

Order Exposure in High-Frequency Markets*

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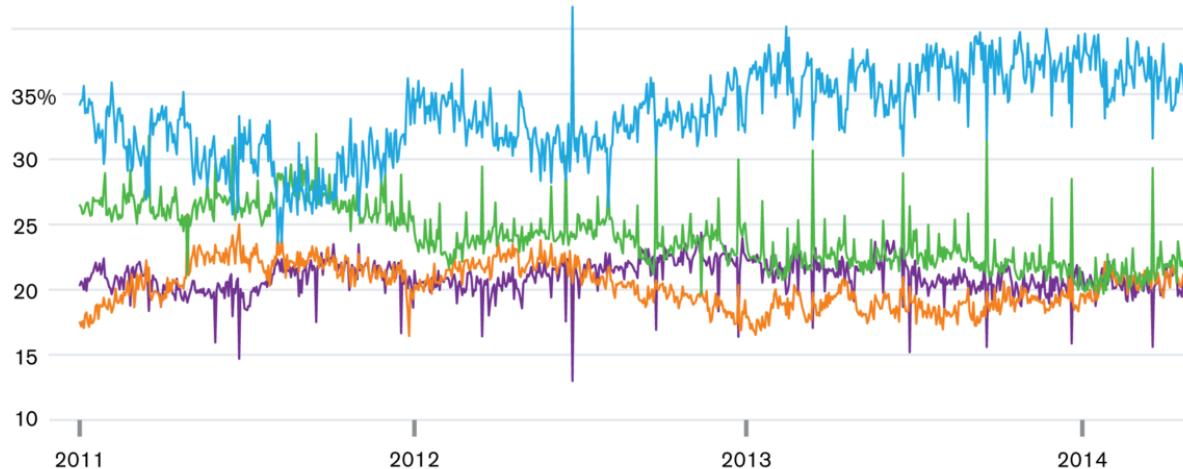
Hidden liquidity

