Learning from DeFi: Would Automated Market Makers Improve Equity Trading?

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Preliminaries & Some Motivation

Basic Idea

- Blockchain: borderless general purpose value and resource management tool
- DeFi: financial applications that run on blockchains
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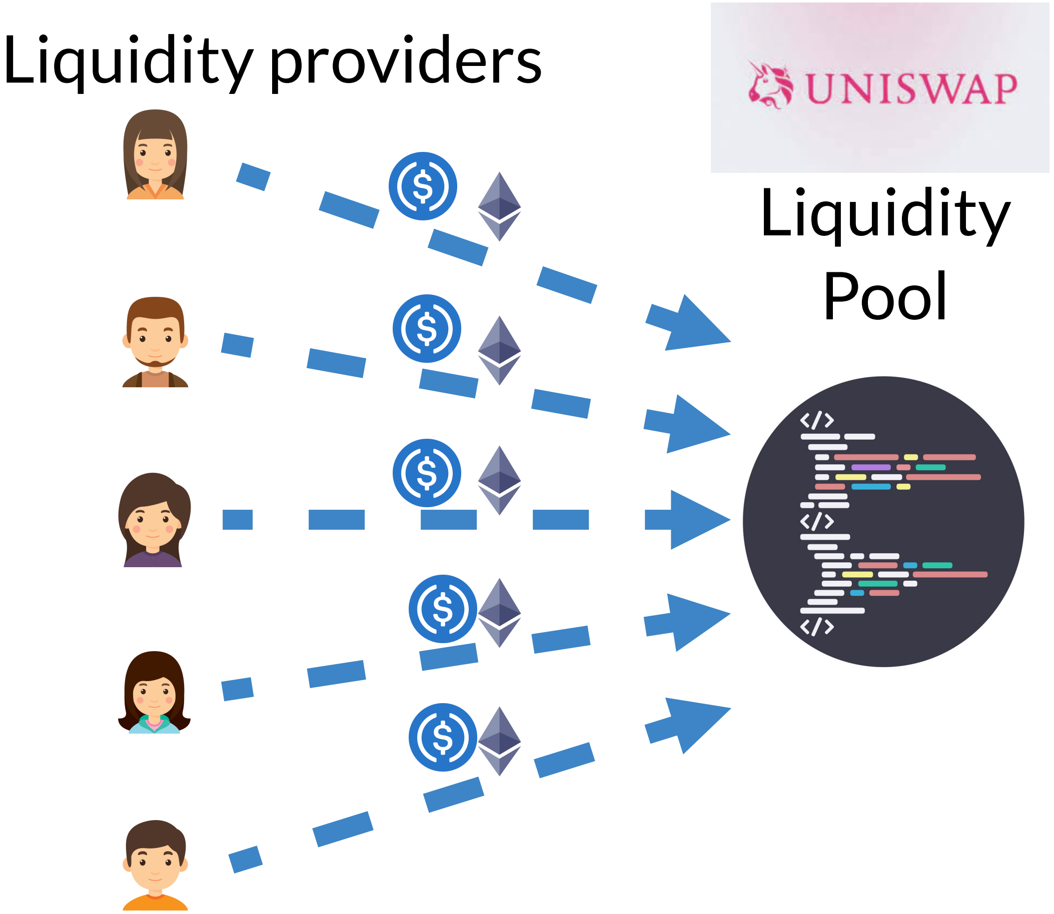
- DeFi: financial applications that run on blockchains
- $\Rightarrow$ brought new ideas and tools
    - one new market institution: automated market makers

Decentralized trading using automated market makers (AMM)

UNISWAP

Liquidity
Pool

Decentralized trading using automated market makers (AMM)



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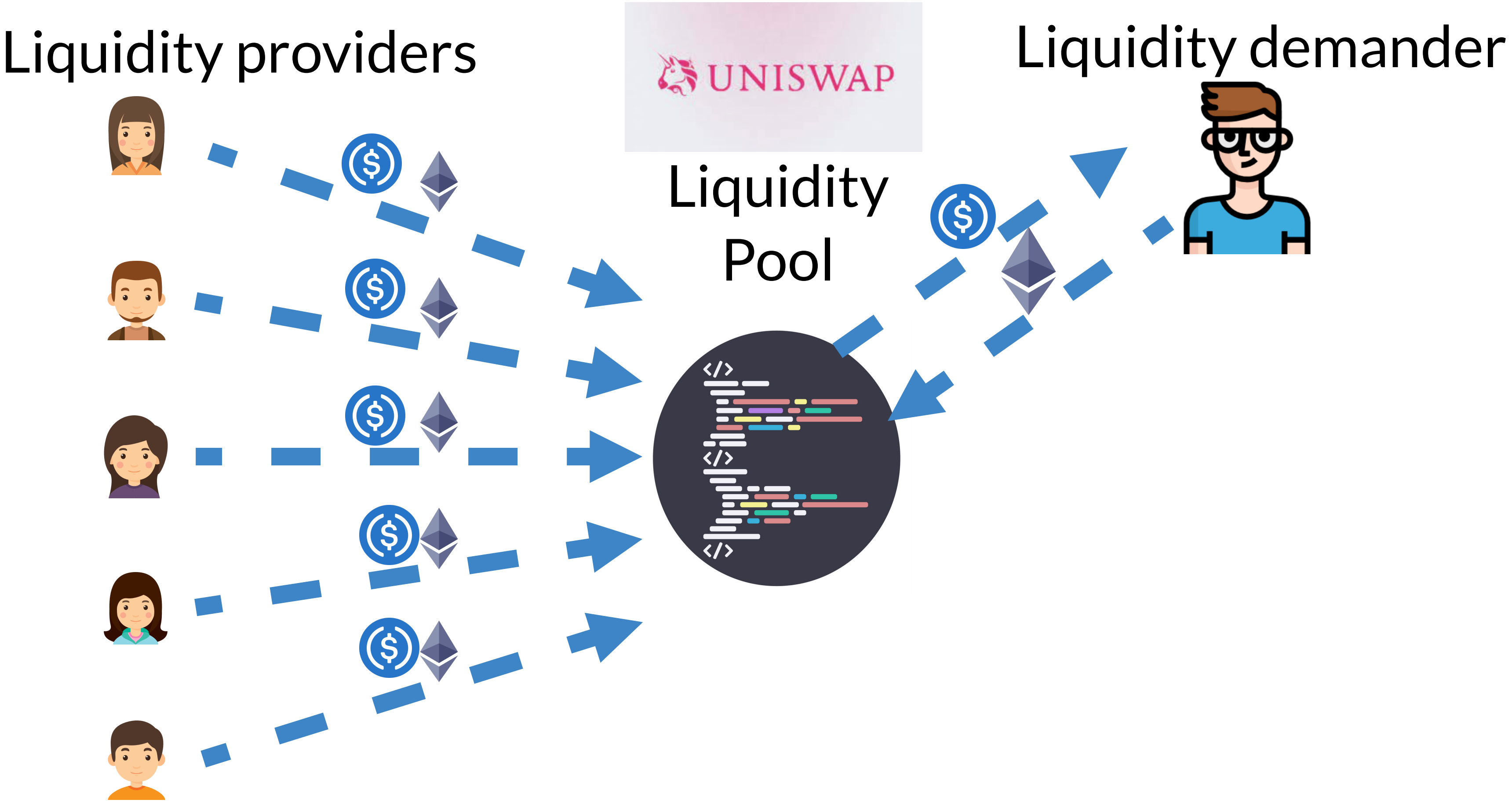

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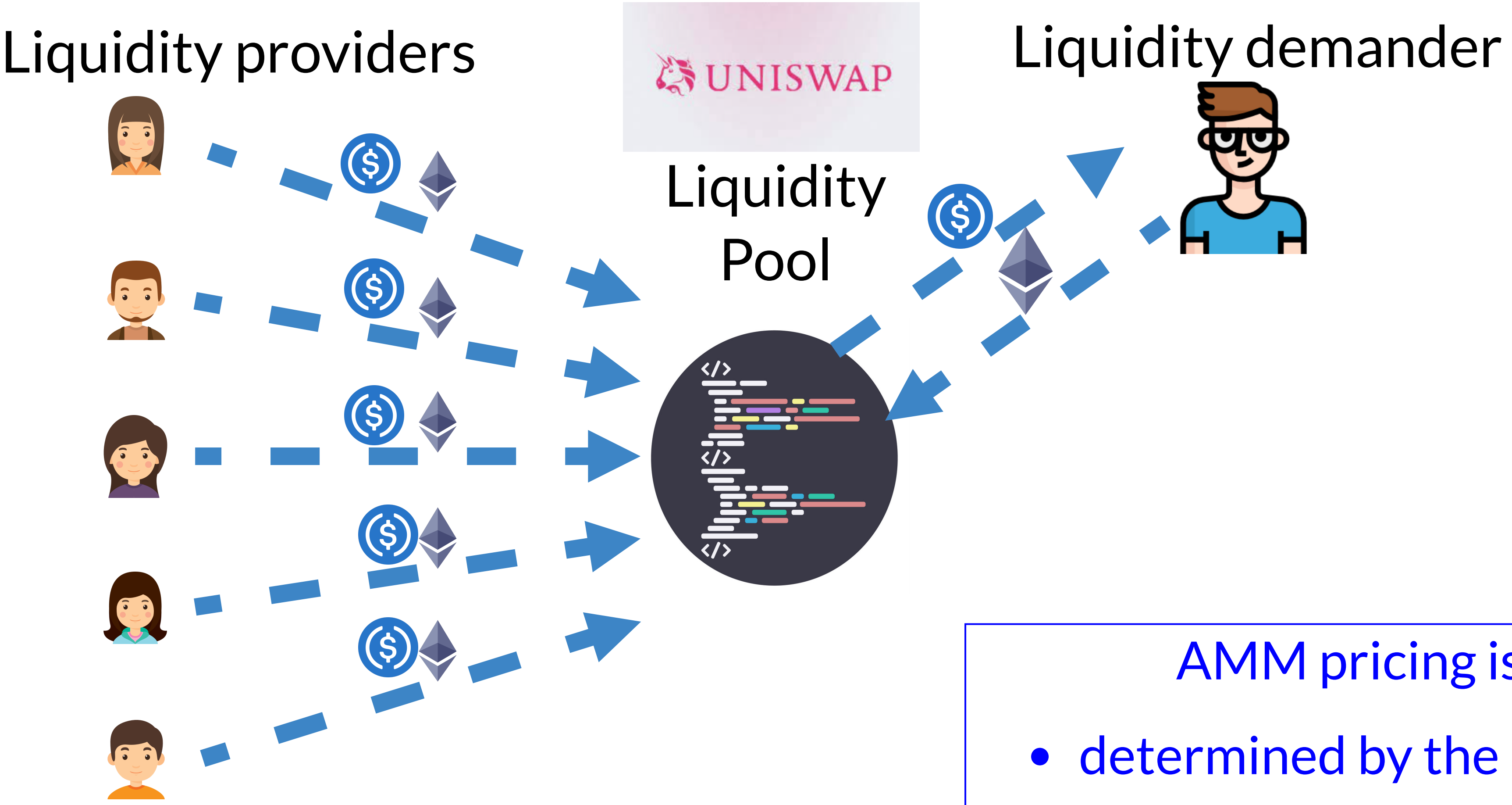

