

# high frequency trading and the *new-market* makers

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# outline

motivation

approach

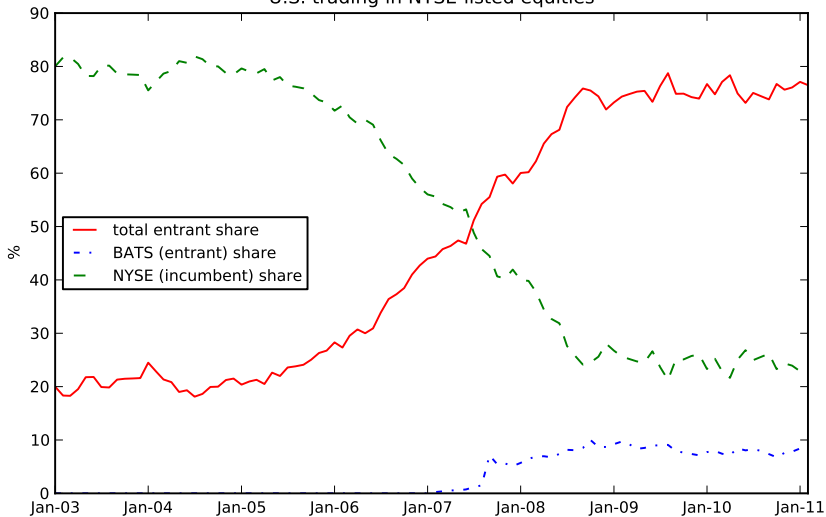
data

results

conclusion

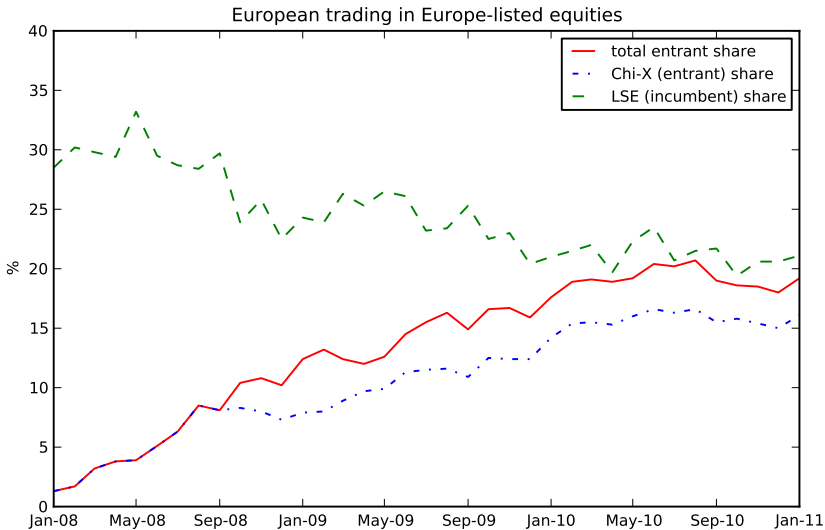
# markets have fragmented

U.S. trading in NYSE-listed equities



source: barclays capital

# markets have fragmented



source: federation european securities exchanges

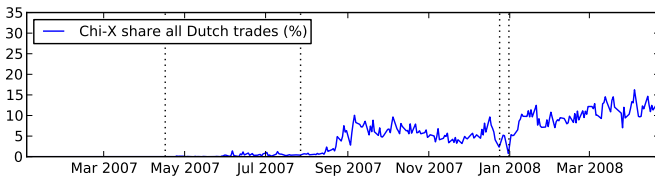
## high-frequency trading has thrived

- SEC calls high-frequency trading “one of the most significant market structure developments in recent years (SEC (2010, p.45))”

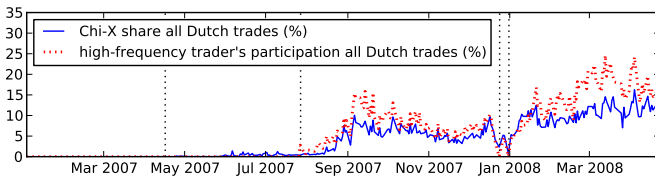
## high-frequency trading has thrived

- SEC calls high-frequency trading “one of the most significant market structure developments in recent years (SEC (2010, p.45))”
- CCSR published a similar discussion document where HFT is declared a focus area for which it solicits research (CCSR (2010, p.31))”

