

THE “ACTUAL RETAIL PRICE” OF EQUITY TRADES

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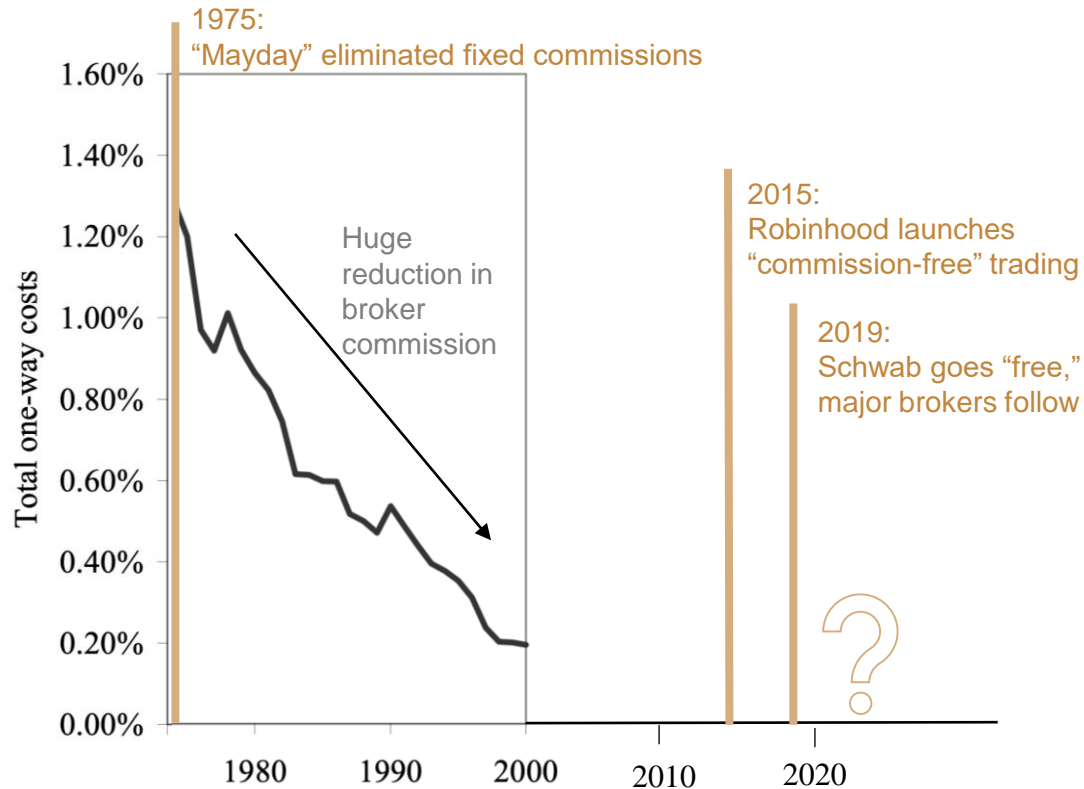
CQA SPRING CONFERENCE

APRIL 4TH, 2024

BIG PICTURE

Trading environment and trading costs

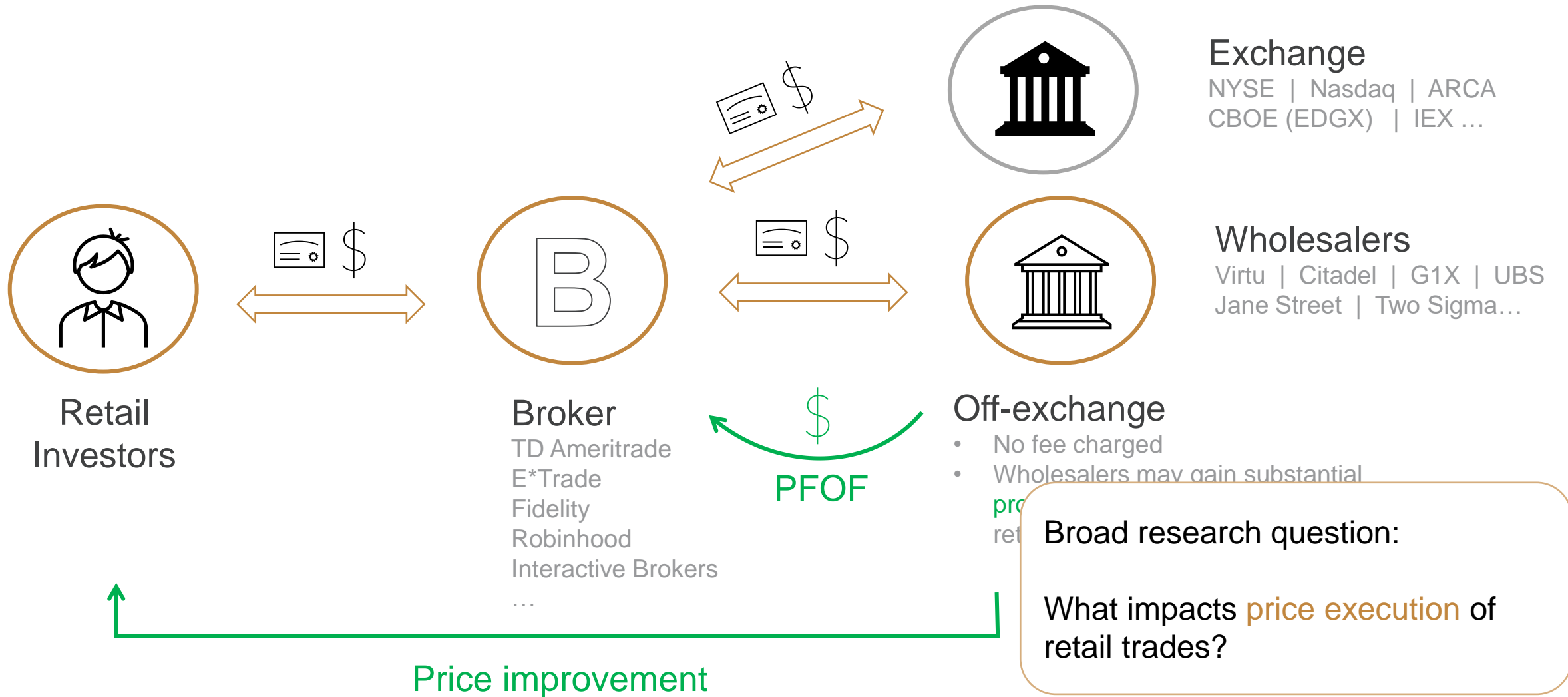
Average one-way trading costs
(half spread + commission)



"...investors should be mindful of how their orders are handled, including the difference between 'free' and 'no commissions'."

- SEC Staff Report on Equity and Options
Market Structure Conditions in Early 2021

CURRENT MARKET STRUCTURE



WHAT IMPACTS PRICE EXECUTION OF RETAIL TRADES? (I)

Payment for Order Flow (PFOF)

It matters: conflicts of interest

Higher PFOF to brokers → Lower price execution to retail investors

Parlour and Rajan (2003):

spreads widen to more than compensate for the payment [theoretical framework]

Bloomfield and O'hara (1997):

more order flow is preferenced, the wider are the spreads [experimental evidence]

WHAT IMPACTS PRICE EXECUTION OF RETAIL TRADES? (I)

Payment for Order Flow (PFOF)

It doesn't matter: best execution

SEC Release No. 37619A

This duty of best execution requires a broker-dealer to seek the most favorable terms reasonably available under the circumstances for a customer's transaction.

FINRA 5310

Best Execution and Interpositioning (a)(1) ... so that the resultant price to the customer is as favorable as possible under prevailing market conditions.

Violation example:

Robinhood was found in violation for **excessive PFOF payments** relative to PI, among other issues, and **sanctioned** by the SEC in 2020.

WHAT IMPACTS PRICE EXECUTION OF RETAIL TRADES? (I)

Payment for Order Flow (PFOF)

“Payment for order flow can raise **real issues** around **conflict of interest**.”

- Gary Gensler, SEC Chief



“The practice of payment for order flow creates **serious conflicts of interest** and **should be banned**.”

- Citadel's Comment on SEC proposal (2004)

April 13, 2004
 Mr. Jonathan G. Katz
 Secretary
 U.S. Securities and Exchange Commission
 450 Fifth Street NW
 Washington, DC 20549-0609

Re: Release No. 34-49175; File No. 97-07-04 —
Competitive Developments in the Options Markets

Dear Mr. Katz:

Citadel Investment Group, L.L.C. (“Citadel Group”) welcomes this opportunity to comment on Commission Release No. 34-49175 (the “Release”). The Release discusses recent changes in the listed options markets and seeks public comment on whether the Commission should take action to improve efficiency and competition in these markets.

Volume has increased in listed options markets in recent years due to improvements in liquidity, transparency, and competition in these markets. The ability of investors to efficiently use the listed options markets is an important cornerstone of our national market system. It is thus crucial that the Commission implement reforms that will further this trend. Specifically:

- The firm quote rule would best serve liquidity and transparency if it applied to all listed option order types up to the displayed size of any quote.
- The practice of payment for order flow creates serious conflicts of interest and should be banned.
- Internalization without meaningful price improvement reduces competition, limits price discovery, leads to market fragmentation, and should be banned.
- The Commission should not yet require the listed options markets to quote in decimals because decimalization would overtax systems already pushed to their limits and lead to less transparent and shallow markets.

Citadel Group welcomes the issuance of the Release and the Commission’s other efforts to consider and open for discussion fundamental issues relating to market structure and regulation. The Commission’s willingness to focus on these difficult issues and ask the hard questions works to ensure that the U.S. markets remain the strongest and most efficient in the world.

“Order flow is an issue that attracted a lot of attention but is **grossly overrated**.”

- Bernie Madoff



“It is important to recognize that the current market structure has resulted in tighter spreads, greater transparency, and meaningfully reduced costs for retail investors.”

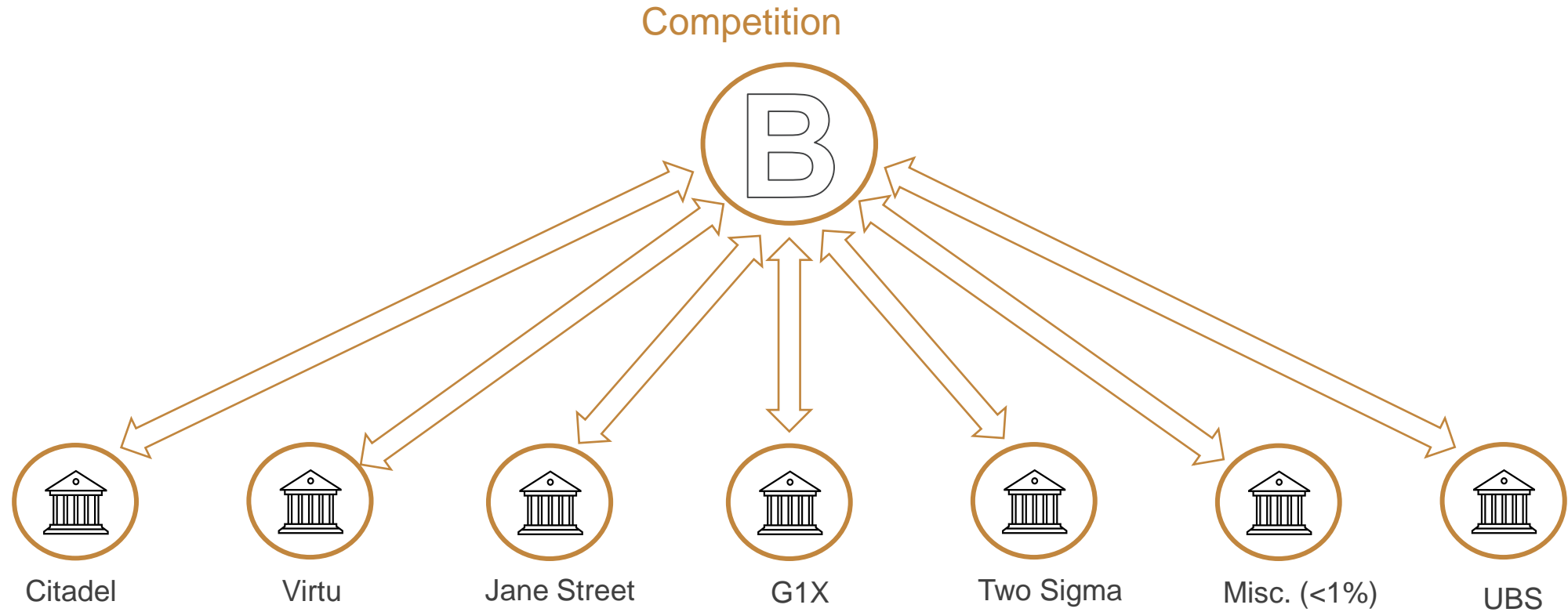
Citadel Pushes Back on Possible SEC PFOF Ban

June 8th, 2022

WHAT IMPACTS PRICE EXECUTION OF RETAIL TRADES? (II)



WHAT IMPACTS PRICE EXECUTION OF RETAIL TRADES? (II)



Lack of competition

- Concentrated market: only four major wholesalers

RESEARCH QUESTION

What impacts price execution quality of retail trades?

- Hypotheses:
 - Variations **across brokers**?
 - YES: conflicts of interests driven by **PFOF**
 - NO: rules on the duty of **best execution**
 - Variations **across wholesalers within brokers**?
 - YES: **lack** of competition
 - NO: **fierce** competition

RESEARCH QUESTION

What impacts price execution quality of retail trades?