AMM pricing is mechanical:

- determined by the amounts of deposits
- most common:
  - constant product
  - $\#USDC \times \#ETH = const$

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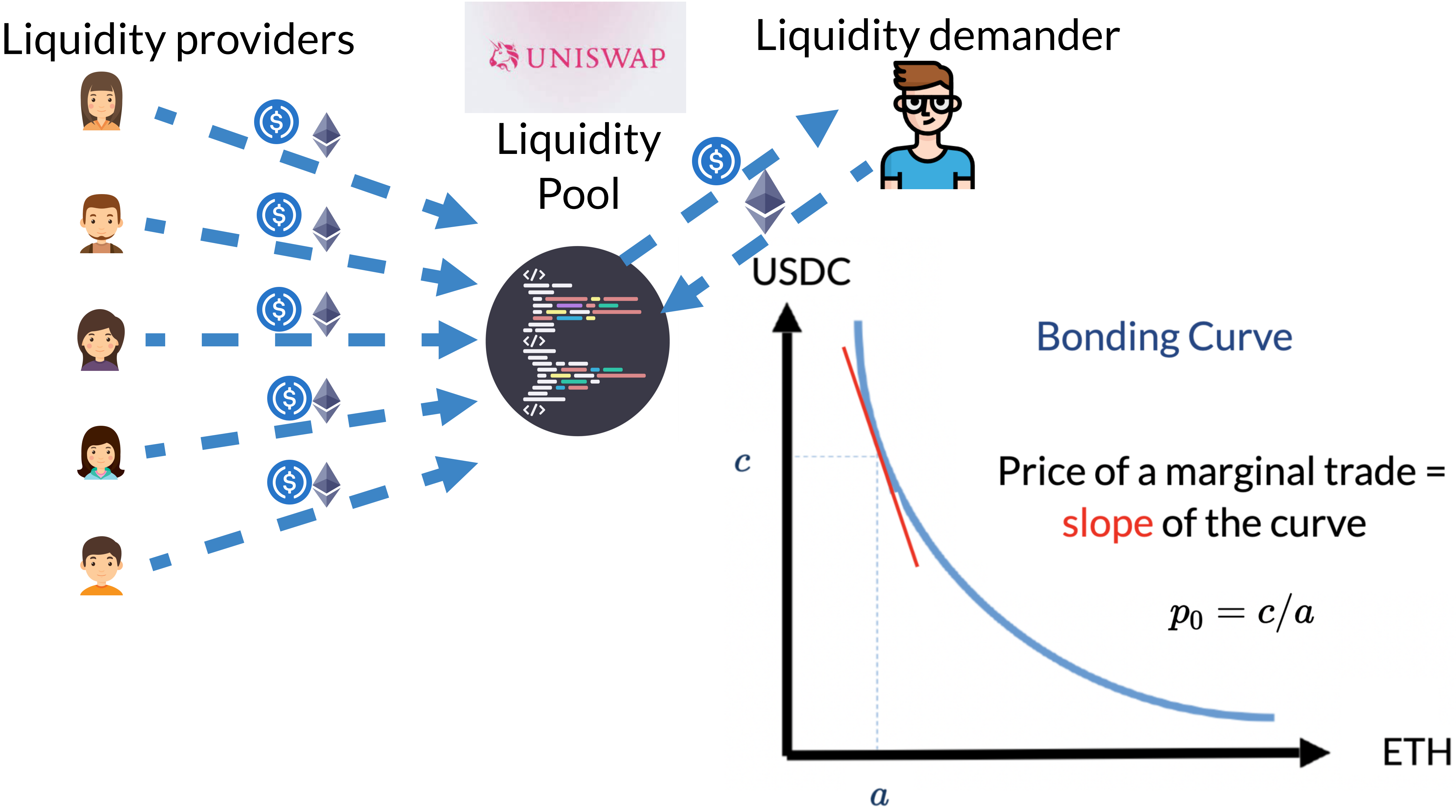

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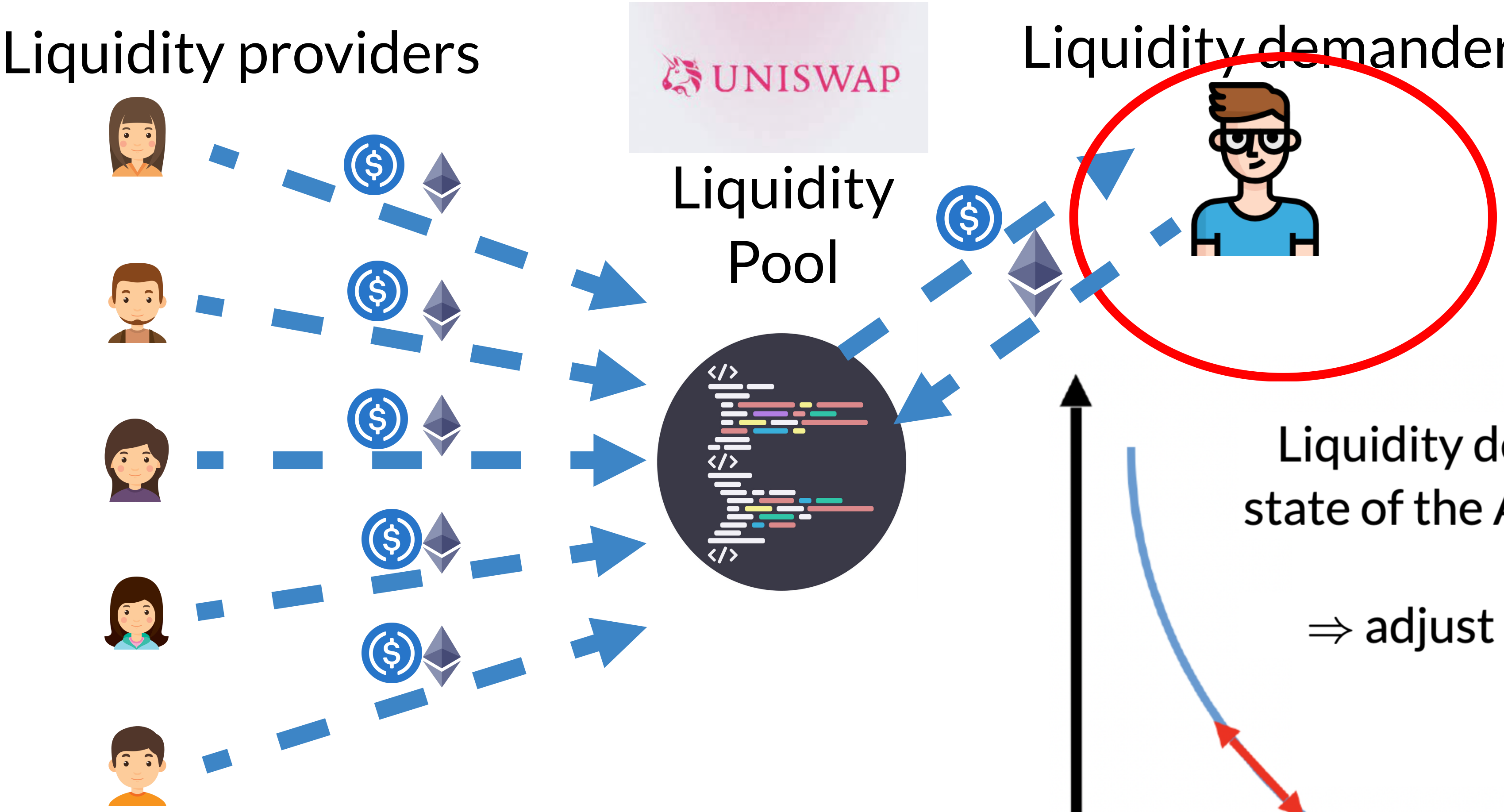