# fragmentation and HFT seem related

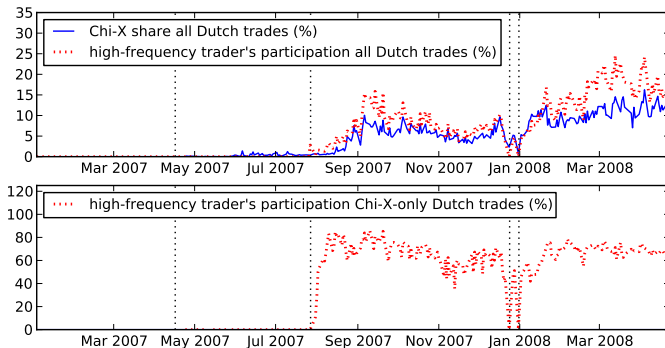


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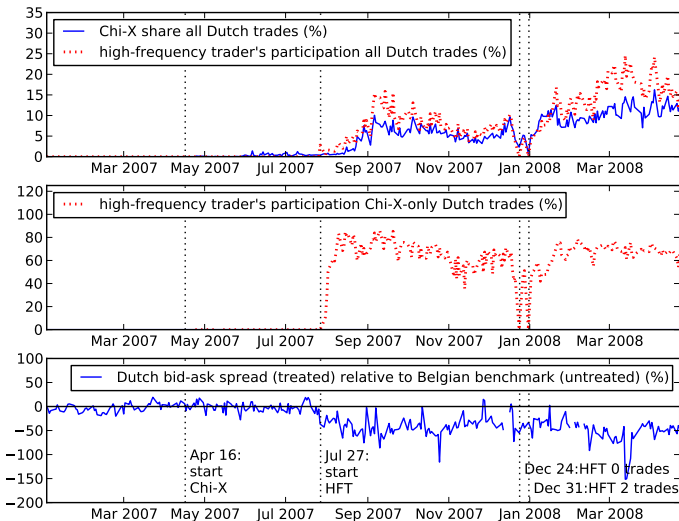




# fragmentation and HFT seem related



# fragmentation and HFT seem related



# literature (incomplete)

## empirics

- high-frequency trading: Brogaard (2010), Kirilenko, Kyle, Samadi, and Tuzun (2010), Menkveld (2011)
- algorithmic trading: Foucault and Menkveld (2008), Chaboud, Chiyoine, Hjalmarsson, and Vega (2009), Hendershott and Riordan (2009), Hasbrouck and Saar (2010), Hendershott, Jones, and Menkveld (2011)

## approach

micro economics perspective: daily profit and capital employed are analyzed separately

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- daily profit

- $\bar{\pi}^* = \frac{1}{T} \sum_{t=1}^T -\Delta n_t P_t$

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- rewriting yields (Sofianos (1995))

- $$\bar{\pi}^* = \frac{1}{T} \sum_{t=1}^T n_{t-1} \Delta p_t - |\Delta n_t^a| p_t s_t + |\Delta n_t^p| p_t s_t$$

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- and subtracting trading fees

- $$\bar{\pi} = \frac{1}{T} \sum_{t=1}^T n_{t-1} \Delta p_t - |\Delta n_t^a| p_t (s_t + \tau^a) + |\Delta n_t^p| p_t (s_t - \tau^p)$$

- = positioning profit – net spread aggr orders + net spread pass orders

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- positioning profit is further decomposed by duration (Hasbrouck and Sofianos (1993))



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- capital employed

- capital tied-up is established through analysis of margin calls

# trade revenue decomposition

HFT realized profit could be....



- HFT sells
- HFT buys

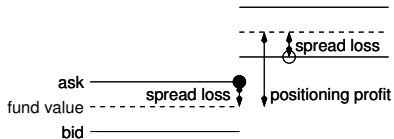
# trade revenue decomposition

HFT realized profit could be....

price  
↑  
time →

○ HFT sells  
● HFT buys

...aggressive speculation...

