

High-frequency trading strategies

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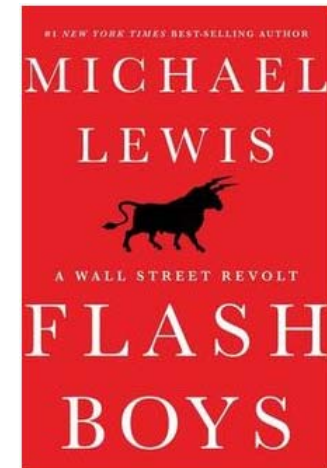
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Is HFT beneficial to market quality?

“The U.S. stock market was now a class system, rooted in speed, of haves and have-nots. The haves paid for nanoseconds; the have-nots had no idea that nanoseconds had value. The haves enjoyed a perfect view of the market; the have-nots never saw the market at all.”

(Michael Lewis, Flash Boys)



- › “there are also HFT firms who believe that 350 microseconds is critical to what they do, as they look to pick up trading signals so that they can race ahead and pick off trades from regular investors.” (Brad Katsuyama, CEO of IEX)
- › The Senate Banking Committee has “expressed concerns about increased market speed, complexity, and potential market fragility as a result of increased automated trading.” (Congressional Research Service Report, 2016)

Is HFT beneficial to market quality?

- › Earlier academic evidence is almost always supportive:
 - “AT improves liquidity and enhances the informativeness of quotes.” (Hendershott, Jones and Menkveld, 2011)
 - “greater AT intensity improves liquidity and informational efficiency” (Boehmer, Fong and Wu, 2012)
 - “increased low-latency activity improves traditional market quality measures—decreasing spreads, increasing displayed depth in the limit order book, and lowering short-term volatility” (Hasbrouck and Saar, 2013)
 - “Overall HFTs facilitate price efficiency” (Brogaard, Hendershott and Riordan, 2014)
 - “Increasing the speed of market-making participants benefits market liquidity” (Brogaard, Hagstromer, Norden and Riordan, 2015)

Is HFT beneficial to market quality?

› But then...

- “I find evidence consistent with HFTs being able to anticipate order flow from other investors.” (Hirschey, 2013)
- “Because speed is a source of market power, it enables fast traders to extract rents from other market participants and triggers a costly arms race that reduces social welfare” (Hoffmann, 2014)
- “trades are followed by limit order cancellations on competing venues” (van Kervel, 2015)
- “Reductions in latency exacerbate quote-fade and latency arbitrage” (Malinova and Park, 2016)
- Van Kervel and Menkveld (2016) and Korajczyk and Murphy (2016) find that HFTs initially trade ‘against the wind’ but eventually trade ‘with the wind’ as the large trade progresses.

- › Much is known about the effects of HFT, the literature is unclear on how HFTs trade to influence financial markets.
 - i.e., what are the information channels that drive HFT behavior?
- › Most of the existing evidence is based on executed trades. The order submission behaviour and strategies of HFTs is not well understood.
- › We examine HFT trading strategies directly by reconstructing the shape of the limit order book at the time of order submissions, cancellations and amendments.

- › Related studies:
 - Malinova and Park (2016): Study HFT order submission behaviour in a multi-market setting
 - Subrahmanyam and Zheng (2016): examine HFT limit order placements on Nasdaq and find that HFT have a stabilizing influence on markets.

1. All traders trade with the order book imbalance but HFT do it better.
2. HFT supply liquidity to the thick side of the order book (where it is not required) and demand liquidity from the thin side of the order book (where it is most needed).
 - Consistent with order anticipation strategies
3. HFT cancel limit orders that are at high risk of being picked off.
4. After the introduction of ITCH (a faster data feed) on the ASX, HFT become even more strategic.
5. By competing with non-HFT, HFT crowd out non-HFT limit orders from the order book.

- › Full order book and trade data for stocks in the S&P/ASX 100 index from *AusEquities* (provided by SIRCA)
 - Data contains stock symbol, date and time of order entry, order size and price, identifier for submitting broker (proprietary HFT firms, institutions, retail)
 - Each order has a unique identifier such that subsequent amendments/executions/cancellation can be traced to the original submitted order
- › We examine the period January 1, 2012 to December 31, 2012
 - ITCH introduced on April 2, 2012 (more later)

Panel A: Stock characteristics					
	Mean	Std.dev.	Q1	Median	Q3
Market capitalization (AUD billions)	13.52	22.77	2.844	10.00	114.8
Dollar volume (AUD millions)	25.54	43.67	5.179	10.51	23.44
Number of trades	2,176	1,718	1,088	1,633	2,614
Price (AUD)	11.67	13.18	3.052	6.431	15.05
Volatility (%)	2.026	1.215	1.280	1.756	2.443
Spread (cents)	1.037	0.369	0.956	1.014	1.119