Recent trend in non-displayed orders

Darkness Rising

Percentage of trading volume, based on daily close

■ Dark pools/other off-exchange ■ NYSE ■ NASDAQ ■ BATS*



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

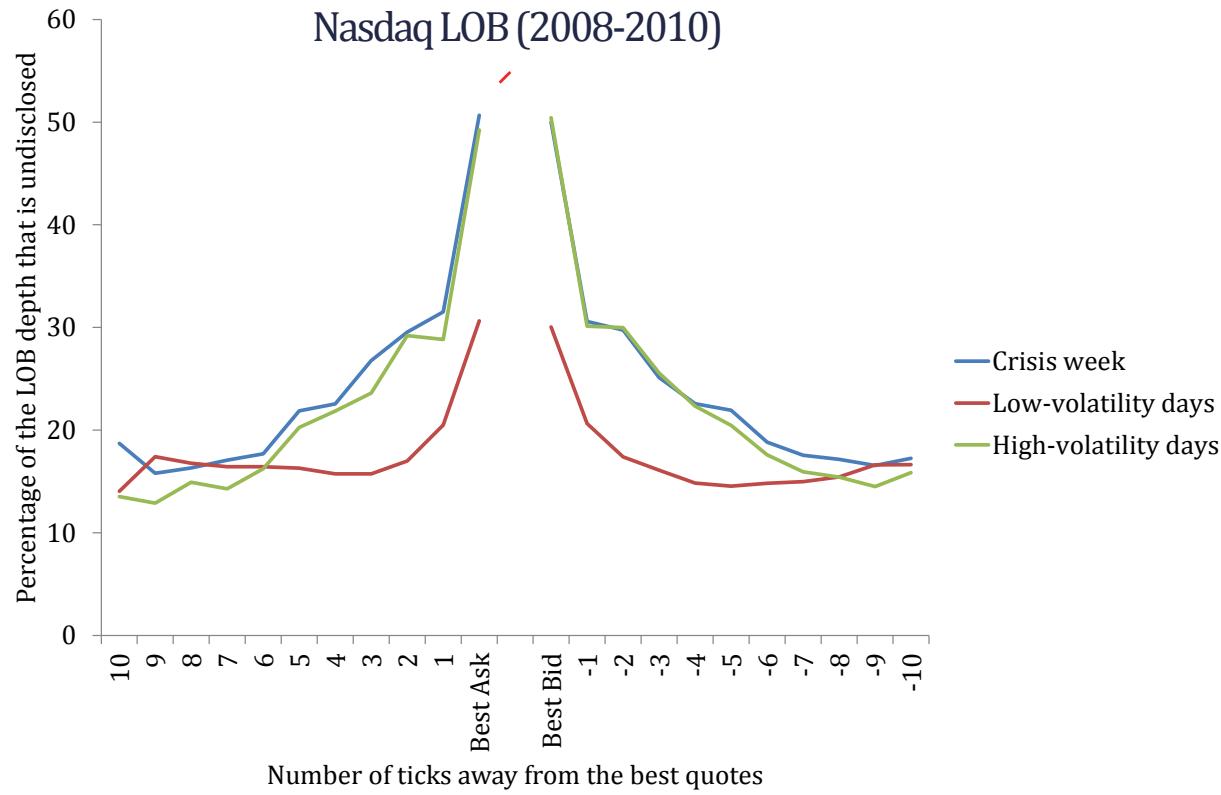
Source: Bloomberg

(2)

35-40% of US trading volume

Hidden liquidity

Hiding when and where it matters most



Source: Elaborated by the authors

Rationale for hiding

Uninformed traders:

- Manage the option value of their LOs (e.g., Copeland and Galai, 1983; Buti and Rindi, 2013)
- Empirically supported (e.g., de Winne & d'Hondt, 2007; Bessembinder et al., 2009; Pardo & Pas

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)

- The **evidence** on hidden order use is **from the pre-HFT era**:
 - de Winne and d'Hondt (2007); Bessembinder et al. (2009); Pardo and Pascual (2012) use 2000-2003 European data.
- Most of the liquidity supply nowadays comes from HFTs (e.g., Hendershott et al., 2011; Hendershott and Riordan, 2013; Menkveld, 2013; Brogaard et al., 2015)

Examining whether, how, and why HFTs hide is important

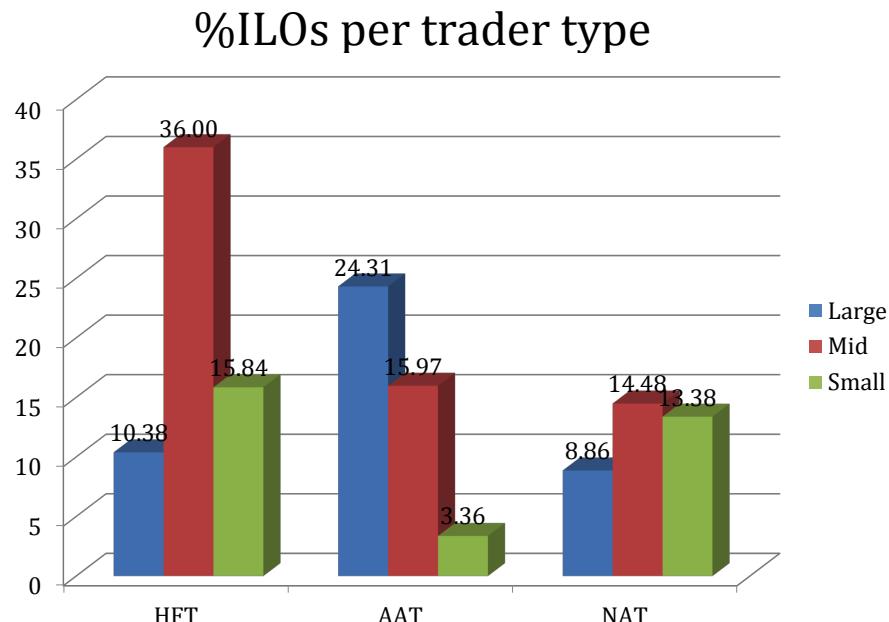
HFTs' incentives to hide?