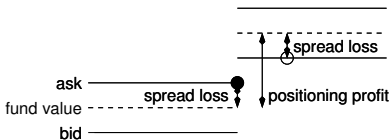


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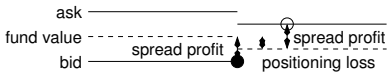
HFT realized profit could be....



...aggressive speculation...



...or passive market making



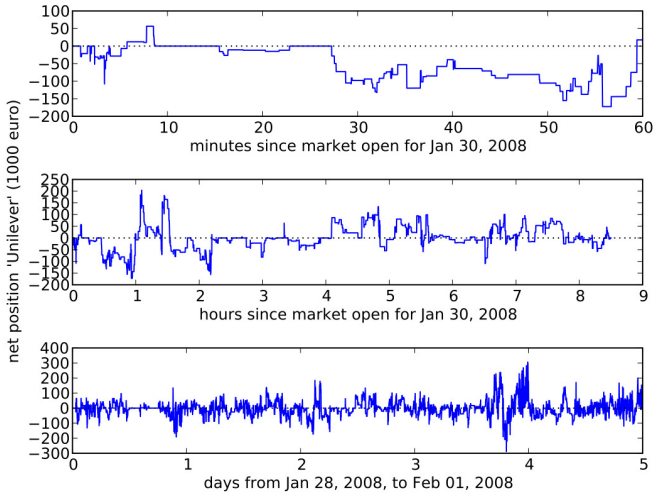
## data

- dutch index stocks that (mostly) trade on incumbent market euronext and entrant market chi-x
- sample period is january 1, 2007 through june 17, 2008 (includes start of chi-x)

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- sample period is january 1, 2007 through june 17, 2008 (includes start of chi-x)
- public quote data
- proprietary trade data with anonymized trader ID

# raw data plot HFT position by frequency



# summary statistics

variable	large stocks	small stocks	all stocks
<i>panel A: high-frequency trader statistics</i>			
fraction of days with zero closing inventory (%)	66.1 (50.5, 87.5)	91.0 (86.0, 97.0)	69.8 (50.5, 97.0)
daily closing inventory (100-share lots)	-0.35 (-1.00, 0.68)	0.04 (-0.05, 0.17)	-0.29 (-1.00, 0.68)
st. dev. daily closing inventory (100-share lots)	12.9 (2.4, 38.4)	1.2 (0.8, 2.0)	11.2 (0.8, 38.4)
high-frequency trader #trades per day	1582 (344, 2458)	315 (93, 434)	1397 (93, 2458)
high-frequency trader trade participation rate (%)	15.7 (8.6, 19.0)	6.9 (2.1, 9.8)	14.4 (2.1, 19.0)
high-frequency trader latency, min time cancel-resubmit (millisec)	1.17 (1.00, 3.00)	4.56 (1.00, 9.00)	1.67 (1.00, 9.00)
<i>panel B: aggregate trading statistics</i>			
daily number of trades incumbent market, euronext (1000)			
daily number of trades entrant market, chi-x (1000)			
avg trade size incumbent market, euronext (€1000)			
avg trade size entrant market, chi-x (€1000)			
half spread (0.5*(ask-bid)) incumbent market, euronext (€)			
relative half spread incumbent market, euronext (basis points)			
avg transaction price (€)			



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daily number of trades incumbent market, euronext (1000)	17.0 (7.6, 23.4)	8.5 (5.3, 10.7)	15.8 (5.3, 23.4)
daily number of trades entrant market, chi-x (1000)	2.5 (0.4, 3.9)	0.5 (0.2, 0.6)	2.2 (0.2, 3.9)
avg trade size incumbent market, euronext (€1000)	31.4 (14.7, 41.7)	15.1 (10.6, 20.2)	29.0 (10.6, 41.7)
avg trade size entrant market, chi-x (€1000)	16.8 (7.8, 21.9)	8.1 (6.7, 10.1)	15.5 (6.7, 21.9)
half spread (0.5*(ask-bid)) incumbent market, euronext (€)	0.007 (0.006, 0.011)	0.016 (0.011, 0.025)	0.008 (0.006, 0.025)
relative half spread incumbent market, euronext (basis points)	1.6 (1.3, 2.5)	2.2 (1.6, 3.6)	1.7 (1.3, 3.6)
avg transaction price (€)	22.97 (11.01, 27.24)	37.39 (19.41, 52.72)	25.08 (11.01, 52.72)

