On the Effects of Continuous Trading

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The issue

- An unchanged feature of market structure: the continuous limit order book (LOB).
- Is it an optimal market design?
- Recent theory suggests that frequent batch auctions are better
  (Budish, Cramton, and Shim, 2015 QJE)

An ilustration: latency arbitrage

- N market participants (with identical speeds)
- They may act as both liquidity takers (“snipers”) or makers
- Snipers attempt to pick the stale quotes of others
- Market makers rush to cancel stale quotes before they get picked off by snipers

Market maker (MM)

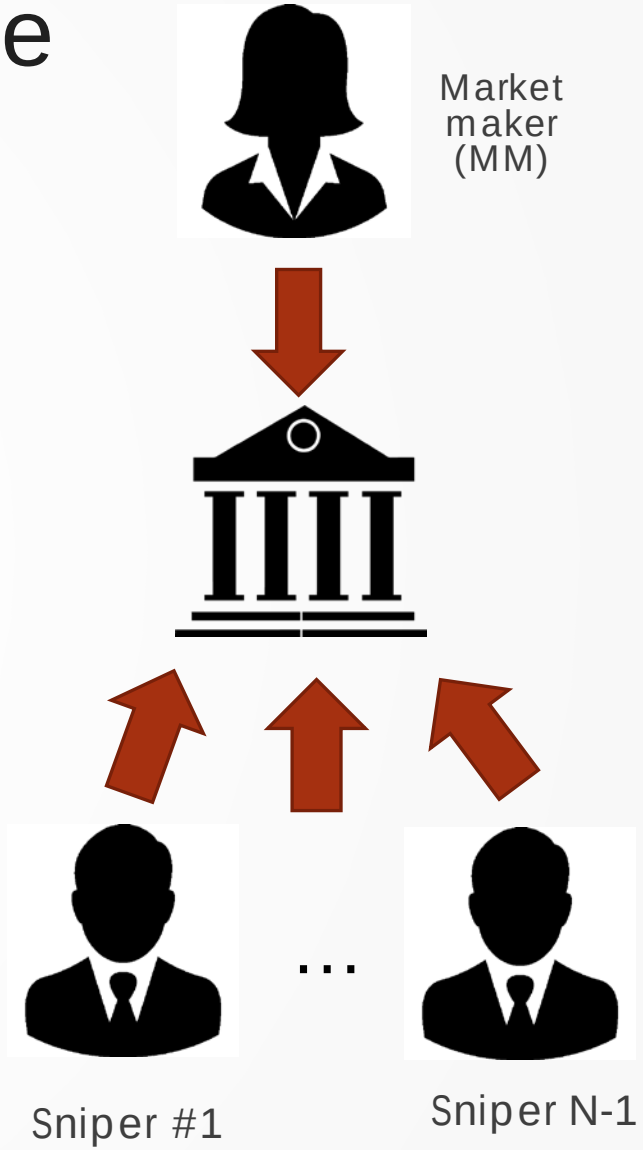
…

Sniper #1

Sniper N-1

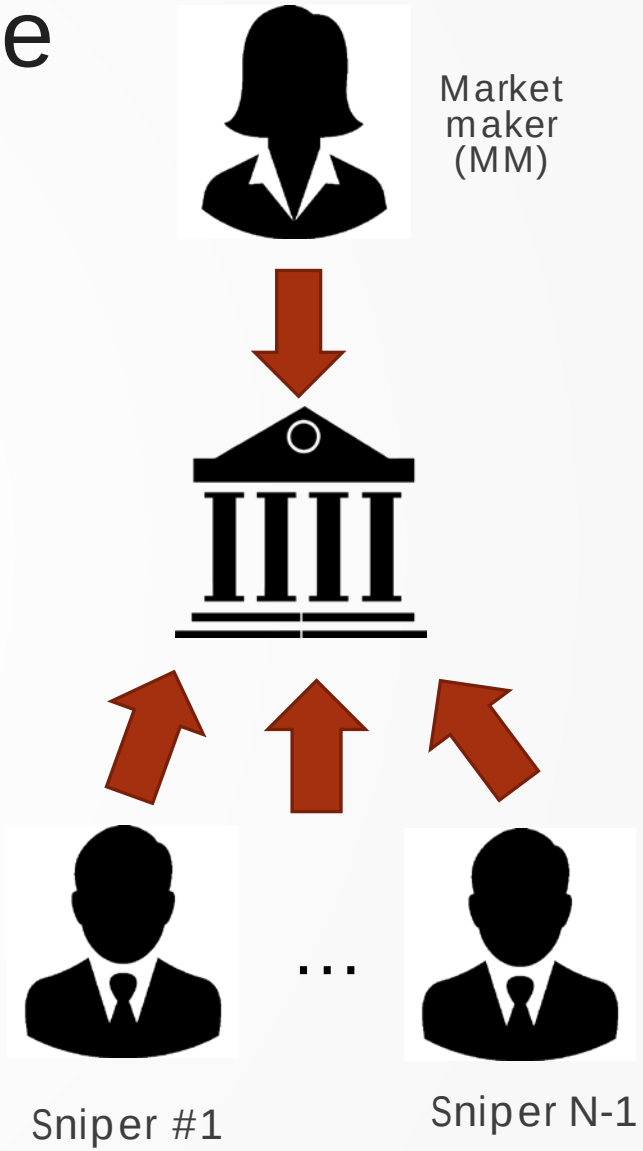
An ilustration: latency arbitrage

- An informative market signal happens
- There are N-1 snipers per stale quote.
- The MMs' probability of being adversely selected is (N-1)/N
- To compensate, the MM will keep spreads wide



An ilustration: latency arbitrage

- A batch auction accumulates orders for a period before matching them
- The MM would have time to revise her stale quote before being picked off
- If actions are not ultra-frequent, she can do so even if other traders are relatively faster



Our paper (overview)

- We use a recent inverse move (from discrete to continuous) by the Taiwan Stock Exchange (TWSE) to test Budish et al.'s (2015 QJE) main prediction.
- In a DID setup, we find that:
  1. Adverse selection costs substantially increase.
  2. Realized spreads decline, but overall trading costs increase.
  3. In the cross section, adverse selection costs increase more among high-volume stocks, where latency arbitrage is expected to be more pronounced (Shkilko and Sokolov, 2020 JF)

Our paper (overview)

- Trading volume increases; additional tests suggests this increase in volume is most likely driven by latency arbitrage.