- Hypotheses:
 - Variations **across brokers**?
 - YES: conflicts of interests driven by **PFOF**
 - NO: rules on the duty of **best execution**
- Challenges:
 - Execution price is not available unless the trade happens
 - All trades in the market would be endogenous
 - Current dataset doesn't have sign of trades nor broker info
- What we did:
 - Opened 6 brokerage accounts in 5 brokers
 - Placed 85,000 parallel market orders worth \$16 million over 5.5 months

THE FIRST DAY

Robinhood

Investing

\$25,611.35

▼ \$150.43 (0.58%) Today

▲ \$0.0000 (0.00%) After-Hours

🎁 Rewards



1D

1W

1M

3M

1Y

ALL

TD Ameritrade

⌵ Balances >

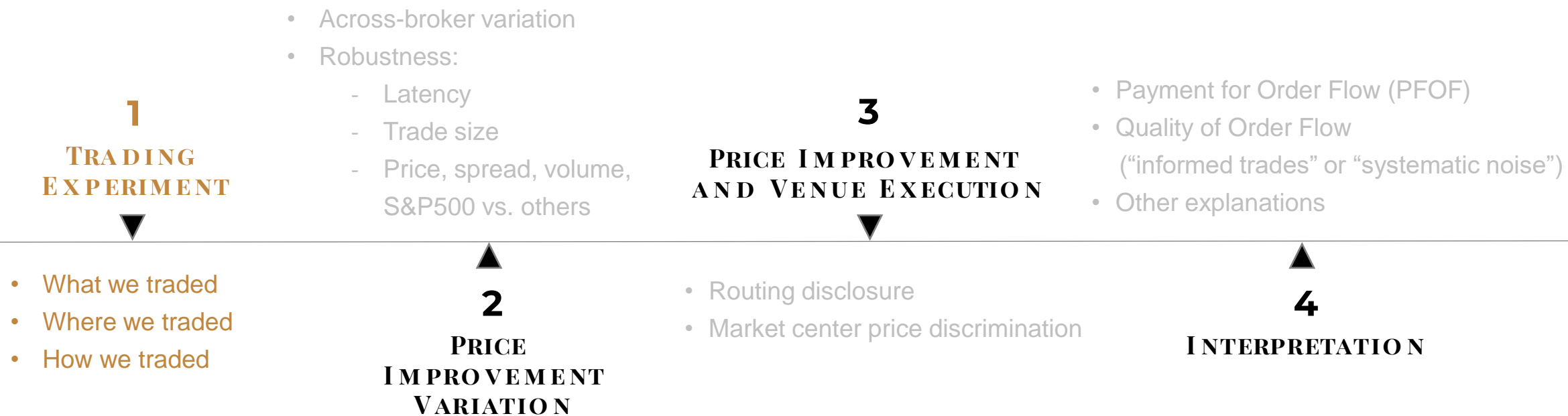
Account value / Today's net change

\$27,055.72

▲ \$12.61 (0.05%)

👁 Show balance history

ROADMAP



WHAT WE TRADED

Stratified sample of 128 stocks by (CRSP Q2, 2021) four dimensions:

1. Price
2. Market capitalization
3. Volatility
4. Liquidity

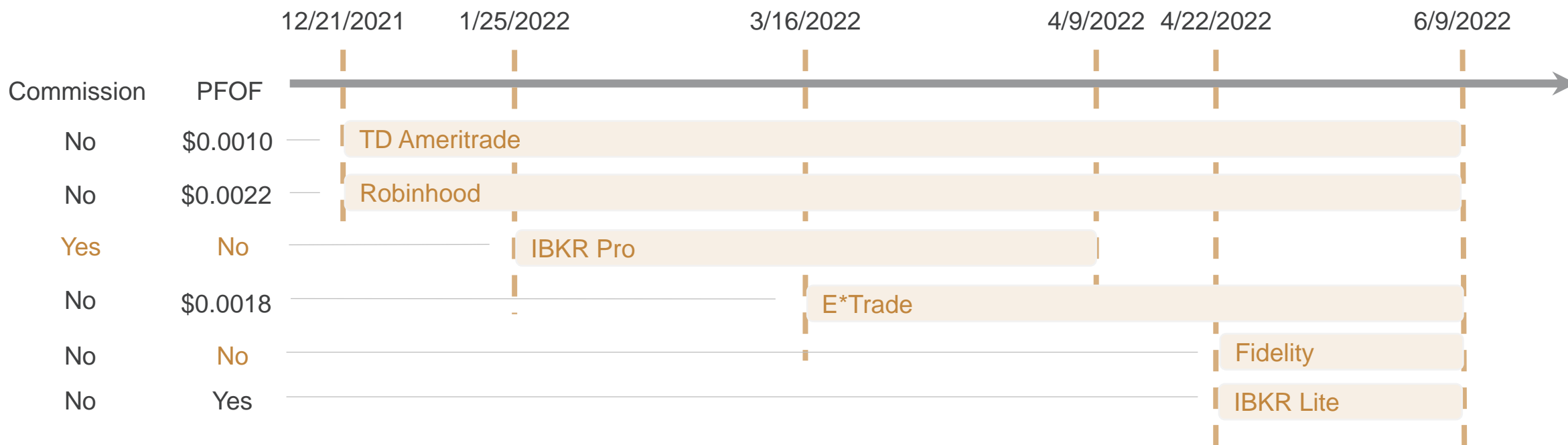
Also added 10 special stocks

- 4 “retail darlings”: NIO, AMC, TSLA, SNDL
- 6 “mega cap”: XOM, V, GOOG, AAPL, NVDA, BAC

Also included 4 Robinhood “Top Movers” over \$1 each day for a time period

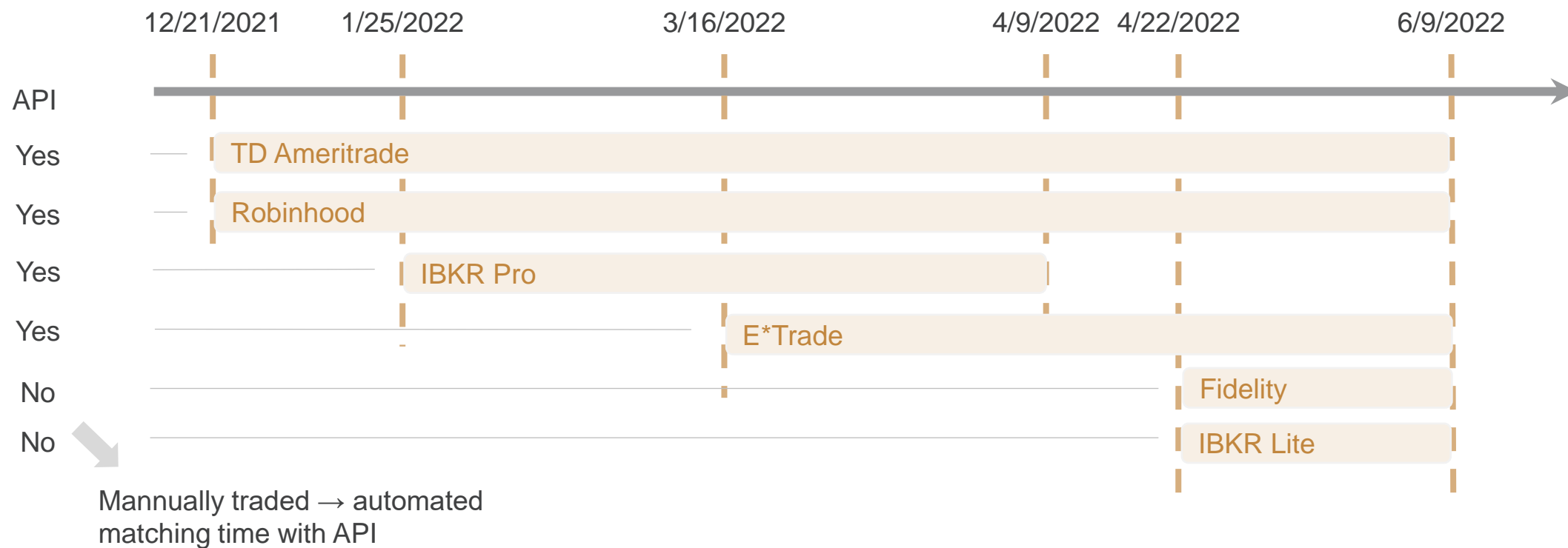
WHERE WE TRADED

Opened 6 brokerage accounts at 5 brokers



Placed 85,000 parallel market orders worth \$16 million over 5.5 months

HOW WE TRADED



HOW WE TRADED

Round-trip trades

- Buy order then sell order (approximately 30 minutes after buy)
- Evenly spaced through the day: starting time 9:40AM ET ~ ending time 3:50PM ET
- Timing of stocks are randomized within day to eliminate time-of-day effects

Randomized Sequencing across brokers

- Eliminates order effects
- Order effects are economically small and statistically insignificant

Main trade size ~\$100

- Round to whole shares (1 share minimum)
- No fractional trading
- Robustness with \$1000 and \$5000 trades, same basic results

ROADMAP



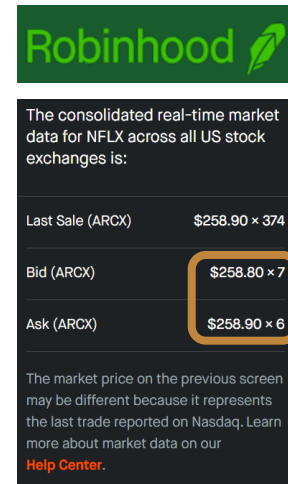
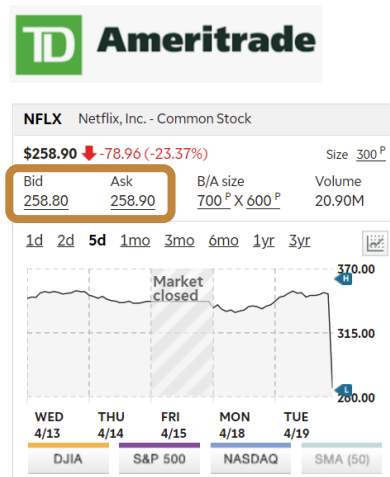
PRICE IMPROVEMENT

Regulation requires:

- prices **at or better than the prevailing best quote** (i.e., NBBO)

NBBO: National Best Bid and Offer

- Displayed across all exchanges
- Based on “round lots” (usually ≥ 100 shares)



PRICE IMPROVEMENT

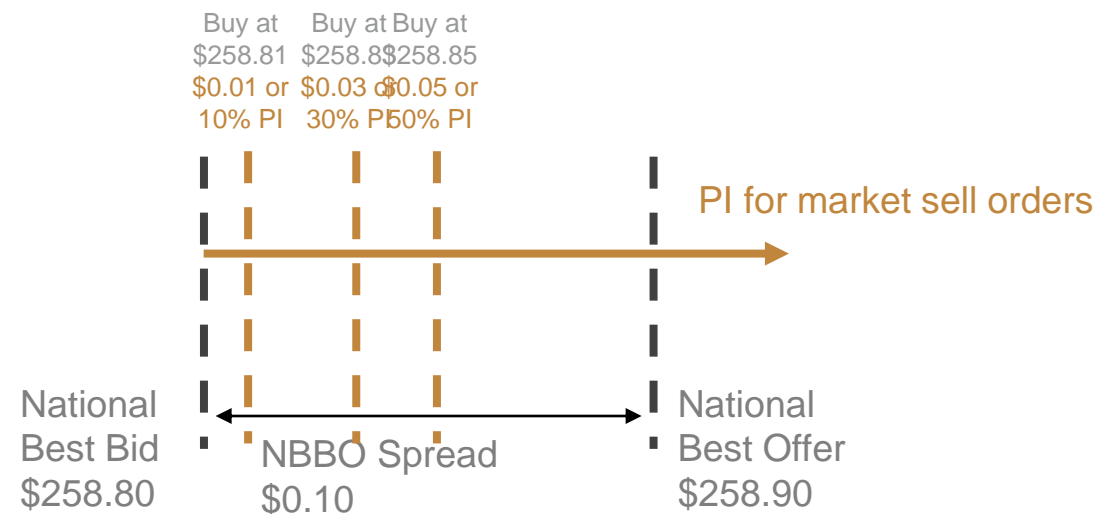
Price Improvement

- Trades executed at prices or within the NBBO
- Measured as the \$ or % of gain

Market order to buy

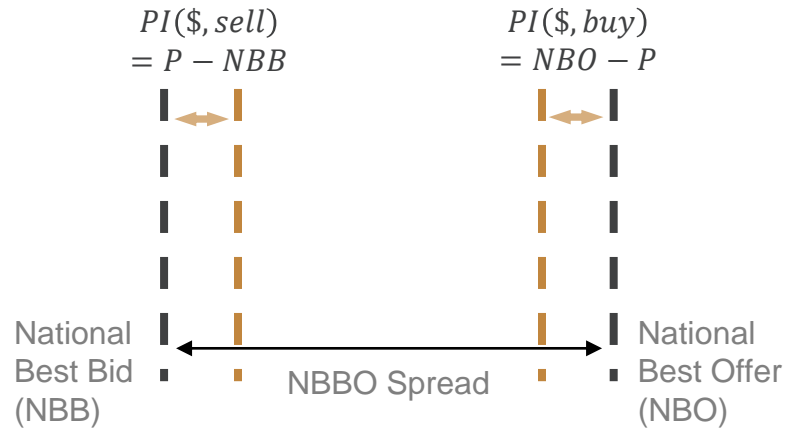


Market order to sell



MEASURING PRICE IMPROVEMENT

Dollar price improvement: $PI(\$)$



Normalized price improvement:

$$PI(\%NBBO) = \frac{PI(\$)}{NBBO \text{ Spread}}$$

Round-trip return:

$$Ret\% = \underbrace{\frac{(Sell \text{ Price} - Buy \text{ Price})}{Buy \text{ Price}}}_{\text{Actual return}} - \underbrace{\frac{(Sell \text{ NBBO Midpoint} - Buy \text{ NBBO Midpoint})}{Buy \text{ NBBO Midpoint}}}_{\text{Midpoint benchmark return}}$$

PRICE IMPROVEMENT

	Mean Price Improvement		PFOF	Round-trip trade costs
	(%NBBO)	(cents / share)	(cents / share)	
→ Midpoint (Benchmark)	50%	8.36		0%
Execution at:				
TD Ameritrade	47.2%	7.84	0.099	-0.072%
Fidelity	35.8%	6.54	0.000	-0.234%
E*Trade	36.1%	5.60	0.180	-0.197%
Robinhood	26.8%	4.44	0.215	-0.314%
IBKR Lite	19.5%	3.56	n.a.	-0.444%
IBKR Pro	18.8%	2.78	0.000	-0.462%
→ NBBO (Worst Possible)	0%	\$0		-0.619%

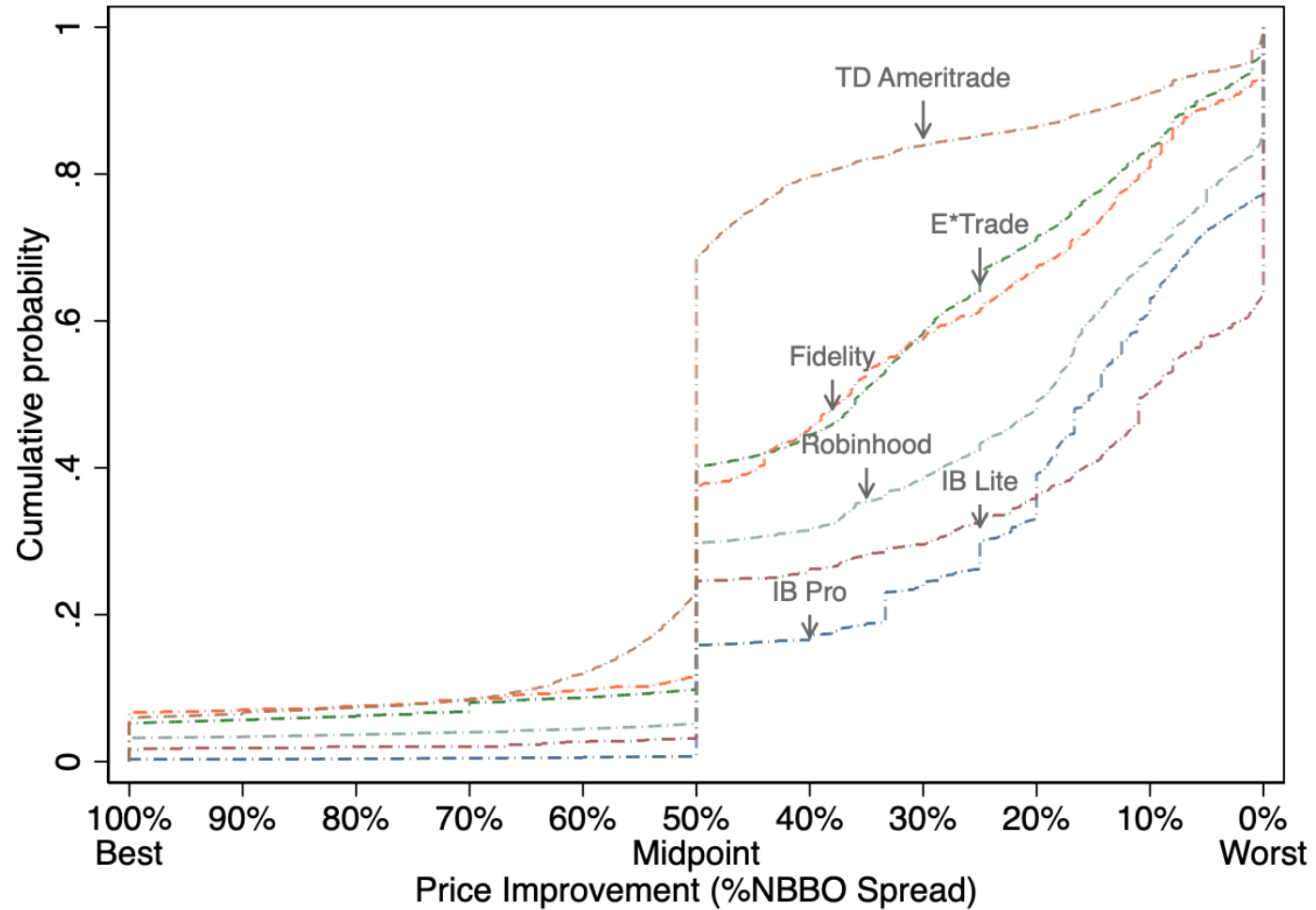
Most pairwise differences are highly statistically significant