- 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; Hirshey, 2016; van Kervel and Menkveld, 2016)
- Non-exposure comes with a delay cost (HLOs lose time priority); it can outweigh the HFTs' informational advantage

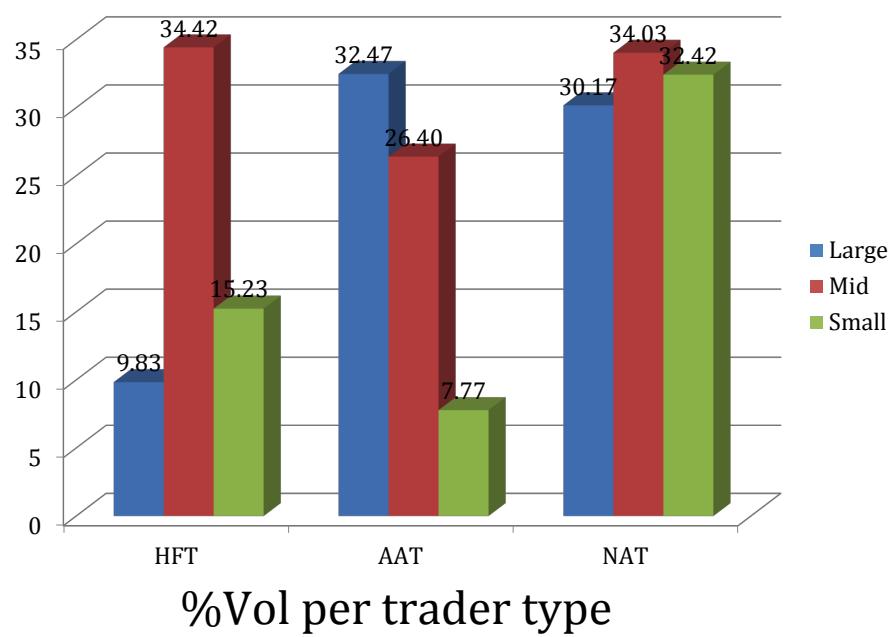
A priori: HFTs should NOT use hidden order

- **National Stock Exchange (NSE) of India**
- Fast-developing market, over 1300 listed firms, top 10(5) by mcap (trades) (WFE)
- Compared to US markets:
 - Less fragmented
 - Clearly specified date for colocation (12/2009)
 - 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

Use of icebergs: Likelihood of hiding



HFTs use ILOs in all
market-cap firms



Use of “icebergs”: Placement in the LOB grid*

Panel A: ILOs placement

Sample	Position	ATs		
		HFTs	AATs	NAT
Large	At	28.93 ***	17.01 ***	1.07 ***
	Near	42.26 ***	24.28 ***	3.74 ***
	Far	28.79 ***	58.71 ***	95.19 ***
Mid	At	56.21 ***	22.26 ***	3.58 ***
	Near	42.01 ***	29.27 **	11.01 ***
	Far	1.77 ***	48.48 ***	85.40 ***
Small	At	53.28 ***	28.42 ***	5.55 ***
	Near	46.53 ***	32.91 ***	15.79 ***
	Far	0.18 ***	38.67 *	78.65 ***