- Price efficiency effects are mixed. We cannot conclude that continuous trading is superior to batch auctions.

Setting

- TWSE - world's 15th largest market
  (Toronto Stock Exchange is the 13th; Australian Secutiries Exchange is the 20th)
- Until recently, it was the only large market using batch auctions (every 5-sec.) to match buyers and sellers
- On **March 23, 2020** launched its new continuous trading platform (all stocks transferred simultaneously).
- Technologically advanced: colocation, direct access to data feeds … (even *before* moving to continuous)

Data

- Sample: 100 largest TWSE-listed stocks
- Period: November 2019 through November 2020
- Trade and quote data from Refinitiv (Thomson Reuters) Tick History database
  - For successful auctions, we know: (i) the number of shares traded, (ii) the allocation price, and (iii) the market quotes; for unsuccessful ones, we only know (iii).
  - For the continuous regime, we have information on all trades and quotes.

COVID-19 outbreak

- The TWSE switched to continuous trading at the onset of the COVID-19 pandemic → posible confounding effects
- We use a DID setup to mitigate this concern:
  - Control sample from the Korean Stock Exchange (KRX)
  - Consistent results with Hong Kong Stock Exchange (HKEX) listed stocks
  - Several event window lenghts, including/excluding the months closest to the event (Feb-April, 2020)

The DID setup

- Standard DID pooled regression that uses matched KRX stocks as controls.

$$Y_{it} = \alpha_i + \beta_1 Post_t + \beta_2 TWSE_i + \beta_3 Post_t \times TWSE_i +$$
$$+\delta_1 Volume_{it} + \delta_2 Volatility_{it} + \delta_3 TradeSize_{it} + \varepsilon_{it}$$

- Pre-event window, Nov. 2019 – Jan. 2020; post-event window, May 2020 – July 2020.
- All continuous variables are winsorized and normalized, and S.E. are double-clustered