# HFT gross profit and capital employed

variable	large stocks	small stocks	all stocks
<i>panel A: gross profit</i>			
gross profit per day (€)	1649 (-50, 2751)	55 (-47, 125)	1416 (-50, 2751)
gross profit per trade (€)	0.99 (-0.15, 1.62)	0.19 (-0.18, 0.78)	0.88 (-0.18, 1.62)
positioning profit per trade (€)	-0.69 (-0.90, -0.30)	-0.61 (-1.79, -0.07)	-0.68 (-1.79, -0.07)
net spread per trade (€)	1.68 (0.76, 2.15)	0.80 (0.25, 1.64)	1.55 (0.25, 2.15)
<i>panel B: capital employed</i>			
actual capital employed			
avg margin specific risk (€1000)			
avg margin gen market risk (€1000)			
max margin specific risk (€1000)			
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capital employed if netting across markets were allowed			
avg margin specific risk (€1000)			
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<i>panel C: Sharpe ratio (based on realized maximum margin)</i>			
actual capital used			
avg daily net return in excess of riskfree rate (bps)			
st dev daily return (bps)			
annualized Sharpe ratio			

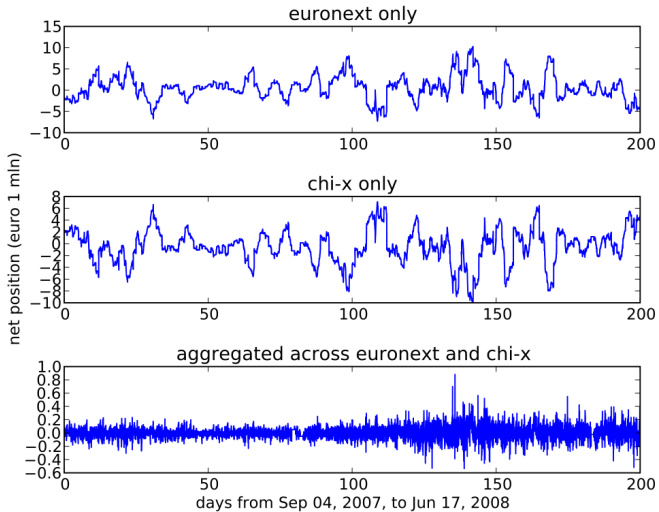
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<i>panel B: capital employed</i>			
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avg margin specific risk (€1000)	308 (62, 441)	62 (13, 83)	272 (13, 441)
avg margin gen market risk (€1000)	95 (18, 139)	18 (4, 25)	84 (4, 139)
max margin specific risk (€1000)	1837 (485, 3206)	522 (90, 1000)	1645 (90, 3206)
max margin gen market risk (€1000)	461 (88, 674)	89 (21, 122)	407 (21, 674)
capital employed if netting across markets were allowed			
avg margin specific risk (€1000)	3.04 (0.79, 3.87)	0.57 (0.20, 0.79)	2.68 (0.20, 3.87)
avg margin gen market risk (€1000)	0.99 (0.25, 1.28)	0.18 (0.07, 0.25)	0.87 (0.07, 1.28)
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avg margin gen market risk (€1000)	0.99 (0.25, 1.28)	0.18 (0.07, 0.25)	0.87 (0.07, 1.28)
<i>panel C: Sharpe ratio (based on realized maximum margin)</i>			
actual capital used			
avg daily net return in excess of riskfree rate (bps)	6.80 (-1.31, 14.11)	0.32 (-2.03, 2.71)	5.86 (-2.03, 14.11)
st dev daily return (bps)	9.96 (6.60, 20.74)	8.14 (3.30, 22.15)	9.69 (3.30, 22.15)
annualized Sharpe ratio	10.77 (-3.14, 14.68)	1.02 (-3.06, 4.60)	9.35 (-3.14, 14.68)