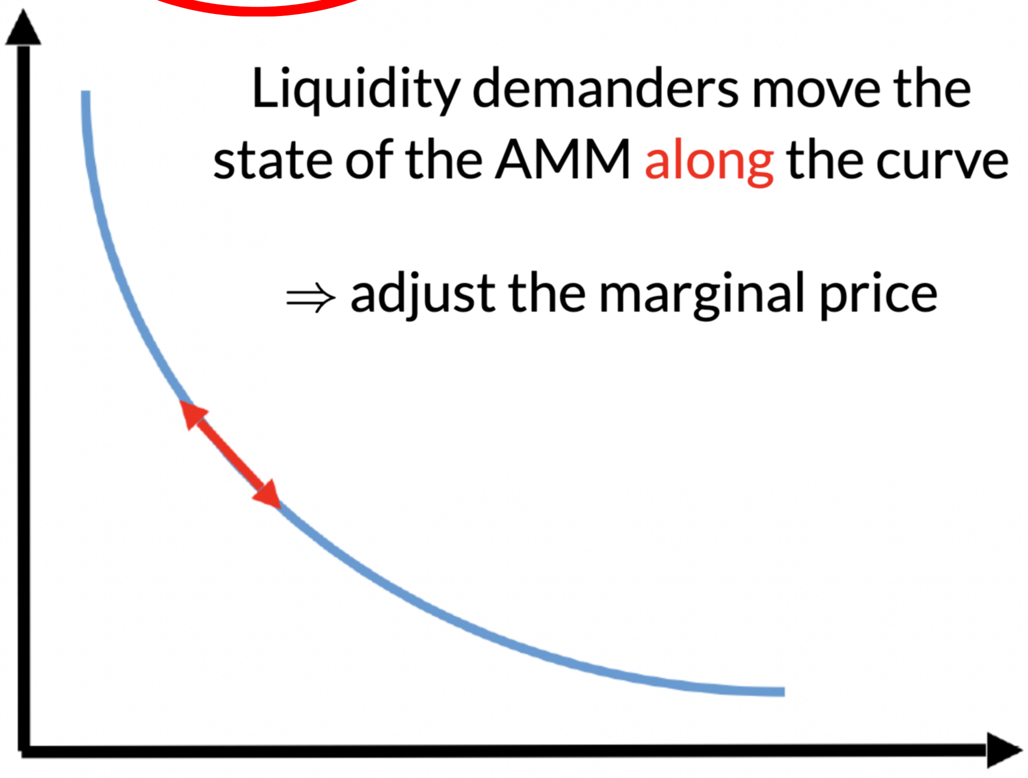

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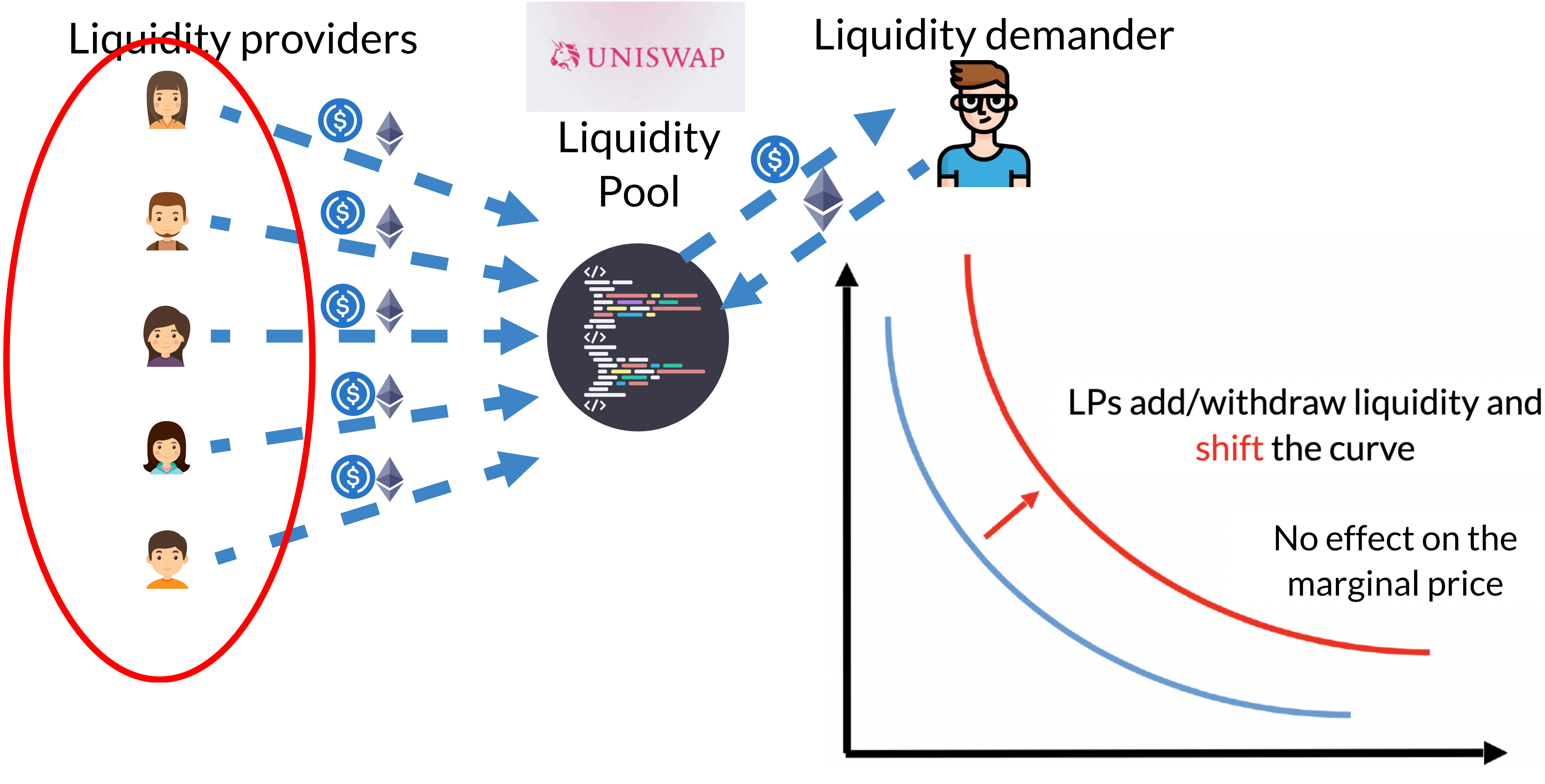

Key Components

- Pooling of liquidity!
- Liquidity providers:
  - pro-rated
    - trading fee income
    - risk
  - use assets that they own to earn passive (fee) income
    - retain exposure to the asset
- Liquidity demanders:
  - predictable price
  - continuous trading
  - ample liquidity

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  1. Can an economically viable AMM be designed for current equity markets?
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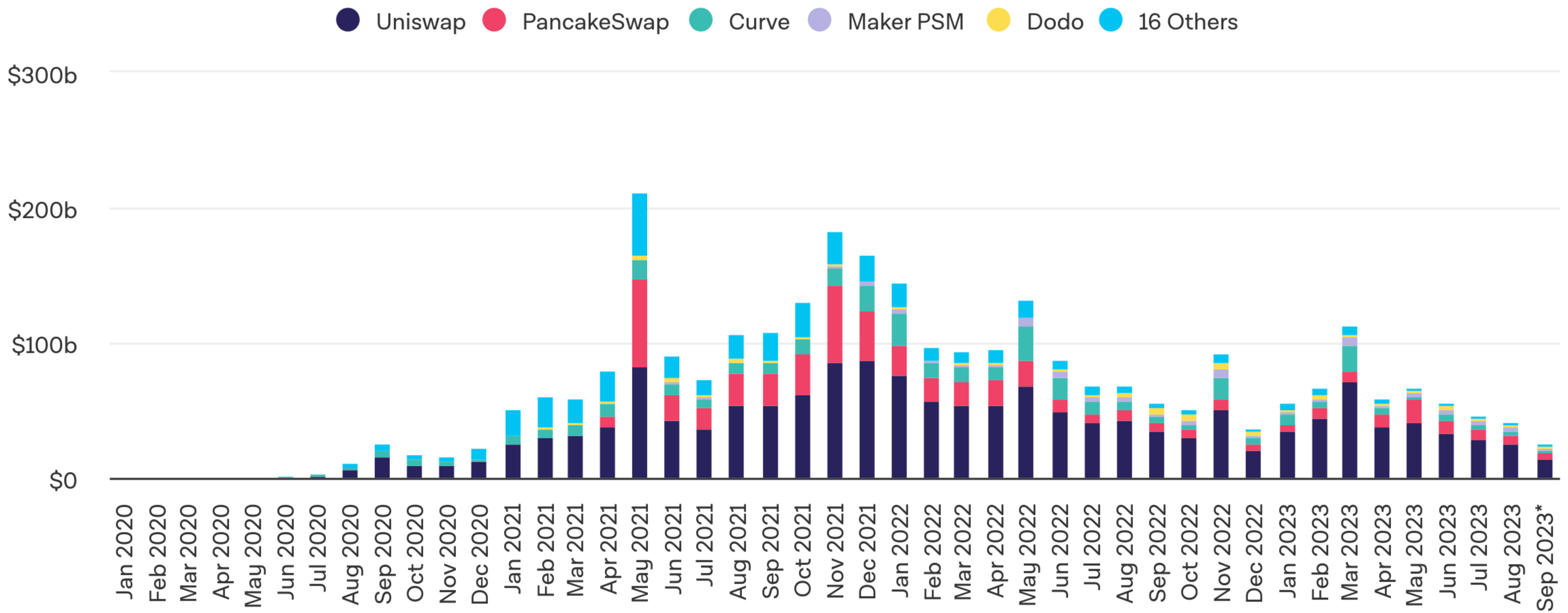
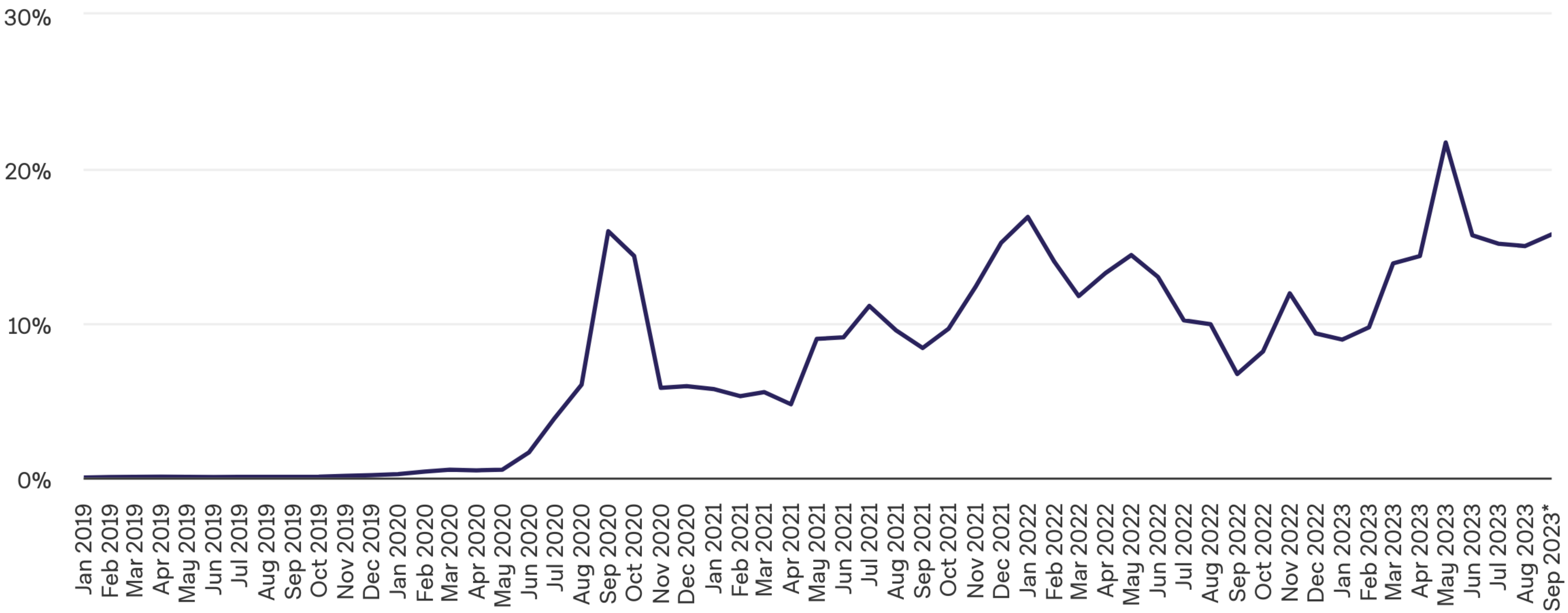
DEX Volume