	HFT	Institutions	Retail
Panel B: Trader characteristics			
Average daily submissions	839.5	12,781	525.6
Average daily cancelations	375.9	4,309	58.79
Average daily trades (active)	241.9	1,463	98.90
Average daily trades (passive)	279.4	3,529	167.7
Median trade size	1,681	926.5	2,187
Median submission to cancel time	128.7	246.8	3,034

Limit Buy Order



Limit Buy Order



Market Buy Order



Market Buy Order

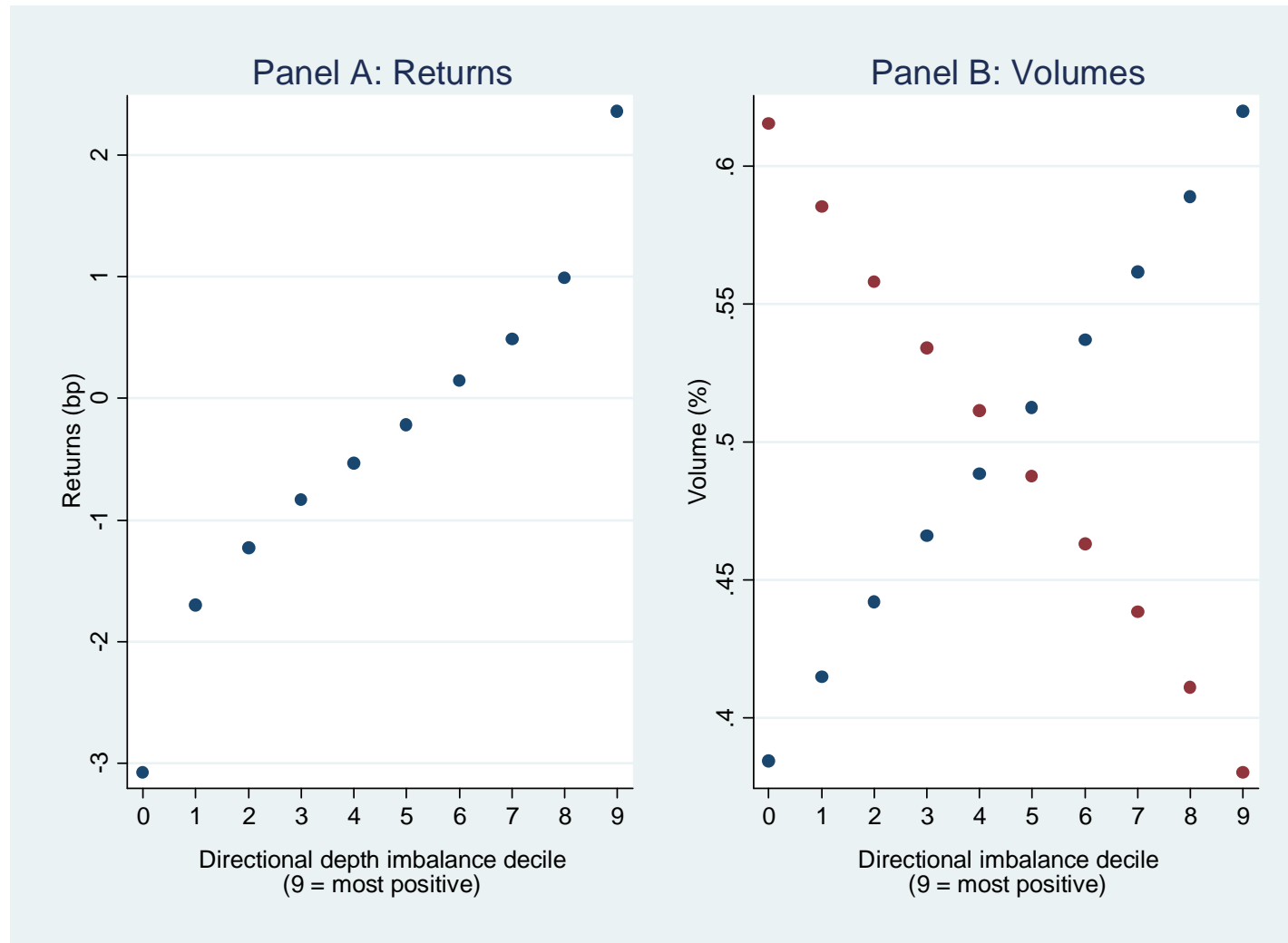


- › We capture the shape of the order book using depth imbalance (DI) at the time of each order book event (i.e., submission, trade, amendment or cancelation):