# net position HFT by market



# positioning profit decomposition

variable	large stocks	small stocks	all stocks
ultra-high frequency, period $\leq$ 5sec (€)	0.49 (0.21, 0.59)	0.24 (0.15, 0.39)	0.45 (0.15, 0.59)
high frequency, 5sec<period $\leq$ 1 min (€)	-0.30 (-0.41, 0.04)	0.02 (-0.08, 0.20)	-0.25 (-0.41, 0.20)
medium frequency, 1min<period $\leq$ 1hour (€)	-0.67 (-0.99, -0.05)	-0.65 (-1.56, -0.17)	-0.67 (-1.56, -0.05)
low frequency, 1hour<period $\leq$ 1day (€)	-0.18 (-0.40, -0.06)	-0.15 (-0.43, -0.08)	-0.17 (-0.43, -0.06)
ultra-low frequency, 1day<period (€)	-0.03 (-0.13, 0.02)	-0.07 (-0.17, -0.01)	-0.04 (-0.17, 0.02)
total positioning profit per trade (€)	-0.69 (-0.90, -0.30)	-0.61 (-1.79, -0.07)	-0.68 (-1.79, -0.07)

*panel B: net position variance decomposition*

ultra-high frequency, period $\leq$ 5sec (€)

high frequency, 5sec<period $\leq$ 1 min (€)

medium frequency, 1min<period $\leq$ 1hour (€)

low frequency, 1hour<period $\leq$ 1day (€)

ultra-low frequency, 1day<period (€)

net position variance (mln shares)

# positioning profit decomposition

variable	large stocks	small stocks	all stocks
ultra-high frequency, period $\leq$ 5sec (€)	0.49 (0.21, 0.59)	0.24 (0.15, 0.39)	0.45 (0.15, 0.59)
high frequency, 5sec<period $\leq$ 1 min (€)	-0.30 (-0.41, 0.04)	0.02 (-0.08, 0.20)	-0.25 (-0.41, 0.20)
medium frequency, 1min<period $\leq$ 1hour (€)	-0.67 (-0.99, -0.05)	-0.65 (-1.56, -0.17)	-0.67 (-1.56, -0.05)
low frequency, 1hour<period $\leq$ 1day (€)	-0.18 (-0.40, -0.06)	-0.15 (-0.43, -0.08)	-0.17 (-0.43, -0.06)
ultra-low frequency, 1day<period (€)	-0.03 (-0.13, 0.02)	-0.07 (-0.17, -0.01)	-0.04 (-0.17, 0.02)
total positioning profit per trade (€)	-0.69 (-0.90, -0.30)	-0.61 (-1.79, -0.07)	-0.68 (-1.79, -0.07)
<i>panel B: net position variance decomposition</i>			
ultra-high frequency, period $\leq$ 5sec (€)	0.042 (0.001, 0.060)	0.001 (0.000, 0.001)	0.036 (0.000, 0.060)
high frequency, 5sec<period $\leq$ 1 min (€)	0.539 (0.017, 0.761)	0.007 (0.001, 0.011)	0.461 (0.001, 0.761)
medium frequency, 1min<period $\leq$ 1hour (€)	9.182 (0.362, 20.336)	0.145 (0.024, 0.307)	7.862 (0.024, 20.336)
low frequency, 1hour<period $\leq$ 1day (€)	4.503 (0.247, 17.624)	0.085 (0.022, 0.271)	3.858 (0.022, 17.624)
ultra-low frequency, 1day<period (€)	1.885 (0.101, 7.284)	0.045 (0.008, 0.170)	1.616 (0.008, 7.284)
net position variance (mln shares)	16.150 (0.728, 45.866)	0.284 (0.059, 0.760)	13.833 (0.059, 45.866)

