

Order Exposure in High-Frequency Markets*

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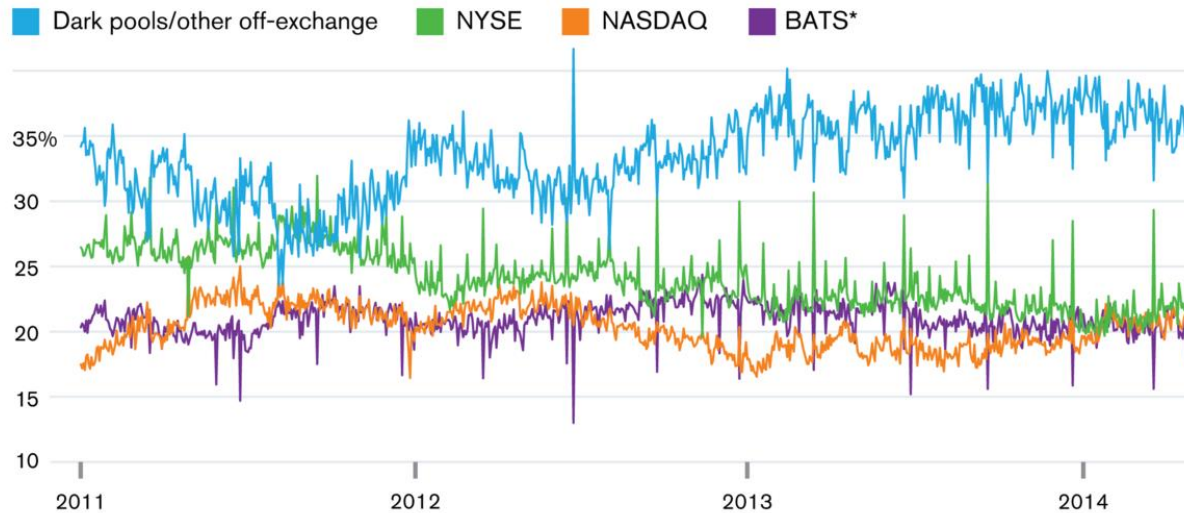
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Recent trend in non-displayed orders