SOURCES: THE BLOCK, THE GRAPH, COINGECKO
UPDATED: SEP 24, 2023

DEX to CEX Spot Trade Volume (%)



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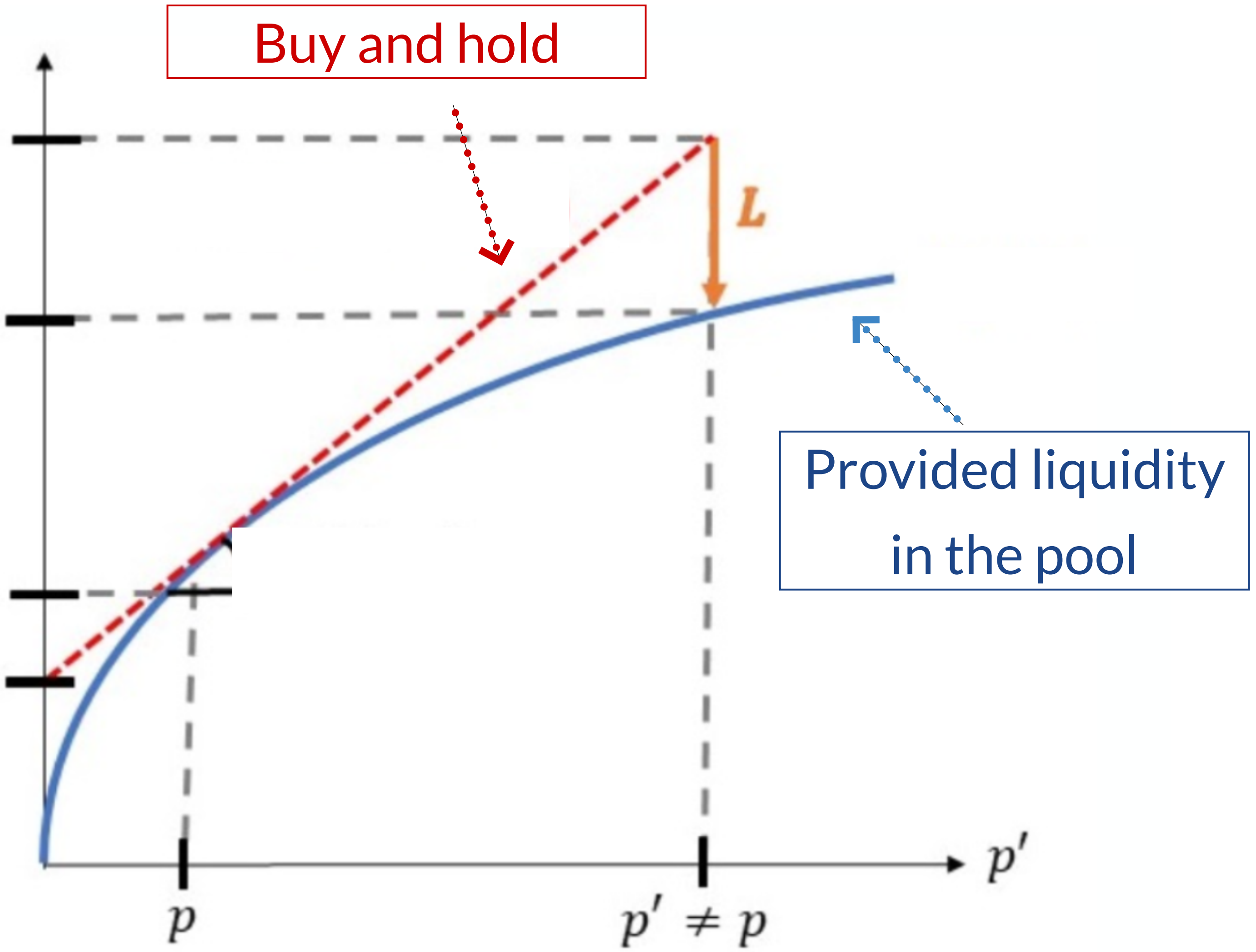
Liquidity Supply and Demand in an Automated Market Maker

Liquidity providers: positional losses

- Deposit asset & cash when the asset price is p
- Withdraw at price $p' \neq p$

- $\rightarrow$ always positional loss relative to a "buy-and-hold"

- Why?
  - adverse selection losses
  - arbitrageurs trade to rebalance the pool



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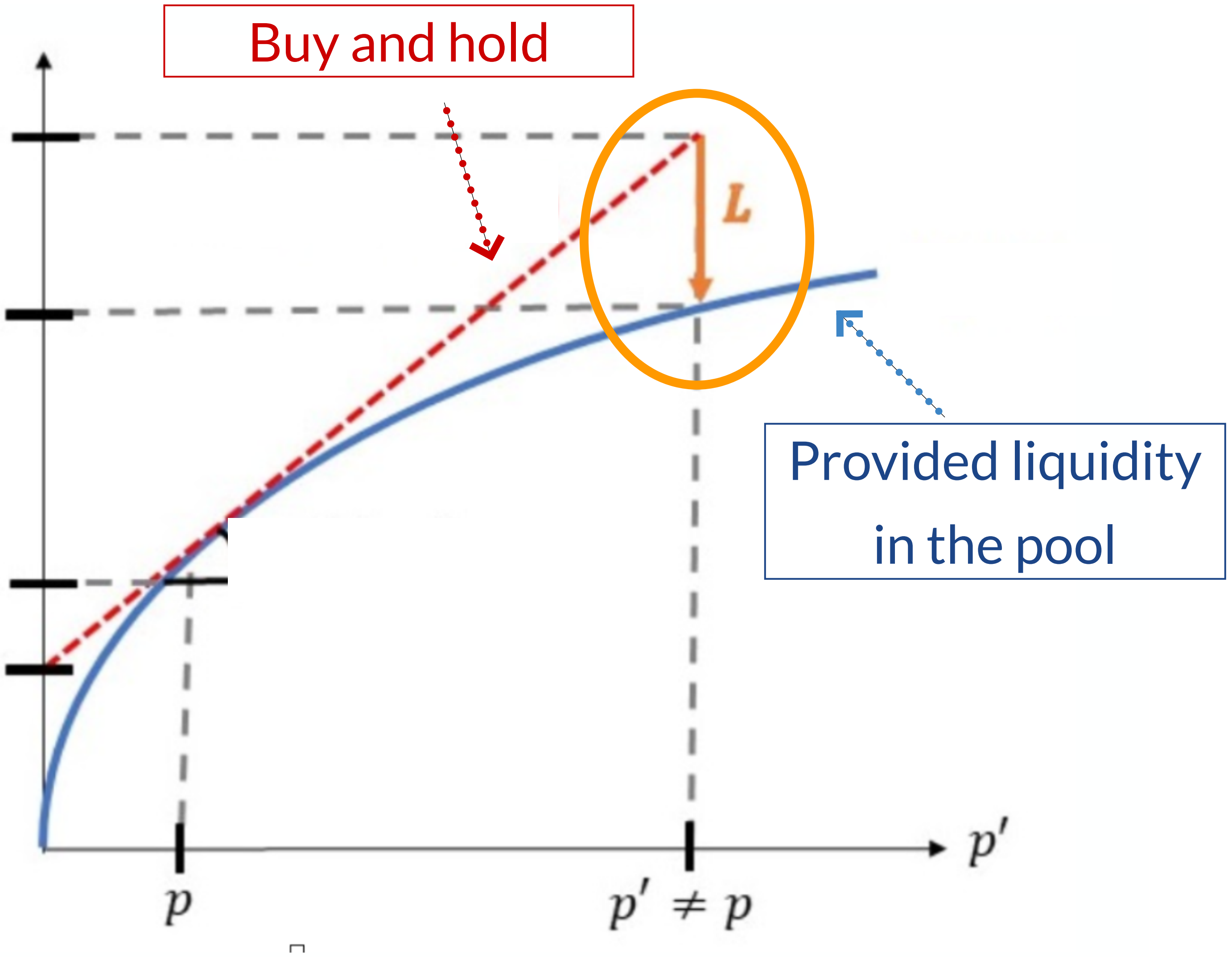

Returns to liquidity providers

$$\int_0^\infty \left(\sqrt{R} - \frac{1}{2}(1+R) + \frac{F}{2}|\sqrt{R}-1|\right) \phi(R)dR + F\frac{V}{2a}.$$

- R = asset return
- F = trading fee
- V = balanced volume
- a = size of the liquidity pool

Similar to Lehar and Parlour (2023), Barbon & Ranaldo (2022).

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(incremental) adverse selection loss when the return is R

- R = asset return
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Similar to Lehar and Parlour (2023), Barbon & Ranaldo (2022).

for reference:

- If the asset price drops by 10% the *incremental* loss for liquidity providers is 13 basis points on their deposit
  - $\rightarrow$ total loss=-10.13%
- If the asset price rises by 10%, the liquidity provider gains 12 basis points less on the deposit
  - $\rightarrow$ total gain =9.88%

Returns to liquidity providers

$$\int_0^\infty \left(\underbrace{\sqrt{R} - \frac{1}{2}(1+R)}_{\text{(incremental) adverse selection loss when the return is } R} + \underbrace{\frac{F}{2}|\sqrt{R}-1|}_{\text{fees earned on informed}} \right) \phi(R)dR + F\frac{V}{2a}.$$

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- V = balanced volume
- a = size of the liquidity pool

For fixed balanced volume V & fee F:

- Larger pool size $\rightarrow$ smaller shares of the fees
- $\rightarrow$ LP expected return $\searrow$ in pool size
- Competitive liquidty provision:
  - $\rightarrow$ find the upper-bound on pool size above which LPs lose money
  - we characterize this by $\bar{\alpha}$ - fraction of the asset's market cap to be deposited to the pool

Similar to Lehar and Parlour (2023), Barbon & Ranaldo (2022).

