, Li, Nikolowa 2019)
Empirical Analysis

- Regressions of fee spread on measures of immediacy
  - Also explain activity variables?

- Highly skewed distributions: Quantile regressions?

- Results suggestive of Pr. Discrim. but other explanations possible:
  - Fees higher during the week: due to higher value trading + bitcoin futures
    - Volatility effect (i.e. trading increases volatility)?
    - Diff in diff: Compare before and after bitcoin futures?
  - Higher Kimchi premium asso. w higher fees: Arbs value immediacy - share profits w miners
    - Cross-currency trades involve more delays and higher volatility (Choi, Lehar, Stauffer 2018)

- Some results have unclear mechanisms
  - Fees higher when min. outtime lower (funds spent sooner)
    - How do immediacy seekers pressure senders to lower outtime?
  - Flows to and fro from exchanges & gambling sites transact at higher fees: exch. traders & gamblers desire immediacy
    - Why not move off-exchange?
Conclusion

• New empirical facts about bitcoin capacity and fees

• New view of mining ecosystem: miners price discriminating between bidders with high and low valuation

• Model: is price discrimination sustainable in long-run?

• Empirics: many suggestive results but need to rule out alternative interpretations