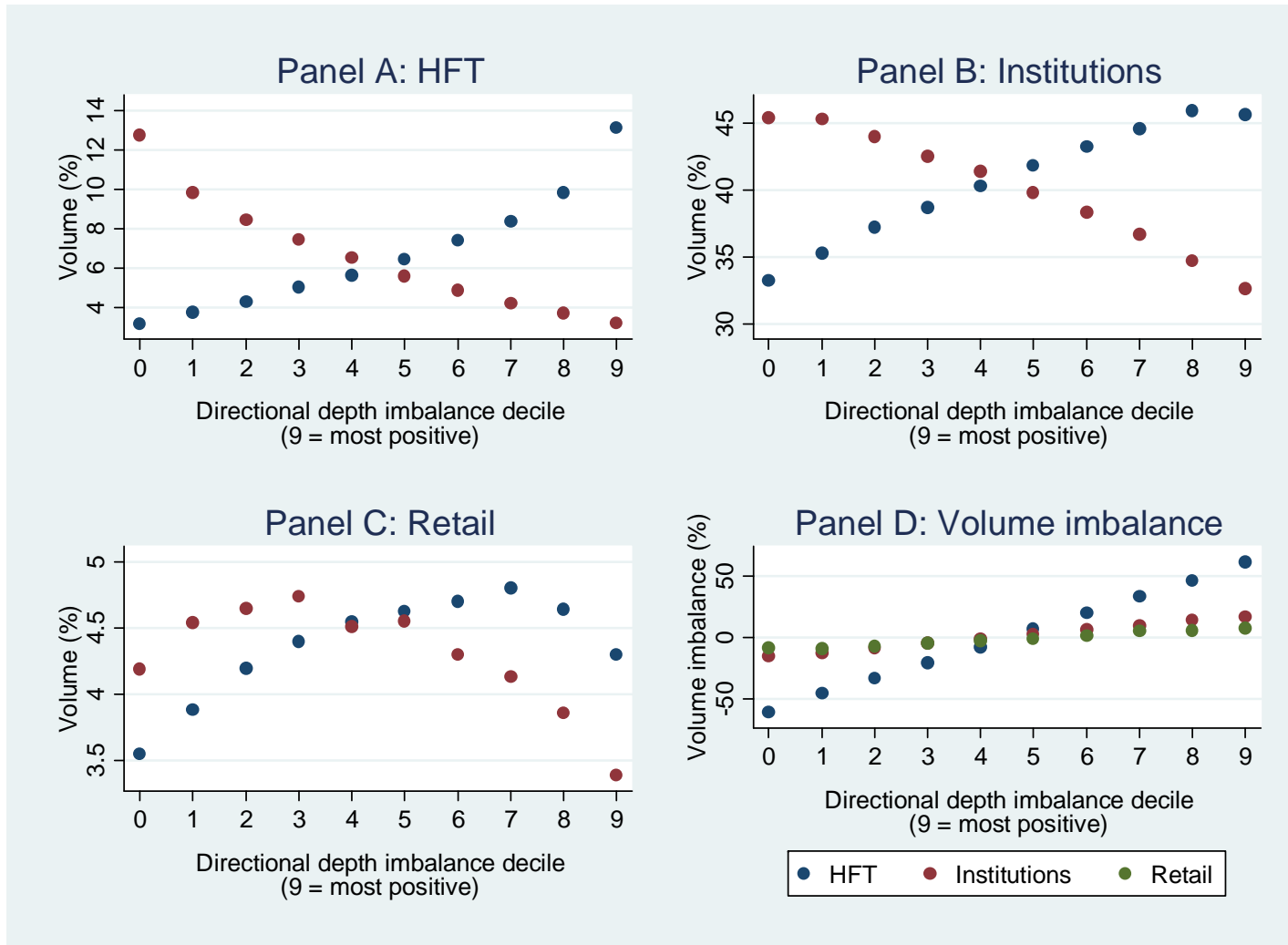
$$DI_t = \frac{\sum_{i=1}^n VolBid_{i,t} - \sum_{i=1}^n VolAsk_{i,t}}{\sum_{i=1}^n VolBid_{i,t} + \sum_{i=1}^n VolAsk_{i,t}}$$

- › We expect:
 1. A positive relationship between DI and future stock returns.
 2. A strategic trader to buy when DI is high and sell when DI is low.