Liquidity Demander's Decision & (optimal) AMM Fees

- Better off with AMM relative to traditional market if

$$\text{AMM price impact} + \text{AMM fee} \leq \text{bid-ask spread}.$$

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- Two opposing forces when fee $F \nearrow$
  1. more liquidity provision
     $\rightarrow$ lower price impact
  2. more fees to pay

Similar to Lehar&Parlour (2023) and Hasbrouck, Riviera, Saleh (2023)

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Result:

competitive liq provision$\rightarrow$ there exists an optimal (min trading costs) fee > 0

- $\rightarrow$ derive closed form solution for competitive liquidity provision
- depends on return distribution, balanced volume, quantity demanded

What's next?

- Have:
  - equilibrium choices for competitive liquidity provision
  - fee that minimizes liquidity demander AMM costs (> 0)
- Next:
  - Calibrate to stock markets
  - AMM Feasible?
    - AMM costs at the optimal fee < bid-ask spread?

How we think of the Implementation of an AMM for our Empirical Analysis

Approach: daily AMM deposits

1. AMMs close overnight.
2. Market: opening auction $\rightarrow p_0$
3. Determine: optimal fee; submit liquidity a, c at ratio $p_0 = c/a$ until break even $\alpha = \overline{\alpha}$
4. Liquidity locked for day
5. At EOD release deposits and fees
6. Back to 1.

Background on Data

All displayed data CRSP $\cap$ WRDS

- CRSP for shares outstanding
- WRDS-computed statistics for
  - quoted spreads (results similar for effective)
  - volume
  - open-to-close returns
  - average trade sizes, VWAP
- Time horizon: 2014 - March 2022
- Exclude "tick pilot" period (Oct 2016-Oct 2018)
- All common stocks (not ETFs) (~7550).
- *Explicitly not cutting by price or size*
- All "boundless" numbers are winsorized at 99%.

Background on Data

Background on Data

Special Consideration 1: What volume?

- some volume may be intermediated
- with AMMs: no need for intermediation
- $\rightarrow$ intermediated volume could disappear
- $\rightarrow$ use volume/2
- Some caveats, e.g.
  - arbitrageur volumes
  - larger volume if AMM has lower trading costs

Background on Data

Special Consideration 2: What's q (the representative order size)?

- use average per day
- take long-run average + 2 std of daily averages
- (also avg $\times 2, \times 4$, depth)

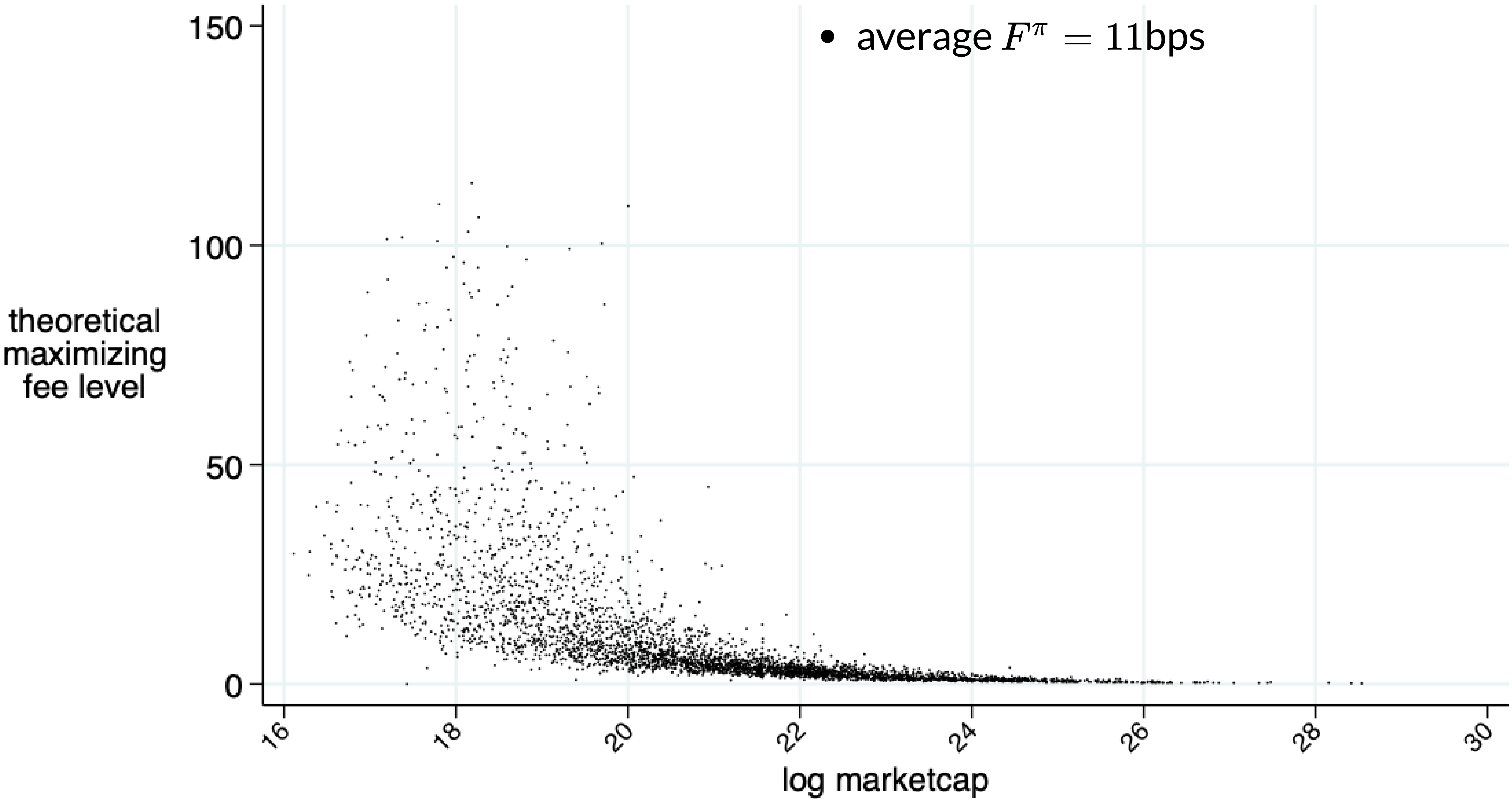
Background on Data

Special Consideration 3:

Where to get returns and volume?

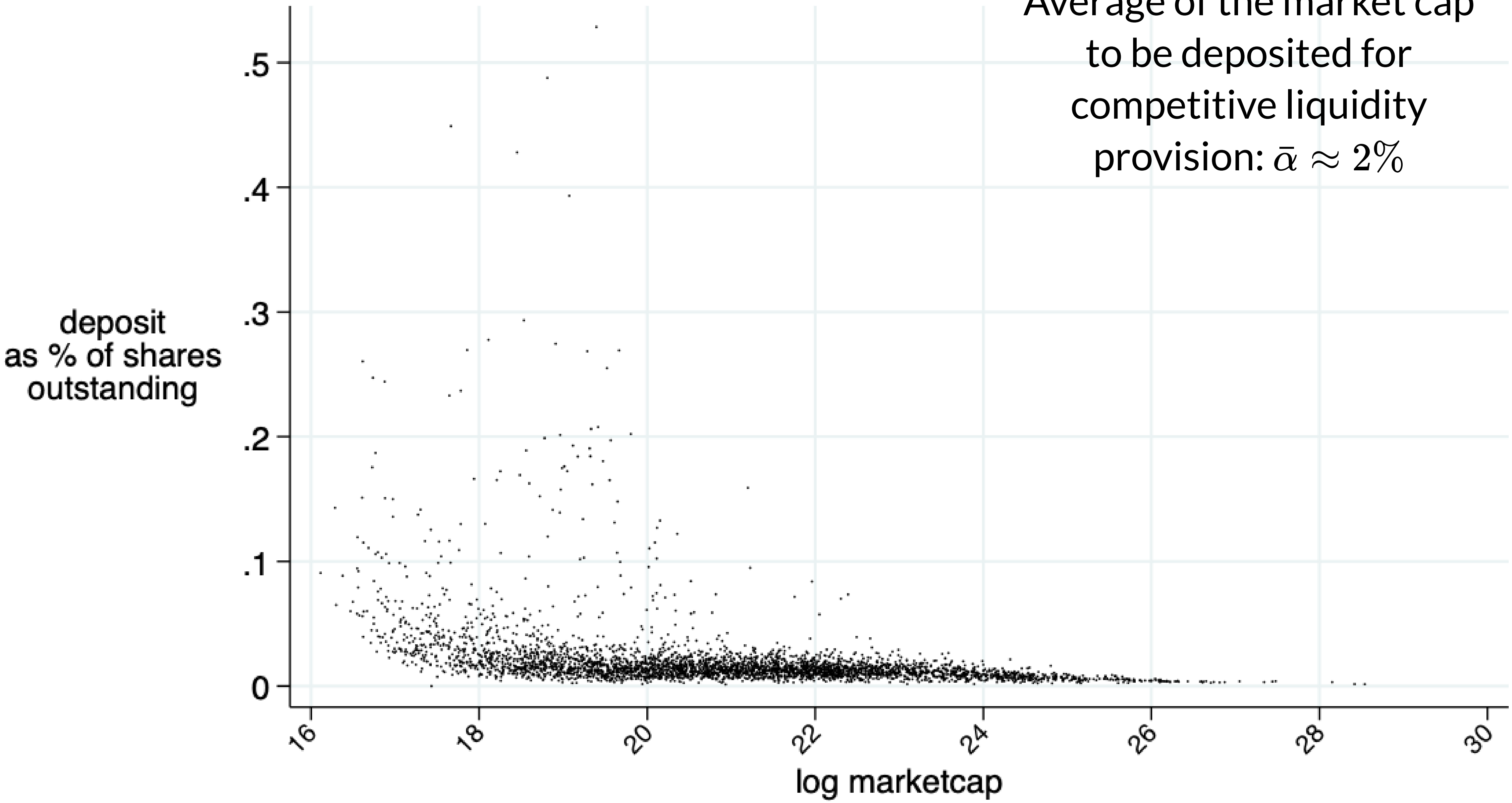
- Approach 1: "ad hoc"
  - "one-day-back" look
  - take yesterday's return and volume when deciding on liquidity provision in AMM
- Approach 2: estimate historical return distribution