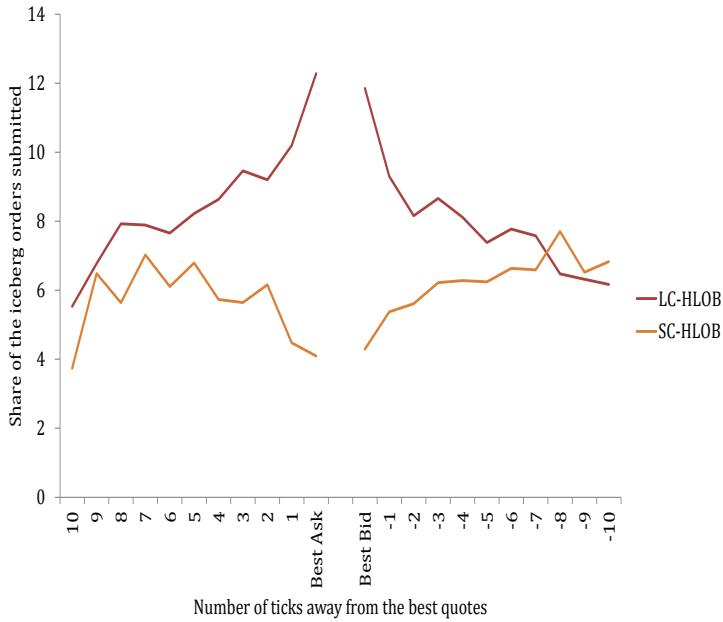
Panel B: DLOs placement

Large	At	0.80	3.31	0.22
	Near	11.41	11.15	1.68
	Far	87.79	85.54	98.09
Medium	At	4.26	4.65	0.94
	Near	38.16	26.55	4.74
	Far	57.57	68.79	94.32
Small	At	6.05	7.35	1.18
	Near	54.98	46.06	7.15
	Far	38.97	46.58	91.66

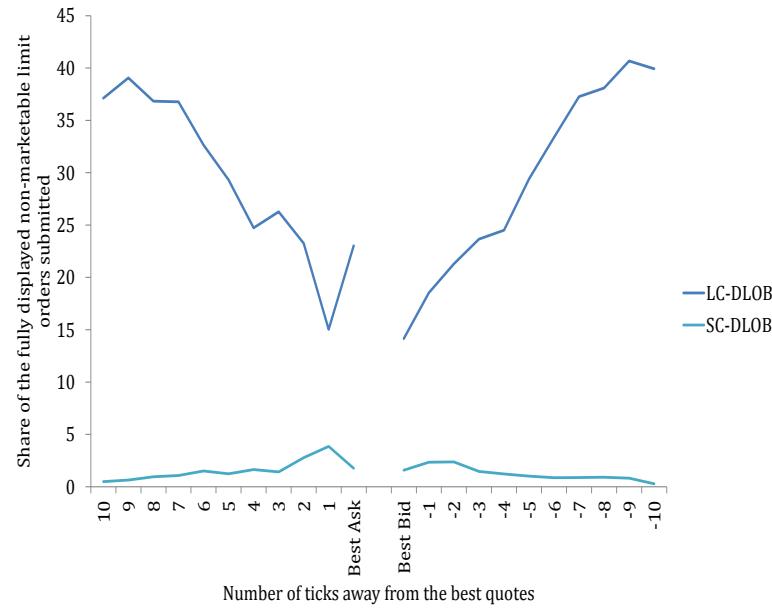
HFTs' are more aggressive than AATs and NATs in placing ILOs.

Similar results with volume placement.

HFTs' Order display conditional on aggressiveness



HFTs' share of ILOs



HFTs' share of DLOs

Use of “icebergs”: Order size (for large caps)

Order size distrib. (%)	ATs					
	HFTs		AATs		NATs	
	DLOs	ULOs	DLOs	ULOs	DLOs	ULOs
(0,50]	5.11	76.28	60.17	55.23	65.99	29.13
(50,75]	0.79	10.15	10.91	8.25	1.52	2.69
(75,100]	1.19	0.55	4.18	6.25	11.14	11.19
(100,200]	22.01	2.24	11.42	12.11	6.36	11.98
(200,500]	46.53	7.91	10.40	11.33	9.03	22.26
(500,1000]	19.02	2.39	1.54	4.03	3.26	10.79
(1000,2500]	2.82	0.44	0.73	2.03	1.46	6.07
>2500	2.53	0.05	0.65	0.77	1.24	5.89
HFTs vs. AATs/NATs (p-value)				0.00		0.00
DLOs vs. ULOs (p-value)	0.00			0.00		0.00

