THE UNIVERSITY OF MELBOURNE

Differential access to dark markets and execution outcomes

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April 12 2022

Dark pool trading in Australia

- Dark pools play an important role in institutional trading
  - Reduce costs by trading at midpoint
  - Reduce information leakage by not displaying orders or trade direction
- Australian equities market has two types of dark pools
  - 2 exchange-operated: open to all investors
    - Centre Point operated by ASX
    - Hidden liquidity on Cboe Australia (previously Chi-X Australia)
  - 13 broker-operated dark pools: allowed to restrict certain types of flow
    - Restricted: no HFT/ELP flow
    - Opt-into restrictions: customer can choose not to trade with HFT/ELP flow

Our research questions

1. Are there observable differences in execution outcomes between exchange pools (with unrestricted access) and broker dark pools (where access can be restricted)?
2. If yes, are these differences causal?
3. Can any observable differences be attributed to variation in access by trader category across types of dark pools?

- An important caveat: we don't observe unexecuted orders – so our results are conditional on execution

Our findings

1. Broker dark pool trades have better average execution outcomes than exchange dark pools
   - Broker dark pool trades have less information leakage and result in less adverse selection risk for liquidity providers than exchange dark pool trades
   - Mixed evidence on price reversals and speed of price adjustments
2. Using pool closures to examine causal effect of venue type confirms that trades in broker dark pools have lower information leakage and less adverse selection risk
3. Results are driven by access restrictions
   - Broker pools that completely restrict HFT/ELP flow have lower information leakage and adverse selection risk than pools that allow traders to opt-out of this flow
   - Differences concentrated in small trades, which are more likely to involve HFT/ELP

Placement in the literature

- Dark pool heterogeneity:
  - Menkveld, Yueshen and Zhu (2017): Pecking order based on price improvement
- HFT and execution outcomes:
  - Back-running theory (Yang and Zhu, 2021)
  - HFT anticipate and trade ahead of order flow (Hirschey 2021)
  - Institutional trading costs ↑ when HFT trade in the same direction (Korajcyzk and Murphy 2018; van Kervel and Menkveld 2019)
  - Implementation shortfalls ↑ when orders exposed to ELP (Battalio, Hatch and Saglam 2022)
- We analyze a new dimension of heterogeneity in dark pools: access restrictions
  1. This causally affects for post-trade outcomes
  2. This is due to segmentation of orders away from HFT/ELP counterparties