Depth imbalance, returns and trading volumes

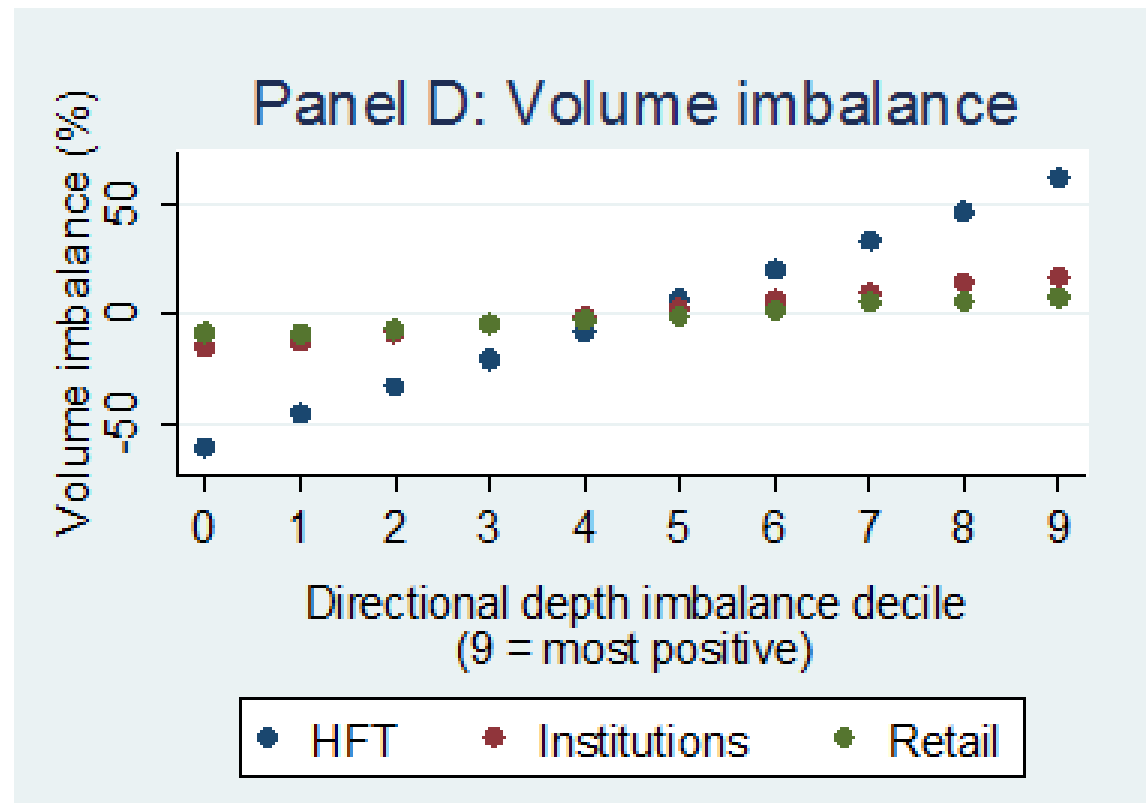


Depth imbalance and trading volumes by broker



Depth imbalance and volume imbalances

$$\text{Volume imbalance}_k \% = \frac{\text{Buy volume}_k - \text{Sell volume}_k}{\text{Buy volume}_k + \text{Sell volume}_k}$$



Depth imbalance and volume imbalances

Depth imbalance decile	Depth imbalance	HFT	Institutions	Retail	HFT vs. Institutions	HFT vs. Retail
0 (most negative)	-0.375	-61.8	-16.8	-6.2	-44.9 ***	-55.6 ***
1	-0.219	-46.8	-12.8	-7.4	-34.0 ***	-39.5 ***
2	-0.141	-34.2	-8.6	-5.6	-25.6 ***	-28.6 ***
3	-0.080	-21.3	-4.6	-4.1	-16.7 ***	-17.2 ***
4	-0.025	-6.9	-1.0	-1.8	-5.9 ***	-5.0 ***
5	0.028	6.4	2.8	0.0	3.5 ***	6.3 ***
6	0.084	20.2	6.0	1.3	14.3 ***	18.9 ***
7	0.146	33.3	9.8	3.7	23.5 ***	29.6 ***
8	0.225	47.1	14.2	4.4	32.9 ***	42.7 ***
9 (most positive)	0.380	62.6	17.1	6.1	45.5 ***	56.5 ***

Depth imbalance and volume imbalances

Dependent variable: $Volume\ imbalance_k\% = \frac{Buy\ volume_k - Sell\ volume_k}{Buy\ volume_k + Sell\ volume_k}$