In stocks, PFOF is small
[Ernst and Spatt, 2022]

All significantly different from 0

Different order of magnitude

CUMULATIVE DISTRIBUTION OF PI(%NBBO)



ROBUSTNESS

1. Trade size and Latency

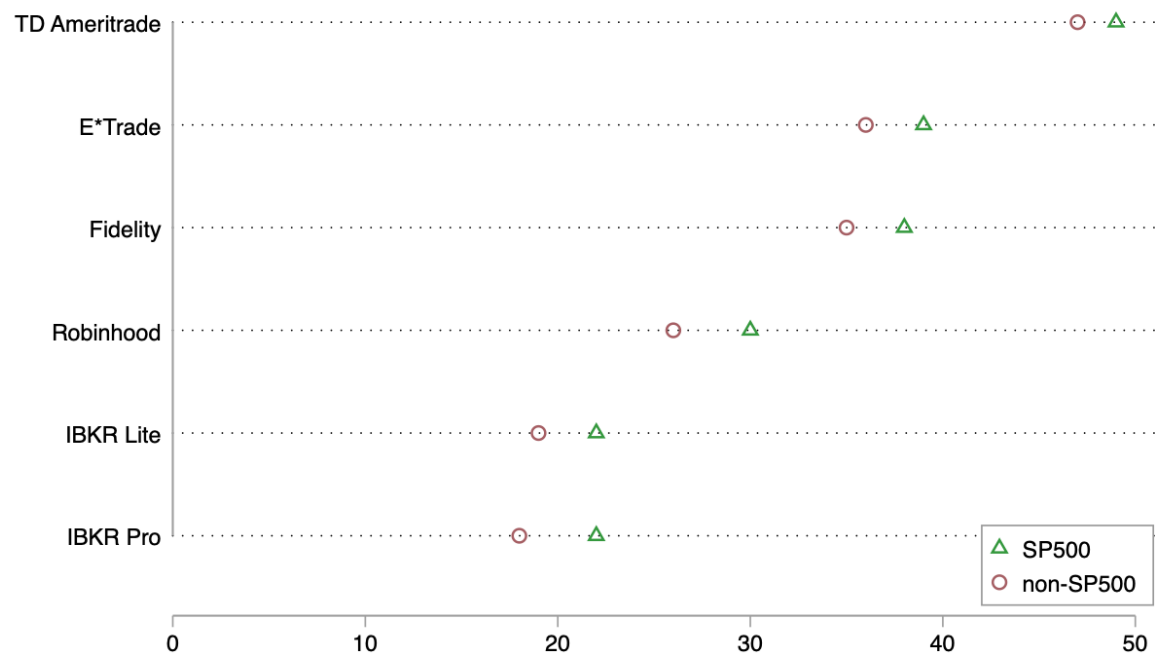
Dep var:	PI(%NBBO)					
Trade size:	\$100		\$1000		\$100	
	Coeff.	T-stat	Coeff.	T-stat	Coeff.	T-stat
Intercept (TD goes first)	0.472	141.55**	0.457	18.33**	0.471	138.31**
E*Trade	-0.111	-38.23**			-0.111	-37.32**
Fidelity	-0.114	-13.54**			-0.109	-12.5**
Robinhood	-0.203	-61.28**	-0.230	-6.30**	-0.203	-61.14**
IBKR Pro	-0.284	-56.10**	-0.287	-8.98**	-0.284	-55.78**
IBKR Lite	-0.277	-32.63**			-0.273	-29.66**
Trade order = 2					0.000	0.09
Trade order = 3					0.001	1.84
Trade order ≥ 4					-0.002	-1.31

Similar results for \$100 vs. Larger (up to \$5000)

ROBUSTNESS

1. Trade size and Latency
2. Stock characteristics: SP500

Average PI(%NBBO): SP500 v. non-SP500



ROBUSTNESS

1. Trade size and Latency
2. Stock characteristics: SP500, Price

Average PI(%NBBO) by Price Buckets



ROBUSTNESS

1. Trade size and Latency
2. Stock characteristics: SP500, Price, Spread

Average PI(%NBBO) by Spread Buckets



ROBUSTNESS

1. Trade size and Latency
2. Stock characteristics: SP500, Price, Spread, Volume

Average PI(%NBBO) by Volume Buckets



WHY LARGE DIFFERENCES MAY EXIST?

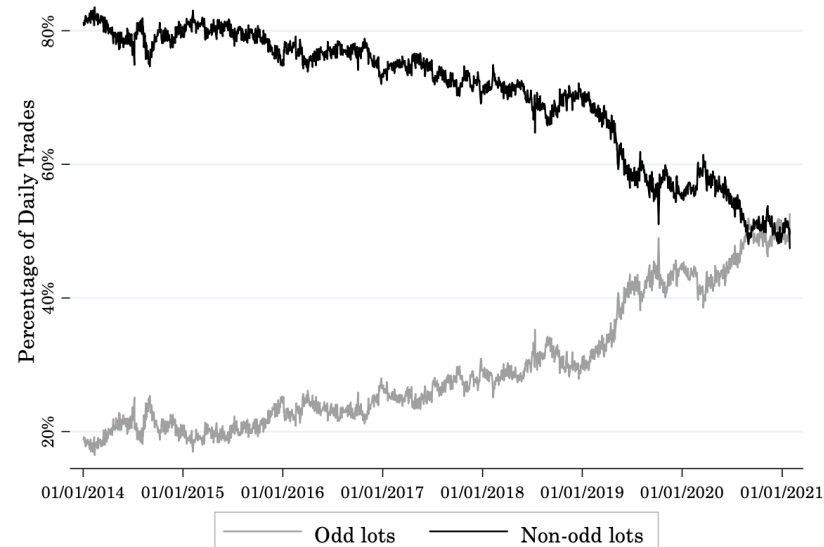
Regulatory and market environment

Regulation “National Market System” (Reg NMS):

- Centered on “round lots” (usually ≥ 100 shares)
- “Odd lots” are excluded from market center’s trade execution statistics
- NBBO is based on “round lots”

Most of equity trades are now odd lots on U.S. exchanges (Bartlett, 2021)

Figure 1. Odd Lot Trading, 2014–20



WHY LARGE DIFFERENCES MAY EXIST?

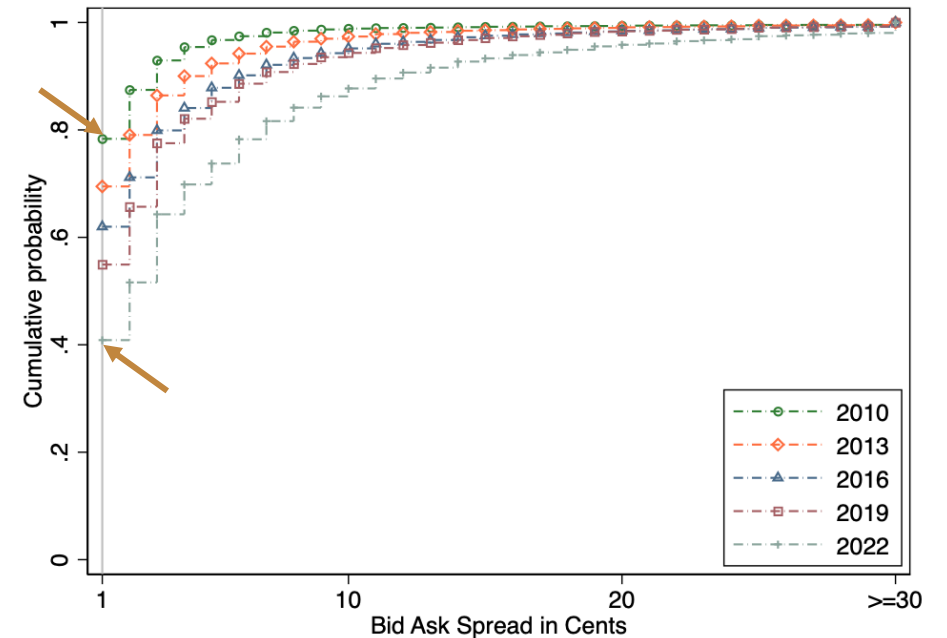
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NBBO spread becomes increasingly larger through years



ROADMAP



WHAT EXPLAINS PRICE IMPROVEMENT VARIATIONS ACROSS BROKERS?

1. Brokers' routing strategies towards various market centers
 - Public disclosure data [Rule 605 report]

BROKER ORDER ROUTING – VENUE CHOICE

Market-center Average Execution Disclosure

Market centers (605): **average execution** by stock, order type, and trade size bin (100-499, 500-1999, etc.)

Example: Virtu 605 Disclosure

```
T|TVIRT|202207|A|12|23|10|32121|32121|0|0|0|0|0|0|0.0000|0.0000|0|0.0000|0.0|0|0.0|0|0.0000|0.0
T|TVIRT|202207|A|13|21|58|7885|6685|1200|0|1200|0|0|0|0|-0.0121|0.0000|0|0.0000|0.0|0|0.0|0|0.0000|0.0
T|TVIRT|202207|A|13|22|3|3899|3899|0|0|0|0|0|0|0.0000|0.0000|0|0.0000|0.0|0|0.0|0|0.0000|0.0
T|TVIRT|202207|A|13|23|4|17237|17237|0|0|0|0|0|0|0.0000|0.0000|0|0.0000|0.0|0|0.0|0|0.0000|0.0
T|TVIRT|202207|A|14|21|8|1000|1000|0|0|0|0|0|0|0.0000|0.0000|0|0.0000|0.0|0|0.0|0|0.0000|0.0
T|TVIRT|202207|A|14|22|1|500|500|0|0|0|0|0|0|0.0000|0.0000|0|0.0000|0.0|0|0.0|0|0.0000|0.0
T|TVIRT|202207|A|15|21|3|500|500|0|0|0|0|0|0|0.0000|0.0000|0|0.0000|0.0|0|0.0|0|0.0000|0.0
T|TVIRT|202207|AA|11|21|5|1172|1072|100|0|100|0|0|0|0|-0.7800|0.0800|0|0.0000|0.0|100|0.0|0|0.0000|0.0
T|TVIRT|202207|AA|11|22|2|2800|2800|0|0|0|0|0|0|0.0000|0.0000|0|0.0000|0.0|0|0.0|0|0.0000|0.0
T|TVIRT|202207|AA|12|21|1965|368121|302739|65382|0|65382|0|0|0|0|-0.0065|0.0245|26500|0.0014|0.0|38282|0.0|600|0.0099|0.0
T|TVIRT|202207|AA|12|22|265|250122|248322|1800|0|1800|0|0|0|0|-0.1110|0.0279|1500|0.0019|0.0|300|0.0|0|0.0000|0.0
T|TVIRT|202207|AA|12|23|80|244303|244303|0|0|0|0|0|0|0.0000|0.0000|0|0.0000|0.0|0|0.0|0|0.0000|0.0
T|TVIRT|202207|AA|12|24|15|109384|109384|0|0|0|0|0|0|0.0000|0.0000|0|0.0000|0.0|0|0.0|0|0.0000|0.0
T|TVIRT|202207|AA|13|21|215|42048|39848|2200|0|2200|0|0|0|0|0.2139|0.0000|0|0.0000|0.0|0|0.0|0|0.0000|0.0
```

- Average execution does not break down by brokers
 - implicit assumption: market centers give **the same execution to all brokers**
- Source of execution differences:
 - Venue choice of brokers [Broker (606)]
 - Average execution differences across market centers [Market centers (605)]



BROKER ORDER ROUTING – VENUE CHOICE

Venue Routing Disclosure

Broker (606): summary of routing and PFOFs by order type/SP500

Example: TD Ameritrade 606 Disclosure, Q1 2022

S&P 500 Stocks

Summary

Non-Directed Orders as % of All Orders	Market Orders as % of Non-Directed Orders	Marketable Limit Orders as % of Non-Directed Orders	Non-Marketable Limit Orders as % of Non-Directed Orders	Other Orders as % of Non-Directed Orders
99.97	25.81	6.93	36.01	31.25

- Routing does not break down by stock
 - implicit assumption: brokers randomly route stocks to market centers according to the reported composition

Venues

Venue - Non-directed Order Flow	Non-Directed Orders (%)	Market Orders (%)	Marketable Limit Orders (%)	Non-Marketable Limit Orders (%)	Other Orders (%)	Net Payment Paid/Received for Market Orders(USD)	Net Payment Paid/Received for Market Orders(cents per hundred shares)	Net Payment Paid/Received for Marketable Limit Orders(USD)	Net Payment Paid/Received for Marketable Limit Orders(cents per hundred shares)	Net Payment Paid/Received for Non-Marketable Limit Orders(USD)	Net Payment Paid/Received for Non-Marketable Limit Orders(cents per hundred shares)	Net Payment Paid/Received for Other Orders(USD)	Net Payment Paid/Received for Other Orders(cents per hundred shares)
Virtu Americas, LLC	28.70	38.02	36.56	2.81	49.09	711,890	10.0000	149,040	10.0000	36,663	33.7900	85,330	9.0500
Citadel Securities, LLC	22.31	16.93	18.19	22.17	27.84	325,847	10.0000	73,388	10.0000	230,111	32.3900	51,378	9.2600
Two Sigma Securities, LLC	15.06	0.49	3.08	35.89	5.77	9,328	10.0000	6,178	10.0000	695,343	33.0100	19,657	10.4800
G1 Execution Services, LLC	14.60	28.68	26.52	9.58	6.11	580,119	10.0000	113,793	10.0000	334,357	36.2200	17,751	10.3600
UBS Securities, LLC	11.70	0.93	2.64	24.66	7.67	17,927	10.0000	6,603	10.0000	435,796	32.6200	30,321	10.3600
Jane Street Capital, LLC	5.24	14.03	12.17	0.86	1.48	280,418	10.0000	51,899	10.0000	5,328	33.5600	1,190	10.2000

WHAT EXPLAINS PRICE IMPROVEMENT VARIATIONS ACROSS BROKERS?