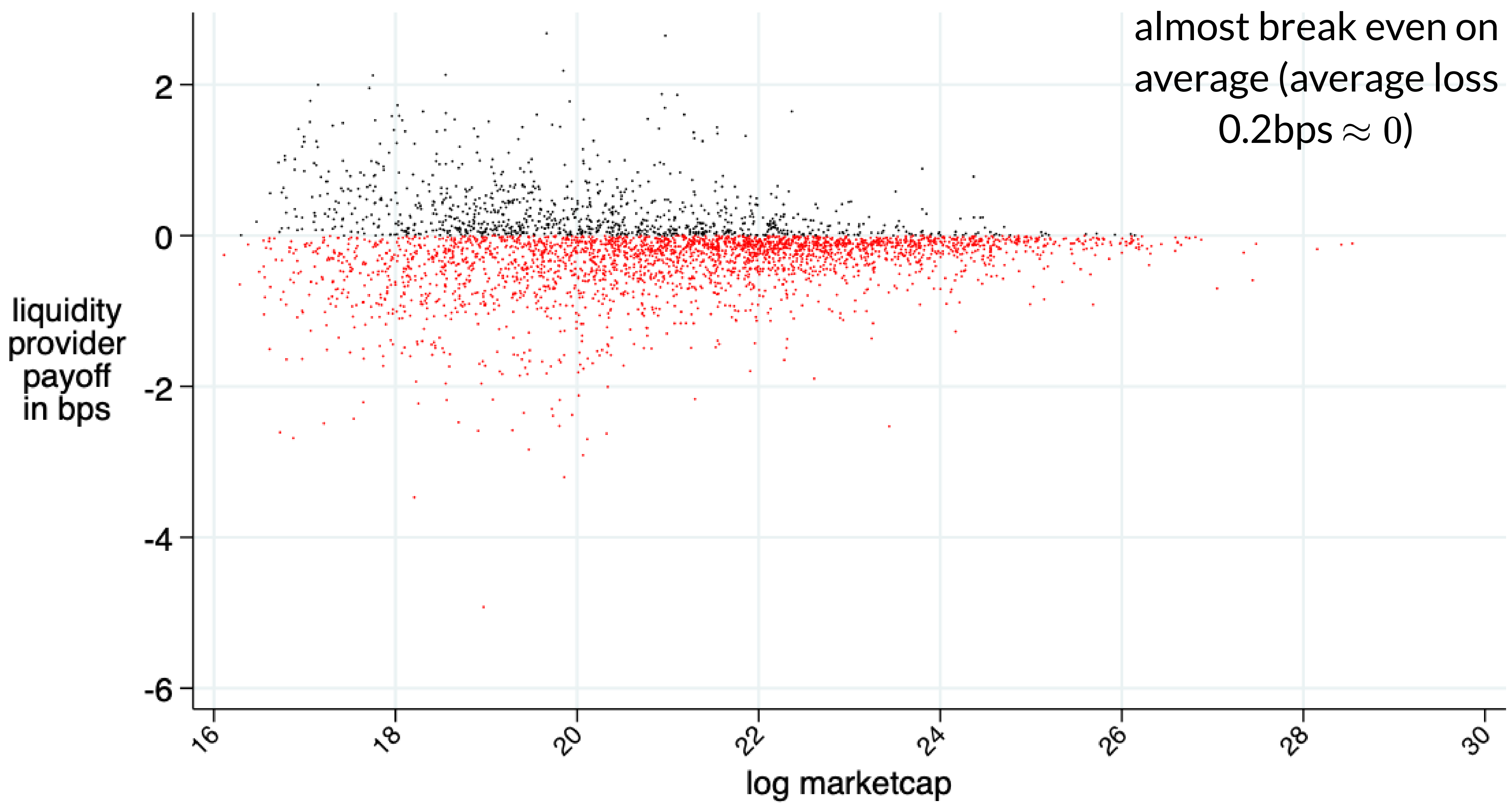
AMMs based on historical returns



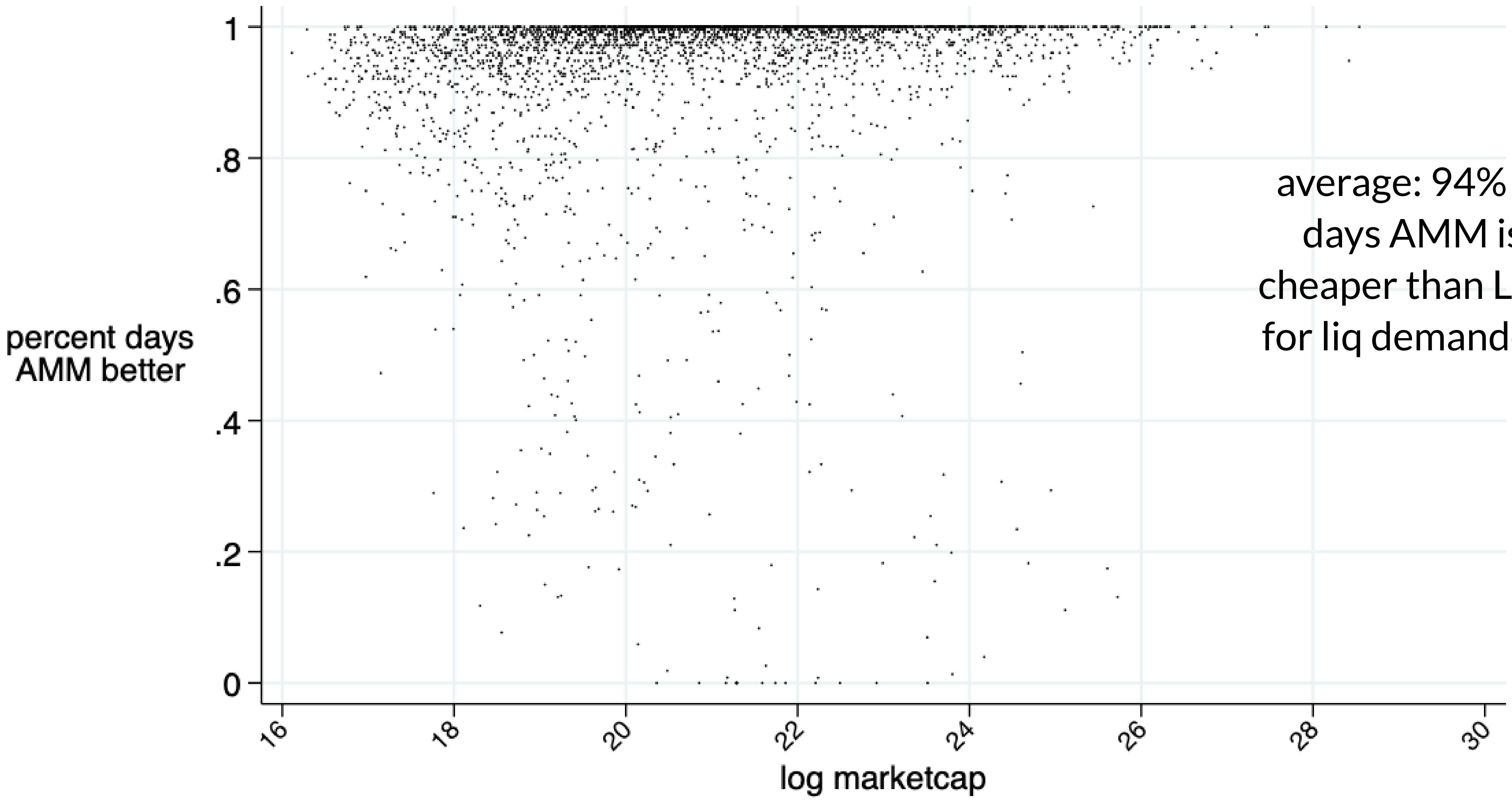
• average $F^{\pi} = 11$bps
theoretical maximizing fee level
150
100
50
0
16
18
20
22
24
26
28
30
log marketcap

Average of the market cap to be deposited for competitive liquidity provision: $\bar{\alpha} \approx 2\%$