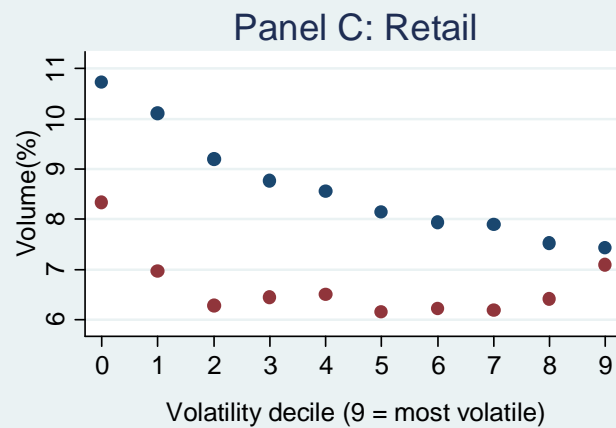
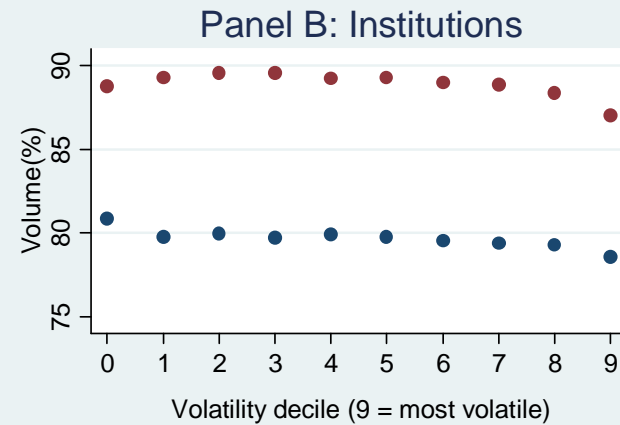
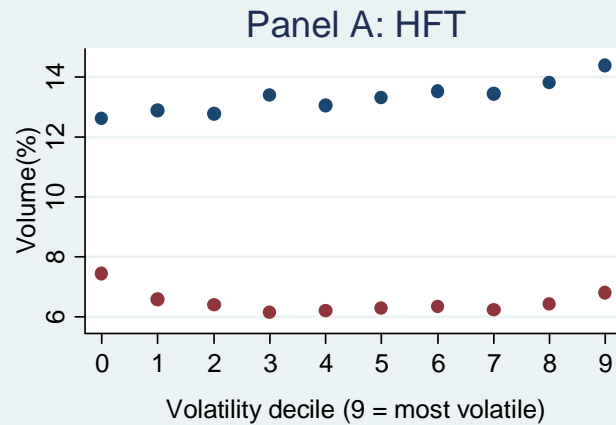
	Volume imbalance%			Trade imbalance%		
	(1) All trading days	(2) Low volatility days	(3) High volatility days	(4) All trading days	(5) Low volatility days	(6) High volatility days
I(HFT) × DI	1.017*** (0.04)	0.980*** (0.04)	1.084*** (0.04)	0.921*** (0.03)	0.895*** (0.04)	0.962*** (0.03)
I(Institutions) × DI	-0.021 (0.02)	0.006 (0.02)	-0.036* (0.02)	0.080*** (0.02)	0.081*** (0.03)	0.088*** (0.02)
I(HFT)	0.015 (0.01)	0.024* (0.01)	0.009 (0.01)	0.022* (0.01)	0.028** (0.01)	0.014 (0.01)
I(Institutions)	0.018* (0.01)	0.024* (0.01)	0.016 (0.01)	0.043*** (0.01)	0.047*** (0.01)	0.036*** (0.01)
DI	-0.204*** (0.03)	-0.183*** (0.03)	-0.242*** (0.03)	-0.138*** (0.02)	-0.140*** (0.03)	-0.129*** (0.02)
Volume	0.011*** (0.00)	0.007** (0.00)	0.008** (0.00)	0.010*** (0.00)	0.006 (0.00)	0.009** (0.00)
Constant	-0.288*** (0.03)	-0.209*** (0.04)	-0.242*** (0.05)	-0.288*** (0.03)	-0.292*** (0.05)	-0.216*** (0.05)
Obs.	503,990	150,376	166,644	503,990	150,376	166,644
Adj. R-square	0.183	0.175	0.198	0.254	0.242	0.283

$$\text{Adjusted DI} = q \times \frac{\sum_{i=1}^n \text{VolBid}_t - \sum_{i=1}^n \text{VolAsk}_t}{\sum_{i=1}^n \text{VolBid}_t + \sum_{i=1}^n \text{VolAsk}_t}$$

	HFT	Institutions	Retail
Panel C: Adjusted depth imbalance			
Trades (active)	0.148	0.024	0.024
Trades (passive)	0.083	-0.030	-0.012
Submissions	0.059	-0.005	0.030
Amendments	0.043	-0.003	0.014
Cancelations	0.017	0.003	0.027