1. Brokers' routing strategies towards various market centers

- Public disclosure data [Rule 605 report] : average execution does not break down by brokers
⊗ implicit assumption: market centers give **the same execution to all brokers**
- Source of execution differences:
 - Average execution differences across market centers [Market centers (605)]
 - Venue choice of brokers [Broker (606)]

2. Brokers receive **different price execution from the same market center**

MARKET CENTER PRICING

Investor's Rights to Routing Data

Report 606(b)(1)

- Upon request, XML and PDF reports for held, exempt not-held and options orders
- Detailed order execution data, including execution venue and time for any customer order
- **Firms must begin collecting data October 1, 2019**

We requested and obtained routing data for our trades

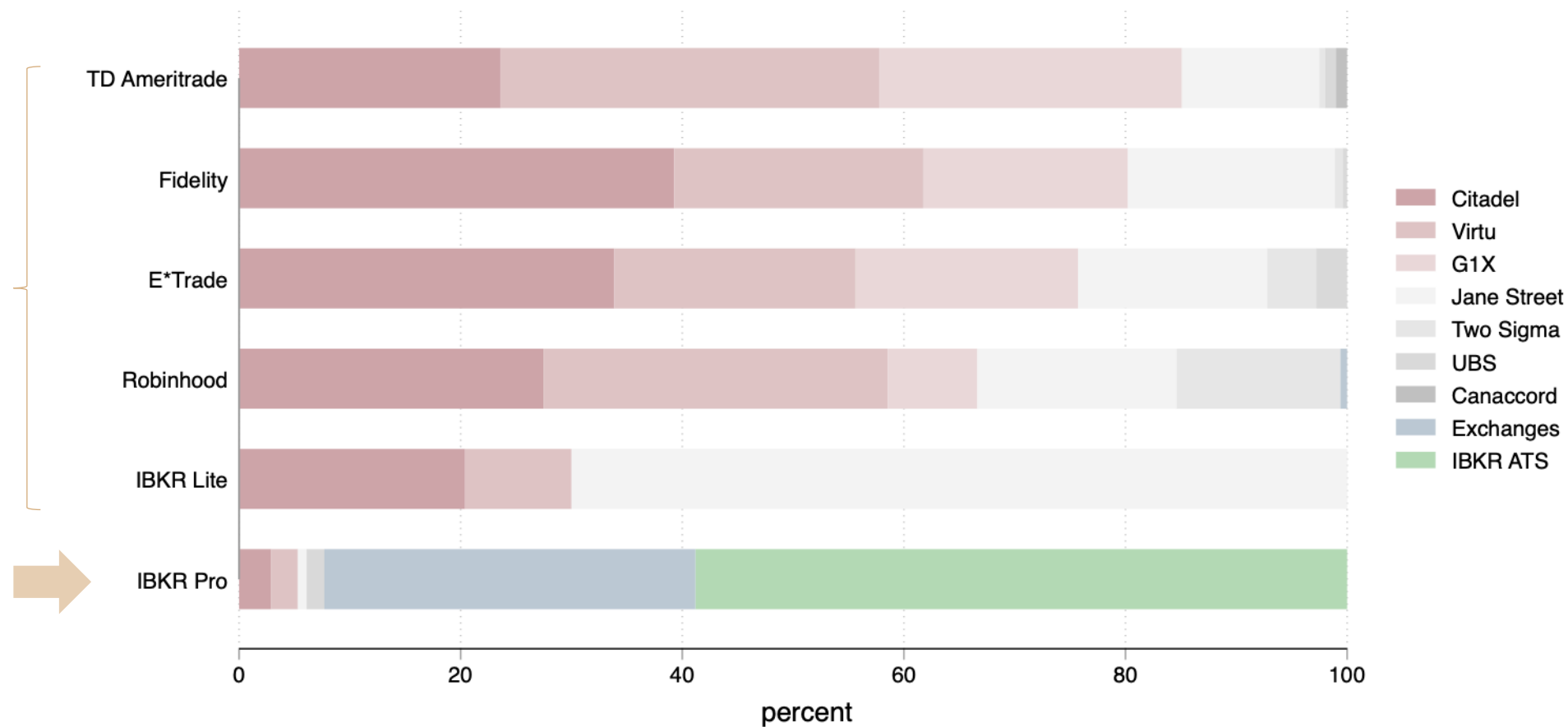


Easiest

Hardest

BROKER ORDER ROUTING – VENUE CHOICE

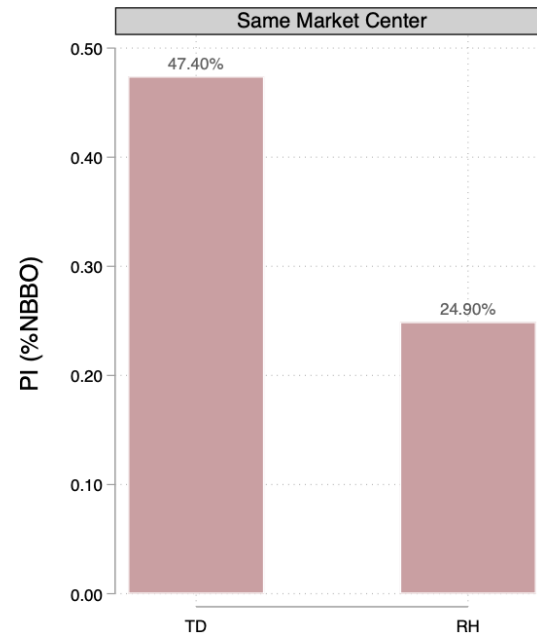
Venue Routing Composition of Our Trades



MARKET CENTER PRICING

Differential Pricing

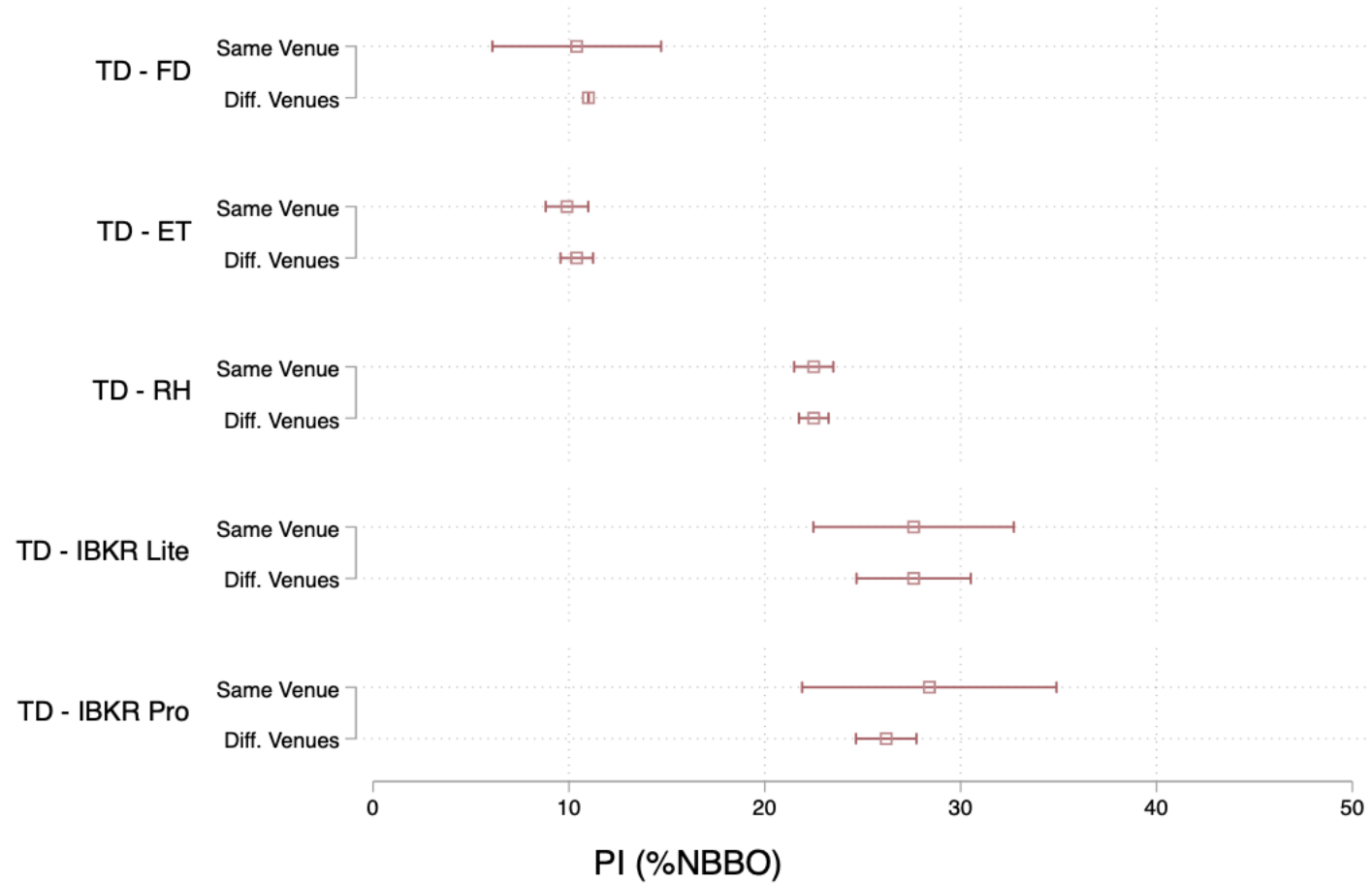
TD vs. RH Overall PI (%NBBO) Diff:
22.5% (t stat = 63.11)



Same-venue Diff:
22.5%
(t stat = 44.14)

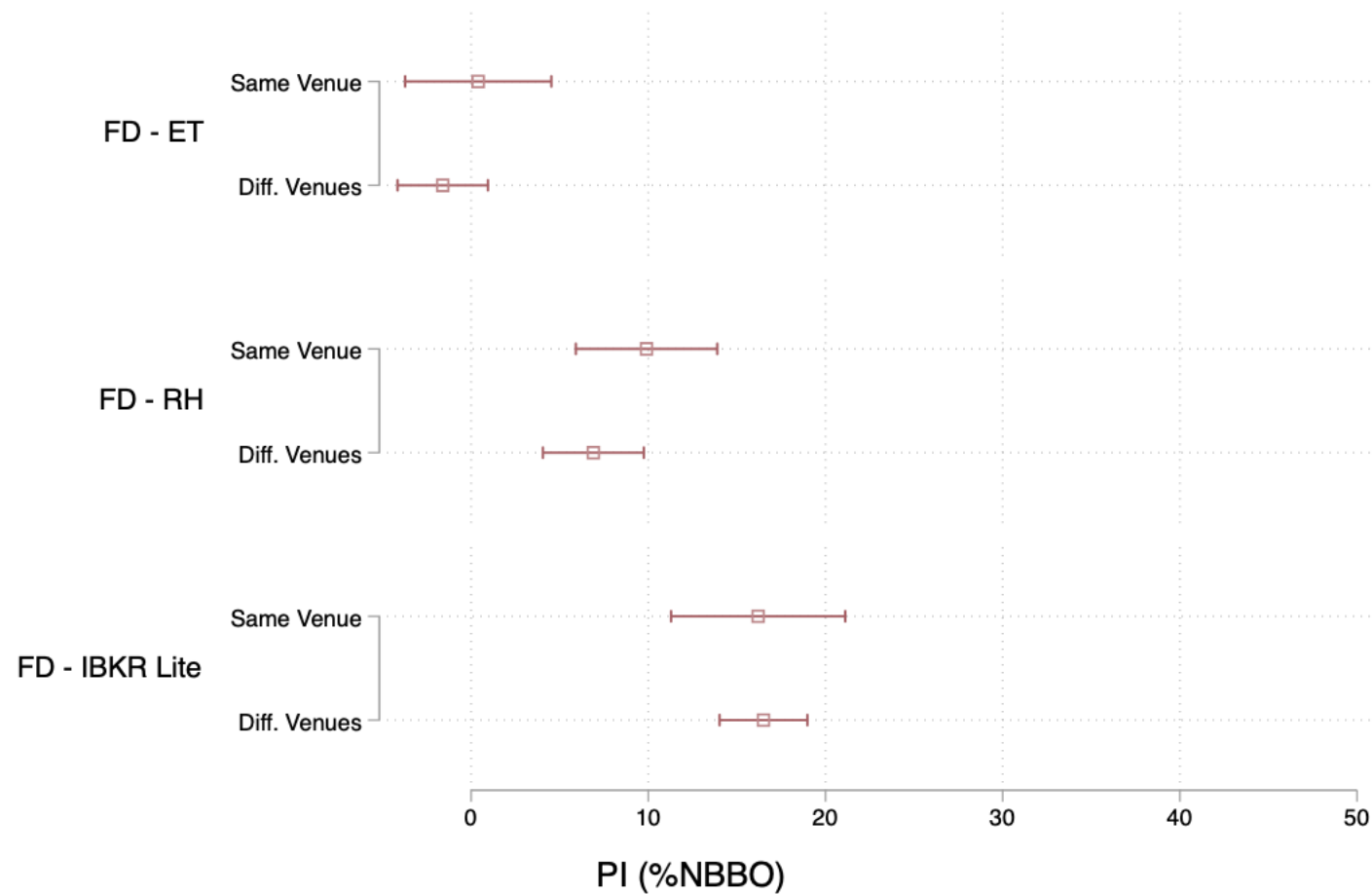
MARKET CENTER PRICING

Same vs. Diff. Venues (I)



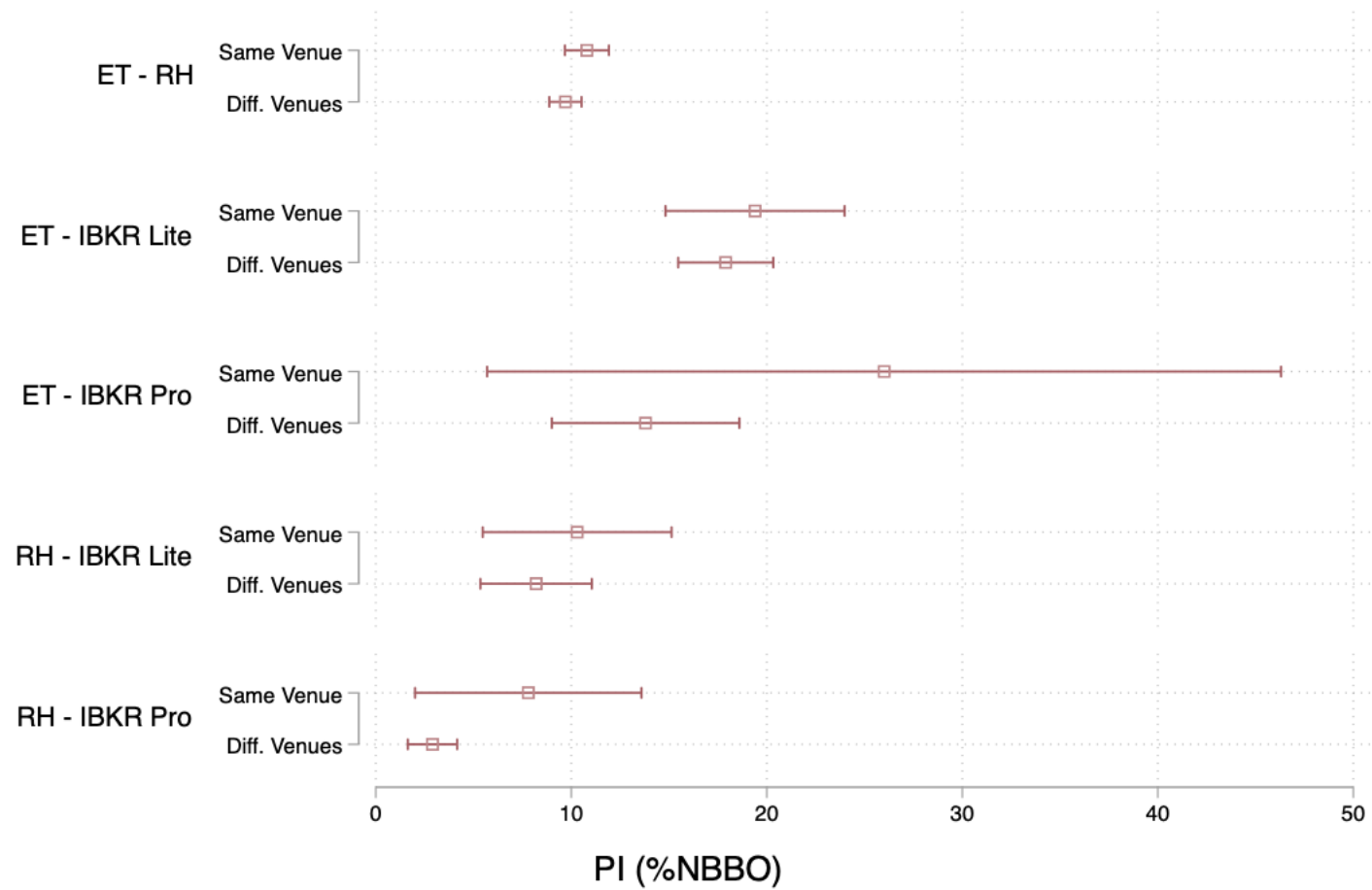
MARKET CENTER PRICING

Same vs. Diff. Venues (II)