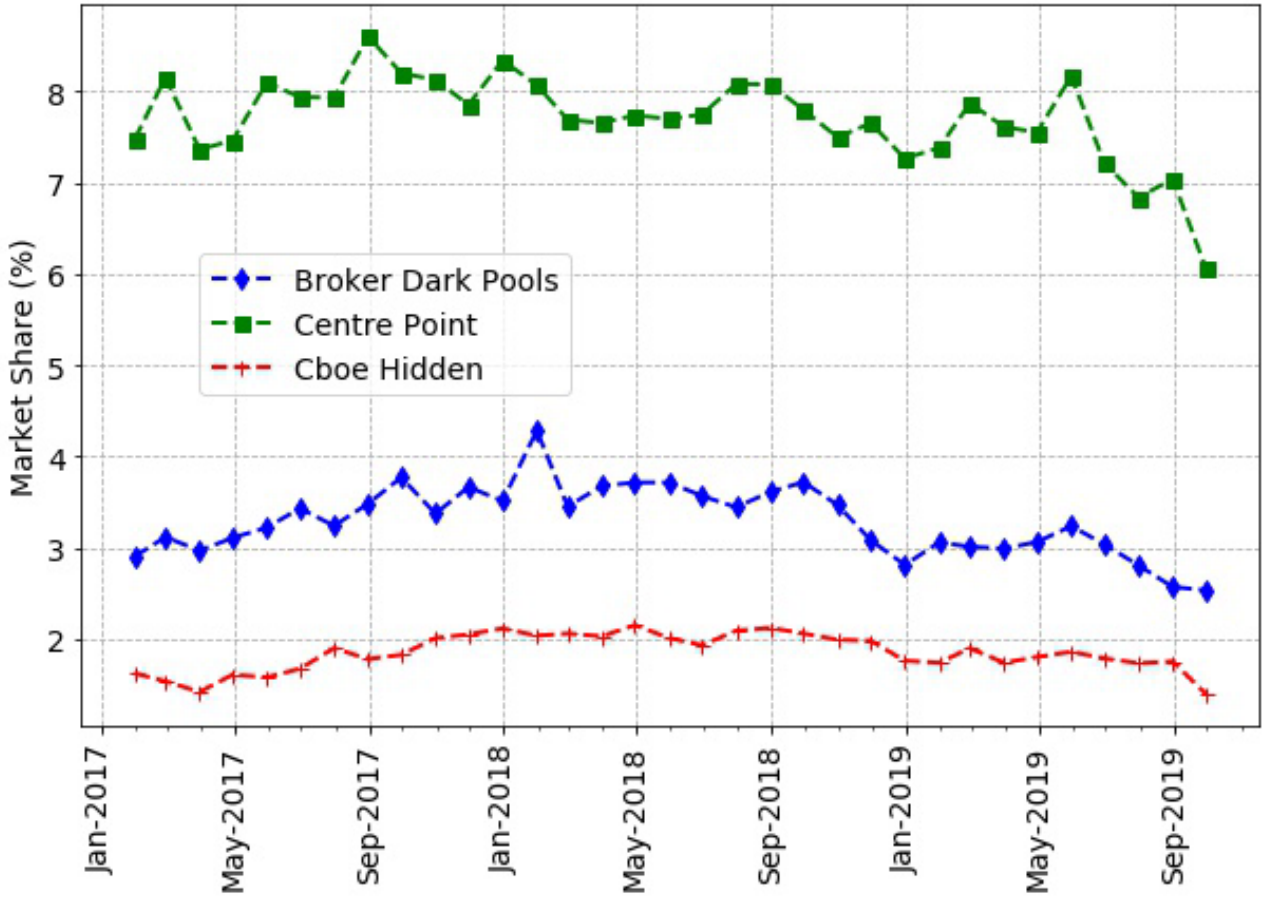
Overview

- Context: sample and trading characteristics
- Execution outcomes variable definitions
- Research design
  - #1 Panel analysis
  - #2 Pool closures
  - #3 Role of restrictions
- Conclusions and caveats

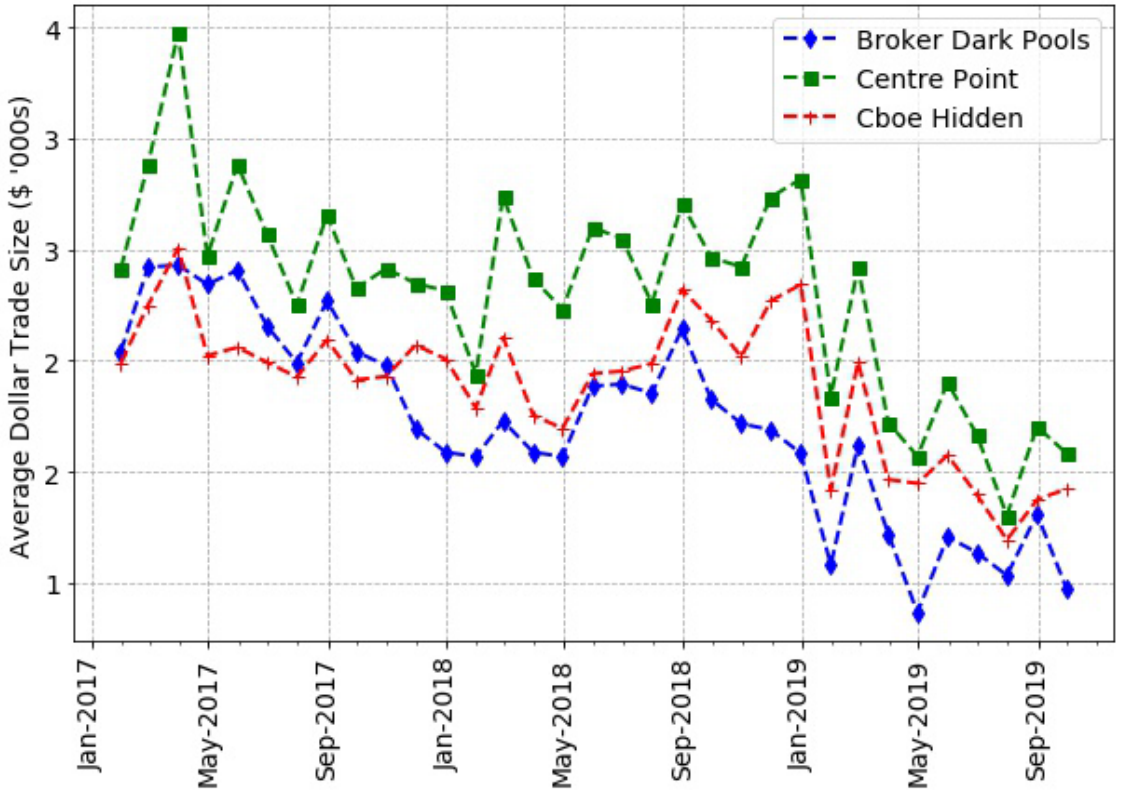
Context: sample and trading characteristics I