	Adjusted depth imbalance (5 levels)			Adjusted depth imbalance (1 level)		
	(1) HFT	(2) Institutional	(3) Retail	(4) HFT	(5) Institutional	(6) Retail
I(Aggressive trade)	0.087*** (0.00)	0.029*** (0.00)	-0.006*** (0.00)	0.330*** (0.01)	0.221*** (0.01)	0.059*** (0.00)
I(Passive trade)	0.024*** (0.00)	-0.026*** (0.00)	-0.041*** (0.00)	0.002 (0.01)	-0.095*** (0.00)	-0.077*** (0.00)
I(Amend)	-0.014*** (0.00)	0.001** (0.00)	-0.015*** (0.00)	-0.026** (0.01)	-0.061*** (0.00)	-0.030*** (0.00)
I(Cancel)	-0.043*** (0.00)	0.008*** (0.00)	-0.003 (0.00)	-0.278*** (0.02)	-0.035*** (0.00)	-0.018*** (0.00)
Volatility	0.380*** (0.10)	0.105** (0.04)	0.206** (0.08)	0.101 (0.08)	0.070 (0.04)	0.046 (0.07)
Volume	-0.001 (0.00)	0.004*** (0.00)	-0.000 (0.00)	0.001 (0.00)	0.002* (0.00)	0.001 (0.00)
Price	-0.007 (0.01)	-0.006** (0.00)	0.001 (0.01)	0.025 (0.02)	-0.003 (0.00)	-0.005 (0.01)
Qspread	3.871*** (0.64)	0.545** (0.26)	-0.496 (0.71)	1.753* (0.99)	-1.009*** (0.27)	-0.483 (0.58)
Constant	-0.004 (0.04)	-0.071*** (0.02)	0.040 (0.03)	-0.025 (0.05)	-0.025 (0.02)	0.033 (0.03)
Obs.	109,351	111,417	110,409	109,351	111,417	110,409
Adj. R-square	0.265	0.132	0.042	0.531	0.712	0.091

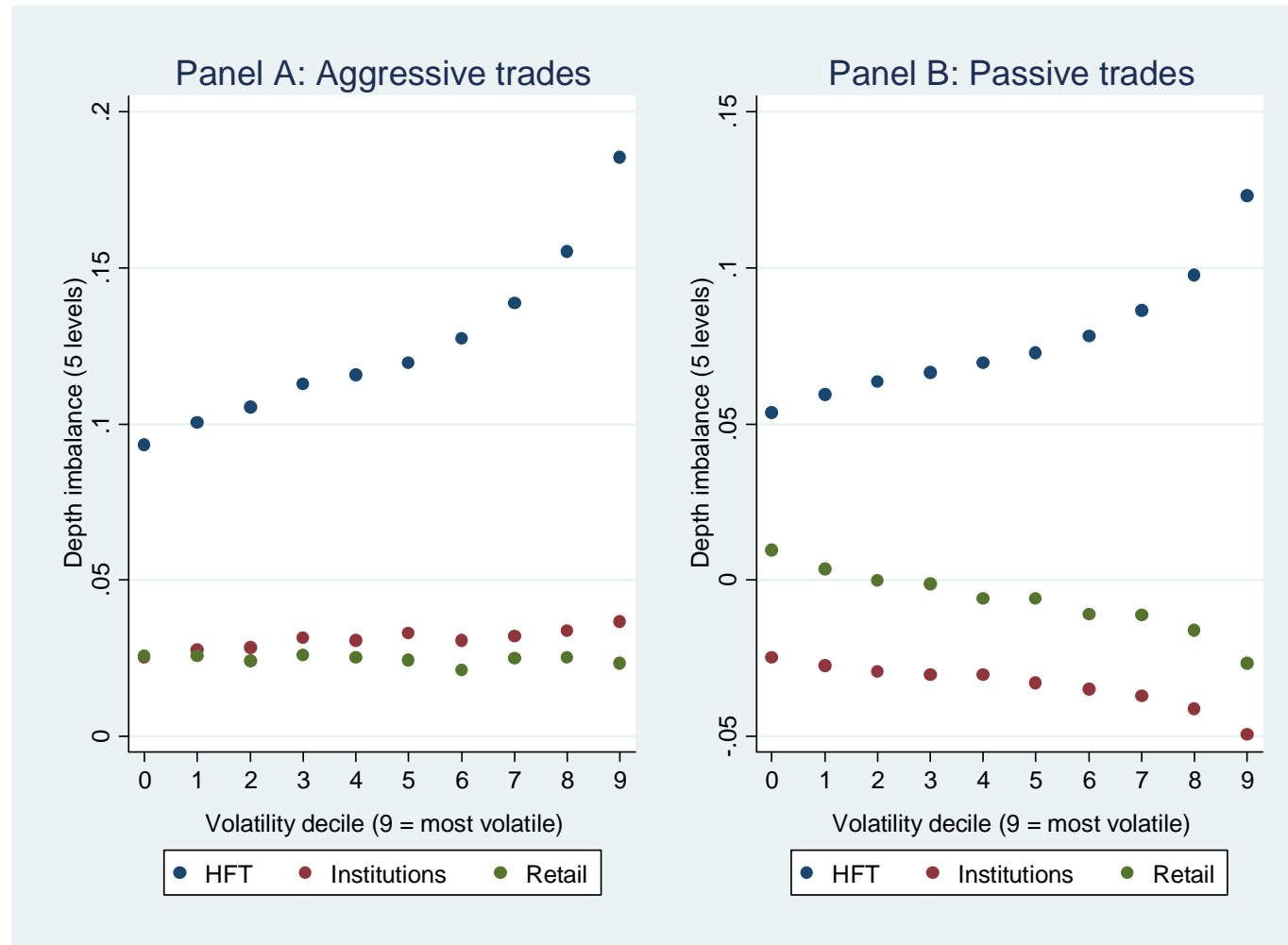
Volatility and trading volumes by broker