MARKET CENTER PRICING

Same vs. Diff. Venues (III)



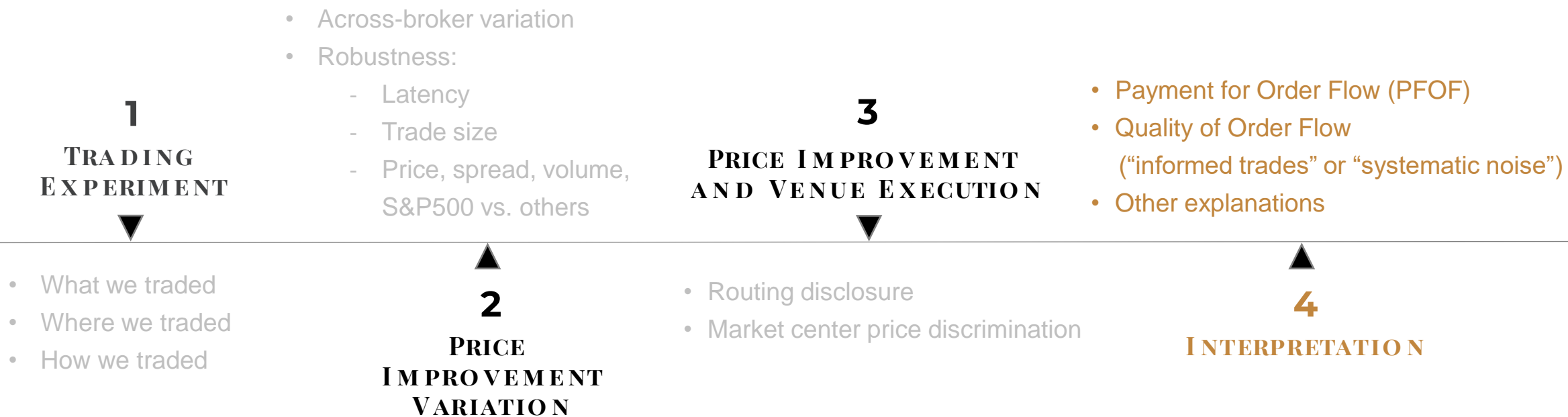
MARKET CENTER PRICING

Same-Venue Parallel Trades by Venue

TD vs. RH Same-Venue PI (%NBBO) Diff:
22.5% (t stat = 44.14)



ROADMAP



POSSIBLE INTERPRETATIONS

1. Payment for order flow

- Greater payments to brokers are systematically offset by worse execution prices

2. Quality of order flow (“toxicity” of order flow)

- Informed trades
- Systematic noise

3. Other explanations

- Size of order flow
- Stability of order flow
- Differing objective function

PFOF DISCLOSURE

Broker (606): summary of routing and PFOFs by order type and SP500/non-SP500

Example: TD Ameritrade 606 Disclosure, Q1 2022

S&P 500 Stocks

Summary

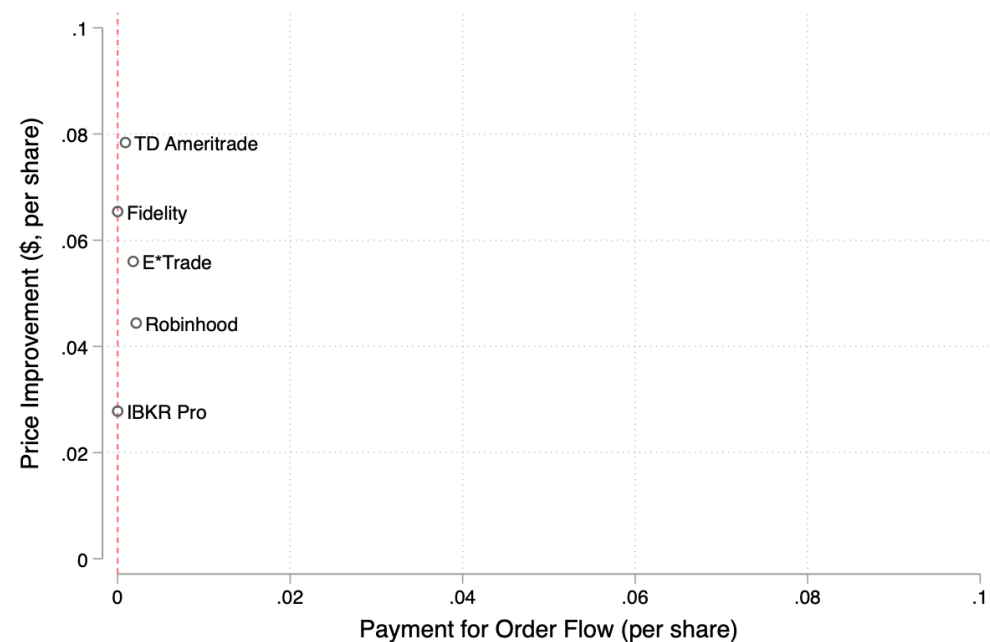
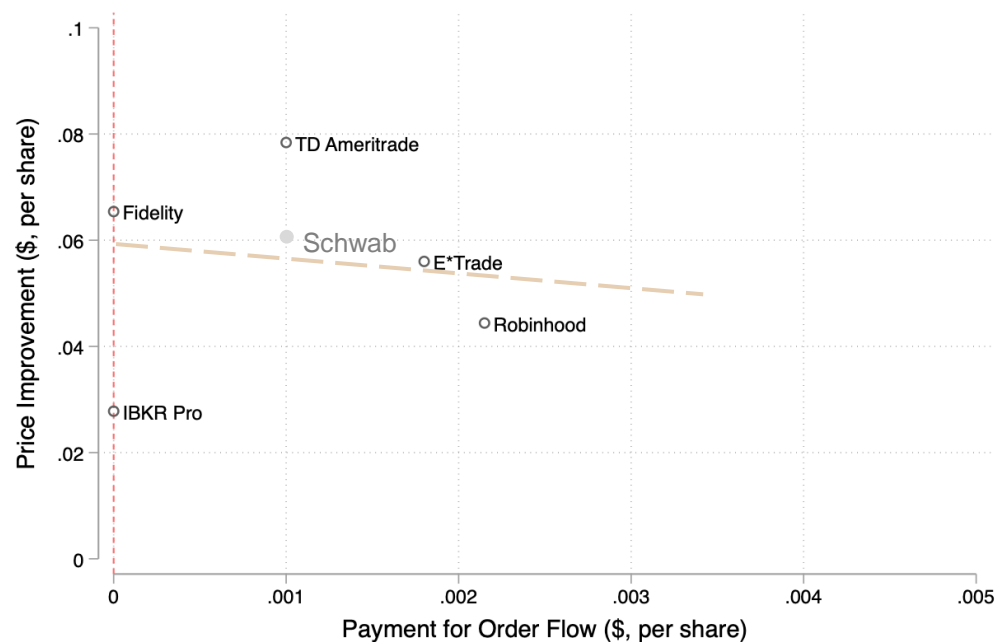
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10 cents
per 100 shares

ARE PI DIFFERENCES EXPLAINED BY PFOF?



- Higher PFOF may have an impact on lower price improvement (with a flat slope)
- But, the **economic magnitude** of the impact may be **too small** to explain large price improvement variations

POSSIBLE INTERPRETATIONS

1. Payment for order flow

[Not main driver]

- Greater payments to brokers are systematically offset by worse execution prices

2. Quality of order flow (“toxicity” of order flow)

- Informed trades
- Systematic noise

3. Other explanations

- Size of order flow
- Stability of order flow
- Differing objective function

QUALITY OF ORDER FLOW

How does the quality (or “toxicity”) of order flow affect execution?

- Asymmetric information [Kyle, 1985]:
 - More informed trades (e.g., IBKR) → less profitable → lower PI
- Systematic noise:
 - Trade herding/momentum trading (e.g., Robinhood) → lower quality flow → lower PI

Suggestive evidence:

- We **do not** directly observe the dispersion in order flow toxicity **across brokers**
- Instead, we assess whether **time-varying** toxicity of order flow can generate variations in price execution with **similar economic magnitude**.
 - Stock-level order flow measured by TAQ

QUALITY OF ORDER FLOW

Proxy for toxicity of order flow: **order imbalance (OIB)** around our trades

- Off-exchange trades from TAQ
- During the minute around our trades
- Sign each trade using the Lee-Ready (1991) classification

Dependent variable: PI (%NBBO)

	(1)	(2)
FD	-0.113** (0.008)	-0.100** (0.008)
ET	-0.111** (0.003)	-0.112** (0.003)
RH	-0.204** (0.003)	-0.203** (0.003)
IBKR Lite	-0.278** (0.008)	-0.264** (0.008)
IBKR Pro	-0.284** (0.005)	-0.271** (0.005)
		Sells Buys
<i>OIB1</i> (Lo Buy)		-0.176** 0.136** (0.006) (0.012)
<i>OIB2</i>		-0.104** 0.075** (0.005) (0.009)

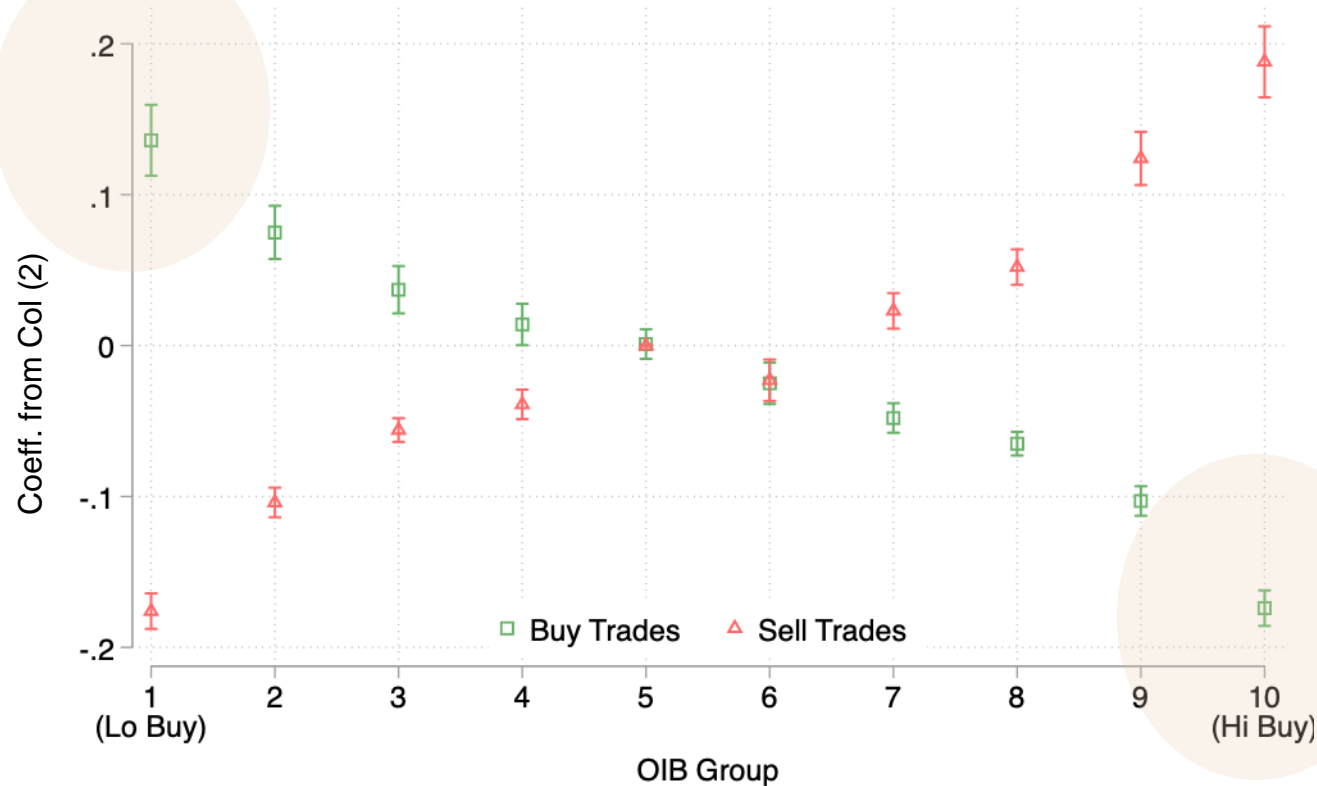
<i>OIB9</i>		0.124** -0.103** (0.009) (0.005)
<i>OIB10</i> (Hi Buy)		0.188** -0.174** (0.012) (0.006)
Venue FEs	NO	NO
Stock FEs	NO	NO
Observations	74,675	74,675
R-squared	0.155	0.253

QUALITY OF ORDER FLOW

Proxy for toxicity of order flow: **order imbalance (OIB)** around our trades

Economic magnitude: Similar between across brokers and across OIB bins

- **Across OIB bins:** Hi Buy vs. Lo Buy → **36.4%** for sells and **31.0%** for buys
- **Across broker:** TD vs. IBKR Pro → **27.1%**



Dependent variable: PI (%NBBO)