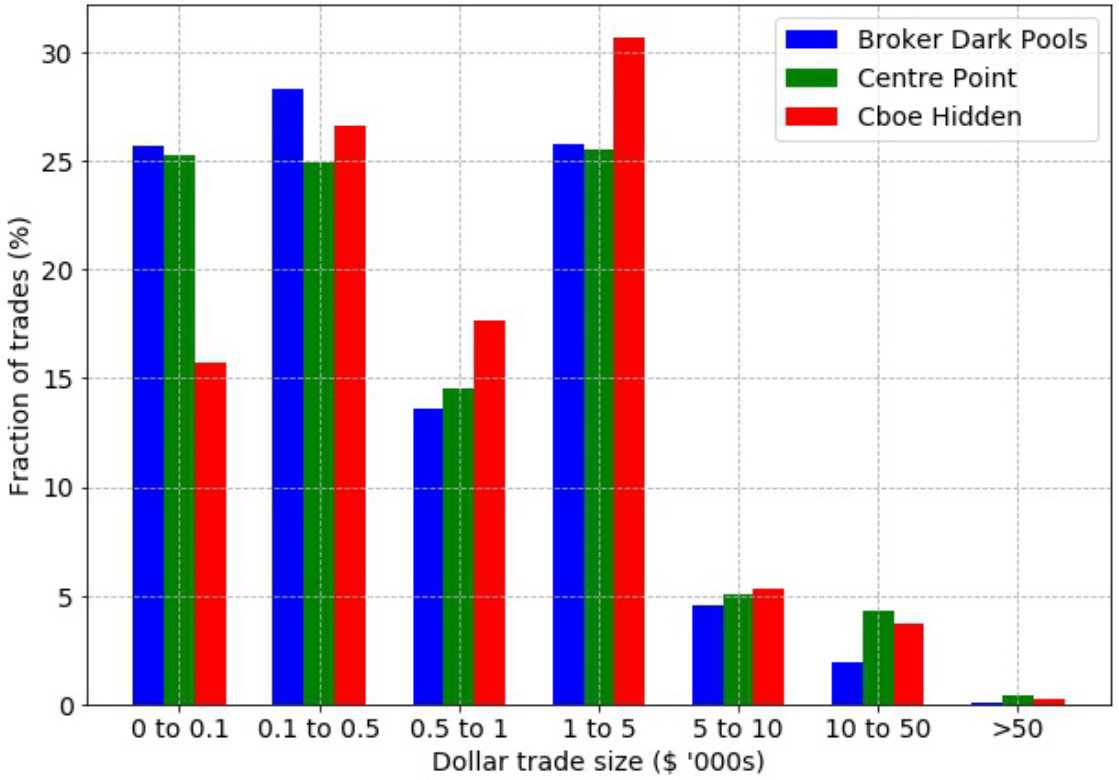
- All dark trades for All Ordinaries stocks for Jan 2017 to Sep 2019
  - Trade and quote data from Refinitiv
- Identify Centrepoint and Cboe hidden trades directly in the data
- BDP trades marked with “NXXT” qualifier
  - Use Cboe-reported venue data for trades reported to Cboe
  - ASX venue data too expensive so use Rozetta broker trade reports
- Remove intermarket sweeps (results insensitive to this)
- Final sample has 185m dark trades across 626 stocks and 693 trading days

Context: sample and trading characteristics II



Context: sample and trading characteristics III





Execution outcome variables

- 92% of trades at midpoint so standard measures don't work ⇒ for each trade i at time s in stock j and day t, compute
  1. **Information leakage:**
  $$100 \times \left|\log M_{ijt}^{s+\tau} - \log M_{ijt}^{s}\right|$$
  2. **Adverse selection:**
  $$100 \times \log(Ask_{ijt}^{s+\tau} / Bid_{ijt}^{s+\tau})$$
  3. **Price reversals:**
  $$1\left(sign\left(r_{ijt}^{s \to s+60s}\right) \neq sign\left(r_{ijt}^{s+60s \to s+30m}\right)\right)$$
  4. **Speed of adjustment:**
  $$100 \times \left|\left(M_{ijt}^{s+30m} - M_{ijt}^{s+60s}\right) / M_{ijt}^{s}\right|$$
- Price impacts and spreads horizons: τ = 500ms, 1s, 10s, 30s, 1m, 5m, 30m