Volatility and trading volumes by broker

	Aggressive Volume %			Aggressive Trade %		
	(1) All stocks	(2) Large stocks	(3) Small stocks	(4) All stocks	(5) Large stocks	(6) Small stocks
I(HFT) × I(Low volatility)	-4.056*** (0.89)	-3.877*** (1.38)	-4.335** (1.81)	-2.707*** (0.96)	-4.520*** (1.21)	-3.260* (1.84)
I(HFT) × I(High volatility)	7.432*** (0.62)	6.520*** (0.91)	7.746*** (1.59)	7.378*** (0.87)	6.614*** (1.19)	7.790*** (1.95)
I(Institutional) × I(Low volatility)	3.319*** (0.80)	-0.733 (0.82)	9.903*** (1.53)	4.910*** (0.77)	1.177 (0.96)	8.316*** (1.36)
I(Institutional) × I(High volatility)	4.481*** (0.52)	6.952*** (0.51)	1.859 (1.20)	2.222*** (0.55)	5.019*** (0.59)	-1.705* (0.88)
I(High volatility)	-3.527*** (0.99)	-7.910*** (0.99)	4.874** (1.86)	-0.801 (1.05)	-5.890*** (1.13)	5.871*** (1.27)
I(HFT)	13.676*** (1.39)	10.160*** (1.75)	14.835*** (3.00)	16.523*** (2.01)	13.366*** (2.65)	16.783*** (3.90)
I(Institutional)	-10.871*** (0.72)	-12.168*** (1.04)	-9.679*** (1.66)	2.625** (1.16)	-5.141*** (1.52)	10.629*** (1.51)
Volatility	86.826*** (24.55)	108.259* (59.77)	14.548 (19.76)	125.915*** (24.72)	160.321** (62.06)	73.512** (27.85)
Volume	-0.697*** (0.08)	-0.849*** (0.12)	-0.631*** (0.14)	-0.617*** (0.11)	-0.786*** (0.17)	-0.352* (0.19)
Constant	59.934*** (1.44)	67.513*** (2.55)	53.625*** (2.58)	42.688*** (2.04)	55.252*** (3.07)	33.113*** (2.46)
Obs.	449,556	175,152	118,303	449,556	175,152	118,303
Adj. R-square	0.241	0.239	0.207	0.200	0.245	0.162