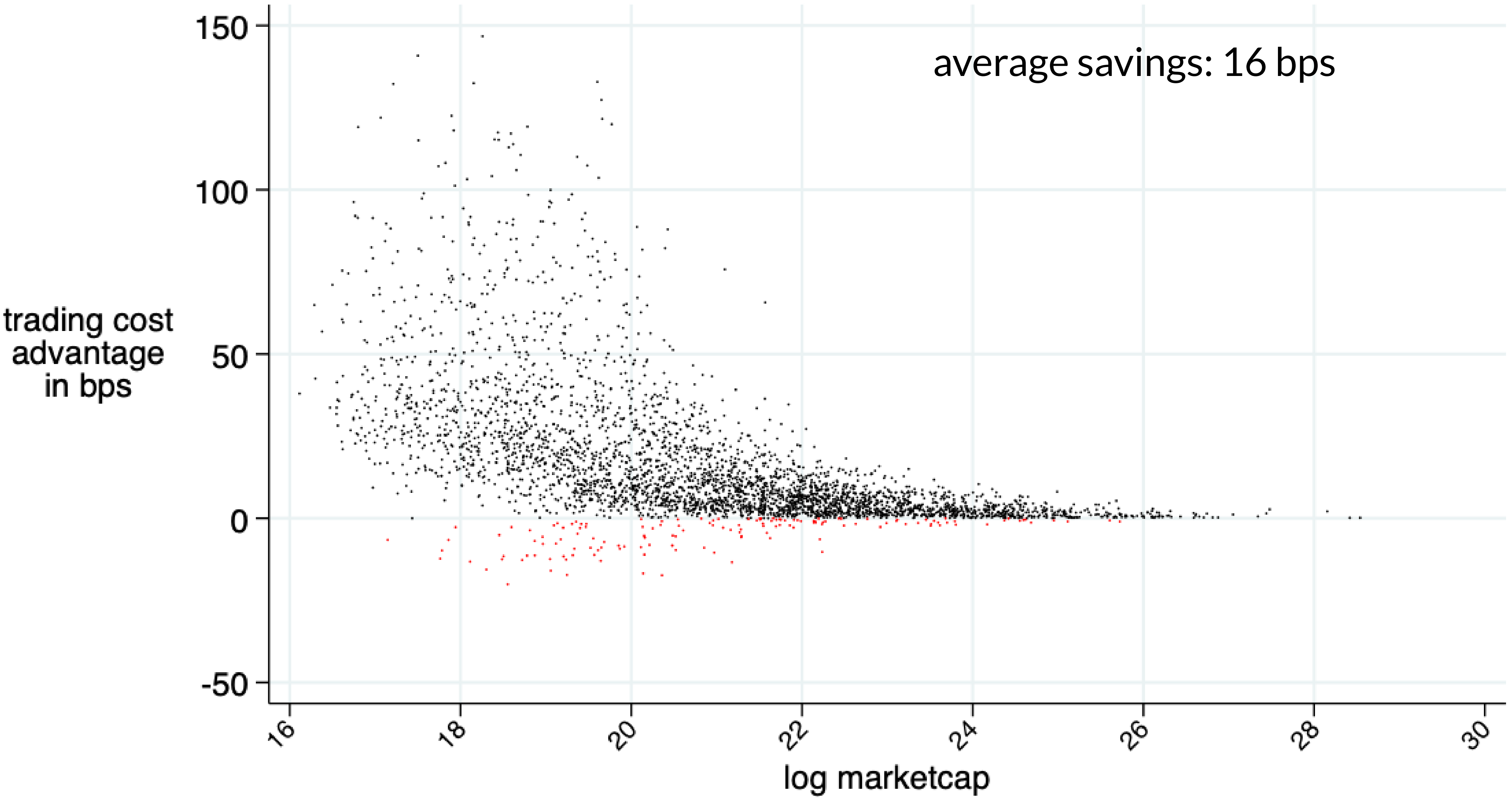


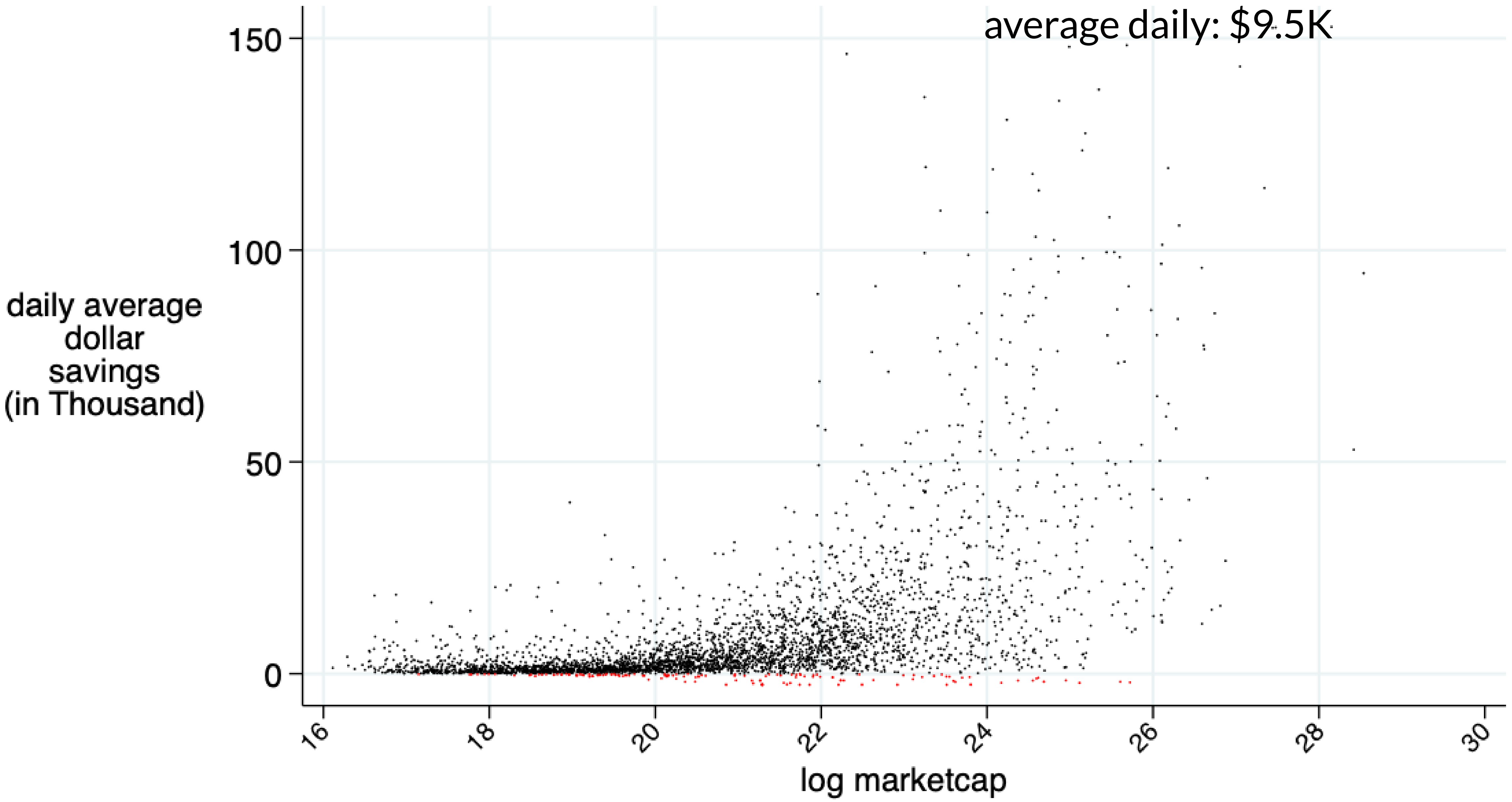


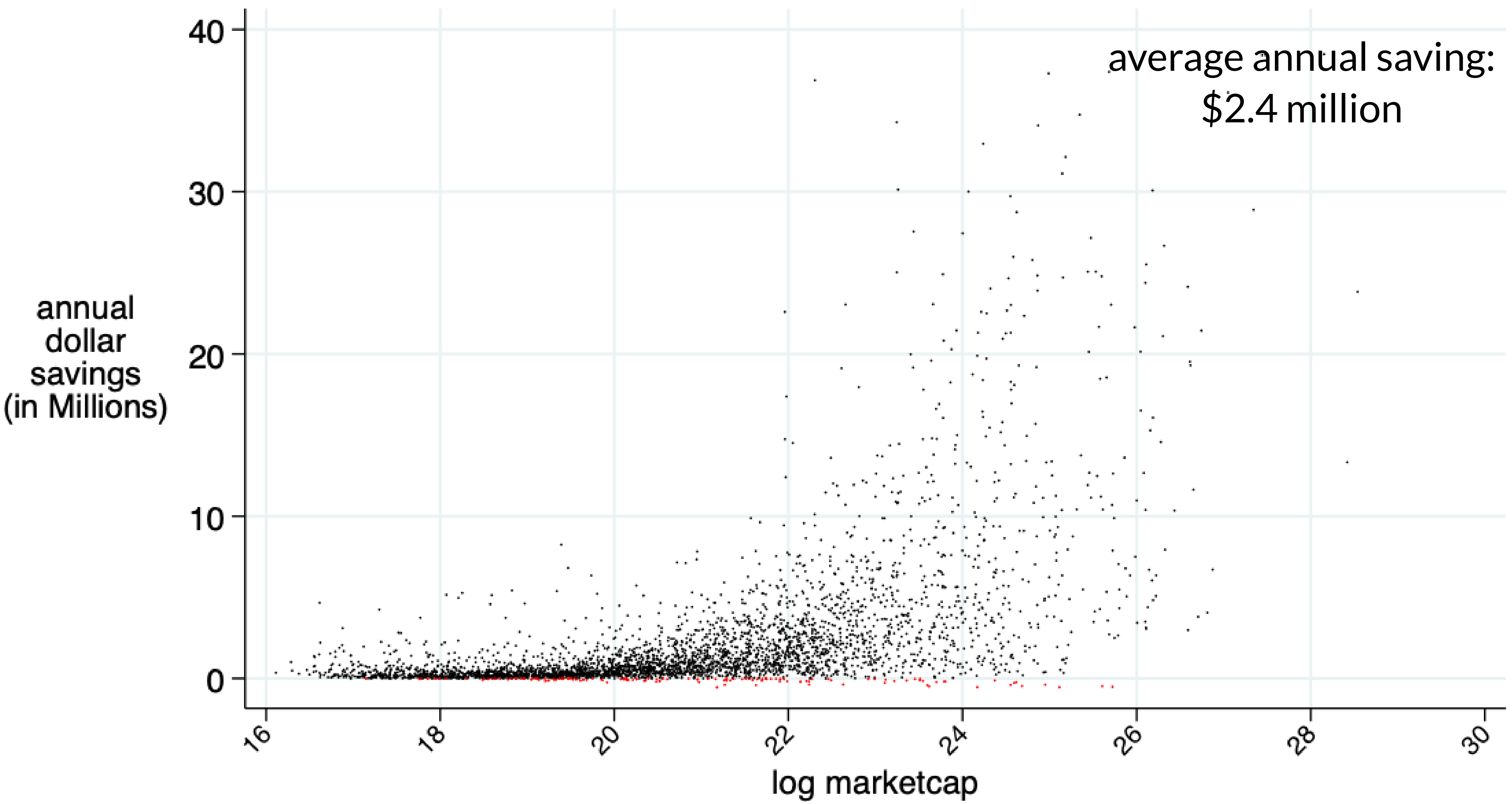
almost break even on average (average loss 0.2bps ≈ 0)
2
0
-2
-4
-6
liquidity provider payoff in bps
16
18
20
22
24
26
28
30
log marketcap