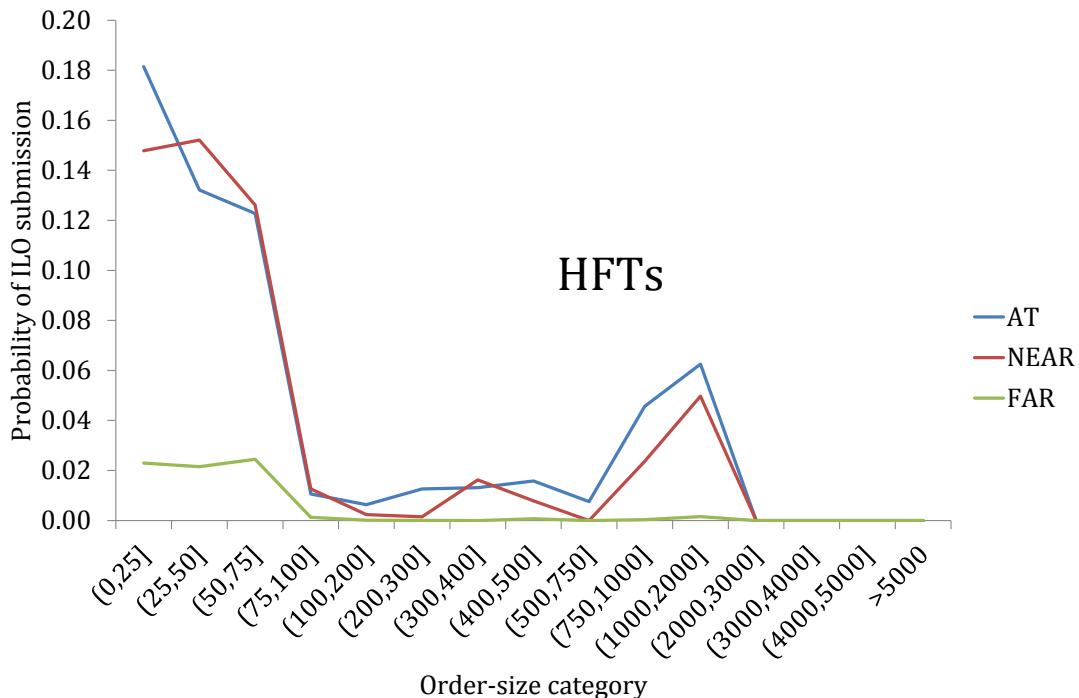
Order size = displayed + hidden

Most (few) of HFTs' ILOs (DLOs) are placed in the under-50-shares category. The pattern reverses for NATs.

For mid and small firms, this percentage increases to 98.72% and 83.96% respectively.