Darkness Rising

Percentage of trading volume, based on daily close

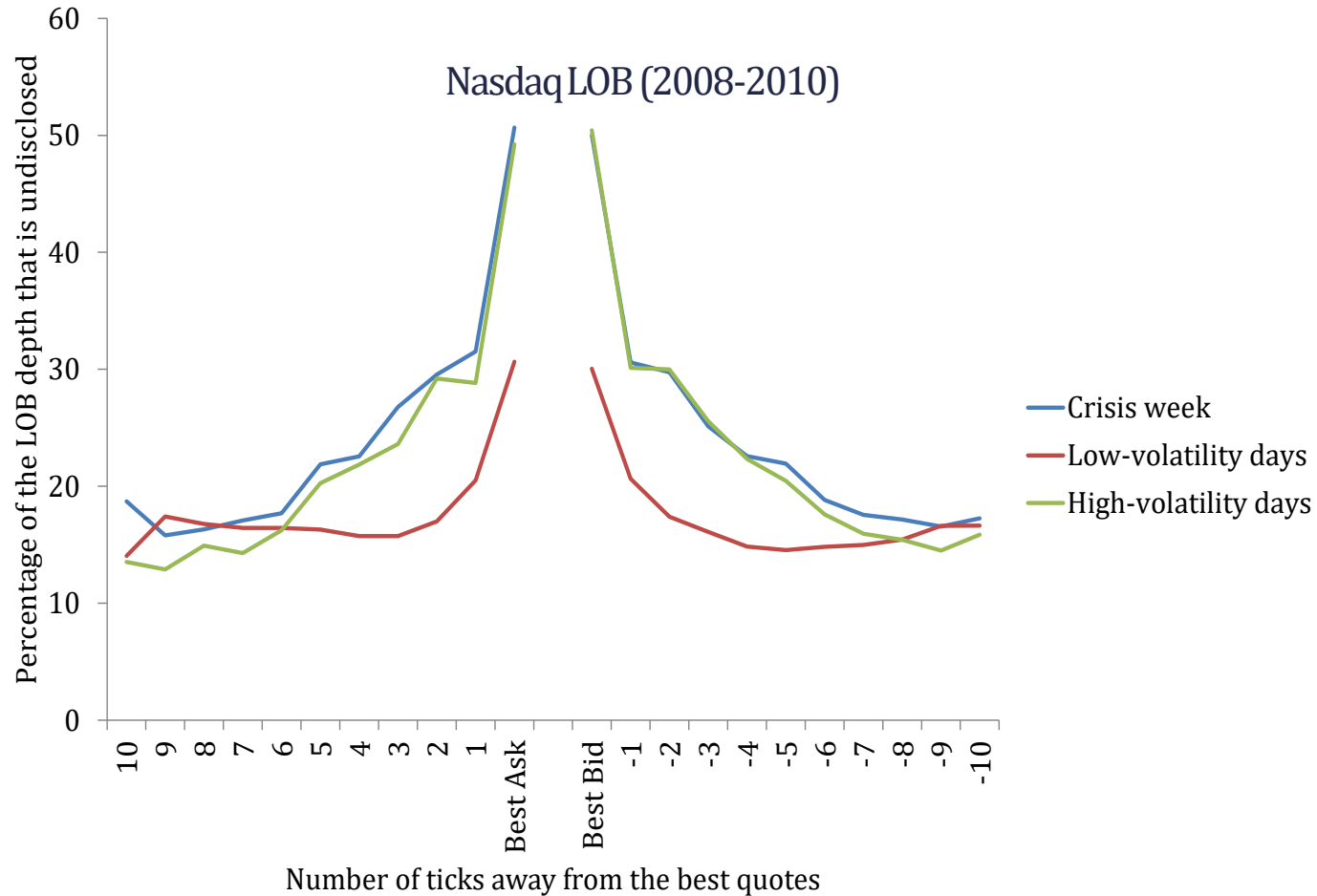


* Includes volume from Direct Edge; the two merged in 2014

Source: Bloomberg

35-40% of US trading volume

Hiding when and where it matters most



Source: Elaborated by the authors

Uninformed traders:

- Manage the option value of their LOs (e.g., Copeland and Galai, 1983)
- Empirically supported (e.g., de Winne & d'Hondt, 2007; Bessembinder, Panayides, and Venkataraman, 2009)

Informed traders:

- Limit information leakage and minimize price impact (e.g., Moinas, 2010; Boutalov and George, 2013).
- Experimental support (e.g., Bloomfield, O'Hara, and Saar, 2015; Gozluklu, 2016)

Modern HF markets

- The **evidence** on hidden order use is **from the pre-HFT era**:
- Most liquidity supply nowadays comes from HFTs (Hendershott et al., 2011; Hendershott and Riordan, 2013; Menkveld, 2013; Brogaard et al., 2015)

Examining whether, how, and why HFTs hide is important

HFTs' incentives to hide?

- HFTs' exposure risk is low: small trade sizes, continuous quote update / monitoring (Biais & Focault, 2014; O'Hara, 2015)
- HFT trades carry short lived information (Brogaard et al., 2014; von Beschwitz et al., 2015; Hirschey, 2016; van Kervel and Menkveld, 2016)
- Non-exposure comes with a delay cost (HLOs lose time priority); it can outweigh the HFTs' informational advantage