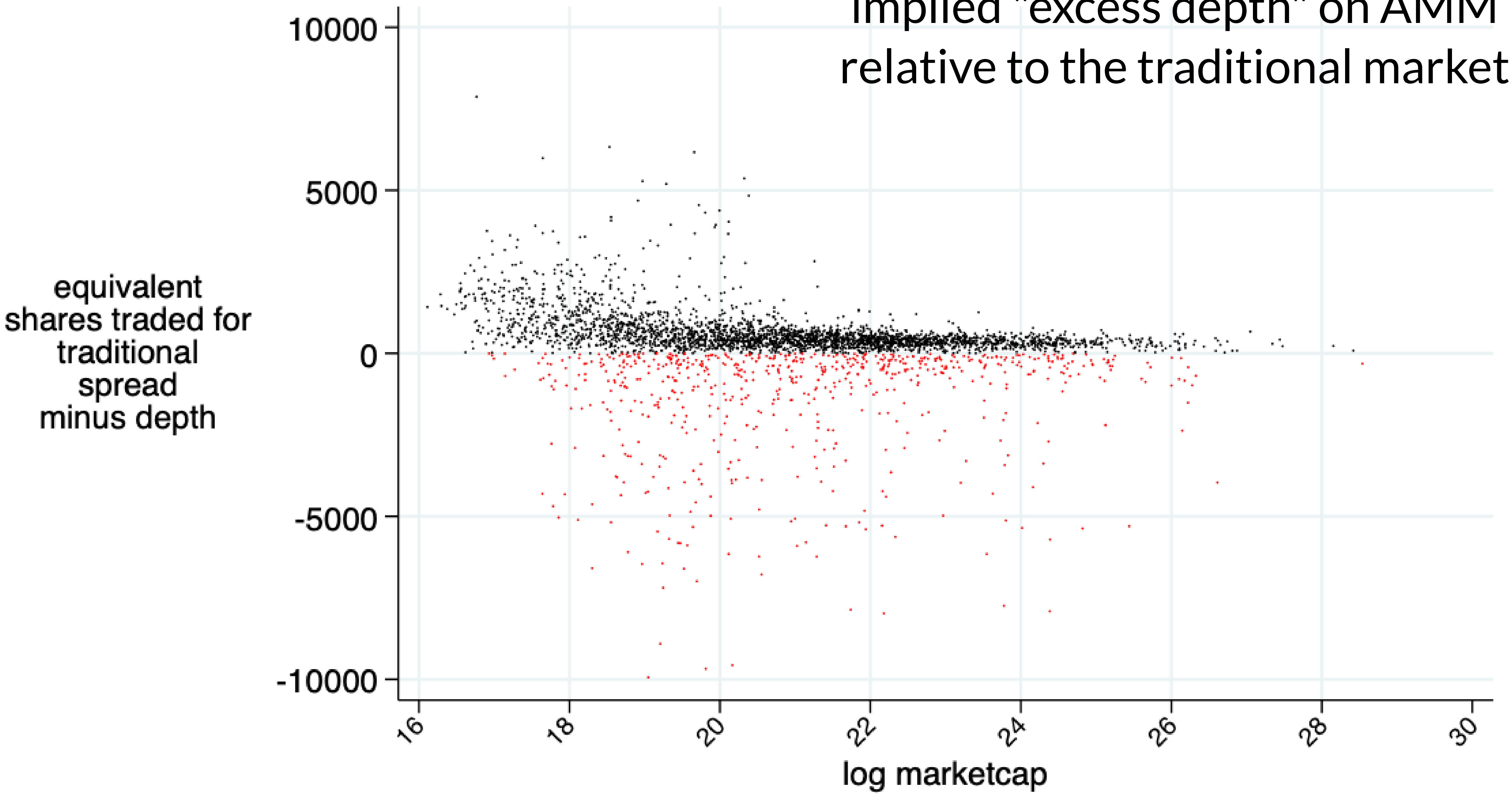
average: 94% of days AMM is cheaper than LOB for liq demanders


average savings: 16 bps
trading cost advantage in bps
150
100
50
0
-50
16
18
20
22
24
26
28
30
log marketcap


average daily: $9.5K
daily average dollar savings (in Thousand)
150
100
50
0
16
18
20
22
24
26
28
30
log marketcap


average annual saving:
$2.4 million
annual dollar savings (in Millions)
40
30
20
10
0
16
18
20
22
24
26
28
30
log marketcap

implied "excess depth" on AMM relative to the traditional market



Sidebar: Capital Requirement

Deposit Requirements

- Our approach: measure liquidity provision in % of market cap
- Share-based liquidity provision is not a problem: the shares are just sitting at brokerages.
- But: AMM requires an off-setting cash amount: $c = a \cdot p(0)$.
- Cash is not free:
  - at 6% annual rate, must pay 2bps per day.
  - Would need to add to fees
- But: do we need "all that cash"?
- No.

Deposit Requirements

- (hand-waving argument)

- 2nd gen AMMs have liquidity provision "bands": specify price range for which one supplies liquidity

- Here: specify range for $R \in (\underline{R}, \overline{R})$
  - Outside range: don't trade.
  - Inside range: "full" liquidity with constant product formula.

- Implication: only need cash and shares to satisfy in-range liquidity demand.

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$\Rightarrow$ Need about 5% of the value of the shares deposited -- not 100% -- to cover up to a 10% return decline

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  1. Yes.
  2. Massively.

Summary

- Source of Savings:
  - Liquidity providers $\neq$ Citadel!
  - $\rightarrow$ no (overnight) inventory costs
  - $\rightarrow$ use idle capital
  - $\rightarrow$ + better risk sharing

- Answers:
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Summary

- AMMs do not require a blockchain - just a concept
- could be run in the existing world (though there are institutional and regulatory barriers)

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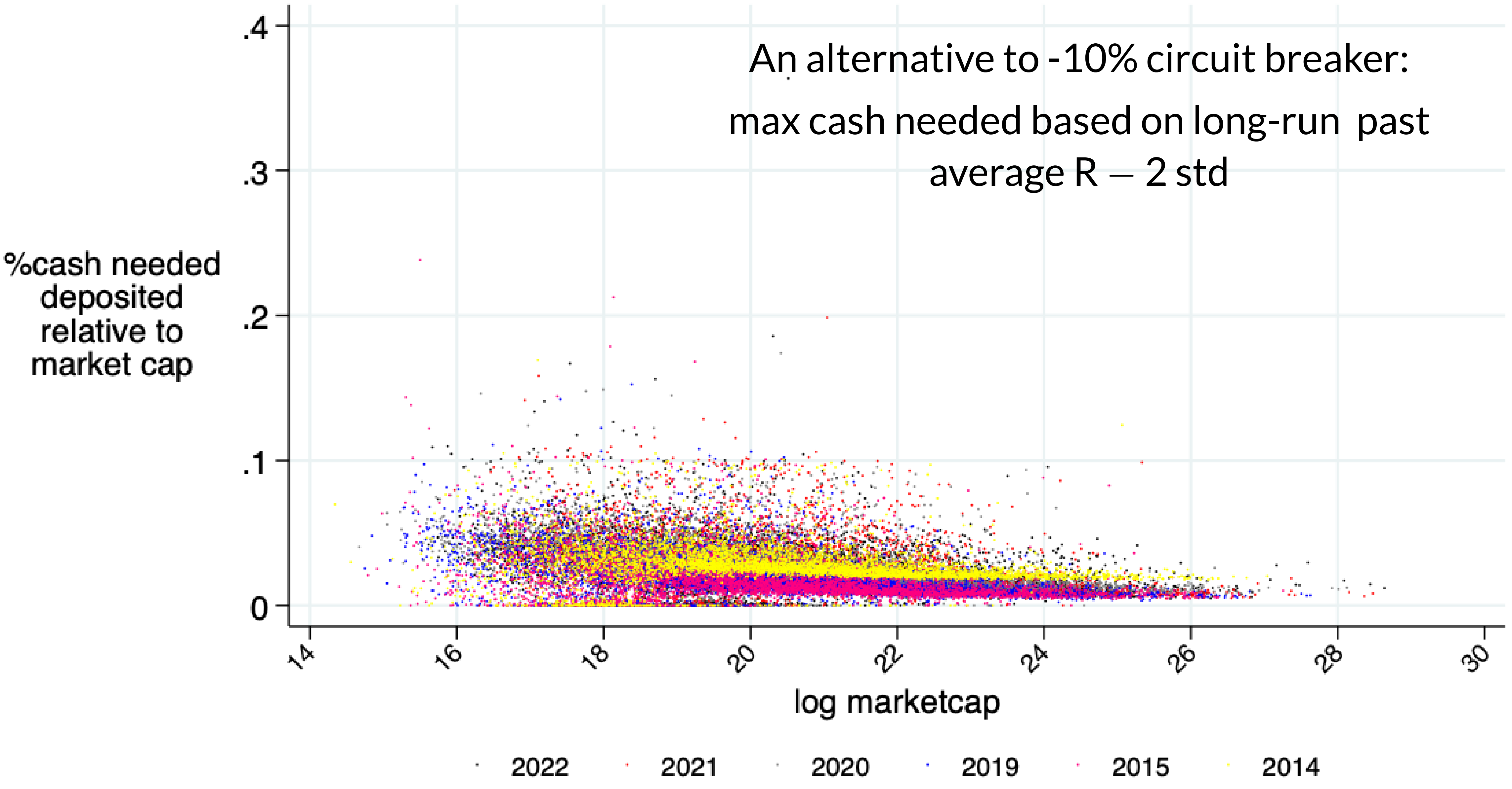
Deposit Requirements

Deposit Requirements

- For return R, the following number of shares change hands:
$$q = a \cdot (1 - \sqrt{R^{-1}}).$$
- Fraction of share deposit used
$$\frac{q}{a} = 1 - \sqrt{R^{-1}}.$$
- Fraction of cash used
$$\frac{\Delta c(\text{"}R\text{"})}{c} = \frac{1 - \sqrt{R^{-1}}}{\sqrt{R^{-1}}}.$$
- Example for $R = .9$ (max allowed price drop $= 10\%$)
$$\frac{\Delta c(\text{"}R\text{"})}{c} = -5\%.$$
- $\Rightarrow$ "real" cash requirements $\neq$ deposits

$\Rightarrow$ Need about 5% of the value of the shares deposited -- not 100% -- to cover up to a 10% return decline



An alternative to -10% circuit breaker:
max cash needed based on long-run past average R – 2 std
%cash needed deposited relative to market cap
.4
.3
.2
.1
0
14
16
18
20
22
24
26
28
30
log marketcap
2022
2021
2020
2019
2015
2014