Research Design #1: Panel analysis

- First approach: form a panel of dark pool trades and estimate effect of trades taking place on broker dark pool vs. exchange-operated dark pool
- Data generating process at the trade level:

$$y_{ijt} = \alpha_j + \gamma_t + \beta BDP_{ijt} + \rho' X_{ijt} + \varepsilon_{ijt}$$

where y_{ijt} is execution outcome for trade i in stock j and day t, BDP_{ijt} is a dummy for trades on a broker dark pool, X_{ijt} are controls

- Sample has 185m trades so we take stock-day averages and estimate:

$$\bar{y}_{jt} = \alpha_j + \gamma_t + \beta \overline{BDP}_{jt} + \rho' \bar{X}_{jt} + \bar{\varepsilon}_{jt}$$

where $\bar{y}_{jt}$ is the stock-day average of variable: $\bar{y}_{jt} = 1 / N_{jt} \sum_i y_{ijt}$

Research Design #1: Summary statistics

	Mean	SD	50%
Price	8.63	18.8	3.38
Daily average depth ('000s)	101	226	33.2
Daily average spread (%)	0.57	0.79	0.34
Broker dark pool	0.27	0.24	0.25
Pre-Cross Spread (%)	0.44	0.43	0.31
Abs 10s PI (%)	0.03	0.05	0.02
Abs 1min PI (%)	0.06	0.08	0.04
Abs 30min PI (%)	0.33	0.31	0.24
10s Bid-ask spread (%)	0.45	0.44	0.32
1min Bid-ask spread (%)	0.47	0.47	0.33
30min Bid-ask spread (%)	0.68	0.71	0.45
Reversal indicator	0.12	0.14	0.07
Adjustment speed	0.31	0.29	0.23

Research Design #1: Panel analysis

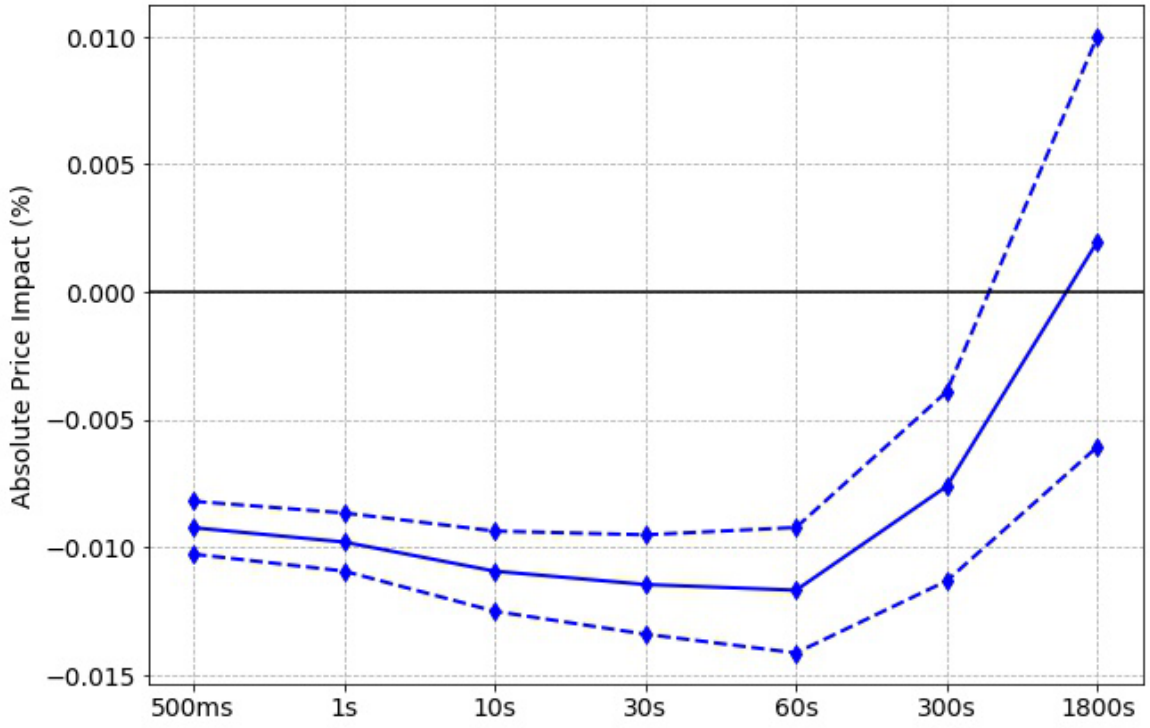
$$\bar{y}_{jt} = \alpha_j + \gamma_t + \beta\overline{BDP}_{jt} + \rho' \bar{X}_{jt} + \bar{\varepsilon}_{jt}$$

where $\bar{y}_{jt}$ is the stock-day average of variable y_{ijt}: $\bar{y}_{jt} = \frac{1}{N_{jt}} \sum_i y_{ijt}$