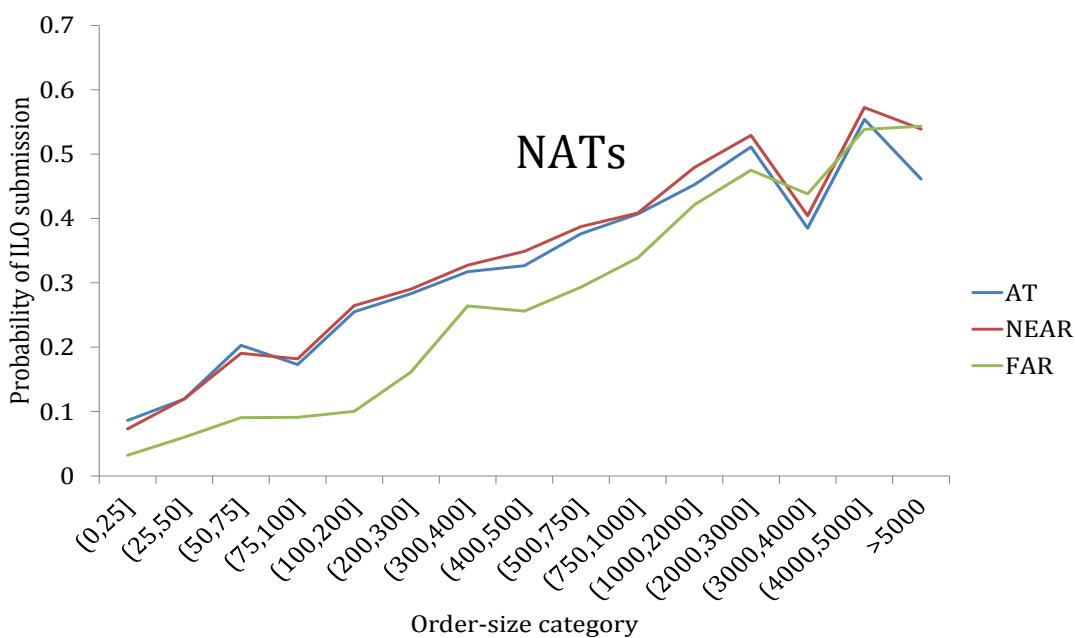
HFTs' ILOs are smaller than those of other traders.

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)



Determinants of the non-exposure decision

Panel A: Decision to hide - logistic model

Variable	ATs		
	HFTs	AATs	NATs
Intercept	-3.9108 ***	-0.8195 **	-1.8061 ***
Price aggressiveness	2865.7587 ***	511.3416 ***	65.7729 ***
Total order size	31.7138 **	19.9858 ***	18.3290 ***
Relative spread	1558.2250 ***	-69.7108	-4.0103
Depth same side	-586.9779 ***	-216.5916 ***	-88.1710 ***
Depth opposite side	39.8854	50.2558 ***	-30.9239 **
Stock volatility	-0.0141	-0.0031	-0.0062 ***
Waiting time	-50.3939 *	24.9165	15.5722 **
Trade frequency	-1.5337	-0.4582	-0.7669 **
Hidden same side	-3.0559	0.0679	-0.2246
LOB order imbalance	15.7592	0.4677	-0.2394
Last trade size	-3.4383 ***	-2.0167 **	-0.4277 *
Market volatility	-0.0017 *	-0.0014	-0.0001
Last half hour indicator	572.6601 ***	72.4503	-169.1852 ***

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

Panel B: Magnitude of hidden volume - Tobit model

Variable	ATs		
	HFTs	AATs	NATs
Intercept	-0.0041	-0.0007 **	-0.0031 ***
Price aggressiveness	0.2880 ***	0.0726 ***	0.0607 **
Total order size	0.0043	0.0067 ***	0.0055 ***
Relative spread	0.1933 ***	-0.0168	0.0709
Depth same side	-0.0479 **	-0.0461	-0.0332 *
Depth opposite side	0.0051	0.0035	-0.0278 **
Stock volatility	0.5508	0.0208	-0.0501 ***
Waiting time	-0.0060	0.0014	0.0049 ***
Trade frequency	-0.0075	-0.0002	-0.0005
Hidden same side	-0.0874	-0.0033	0.0004
LOB order imbalance	0.0007	0.0010	0.0016
Last trade size	-0.0003	-0.0003	-0.0001
Market volatility	0.0000	0.0000	0.0000
Last half hour indicator	0.0544	0.0843	-0.0466

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

HFTs' reactions are stronger but in the same direction as AATs & NATs

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%	
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%	
	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

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

Hasbrouck (1991) VAR model

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

“The other” Hasbrouck
(1991) model

HFTs' ILOs convey less information than other traders' ILOs.

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)

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 not 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 millisec 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 ***

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

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

HFTs undercut more often than other traders using ILOs.

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

Conclusion

- 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

Thank you!