A priori: HFTs should NOT use hidden order

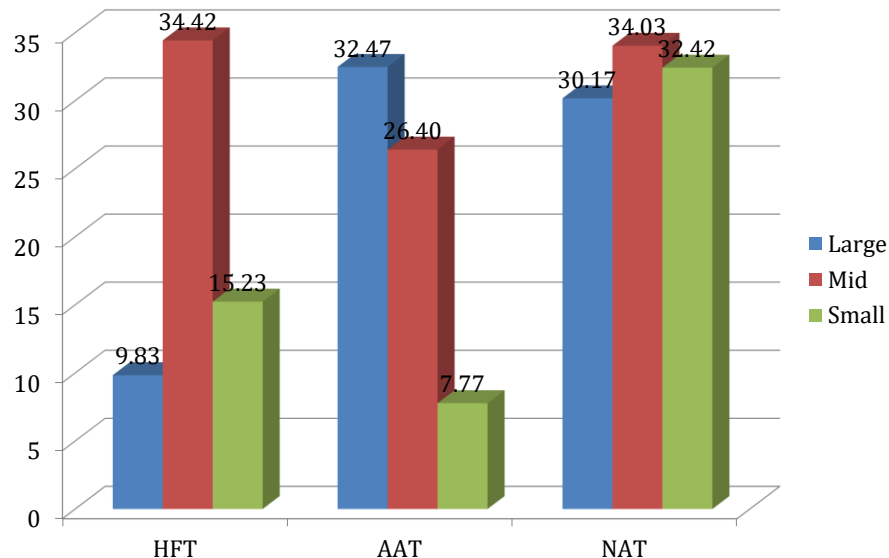
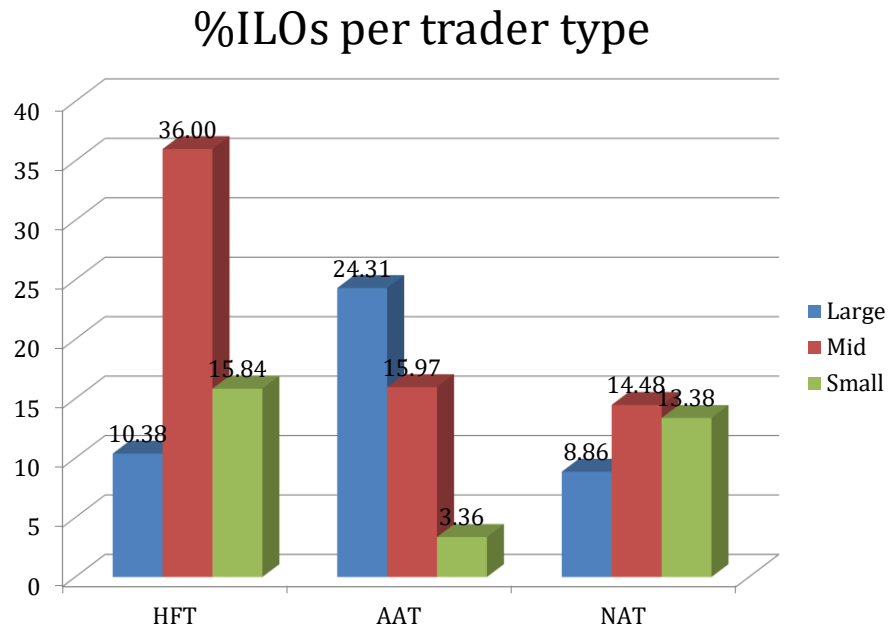
- **National Stock Exchange (NSE) of India**
- Compared to US markets:
 - Less fragmented
 - Clearly specified date for colocation
 - No dark pools as substitutes for hidden orders in lit venues
 - Allows iceberg orders with 10% original display volume
 - **Detail-rich data:**
hidden volume and trader type flags

Identifying HFTs

We exploit to internal flags in the data

	"Client account"	
"Order entry mode"	Proprietary	Agency
Algorithmic trader (AT)	High-frequency traders (HFTs)	Agency Algorithmic Traders (AATs)
Non-AT	Non-algorithmic traders (NATs)	