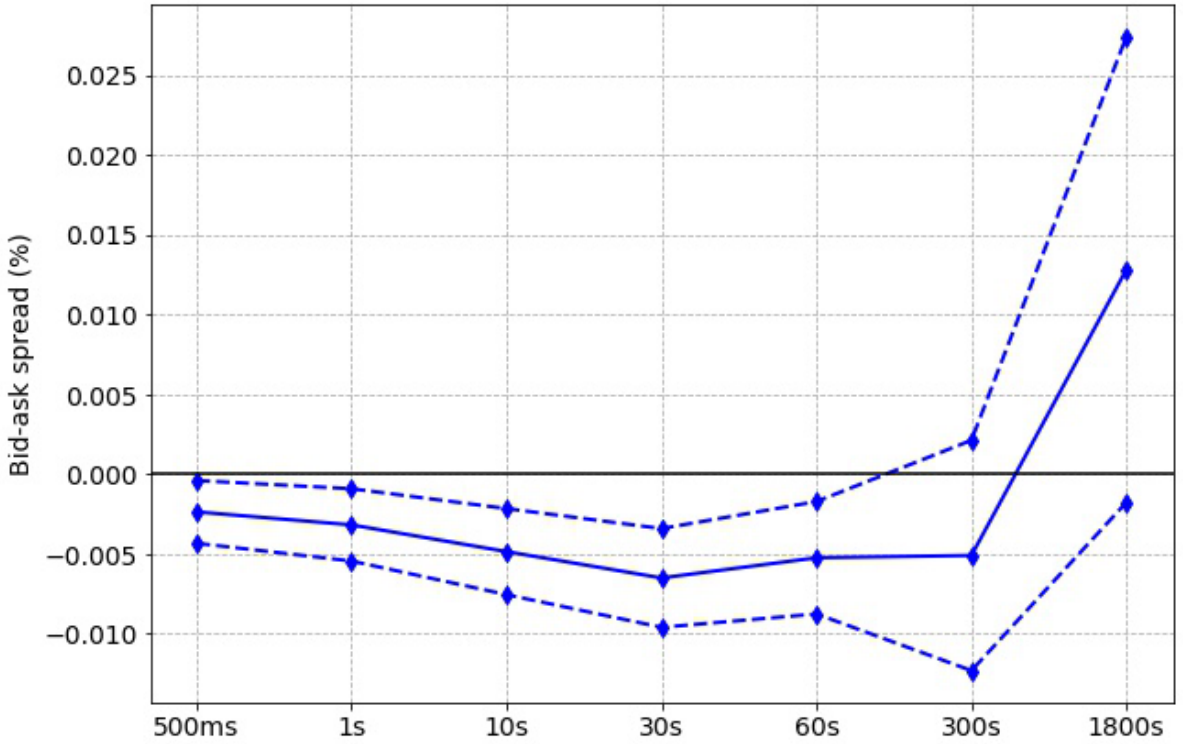
	Abs PI 60s	Abs PI 30m	Spread 60s	Spread 30m	Reversals	Adjustment
β	-0.0117***	0.0020	-0.0053***	0.0128*	-0.0069***	0.0053
t-statistic	-9.35	0.48	-2.93	1.72	-3.65	1.34
FE	N&T	N&T	N&T	N&T	N&T	N&T
Controls	X	X	X	X	X	X
R^2	0.11	0.13	0.76	0.21	0.13	0.10
N_{obs}	242,825	242,825	242,825	242,825	242,825	242,825