## net spread decomposition

variable	large stocks	small stocks	all stocks
<i>panel A: high-frequency trader in both markets</i>			
entrant market (chi-x) trade share (%)	49.8 (43.7, 62.8)	56.5 (51.6, 63.6)	50.8 (43.7, 63.6)
net spread per trade (€)	1.68 (0.76, 2.15)	0.80 (0.25, 1.64)	1.55 (0.25, 2.15)
<i>panel B: high-frequency trader in incumbent market (euronext)</i>			
#trades per day	770 (216, 1189)	180 (48, 276)	684 (48, 1189)
fraction of passive trades (%)	79.5 (70.5, 82.5)	70.0 (58.7, 81.6)	78.1 (58.7, 82.5)
net spread per trade (€)	0.72 (0.09, 1.27)	-0.07 (-0.44, 1.01)	0.61 (-0.44, 1.27)
net spread per trade, passive orders (€)			
gross spread per trade, passive orders (€)			
exchange fee per trade, passive orders (€)			
clearing fee per trade, passive orders (€)			
net spread per trade, aggressive orders (€)			
gross spread per trade, aggressive trades (€)			
exchange fee per trade, aggressive orders (€)			
clearing fee per trade, aggressive orders (€)			



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fraction of passive trades (%)	79.5 (70.5, 82.5)	70.0 (58.7, 81.6)	78.1 (58.7, 82.5)
net spread per trade (€)	0.72 (0.09, 1.27)	-0.07 (-0.44, 1.01)	0.61 (-0.44, 1.27)
net spread per trade, passive orders (€)	1.26 (0.31, 2.03)	0.23 (0.05, 1.50)	1.11 (0.05, 2.03)
gross spread per trade, passive orders (€)	2.25 (1.25, 2.99)	1.17 (0.97, 2.44)	2.09 (0.97, 2.99)
exchange fee per trade, passive orders (€)	-0.68 (-0.71, -0.65)	-0.64 (-0.66, -0.62)	-0.68 (-0.71, -0.62)
clearing fee per trade, passive orders (€)	-0.30 (-0.32, -0.29)	-0.30 (-0.31, -0.29)	-0.30 (-0.32, -0.29)
net spread per trade, aggressive orders (€)	-1.35 (-2.21, -0.80)	-0.75 (-1.12, -0.23)	-1.26 (-2.21, -0.23)
gross spread per trade, aggressive trades (€)	-0.39 (-1.28, 0.17)	0.16 (-0.23, 0.66)	-0.31 (-1.28, 0.66)
exchange fee per trade, aggressive orders (€)	-0.67 (-0.70, -0.63)	-0.63 (-0.64, -0.62)	-0.67 (-0.70, -0.62)
clearing fee per trade, aggressive orders (€)	-0.29 (-0.30, -0.26)	-0.28 (-0.29, -0.27)	-0.29 (-0.30, -0.26)

# net spread decomposition

variable	large stocks	small stocks	all stocks
<i>panel C: high-frequency trader in entrant market (chi-x)</i>			
#trades per day	812 (128, 1269)	135 (45, 183)	713 (45, 1269)
fraction of passive trades (%)	77.1 (71.4, 81.8)	83.3 (79.0, 90.7)	78.0 (71.4, 90.7)
net spread per trade (€)	2.63 (1.88, 3.17)	1.92 (1.46, 3.05)	2.52 (1.46, 3.17)
net spread per trade, passive orders (€)			
gross spread per trade, passive orders (€)			
exchange fee per trade, passive orders (€)			
clearing fee per trade, passive orders (€)			
net spread per trade, aggressive orders (€)			
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# net spread decomposition