	(1)	(2)
FD	-0.113** (0.008)	-0.100** (0.008)
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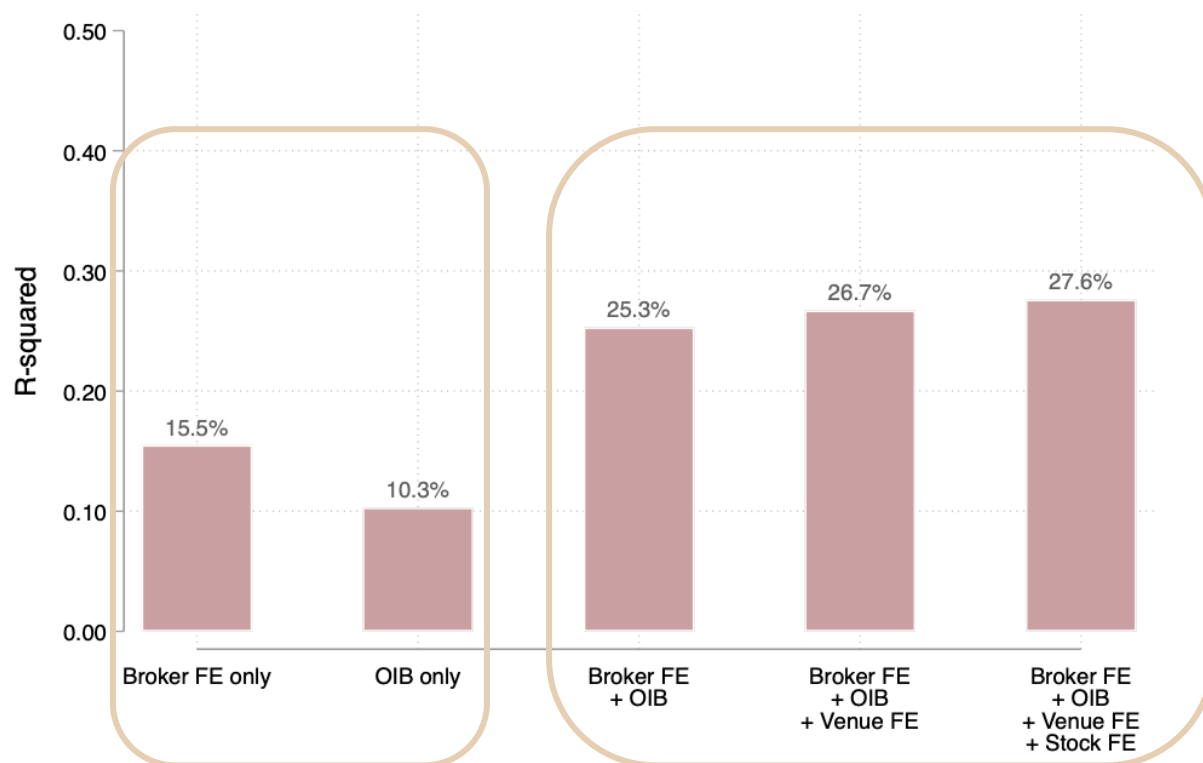
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QUALITY OF ORDER FLOW

Proxy for toxicity of order flow: **order imbalance (OIB)** around our trades

Economic magnitude: Similar between across brokers and across OIB bins
[suggestive evidence for quality of order flow as one explanation]

Economic significance: **Broker FE ~ OIB** >> **Venue FE ~ Stock FE ~ 0**



Dependent variable: PI (%NBBO)

	(1)	(2)
FD	-0.113** (0.008)	-0.100** (0.008)
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POSSIBLE INTERPRETATIONS

1. Payment for order flow

[NO]

- Greater payments to brokers are systematically offset by worse execution prices

2. Quality of order flow (“toxicity” of order flow)

[SUGGESTIVE EVIDENCE]

- Informed trades
- Systematic noise

3. Other explanations

- Size of order flow
- Stability of order flow
- Differing objective function

OTHER EXPLANATIONS

Size of order flows:

- Given fixed costs, larger aggregate order flow (e.g., TD) → more attractive → higher PI

Stability of order flows:

- Optimize on aggregate level (e.g., TD) → more stable → higher PI
- Optimize on stock level (e.g., Robinhood smart routing) → less stable → lower PI

Differing objective function:

- Care about dimensions other than PI in equity (e.g., PI in options, trade execution) → lower PI

CONCLUSION

Price execution **across brokers**

- **Substantial variation** across brokers

Market centers provide **differential prices**

- Same venue ~ different venue ~ overall differences across brokers
- Possible explanations:
 - **PFOF (not main driver) | Quality of order flow (suggestive evidence)**
 - Size of order flow | Stability of order flow | Differing objective function

Policy implication

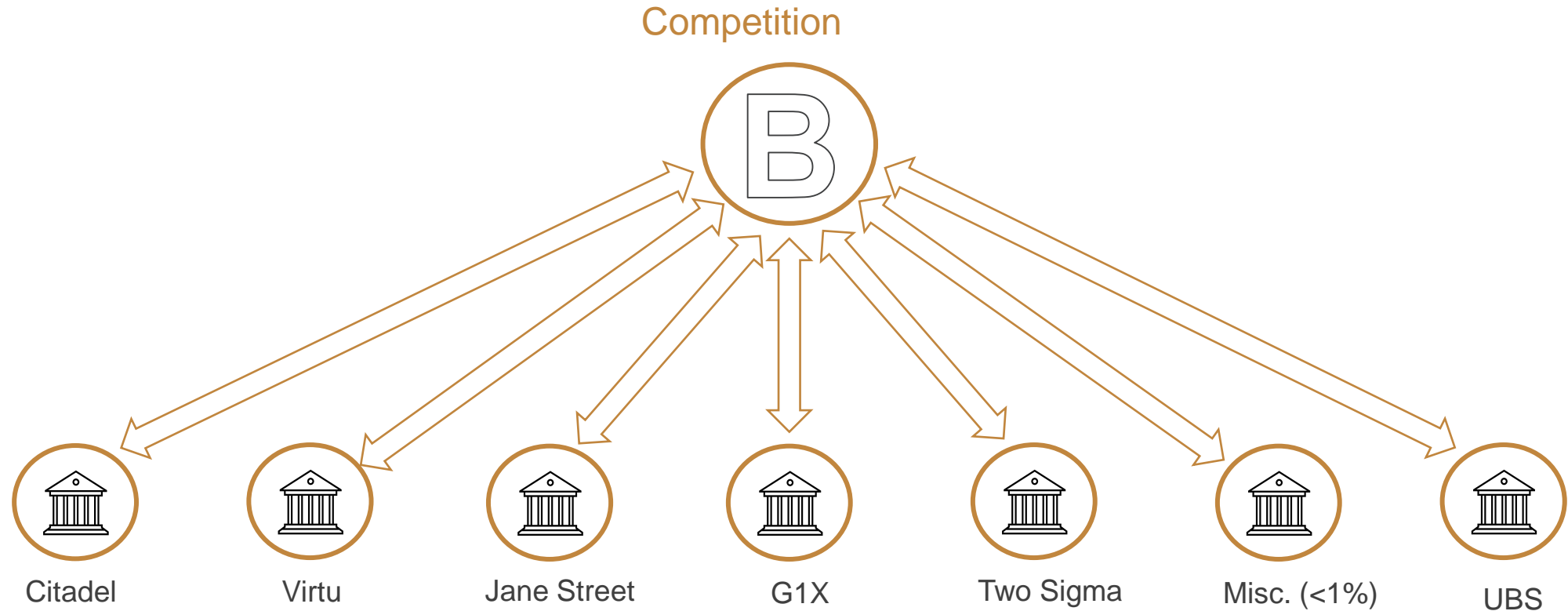
- Improve disclosure to increase transparency
 - 606 report [broker]: include overall PI (**magnitude**, e.g., %NBBO);
 - 605 report [market center]: include **odd lots** and **broker-level** price execution

[NEXT]

Price execution **within broker**

- Variations **across wholesalers?**
 - YES: **lack** of competition
 - NO: **fierce** competition

WHAT IMPACTS PRICE EXECUTION OF RETAIL TRADES? (II)



Lack of competition

- **Concentrated market:** only four major wholesalers
- **No order-by-order competition:** once order is routed, not subject to any competition

PREVIEW OF ONGOING WORK

Price execution **within broker**: Are there variations **across wholesalers**?

- Answer: [YES] - **persistent dispersion**

1. Broker responsiveness

- Lack of responsiveness: only some brokers appear to be responsive

2. Market share and execution quality

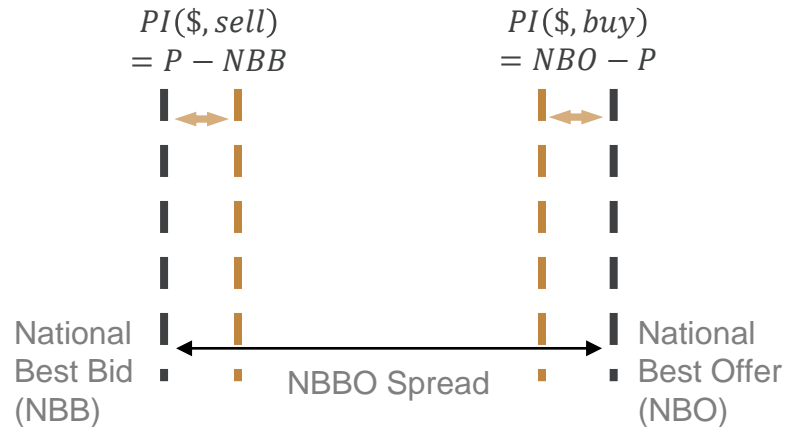
- **Responsive** brokers: higher E/Q (lower quality) ↔ lower market share
- **Unresponsive** brokers: higher E/Q (lower quality) ↔ higher market share [why?]

3. Impact of market entry

- **Event study**: Jane Street enters Robinhood's market

MEASURING PRICE IMPROVEMENT

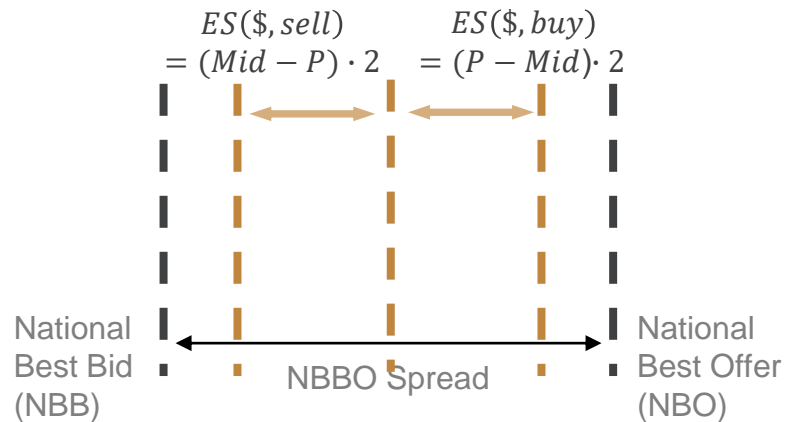
Dollar price improvement: $PI(\$)$



Normalized price improvement:

$$PI(\%NBBO) = \frac{PI(\$)}{NBBO \text{ Spread}}$$

Dollar effective spread: $ES(\$)$



Normalized effective spread:

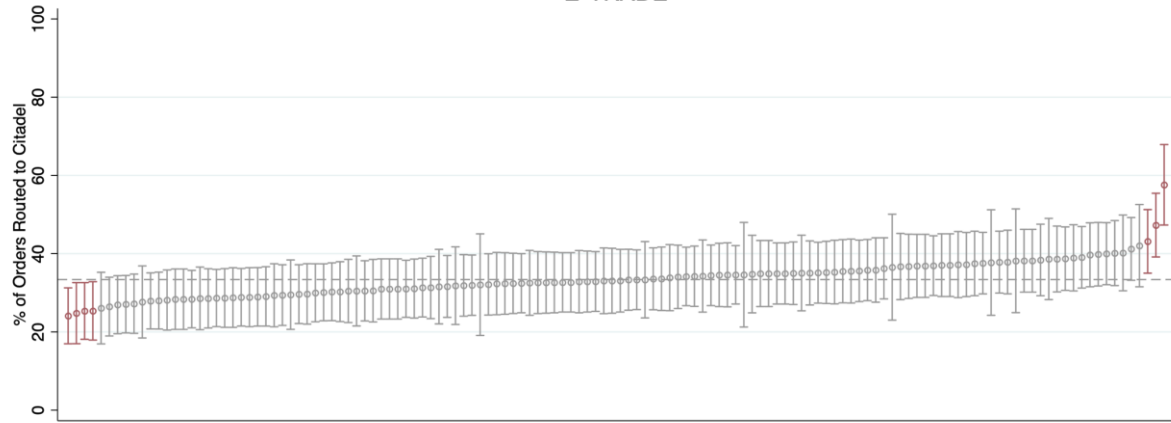
$$E/Q = \frac{ES(\$)}{NBBO \text{ Spread}}$$

$$2 \cdot PI(\%NBBO) + E/Q = 1$$

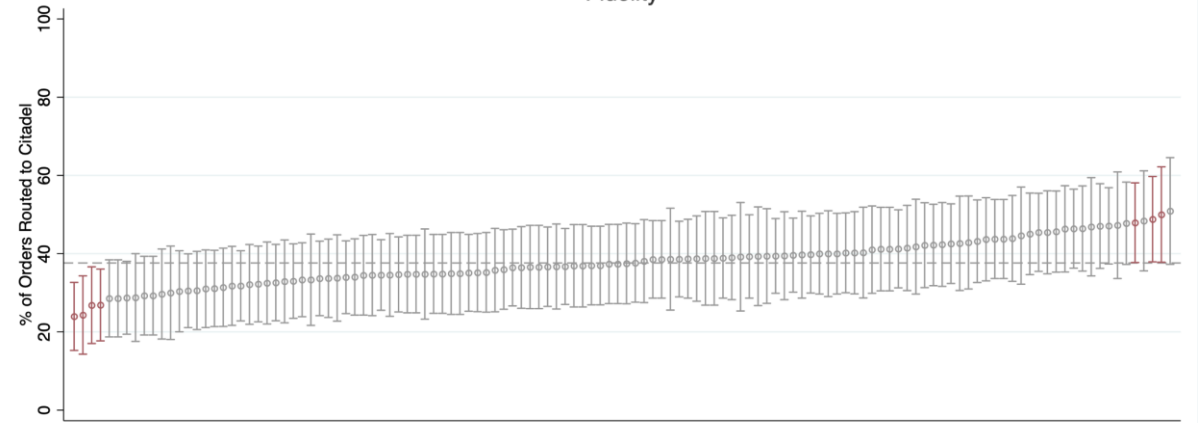
- Inverse relationship
- If $E/Q = 0$, midpoint pricing [free trade]
- If $E/Q = 1$, no price improvement ["worst" possible]