Volatility and depth imbalance by broker



Dependent variable: *Adjusted depth imbalance*

	Active trades			Passive trades		
	(1) All stocks	(2) Large stocks	(3) Small stocks	(4) All stocks	(5) Large stocks	(6) Small stocks
I(HFT) × I(Low volatility)	-0.048*** (0.00)	-0.034*** (0.00)	-0.054*** (0.01)	-0.055*** (0.00)	-0.039*** (0.00)	-0.064*** (0.01)
I(HFT) × I(High volatility)	0.065*** (0.00)	0.064*** (0.01)	0.074*** (0.01)	0.080*** (0.00)	0.068*** (0.01)	0.092*** (0.01)
I(Institutional) × I(Low volatility)	-0.013*** (0.00)	-0.007* (0.00)	-0.009 (0.01)	-0.008** (0.00)	-0.008** (0.00)	-0.004 (0.01)
I(Institutional) × I(High volatility)	0.010*** (0.00)	0.007** (0.00)	0.009** (0.00)	0.007*** (0.00)	0.003 (0.00)	0.005* (0.00)
I(High volatility)	-0.004 (0.00)	-0.013** (0.01)	0.007 (0.01)	-0.040*** (0.00)	-0.034*** (0.00)	-0.038*** (0.01)
I(HFT)	0.115*** (0.00)	0.098*** (0.01)	0.120*** (0.01)	0.101*** (0.01)	0.082*** (0.01)	0.110*** (0.01)
I(Institutional)	0.002 (0.00)	0.007** (0.00)	0.003 (0.01)	-0.022*** (0.00)	-0.026*** (0.00)	-0.019*** (0.00)
Volatility	1.414*** (0.23)	1.677*** (0.47)	1.463*** (0.32)	-0.139 (0.15)	-0.132 (0.22)	-0.083 (0.16)
Volume	-0.006*** (0.00)	-0.004*** (0.00)	-0.008*** (0.00)	-0.002*** (0.00)	-0.000 (0.00)	-0.003** (0.00)
Constant	0.076*** (0.01)	0.052*** (0.01)	0.082*** (0.02)	0.023*** (0.01)	0.008 (0.01)	0.058*** (0.01)
Obs.	519,904	189,054	168,110	519,670	191,623	174,017
Adj. R-square	0.157	0.185	0.155	0.148	0.189	0.149

What happens when trading speeds increase?

- › ASX ITCH: designed to meet the requirements of speed sensitive traders and increased market information access speeds by up to 7 times existing connections.
 - Implemented on April 2, 2012
 - Pre period: March 2, 2012 to April 1, 2012
 - Post-period: April 9, 2012 to May 9, 2012
 - This event creates benefits for HFT participants, who are the most speed sensitive.

HFT strategies and trading speeds

	(1)		(2)	(3)	(4)		(5)	(6)
	Volume imbalance (%)		Post-ITCH	F-Test	Trade imbalance (%)		Post-ITCH	F-Test
	Pre-ITCH				Pre-ITCH			
I(HFT) × Depth imbalance	0.942*** (0.05)		1.064*** (0.06)	5.350** (0.023)	0.938*** (0.05)		1.066*** (0.05)	7.71*** (0.007)
I(Institutional) × Depth imbalance	-0.030 (0.04)		-0.038 (0.04)	0.040 (0.850)	0.017 (0.04)		0.128*** (0.04)	5.27** (0.024)
Depth imbalance	-0.095** (0.05)		-0.118** (0.05)	0.480 (0.490)	-0.028 (0.04)		-0.121*** (0.04)	6.36** (0.014)
I(HFT)		0.025 (0.02)				0.026 (0.02)		
I(Institutional)		0.033** (0.02)				0.040** (0.02)		
Volume		0.016*** (0.00)				0.019*** (0.01)		
Constant		-0.373*** (0.06)				-0.561*** (0.07)		
Obs.		80,666				80,666		
Adj. R-square		0.186				0.278		

Do HFT crowd out the limit order book?

- › As HFTs become faster, we expect the probability of fill for non-HFT limit orders to decrease.
 - i.e., it becomes more difficult for non-HFT traders to receive executions for their limit orders.
- › Examine only limit orders submitted to the best bid or ask:

$$P(\text{fill}) = \frac{\sum \text{TradeVolume}}{\sum \text{SubmitVolume}}$$

Probability of fill and trading speeds

	(1)	(2)
I(Non-HFT) × I(Post-ITCH)	-0.037*** (0.01)	
I(Non-HFT)		
I(Institutional) × I(Post-ITCH)		-0.021** (0.01)
I(Institutional)		-0.069*** (0.02)
I(Retail) × I(Post-ITCH)		-0.057*** (0.02)
I(Retail)		0.301*** (0.02)
I(Post-ITCH)	0.028* (0.02)	0.029* (0.02)
Volatility	0.087 (0.17)	0.072 (0.17)
Volume	0.071*** (0.00)	0.069*** (0.00)
Price	0.031 (0.04)	0.033 (0.04)
Qspread	-1.359 (2.37)	-1.328 (2.38)
Constant	-0.564*** (0.08)	-0.534*** (0.08)
Obs.	10,646	10,646
Adj. R-square	0.190	0.586

- › HFT trade on information contained in the limit order book. Our findings provide an explanation for how HFT:
 - i. Predict future order flow
 - ii. Increases stock volatility
- › HFT supply liquidity to the thick side of the order book (where it is not required) and demand liquidity from the thin side of the order book (where it is most needed). This trading behaviour exacerbates future order book imbalances.
- › HFT become more strategic with faster trading speeds. However, HFT strategies come at the cost of crowding out non-HFT limit orders from the order book.