Adverse selection costs

	Price impact		Realized spread	
	[1]		[2]	
Panel A: Univariate results				
Pre	4.66		17.73	
Post	8.43		15.07	
Panel B: Regression results				
Post	0.039		0.226	***
	(0.05)		(0.09)	
TWSE	-0.436	***	0.261	***
	(0.03)		(0.06)	
Post×TWSE	0.835	***	-0.505	***
	(0.06)		(0.12)	
Volume	-0.100	***	-0.055	**
	(0.02)		(0.03)	
Volatility	0.522	***	-0.266	***
	(0.03)		(0.04)	
Trade size	0.089	***	-0.031	
	(0.02)		(0.02)	
Intercept	-0.020		-0.115	***
	(0.03)		(0.05)	
Adj. R^2	0.363		0.164	

- Continuous trading is associated with a substantial (36%) increase in adverse selection, consistent with Budish et al. (2015)

Other market-making costs

	Price impact		Realized spread	
	[1]		[2]	
Panel A: Univariate results				
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- Continuous trading is associated with a 10% decrease in realized spreads
- Consistent with reduced inventory costs, operative costs, enhanced competition in market making …

Liquidity

	Quoted spread		Quoted depth		Effective spread	
	[1]		[2]		[3]	
Panel A: Univariate results						
Pre	23.05		427.73		22.38	
Post	24.48		323.48		23.50	
Panel B: Regression results						
Post	0.365	***	-0.024		0.351	***
	(0.12)		(0.09)		(0.12)	
TWSE	-0.270	***	0.101	*	-0.163	**
	(0.08)		(0.06)		(0.08)	
Post×*TWSE*	0.508	***	-0.193	*	0.304	**
	(0.15)		(0.11)		(0.15)	
Volume	-0.255	***	0.501	***	-0.207	***
	(0.02)		(0.03)		(0.02)	
Volatility	0.222	***	-0.400	***	0.263	***
	(0.03)		(0.03)		(0.03)	
Trade size	0.086	***	0.010		0.078	***
	(0.03)		(0.02)		(0.02)	
Intercept	-0.186	***	0.012		-0.179	***
	(0.06)		(0.05)		(0.06)	
Adj. R^2	0.137		0.137		0.114	

- The switch to continuous trading is followed by a decline in liquidity
- ΔQuoted spread = 13.3%
- ΔEffect. spread = 5.1%
- ΔDepth = - 3.4%

Shkilko and Sokolov (2020), Brogaard et al., (2015), Conrad et al. (2015) report similar variations for exogenous shocks to latency arbitrage or technology

Price efficiency

	Return autocorrelation				Price delay			
	60s		PC1		60s		PC1	
	[1]		[2]		[3]		[4]	
Panel A: Univariate results								
Pre	0.095		0.319		0.852		0.818	
Post	0.100		0.252		0.739		0.719	
Panel B: Regression results								
Post	0.113	***	0.229	***	-0.542	***	-0.622	***
	(0.04)		(0.05)		(0.07)		(0.07)	
TWSE	-0.003		0.284	***	0.010		-0.016	
	(0.03)		(0.04)		(0.04)		(0.04)	
Post×TWSE	0.004		-0.548	***	-0.007		0.044	
	(0.05)		(0.08)		(0.08)		(0.09)	
Volume	0.019		0.009		0.091	***	0.114	***
	(0.01)		(0.01)		(0.02)		(0.02)	
Volatility	-0.106	***	-0.095	***	-0.128	***	-0.145	***
	(0.01)		(0.02)		(0.03)		(0.03)	
Trade Size	0.036	***	0.057	***	-0.042	***	-0.031	**
	(0.01)		(0.01)		(0.01)		(0.02)	
Incercept	-0.058	***	-0.117	***	0.276	***	0.317	***
	(0.02)		(0.03)		(0.04)		(0.04)	
Adj. R^2	0.010		0.034		0.089		0.105	

- Our results are mixed, differing across metrics and as we vary the estimation horizon
- Price efficiency benefits do not outweigh the negative effects in liquidity.