PROPORTIONAL BROKERS

E*TRADE



Fidelity



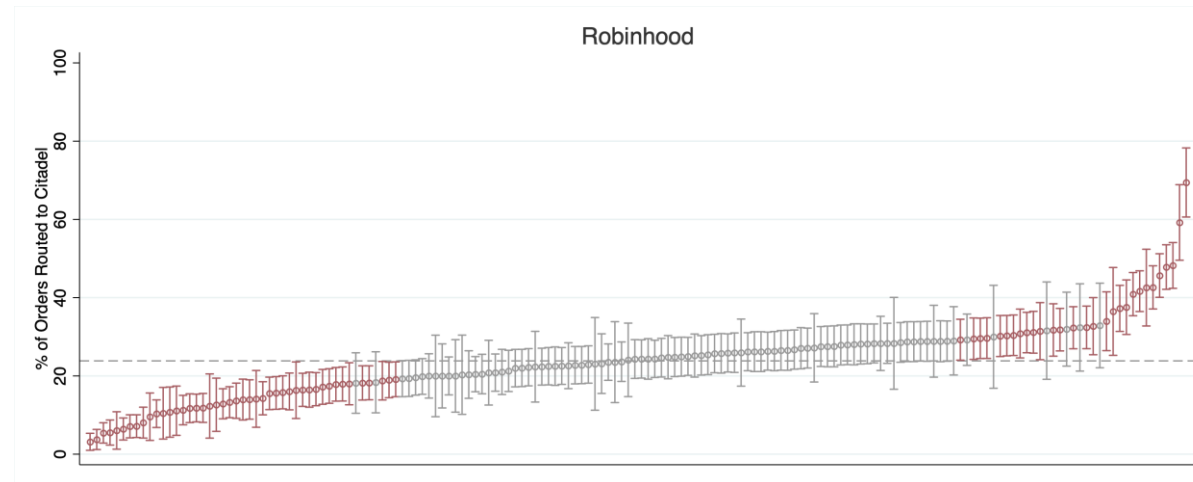
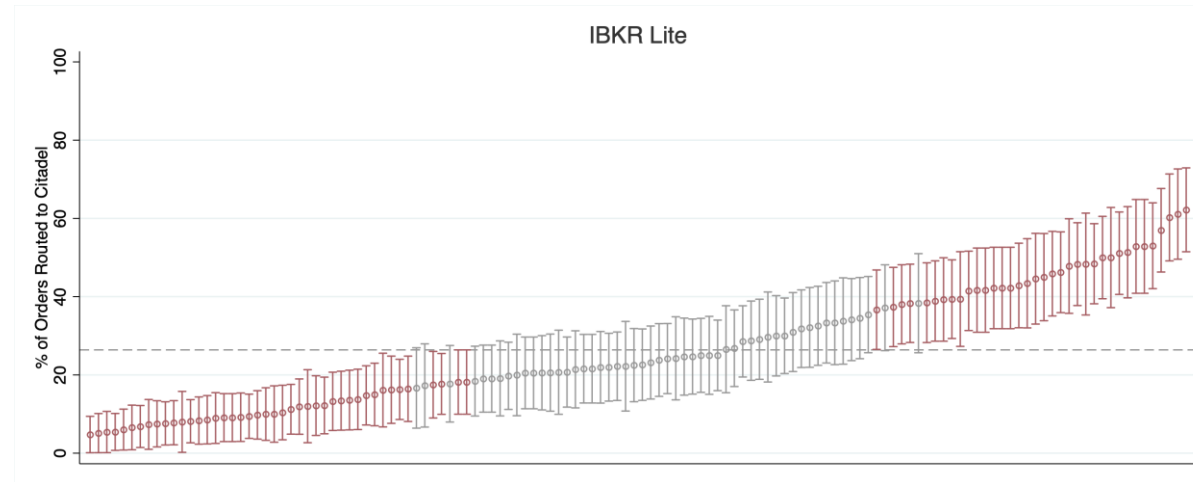
Schwab



TD Ameritrade



SELECTIVE BROKERS



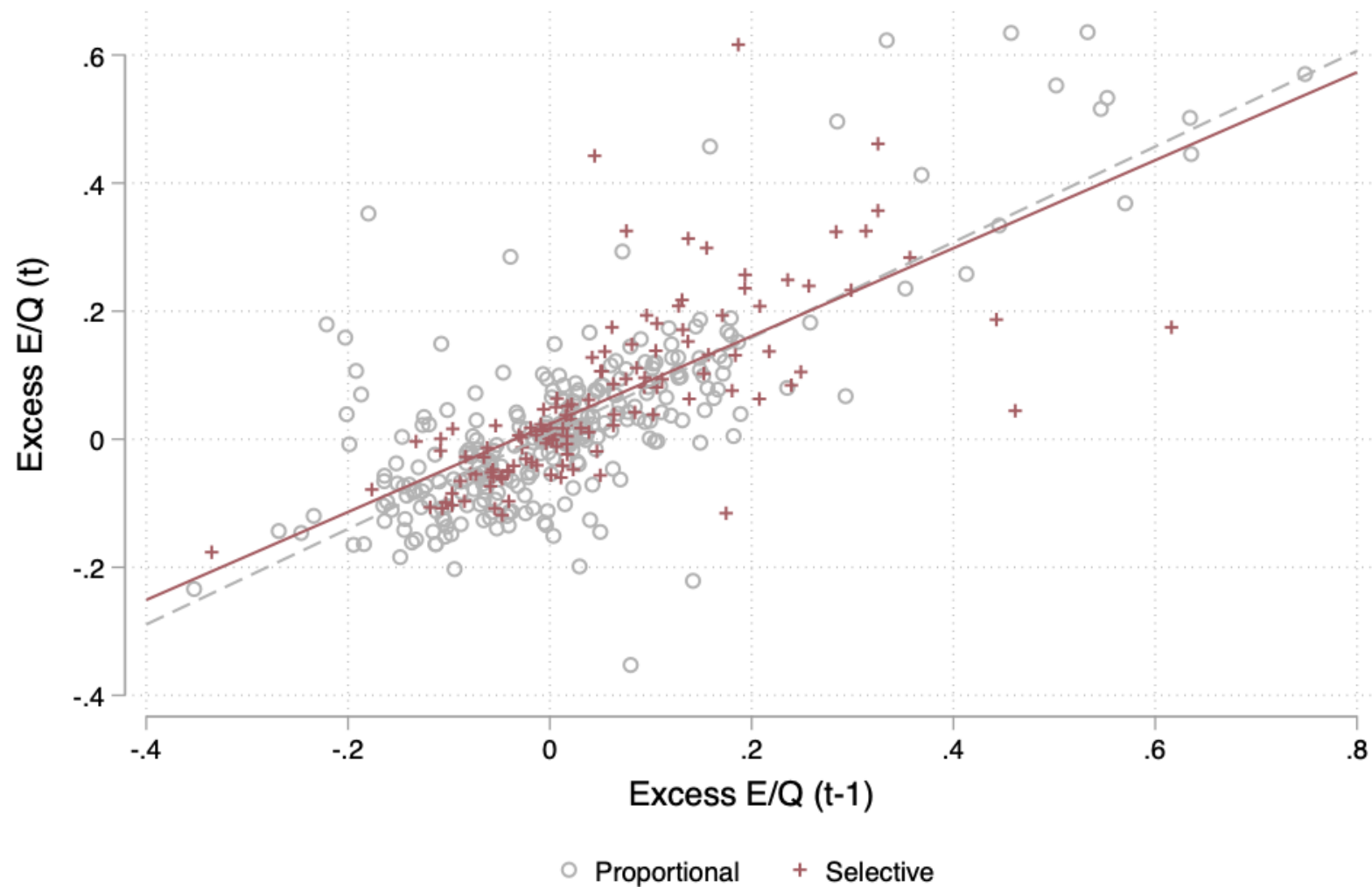
ACROSS-WHOLESALE DISPERSION

Hypothesis – Perfect Bertrand Competition:

- **Perfect competition (brokers can frictionlessly switch)** → no dispersion across wholesalers
[only wholesalers with best execution can get any order flow]

	Average E/Q	Citadel	Virtu	Jane Street	G1X	Sigma	UBS
E*Trade	0.322	0.093** (6.1)	-0.131** (-17.1)	-0.037** (-3.0)	0.048** (3.9)	0.068* (2.4)	-0.023 (-0.5)
Fidelity	0.142	0.100** (6.3)	-0.114** (-9.0)	-0.028 (-1.4)	-0.059** (-4.4)	0.089 (1.6)	0.010 (0.4)
IBKR Lite	0.527	0.008 (0.4)	0.247** (9.6)	-0.060** (-4.7)			
Robinhood	0.421	-0.015 (-1.0)	-0.046** (-5.5)	-0.045 (-1.7)	0.129** (6.6)	0.130** (7.0)	
Schwab	0.229	0.123** (11.9)	-0.114** (-5.7)	-0.049** (-3.0)	0.005 (0.9)	-0.034 (-0.7)	-0.043 (-1.5)
TD Ameritrade	0.093	0.041** (4.1)	0.020 (1.7)	-0.064** (-3.5)	-0.066** (-9.4)	0.284** (3.4)	0.170* (2.5)

PERSISTENT DISPERSION

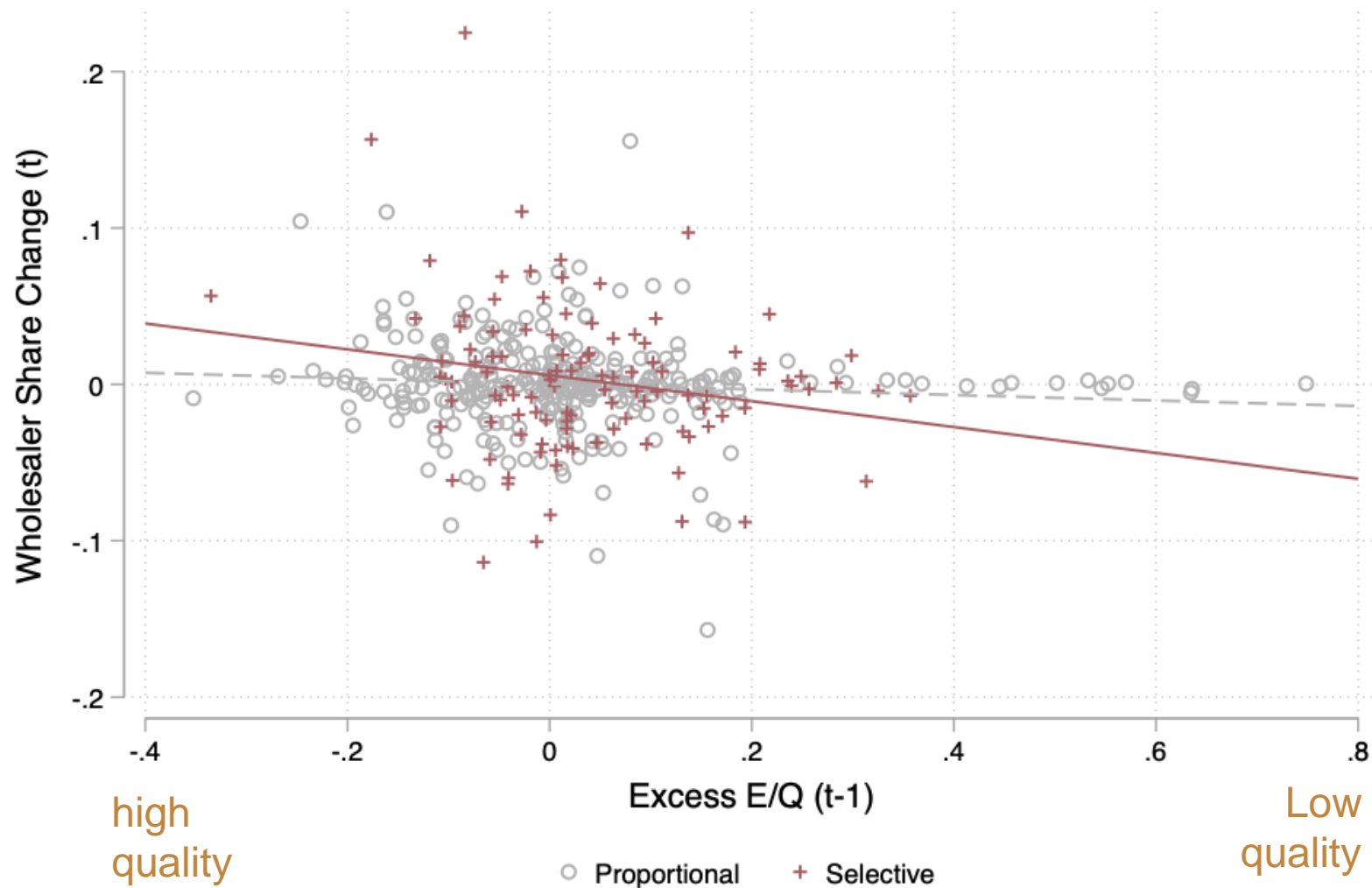


BROKER RESPONSIVENESS

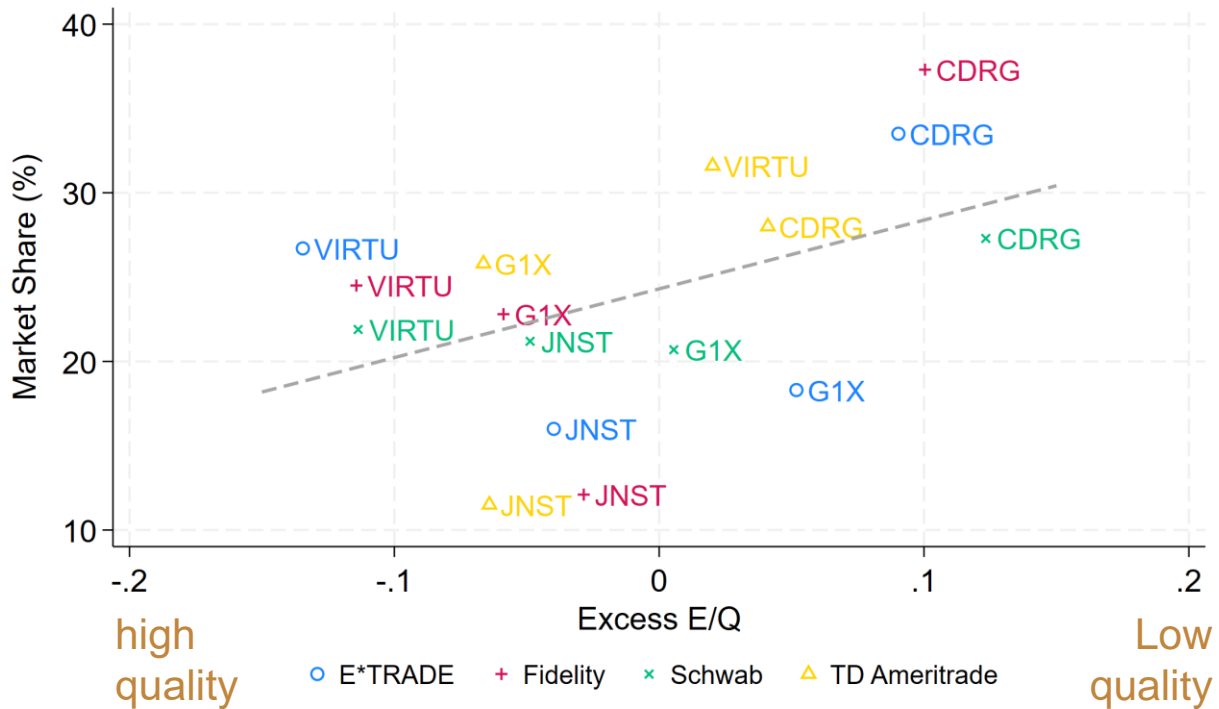
Typical assumption for competitive marketplace

- **Economic incentive:** wholesaler's execution quality is predictable
- **Fiduciary duty:** FINRA best execution guidance
 - Section .09 requires retail brokers to conduct regular **reviews**
 - *“... a member must determine whether any material differences in execution quality exist ... and, if so, **modify the member's routing arrangements** or justify why it is not modifying its routing arrangements.”*