Research Design #1: Panel analysis

Information leakage



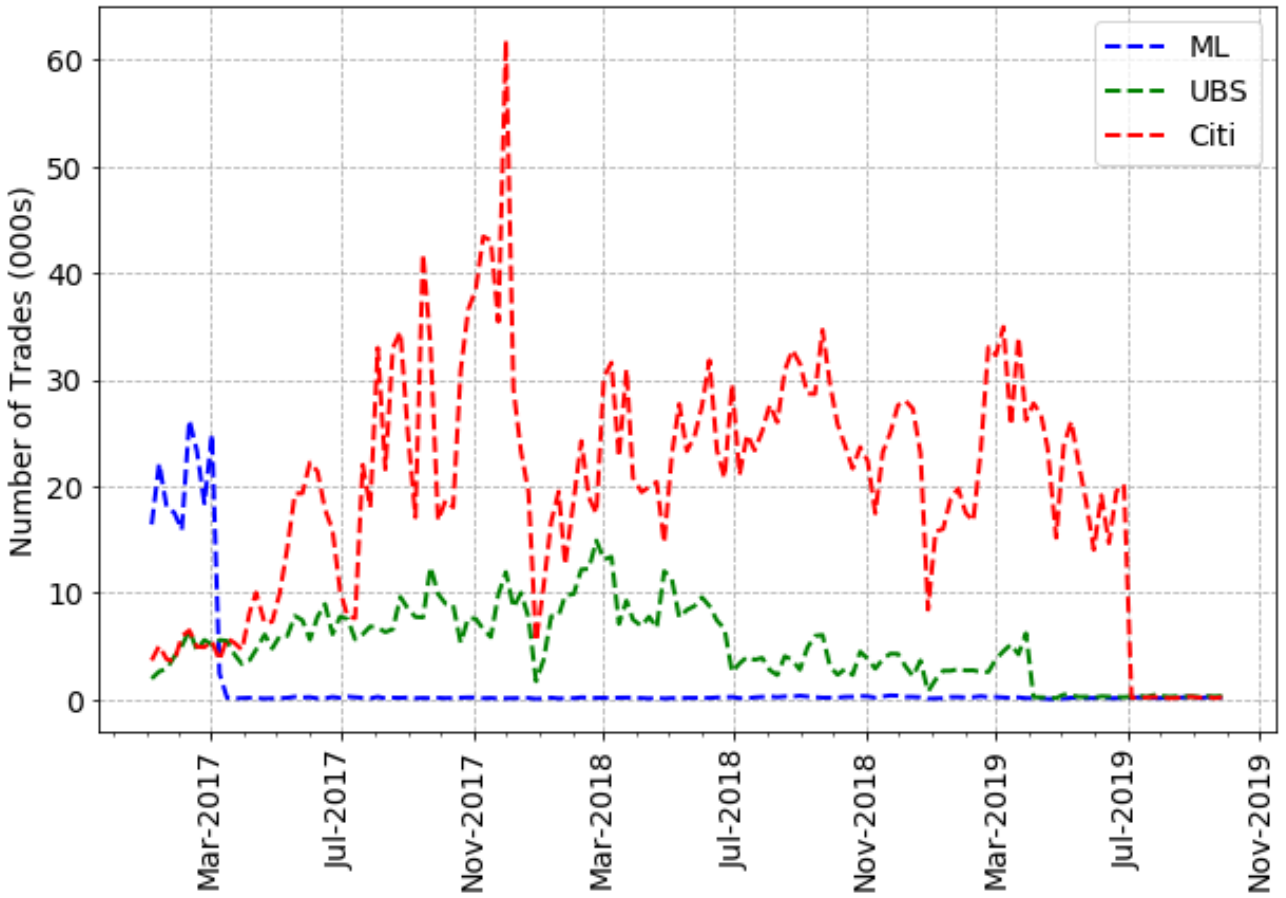
Adverse selection



Research Design #2: Dark pool closures

- Identification issue in panel analysis: orders may be routed to different pools strategically?
- Three dark pools closed during our sample period:
  - BAML (March 6, 2017), UBS (April 1, 2019) and Citigroup (July 1, 2019)
- When the pool closes, brokers can no longer execute in a BDP
  - All dark pool trades of these brokers now must be routed to an exchange dark pool
- We use this as a source of exogenous variation in order routing decisions

Research Design #2: Trading in dark pools around closures



Research Design #2: Matching approach

- For each closure event, isolate CP trades from brokers whose pool close plus all broker dark pool trades in the month after the pool closure
- Match these via propensity score matching
  1. Estimate a separate Logit model for each stock where the dependent variable is a trade classification dummy (BDP = Treated; CP from closing broker = Control)
  2. Match treated to control within stocks based on estimated propensity score, with a caliper of 0.25 standard deviations to ensure close matches on observables
  3. Estimate the ATT as the difference in means of BDP trades with matched CP trades from closing brokers
- Assumption: brokers route a representative sample of trades to public dark pools after closure

Research Design #2: Matching results

- Consistent results using matched analysis:

	BAML	UBS	Citi
Abs. PI (60s)	-0.0084***	-0.0044***	-0.0031***
Bid-ask Spread (60s)	-0.0264***	-0.0016***	-0.0023***
Reversal Indicator	0.0060**	-0.0024	0.0011
Price Adjustment	0.0051**	0.0023	-0.0041*

- Abs PI and bid-ask spread are defined at 60s horizon
  - Similar results at 300s horizon
  - No effect at 30min on Abs PI but some evidence of positive effect on bid-ask spreads

Robustness: Do trades in exchange pools change after closure?