Volatility, volume, and gains from trade

	Volatility		Volume		Trade size	
	[1]		[2]		[3]	
Panel A: Univariate results						
Pre	0.013		5,193		4,279	
Post	0.017		7,434		3,360	
Panel B: Regression results						
Post	0.037		0.160	***	0.441	***
	(0.05)		(0.05)		(0.08)	
TWSE	-0.078	***	-0.093	***	0.624	***
	(0.03)		(0.03)		(0.06)	
Post×TWSE	0.149	**	0.174	***	-1.206	***
	(0.06)		(0.06)		(0.10)	
Volume	0.649	***			0.219	***
	(0.02)				(0.02)	
Volatility			0.625	***	0.133	***
			(0.02)		(0.02)	
Trade size	0.084	***	0.134	***		
	(0.01)		(0.02)			
Intercept	-0.019		-0.081	***	-0.225	***
	(0.03)		(0.03)		(0.04)	
Adj. R^2	0.482		0.502		0.184	

- Literature: Toxic arbitrage generates substantial volume and increases volatility (Roşu, 2019 JFM; Aquilina, Budish and O'Neill, 2021)
- Consistently, the switch to continuous trading comes with an increase in trading volume (5.8%) and price volatility (5.4%)

Arbitrage and non-arbitrage volume

- "Arbitrage volume": followed by a rapid change in the mid-quote (Shkilko and Sokolov, 2020)

	seconds after a trade									
	0.10		0.25		0.50		0.75		1.00	
arbitrage	1.099	***	1.197	***	1.082	***	1.007	***	0.965	***
	(0.07)		(0.07)		(0.07)		(0.06)		(0.06)	
non-arbitrage	-0.037	**	-0.092	**	-0.123	***	-0.149	***	-0.159	**
	(0.04)		(0.04)		(0.04)		(0.05)		(0.05)	

- With the switch to continuous trading, non-arb. volume decreases, while arbitrage volume increases.
- Our results point to a possible lower gains from trade for traditional end-users of liquidity.

Informed trading around EAs

	TWSE		DID	
	[1]		[2]	
Panel A: Univariate results				
Pre	0.917			
Post	0.763			
Panel B: Regression results				
Post	-0.154		-0.051	
	(0.10)		(0.16)	
TWSE			-0.040	
			(0.16)	
Post x TWSE			-0.103	
			(0.19)	
Intercept	0.917	***	0.957	***
	(0.10)		(0.13)	
Adj. R^2	0.010		0.006	
Obs.	289		544	

- How much information is incorporated into prices prior to earnings announcements (EAs)?
- Price Jump Ratio (PJR) (Weller, 2018 RFS): If fundamentally informed trading increases, PJR should decline
- We find no discernible changes in the PJR
- We obtain the same for macro news and mergers & acquisitions

Cross-sectional tests

- We expect speed races to be more common in higher-volume stocks (Aquilina, Budish, and O'Neil, 2021 QJE)

	Price impact		Realized spread		Quoted spread		Quoted depth		Effective spread		Volume	
	[1]		[2]		[3]		[4]		[5]		[6]	
Higher	0.953	***	-0.430	**	0.715	***	-0.392	**	0.467	*	0.371	***
Medium	0.835	***	-0.505	***	0.508	***	-0.193	*	0.304	**	0.174	***
Lower	0.725	***	-0.658	***	0.170		-0.027		0.006		0.051	

- Adverse selection increase is more pronounce in higher-volume stocks (39%) than in lower-volume stocks (33%); realized spreads also decline more for higher-volume stocks (15% vs. 8.5%).

Conclusion

- Optimizing market design is an intricate balancing act, with net liquidity effects depending on multiple factors.
- The TWSE transition from frequent batch auctions to continuous trading is associated with **(1)** higher adverse selection costs and **(2)** lower realized spreads, but overall trading costs increase (except for lower-volume stocks).
- Generalizable? We believe **(1)** will likely persist, **(2)** is far less certain → FBAs should be carefully calibrated.

Conclusion

- The decrease in liquidity is not compensated by price efficiency improvements.
- The increase in trading costs reduces the participation of some end-users of liquidity → lower gains from trade
- This negative effect on volume is surpassed by the increase in latency arbitrage volume → higher revenues for the exchanges
- The industry may be reluctant to change the status quo, even when doing so could be welfare-enhancing (Budish, Kee, and Shim, 2021)

Thank you!