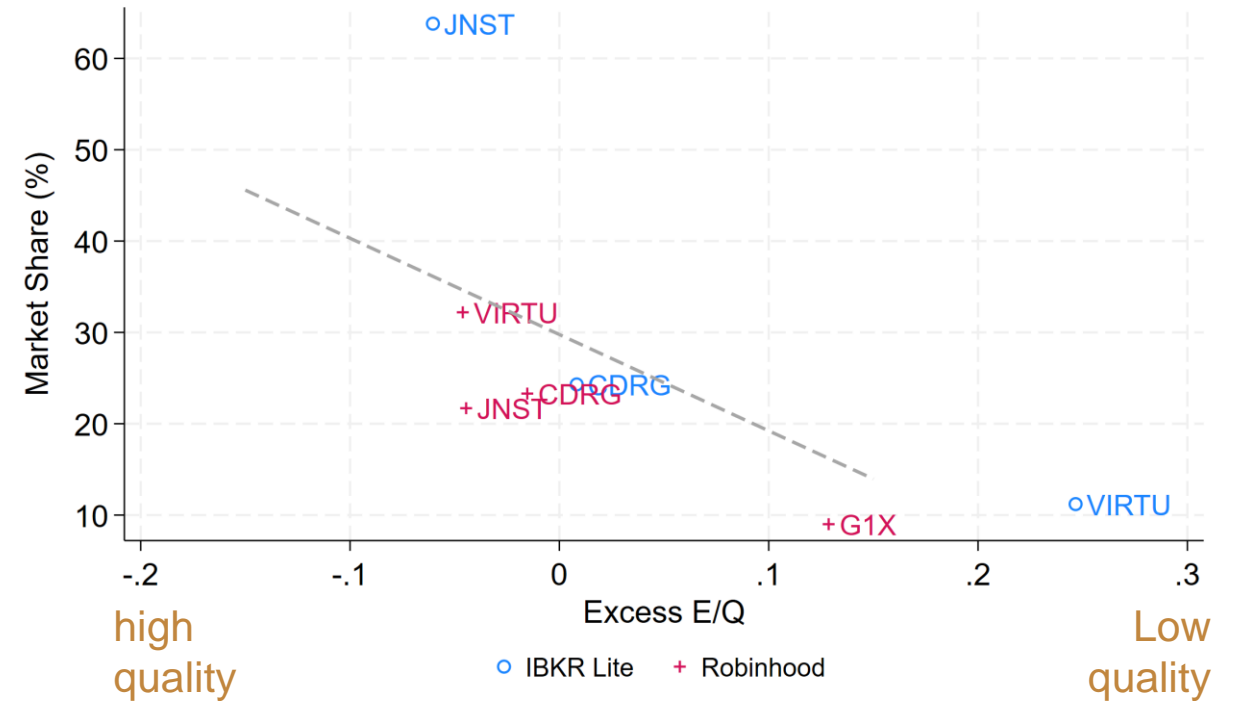
BROKER RESPONSIVENESS



MARKET SHARE AND EXECUTION QUALITY



Proportional
(Unresponsive)



Selective
(Responsive)

HYPOTHETICAL PRICE IMPROVEMENT

To help estimate the cost of limited responsiveness,

- Assume each month t , brokers route all trades to wholesaler with best execution month $t-1$
- Assume price execution equal to what we observe from that wholesaler in month t

	Original	Updated	Change	t-value	PI Change %
Proportional:					
E*TRADE	0.365	0.234	-0.131	-10.05 **	-35.9%
Fidelity	0.192	0.093	-0.099	-4.87 **	-51.6%
Schwab	0.240	0.160	-0.079	-4.80 **	-33.3%
TD Ameritrade	0.118	0.047	-0.071	-8.15 **	-60.2%
Selective:					
IBKR Free	0.575	0.530	-0.046	-3.77 **	-7.8%
Robinhood	0.402	0.346	0.028	-5.23 **	-13.9%
Average					-33.8%

IMPACT OF MARKET ENTRY

Market share:

	Pre-Jane Street	Post-Jane Street	Difference	t-value		% Change
Virtu	39.0%	28.6%	-10.4%	-7.58	**	-26.7%
Citadel	26.6%	21.5%	-5.1%	-4.13	**	-19.2%
Two-Sigma	18.1%	18.7%	0.6%	0.57		3.2%
G1X	13.0%	8.1%	-4.9%	-4.43	**	-37.7%
Jane Street	2.7%	22.5%	19.8%	19.57	**	733.3%

Drop in market share

Excess E/Q:

	Pre-Jane Street	Post-Jane Street	Difference	t-value		% Change
Overall	0.548	0.470	-0.078	-5.66	**	-14.3%
Virtu	0.483	0.448	-0.035	-1.15		-7.2%
Citadel	0.536	0.398	-0.138	-5.91	**	-25.7%
Two-Sigma	0.612	0.597	-0.015	-0.42		-2.4%
G1X	0.703	0.643	-0.061	-2.53	*	-8.6%
Jane Street	0.238	0.391	0.154	2.00		64.7%

Improvement across existing wholesalers

OVERALL CONCLUSION

Price execution **across brokers**

- **Substantial variation** across brokers
- Market centers provide **differential prices to brokers**
 - **PFOF (not main driver) | Quality of order flow (suggestive evidence)**
 - Size of order flow | Stability of order flow | Differing objective function

Price execution **within brokers** [ongoing work]

- Persistent dispersion **across wholesalers**
- Lack of competition:
 - Lack of responsiveness | market share and execution quality | impact of market entry

Policy implication

- Improve disclosure to increase transparency
 - 606 report [broker]: include overall PI (**magnitude**, e.g., %NBBO);
 - 605 report [market center]: include **odd lots** and **broker-level** price execution

PREVIEW OF RESULTS

Question:

- Does the price execution vary across brokers?

Answer: [YES] - Differences are persistent and economically important

Explanations:

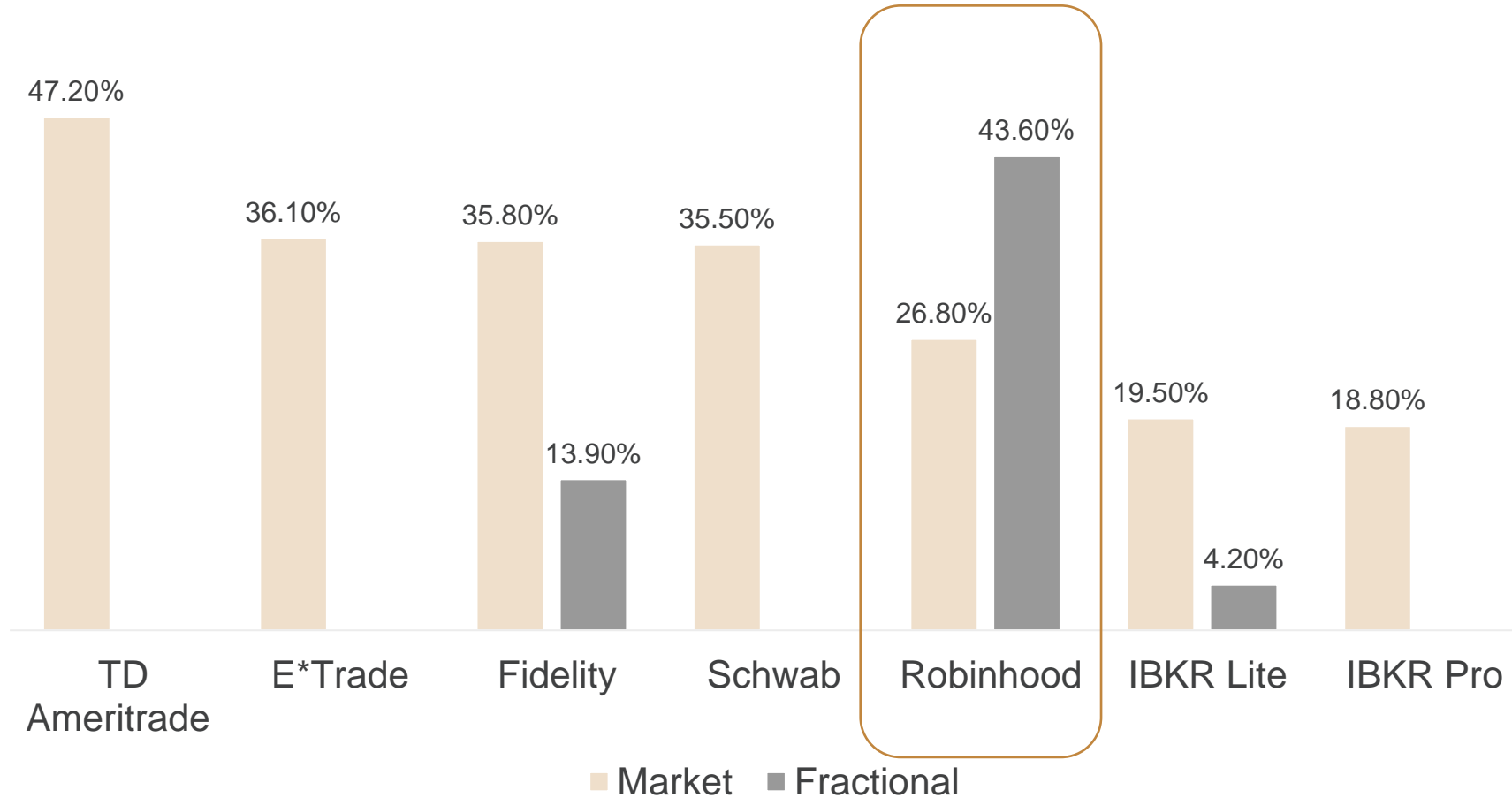
- Brokers receive differential pricing at the same market center

Why?

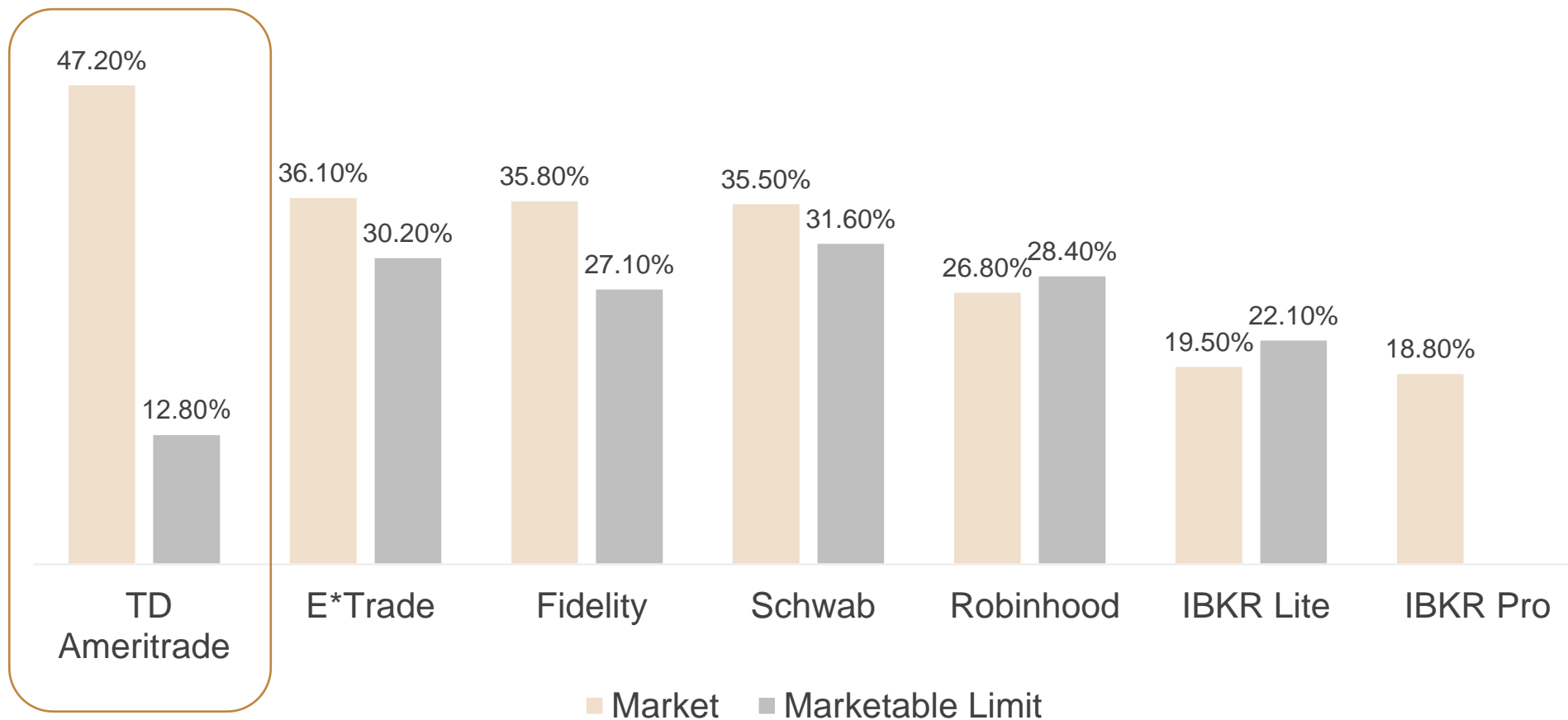
- PFOF [NOT MAIN DRIVER]
- Quality of order flow [SUGGESTIVE EVIDENCE]
- Other explanations

[Size of order flow | Stability of order flow | Differing objective function]

FRACTIONAL SHARE ORDERS



MARKETABLE LIMIT ORDERS



RELATED LITERATURE

- Nasdaq market makers avoided odd-eighth quotes (1990s): Christie & Schultz (1994a, 1994b)
- Discount brokers reduce transactions costs: Bakos et al. (2005)
 - Trading experiment in 1999
 - Commissions vary across brokers, but price improvement does not
- Practitioners run trading experiments: Brad Katsuyama, IEX ("Flash Boys")
- Levy (2022)
 - Three brokers (TD, IBKR, Robinhood)
 - Starting from May 2022
 - About 1000 trades
- The effects of stock lending on security prices: Kaplan, Moskowitz, and Sensoy (2013)

SUMMARY STATISTICS

	Mean	Std. Dev.	10th	Q1	Median	Q3	90th
Price, execution	\$73.64	\$217.11	\$2.36	\$6.14	\$17.98	\$61.88	\$179.49
Price Improvement (\$)	\$0.0581	\$0.1727	\$0.0010	\$0.0047	\$0.0125	\$0.0450	\$0.1250
Bid-Ask Spread (\$)	\$0.17	\$0.40	\$0.01	\$0.02	\$0.05	\$0.15	\$0.35
Bid-Ask Spread (%)	0.64%	1.06%	0.03%	0.11%	0.28%	0.68%	1.66%
Trade Dollar Size	\$157.03	\$271.09	\$85.60	\$97.10	\$100.20	\$109.50	\$207.30

SO, WHAT DRIVES DIFFERENTIAL PRICING BY MARKET CENTERS?

Market centers are systematically giving **differential execution prices** to brokers

- **Unlike exchanges**, they don't have to give the same prices to everyone
- **No contractual agreement** between brokers and market centers
- For one broker, all market centers get to **pay same PFOF** to avoid conflicts
- Market centers must decide **whether to take orders** and **what PI** to provide
- There is **competition** across market centers for flows

BROKER ORDER ROUTING – VENUE CHOICE

Expected PI (\$) vs. Actual PI (\$)

$$\text{Expected PI} = \sum_s x_c PI_s^c$$

Average PI(\$)
in stock s for
market center c
[based on market center 605]

Broker's order flow weight
for market center c
[based on broker 606]

Implicit assumptions:

- (1) market centers give **the same execution** to all brokers
- (2) brokers **randomly route** stocks to market centers according to the reported composition