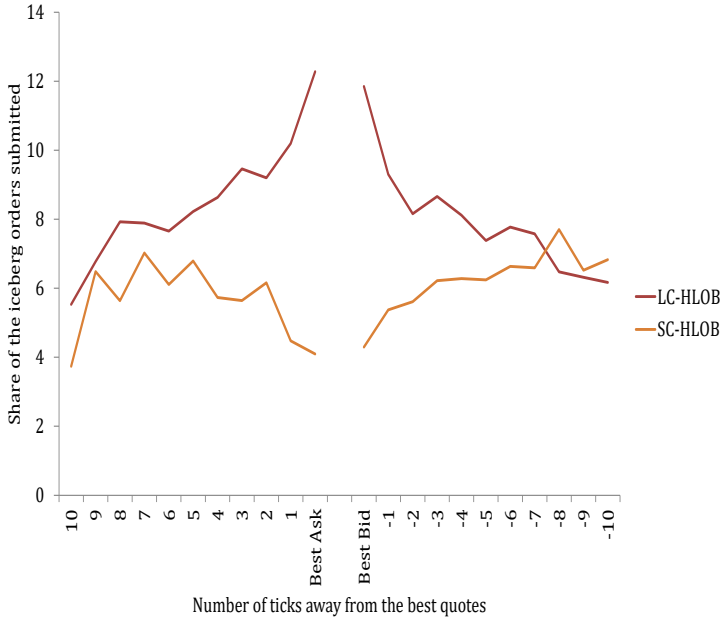
Use of icebergs: Likelihood of hiding



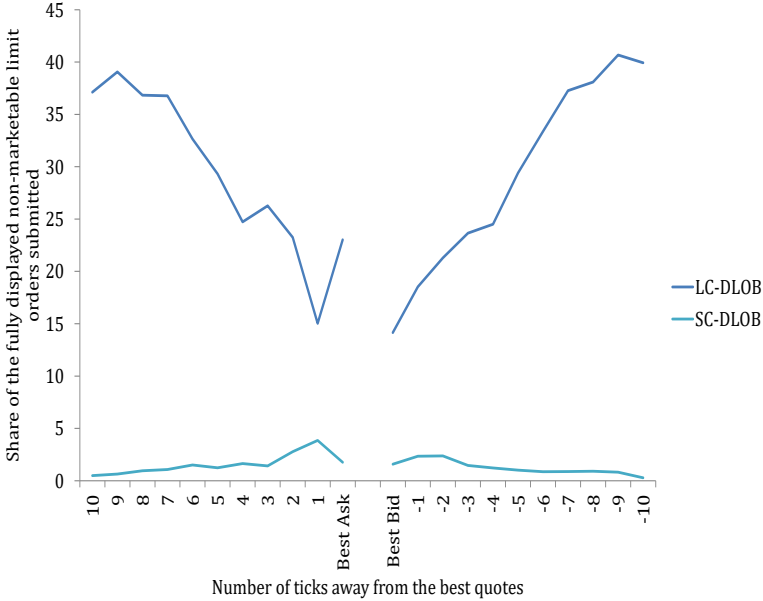
%Vol per trader type

HFTs use ILOs in all market-cap firms

HFTs' Order display conditional on aggressiveness

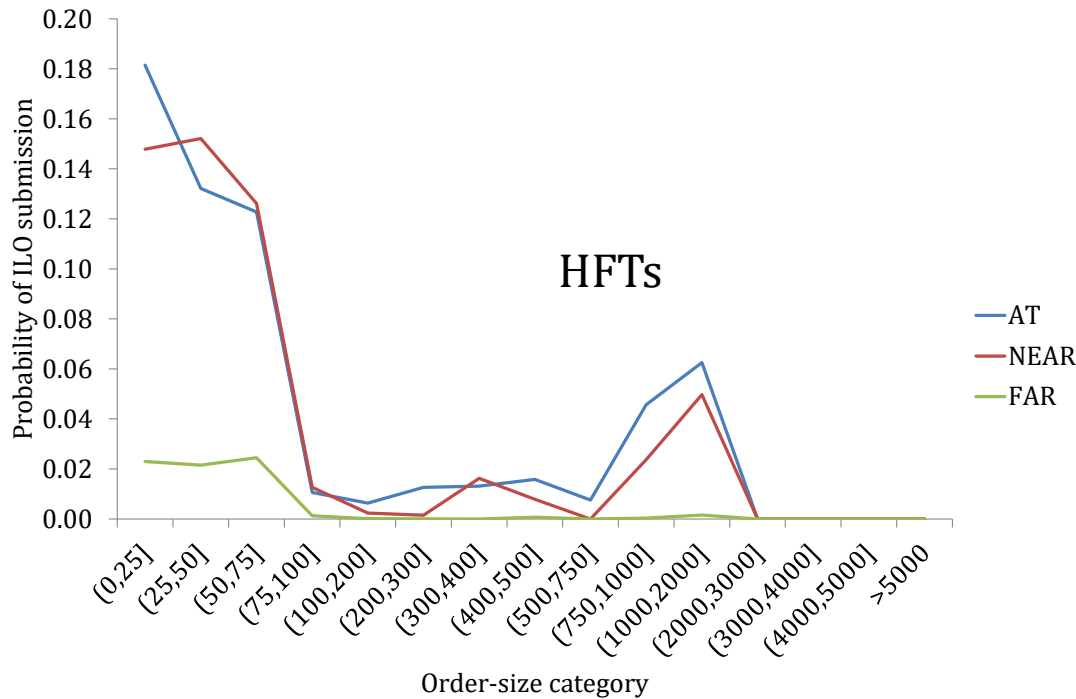


HFTs' share of ILOs



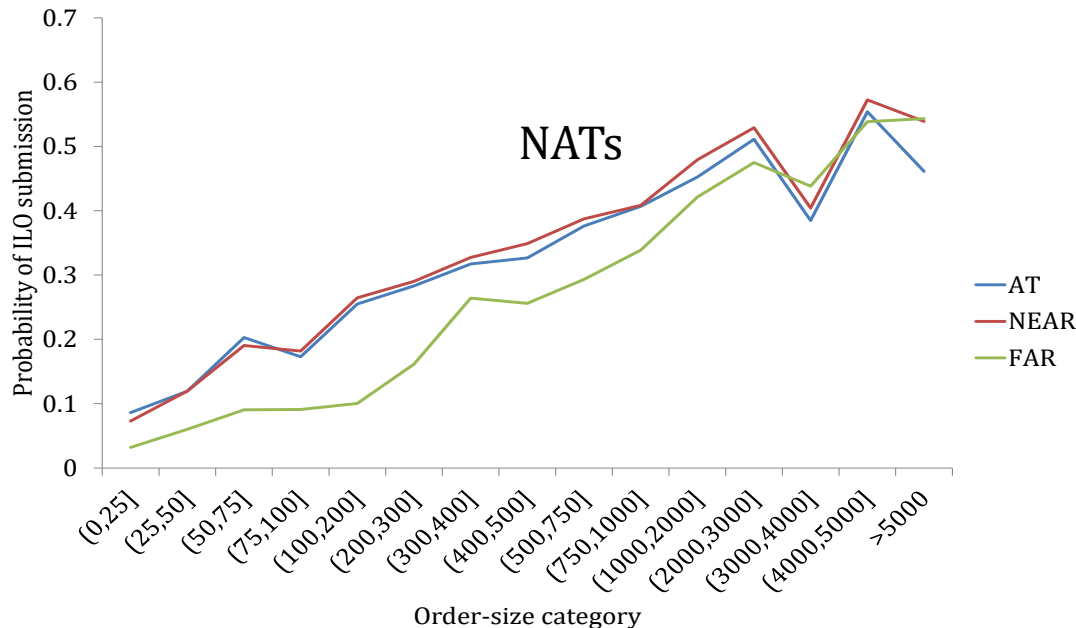
HFTs' share of DLOs

Use of “icebergs”: Prob (ILO/size) (large caps)



HFTs’ use of ILOs
looks inconsistent
with the “picking-off
risk” explanation

(e.g., Buti and Rindi,
2013; BPV, 2009)



Execution probability of ILOs: Ordered logit model

Variable	Buy order	Sell order
	Coef.	Coef.
Aggressiveness	273.80 ***	159.74 ***
Order size	-2405.28 **	-2055.99 **
ILO (d)	-0.4301 **	-0.2509
HFT (d)	-2.2576 ***	-2.2935 ***
Agency-AT (d)	-1.6361 ***	-1.4190 ***
ILO x HFT (d)	2.5816 ***	1.7313 ***
ILO x Agency-AT (d)	1.3648 ***	0.9437 ***
Relative spread	530.13 ***	490.81 ***
Depth same side	-85.85 ***	-59.61 **
Depth other side	62.54 ***	72.19 ***
LOB imbalance	-0.1518 ***	0.1550 ***
Last half hour (d)	0.2398 ***	0.2658 ***
Order imbalance	-0.1464 ***	0.1131 **
Trading frequency	1.1414 **	1.4850 **
Momentum	7.7690	3.9942
Volatility	4897.55	6661.67

***, **, * means statistically significant at the 1%, 5% and 10% level, respectively

(d) means dummy variable

Cross-sectional average coefficients and CRS05 t-stat

ILO cancelled before
execution: EXEC=1

ILO partially
executed, then
cancelled: EXEC = 2

ILO fully executed:
EXEC = 3

**HFTs have a higher
likelihood of
execution**

compared to other
traders.