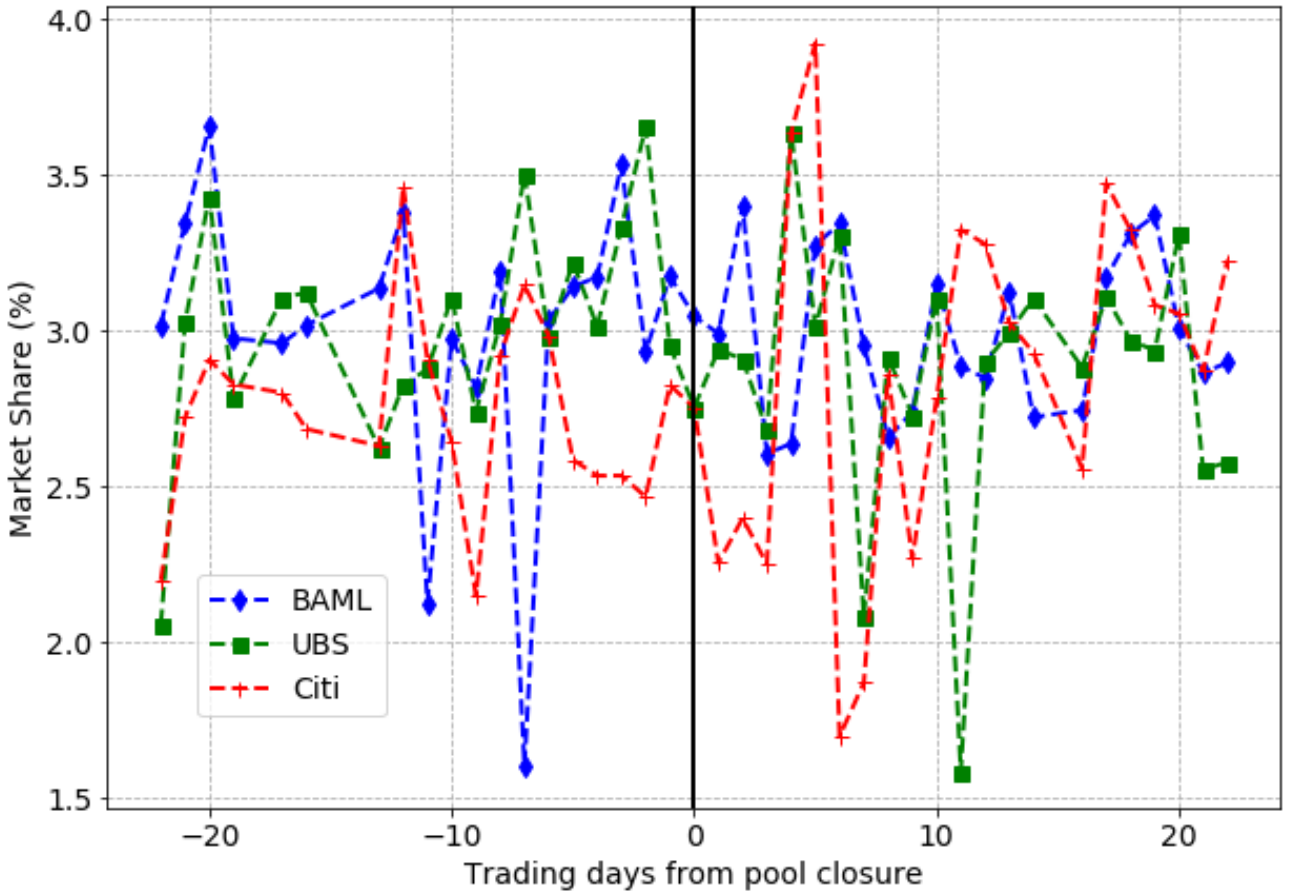
$$y_{ijbt} = \alpha_j + \gamma_t + \mu_b + \beta\tau_{bt} + \rho' X_{jt} + \varepsilon_{jt}$$

where τ_{bt} is the treatment status for a trade from closing broker after pool closure

	BAML		UBS		Citi	
	Abs PI	Spread	Abs PI	Spread	Abs PI	Spread
β	-0.0024***	0.0052***	0.0006	-0.0011*	0.0000	0.0005
t-statistic	-4.02	5.36	0.99	-1.80	0.05	1.13
FE	N&T	N&T	N&T	N&T	N&T	N&T
Controls	X	X	X	X		
R^2	0.06	0.26	0.06	0.22	0.07	0.27
N_{obs}	3.99m	3.99m	5.14m	5.14m	6.43m	6.43m

- Interpretation: No changes for two of three events; some evidence that the BAML event is “contaminated” by changes in order flow after closure