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#trades per day	812 (128, 1269)	135 (45, 183)	713 (45, 1269)
fraction of passive trades (%)	77.1 (71.4, 81.8)	83.3 (79.0, 90.7)	78.0 (71.4, 90.7)
net spread per trade (€)	2.63 (1.88, 3.17)	1.92 (1.46, 3.05)	2.52 (1.46, 3.17)
net spread per trade, passive orders (€)	2.63 (1.97, 3.15)	1.87 (1.46, 3.14)	2.52 (1.46, 3.15)
gross spread per trade, passive orders (€)	2.46 (1.97, 3.05)	1.90 (1.49, 3.17)	2.38 (1.49, 3.17)
exchange fee per trade, passive orders (€)	0.34 (0.18, 0.45)	0.16 (0.11, 0.21)	0.31 (0.11, 0.45)
clearing fee per trade, passive orders (€)	-0.16 (-0.18, -0.14)	-0.19 (-0.22, -0.17)	-0.17 (-0.22, -0.14)
net spread per trade, aggressive orders (€)	2.61 (1.51, 3.36)	2.21 (1.43, 3.78)	2.55 (1.43, 3.78)
gross spread per trade, aggressive trades (€)	3.30 (1.91, 4.11)	2.65 (1.83, 4.18)	3.21 (1.83, 4.18)
exchange fee per trade, aggressive orders (€)	-0.48 (-0.61, -0.18)	-0.22 (-0.28, -0.18)	-0.45 (-0.61, -0.18)
clearing fee per trade, aggressive orders (€)	-0.21 (-0.22, -0.19)	-0.21 (-0.23, -0.20)	-0.21 (-0.23, -0.19)

## HFT position, price innovation, and price pressure

state space model naturally decomposes price changes ( $\Delta p_{t,\tau}$ ) into

- a transitory component (pricing error  $s_{t,\tau}$ )
- a permanent component (efficient price innovation  $\Delta m_{t,\tau}$ )

$$p_{t,\tau} = m_{t,\tau} + s_{t,\tau}$$

$$m_{t,\tau} = m_{t,\tau-1} + \eta_{t,\tau}$$

$$s_{t,\tau} = \varepsilon_{t,\tau}$$

Menkveld, Koopman, and Lucas (2007)

# HFT position, price innovation, and price pressure

$$\begin{aligned}p_{t,\tau} &= m_{t,\tau} + s_{t,\tau} \\m_{t,\tau} &= m_{t,\tau-1} + \kappa_\tau \tilde{n}_{t,\tau} + \eta_{t,\tau} \quad (\text{where } \tilde{n}_{t,\tau} := n_{t,\tau} - E_{t,\tau-1}(n_{t,\tau})) \\s_{t,\tau} &= \alpha_\tau n_{t,\tau} + \varepsilon_{t,\tau}\end{aligned}$$

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 p_{t,\tau} &= m_{t,\tau} + s_{t,\tau} \\
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 s_{t,\tau} &= \alpha_{\tau} n_{t,\tau} + \varepsilon_{t,\tau}
 \end{aligned}$$

variable	time	large stocks	small stocks	all stocks
<i>panel A: net position</i>				
stdev net position, $\sigma(n)$ (€1000)	9:00-12:00	64.6 (22.7, 80.3)	15.4 (7.2, 20.4)	57.5 (7.2, 80.3)
	12:00-15:00	80.3 (25.1, 101.8)	19.0 (7.2, 25.5)	71.3 (7.2, 101.8)
	15:00-17:30	95.4 (24.8, 128.9)	19.9 (7.3, 26.7)	84.4 (7.3, 128.9)
ar1 coefficient net position, $n$	9:00-12:00	0.46 (0.38, 0.68)	0.56 (0.48, 0.73)	0.48 (0.38, 0.73)
	12:00-15:00	0.50 (0.43, 0.69)	0.56 (0.48, 0.72)	0.51 (0.43, 0.72)
	15:00-17:30	0.39 (0.30, 0.64)	0.43 (0.35, 0.62)	0.40 (0.30, 0.64)
	17:30-9:00 (+1)	0.02 (-0.01, 0.09)	0.04 (-0.03, 0.12)	0.02 (-0.03, 0.12)

# HFT position, price innovation, and price pressure

$$p_{t,\tau} = m_{t,\tau} + s_{t,\tau}$$

$$m_{t,\tau} = m_{t,\tau-1} + \kappa_{\tau} \tilde{n}_{t,\tau} + \eta_{t,\tau} \quad (\text{where } \tilde{n}_{t,\tau} := n_{t,\tau} - E_{t,\tau-1}(n_{t,\tau}))$$