Time to completion of ILOs: Survival analysis

Variable	Orders to buy	Orders to sell
	Coef.	Coef.
Intercept	16.71 ***	17.09 ***
Midquote-limit price	2.82 **	-1.67 ***
Last trade buy indicator (d)	0.08 *	-0.09
Depth same side	227.39 ***	221.04 **
Depth same side^2	-169.52 **	-151.71 **
Depth other side	-196.99 ***	-227.55 ***
Order size (total)	47.15 ***	37.37 **
Trading frequency	-14.24 **	-10.34 *
Relative trading frequency	-1.50 ***	-1.45 ***
ILO (d)	1.45 ***	1.14 ***
HFT (d)	2.78 ***	2.48 ***
AAT (d)	0.44	0.05
ILO x HFT (d)	-3.61 ***	-2.76 ***
ILO x AAT (d)	-1.51 ***	-1.18 **

***, **, * means statistically significant at the 1%, 5% and 10% level, respectively

(d) means dummy variable

Cross-sectional average coefficients and CRS05 t-stat

HFTs' ILOs take shorter time to fully execute

compared to other traders.

OVERALL: HFTs efficiently place their ILOs (so that their time to execution is shorter and the execution probability is higher)

...

Costs of ILOs execution

Panel A: Implementation shortfall

Coefficients of interest	All fill rates	
	Coef.	%Signif. (pos.)
ILO	0.0121	56.67 (40.00)
ILO x HFT	-0.0445	40.00 (13.33)
ILO x AAT	-0.0016	66.67 (36.67)

Panel B: Effective costs

	All fill rates		Fill rate >0%	
	Coef.	%Signif. (pos.)	Coef.	%Signif. (pos.)
ILO	-0.0139	90.00 (13.33)	-0.0128	73.33 (13.33)
ILO x HFT	0.0126	73.33 (66.67)	0.0503	76.67 (73.33)
ILO x AAT	0.0134	93.33 (80.00)	0.0184	86.67 (80.00)

Panel C: Opportunity costs of non-execution

	All fill rates		Fill rate <100%	
	Coef.	%Signif. (pos.)	Coef.	%Signif. (pos.)
ILO	0.0432	70.00 (56.67)	0.1359	56.67 (40.00)
ILO x HFT	-0.0714	46.67 (13.33)	-0.1022	50.00 (13.33)
ILO x AAT	-0.0292	83.33 (33.33)	-0.0633	70.00 (26.67)

Complete regressions reported in the paper.

ILOs submitted by HFTs show the lowest IS:

- Executed at less favorable prices (**largest price impact**) ...
- ... but with less adverse price movements after submission (**lowest opportunity cost**)

Informativeness of ILOs: Permanent price impact

Hasbrouck (1991) VAR model

Panel A: Continuously-compound return (in basis points) IRF

Message	Trader type		
	HFT	AAT	NAT
Trades	1.2271 *** (0.1382)	0.7259 *** (0.1017)	0.8582 *** (0.1474)
DLO	0.0816 ** (0.0318)	0.0568 *** (0.0099)	0.1640 *** (0.0260)
ILO	0.1913 *** (0.0536)	0.2401 *** (0.0328)	0.2170 *** (0.0308)
Cancellations	0.0793 *** (0.0291)	0.0454 *** (0.0117)	0.1233 *** (0.0254)

Panel B: Differences

Message	Trader type		
	AT vs HFT	NAT vs HFT	NAT vs AT
Trades	-0.5013 *** (0.0932)	-0.3689 *** (0.1143)	0.1323 (0.1022)
DLO	-0.0248 (0.0260)	0.0825 ** (0.0341)	0.1073 *** (0.0223)
ILO	0.0487 (0.0381)	0.0257 (0.0415)	-0.0230 * (0.0126)
Cancellations	-0.0339 (0.0324)	0.0440 ** (0.0219)	0.0779 *** (0.0235)

***, **, * means statistically different from zero at usual levels

HFTs' ILOs are not more informative than other traders' ILOs.