Robustness: Remaining dark pool market shares



Research Design #3: Role of restrictions

- Can restricted access explain these results?
  - Exchange dark pools include significant trading activity from HFT
  - HFT can “fish” to detect liquidity supply
  - Then trade in the same direction as the liquidity supply
- Testing this:
  - Stratify the broker dark pools into restricted vs. opt-into restrictions access and compare execution outcomes across these categories
  - Stratify dark pool trades by trade size and compare execution outcomes across broker and exchange dark pools for small and large trades

Restricted vs. opt-into restrictions

No HFT/ ELP	Opt-into no HFT/ELP
UBS PIN	Credit Suisse Crossfinder
Citi Match	Macquarie MAQX
CLSA Match	Deutsche Super X
Liquidnet	Instinet BLX
	JP Morgan JPM-X
	Morgan Stanley Pool
	Virtu ITG
	Goldman Sachs Sigma X
	Merrill Lynch Instinct X

Channels #1: Restricted vs. opt-into restrictions pools

$$\bar{y}_{jt} = \alpha_j + \gamma_t + \beta \overline{Restricted}_{jt} + \rho' \bar{X}_{jt} + \bar{\varepsilon}_{jt}$$

where $\bar{y}_{jt}$ is the stock-day average as per main panel results

	Abs PI	Spread	Reversals	Adjustment
β	-0.0080***	-0.0037*	-0.0099**	-0.0236***
t-statistic	-3.94	-1.69	-2.40	-4.25
FE	N&T	N&T	N&T	N&T
Controls	X	X	X	X
R^2	0.10	0.77	0.09	0.13
N_{obs}	192,068	192,068	192,068	192,068

- Interpretation: Pools that do not permit any HFT/ELP have lower price impact and post-trade spreads than those that permit HFT/ELP

Channels #2: Small vs. large trades

$$\bar{y}_{jt} = \alpha_j + \gamma_t + \beta_0 \bar{D}_{jt}^{size \leq \bar{v}} + \beta_1 \overline{BDP}_{jt}^{size \leq \bar{v}} + \beta_2 \overline{BDP}_{jt}^{size > \bar{v}} + \rho' \bar{X}_{jt} + \bar{\varepsilon}_{jt}$$

where $\bar{y}_{jt}$ is the stock-day average as per main panel results

	Abs PI	Spread	Reversals	Adjustment
$BDP \times D^{size \leq \bar{v}}$	-0.0188***	-0.0062	-0.0077	-0.0119
$BDP \times D^{size > \bar{v}}$	-0.0101***	-0.0052***	-0.0066***	0.0093*
FE	N&T	N&T	N&T	N&T
Controls	X	X	X	X
R^2	0.11	0.75	0.10	0.13
N_{obs}	242,844	242,844	242,844	242,844

- Interpretation: Difference in price impact is largest for smaller trades where likelihood of interacting with HFT is higher

Conclusions and caveats

- Broker dark pools have less information leakage and less adverse selection
- Allowing venues to restrict access may be beneficial for execution outcomes for some investors
- Useful to inform market structure regulation:
  - US ATS fair access requirements likely beneficial for investors
  - EU ban on BCNs likely harmful
- Does not consider another important dimension of execution quality: execution risk
- Does not consider impact of dark trading on aggregate market quality

Appendix #1: Matching approach

- Sample for each closure is all CP trades from broker whose pool closes and all other BDP trades
- Estimate logit for treatment status (trade is on a BDP vs. CP) with stock and trade controls
- For each BDP trade i in stock j, Y_{ij}, find its nearest neighbour CP trade as per:

$$\tilde{Y}_{ij} = \left\{ kj \in I_0 : \hat{e}_{kj} = \min_{kj \in I_0} \left[\hat{e}_{ij} - \hat{e}_{kj} \right] < 0.25\, \hat{\sigma}_{\varepsilon_j} \right\}$$

- ATT is:

$$\widehat{ATT} = \frac{1}{N_m} \sum \left(Y_{ij} - \tilde{Y}_{ij} \right)$$

  where N_m is the number of BDP trades matched within the caliper
- Cluster SEs at stock level when computing $\widehat{ATT}$

Appendix #2: Robustness checks

- Including intermarket sweeps:
  - Stronger results when we do this
- Excluding ASX NXXT trades > A$50k:
  - No change in results if we include these or not
- Excluding Cboe hidden trades from exchange dark pool category:
  - Similar results when just focussing on CP as the control group
- Tick constraints:
  - More total DP trading in tick constrained stocks (as expected)
  - But no effect on choice between BDP vs. exchange dark pool trading so not likely to drive results