$$s_{t,\tau} = \alpha_{\tau} n_{t,\tau} + \varepsilon_{t,\tau}$$

variable	time	large stocks	small stocks	all stocks
<i>panel B: permanent price change (<math>\Delta m</math>)</i>				
cond adverse selection, $\kappa$ (bp/€1000)	9:00-12:00	-0.036 (-0.073, -0.023)	-0.098 (-0.420, -0.049)	-0.045 (-0.420, -0.023)
	12:00-15:00	-0.024 (-0.053, -0.010)	-0.068 (-0.216, -0.029)	-0.031 (-0.216, -0.010)
	15:00-17:30	-0.019 (-0.042, -0.011)	-0.070 (-0.278, -0.028)	-0.027 (-0.278, -0.011)
	17:30-9:00 (+1)	0.014 (-0.377, 0.101)	0.102 (-0.453, 3.477)	0.027 (-0.453, 3.477)
	var adv selection, $\sigma^2(\kappa\tilde{n})$ (bp <sup>2</sup> /hr)	9:00-12:00	42.2 (8.8, 61.0)	13.1 (3.7, 54.6)
	12:00-15:00	31.8 (2.5, 68.4)	9.0 (1.1, 23.0)	28.5 (1.1, 68.4)
	15:00-17:30	31.3 (6.2, 70.0)	13.3 (2.6, 74.5)	28.7 (2.6, 74.5)
	17:30-9:00 (+1)	0.3 (0.0, 0.7)	0.7 (0.0, 10.4)	0.3 (0.0, 10.4)
var perm price change, $\sigma^2(\Delta m)$ (bp <sup>2</sup> /hr)	9:00-12:00	10953 (5330, 16029)	7015 (3878, 29296)	10378 (3878, 29296)
	12:00-15:00	7336 (3237, 15730)	3919 (2506, 12627)	6837 (2506, 15730)
	15:00-17:30	8092 (2977, 17613)	5416 (2824, 32240)	7702 (2824, 32240)
	17:30-9:00 (+1)	690 (374, 1070)	764 (436, 3720)	700 (374, 3720)

# HFT position, price innovation, and price pressure

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 m_{t,\tau} &= m_{t,\tau-1} + \kappa_{\tau} \tilde{n}_{t,\tau} + \eta_{t,\tau} \quad (\text{where } \tilde{n}_{t,\tau} := n_{t,\tau} - E_{t,\tau-1}(n_{t,\tau})) \\
 s_{t,\tau} &= \alpha_{\tau} n_{t,\tau} + \varepsilon_{t,\tau}
 \end{aligned}$$

variable	time	large stocks	small stocks	all stocks
<i>panel C: price pressure (s)</i>				
cond price pressure, $\alpha$ (bp/€1000)	9:00-12:00	-0.043 (-0.132, -0.017)	-0.148 (-0.540, -0.084)	-0.059 (-0.540, -0.017)
	12:00-15:00	-0.027 (-0.102, -0.007)	-0.101 (-0.431, -0.019)	-0.038 (-0.431, -0.007)
	15:00-17:30	-0.066 (-0.330, 0.108)	0.058 (-0.379, 2.092)	-0.048 (-0.379, 2.092)
var price pressure, $\sigma^2(\alpha n)$ (bp <sup>2</sup> )	9:00-12:00	7.1 (1.3, 12.5)	4.5 (1.7, 28.3)	6.7 (1.3, 28.3)
	12:00-15:00	4.5 (0.5, 10.0)	2.9 (0.1, 17.2)	4.3 (0.1, 17.2)
	15:00-17:30	102.0 (0.1, 504.2)	53.6 (0.4, 234.2)	94.9 (0.1, 504.2)
var pricing error, $\sigma^2(s)$ (bp <sup>2</sup> )	9:00-12:00	10.1 (1.5, 27.5)	10.6 (1.9, 33.2)	10.2 (1.5, 33.2)
	12:00-15:00	9.5 (0.8, 20.0)	16.2 (6.1, 55.1)	10.5 (0.8, 55.1)
	15:00-17:30	115.4 (15.8, 523.7)	65.8 (1.0, 253.6)	108.2 (1.0, 523.7)



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- strategy's sharpe ratio is 9.35
- HFT position correlates with price changes, both with pricing errors and with efficient price innovations

# high frequency trading and the *new-market* makers

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