Informativeness of ILOs: Trade-related efficient variance

Panel A: OF-related efficient variance (OFEV) decomposition

Message	All traders	NAT	AAT	HFT
Trades	67.05	29.57 *** (2.24)	21.39 *** (3.13)	16.09 *** (1.69)
Limit orders	25.95	10.52 *** (0.93)	9.25 *** (1.21)	6.18 *** (1.03)
Iceberg orders	7.84	1.69 *** (0.14)	5.68 *** (0.87)	0.46 ** (0.18)
Cancellations	-0.84	-1.34 *** (0.25)	-1.78 ** (0.73)	2.29 *** (0.72)
All orders		40.44	34.54	25.02

Panel B: Differences

Message	NAT vs AAT	NAT vs HFT	AAT vs HFT
Trades	8.18 *** (2.88)	13.49 *** (2.06)	5.30 ** (2.19)
Limit orders	1.27 (1.12)	4.34 *** (1.09)	3.07 *** (0.70)
Iceberg orders	-3.99 *** (0.90)	1.23 *** (0.21)	5.22 *** (0.95)
Cancellations	0.44 (0.60)	-3.63 *** (0.71)	-4.07 *** (0.85)

“The other” Hasbrouck
(1991) model

**HFTs’ ILOs convey
less information
than other traders’
ILOs.**

Informativeness of ILOs:

Information shares

Hasbrouck (1995)

Trader type	Order	Information shares (%)		
		Min.	Max.	Avg.
HFTs	DLO	15.87	45.83	30.85
	ILO	5.91	6.34 ***	6.13 **
AATs	DLO	8.81 ***	34.44 ***	21.62 ***
	ILO	5.00	10.25 ***	7.62 **
NATs	DLO	16.22	47.62	31.92
	ILO	6.36	17.39	11.87

***, ** means statistically different than the NAT's statistic at the usual levels

Both AATs and NATs have larger information shares for ILOs than HFTs.

Undercutting

- HFTs' ILOs less informationally-motivated
- Not to reduce exposure risk (large orders)
- ... **then WHY do HFTs hide?**

In the absence of theory, we test one possible explanation

UNDERCUTTING

An undercutting order is:

- Within 10 millisecond of previous order
- On the same side
- Price improving

Undercutting: the evidence

Panel A: Descriptive statistics on front-running (% of orders)

Order	TraderType	Bid side	Ask side
ILO	HFT	5.60 ***	6.07 ***
	AAT	3.40 ***	3.48 ***
	NAT	0.81 ***	0.80 ***
DLO	HFT	2.60 ***	2.73 ***
	AAT	5.17 ***	5.58 ***
	NAT	1.06 ***	1.08 ***

HFTs undercut more often than other traders **using ILOs**.

Panel B: Logit model on front-running

Variable	Coef.	Odds ratio	CRS t-stat
DispSize_of_FR_Order	0.0004 ***	1.00	10.03
Aggr_of_FR_Order	-0.0744 ***	0.93	-119.14
HFT	0.7620 ***	2.14	39.49
AAT	0.9856 ***	2.68	40.69
HFTILO	0.4149 ***	1.51	7.67
AATILO	-0.1902	0.83	-0.06
NATILO	-0.5556 ***	0.57	-3.96
HidVolDetected	0.4489 ***	1.57	66.72
Spread	0.0300 ***	1.03	39.78
DepthSame/100	0.3798 ***	1.46	10.71
DepthOpposite/100	-0.9478 ***	0.39	-9.27
Volatility*10000	0.0134 ***	1.01	22.57
Intercept	-4.0663 ***		-183.04

HFTs are likely to use ILOs to undercut controlling for order, stock, and market attributes.

***, **, * means statistically different from zero at the 1%, 5%, and 10% level

- Contrary to extant theory, HFTs extensively hide orders
- HFTs' hidden orders are:
 - small and aggressive
 - efficient – faster time to completion, greater fill rates, and lower overall costs
 - not informationally motivated
- Need new theory, and in that direction...
- HFTs' hidden orders undercut standing orders