

# Cross-Venue Liquidity Provision: High Frequency Trading and Ghost Liquidity

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*Our own views and not necessarily those of ESMA*

# The concept of “ghost” or “phantom” liquidity (GL)

GL = **liquidity overprovision** / liquidity supplied to markets but not intended to be executed in full => **fast cancellations**

- **GL in a single market setting:** fast traders temporarily overprovide depth to get to the front of the limit order queue, then cancel (Yueshen, 2014; Blocher, Cooper, Seddon, & van Vliet, 2016; Dahlström, Hågströmer, & Nordén, 2018)
- **GL in fragmented markets**
  - A fast liquidity provider / 2 markets A & B
  - Submitting LO on A only => Miss out trading opportunities on B
  - Duplicating LO on B => Increase execution probability  
& Avoid time priority on A
  - When executed on one venue => **fast cancellation** on the other one  
=> **inaccessible** to unsophisticated liquidity traders
  - However **risk of over-execution**, in particular by SORs

## The concept of “ghost” or “phantom” liquidity (GL) – cont’d

GL = **liquidity overprovision** / liquidity supplied to markets but not intended to be executed in full => **fast cancellations**

- **Key implications**
  - **Unstable** form of liquidity in fragmented markets
  - **Overestimation of consolidated depth** available to slow liquidity traders
  - **Challenge the liquidity benefits of fragmentation** found in the literature (Foucault & Menkveld, 2008; O’Hara & Ye, 2011; Degryse, De Jong, & van Kervel, 2015; Gresse, 2017)

# Paper motivation and research questions

- **Limit order duplication** in multiple order books
  - ESMA (2014,6) reports on HFT and duplicated orders
    - About 20% of all orders are duplicated.
    - About 24% of those are cancelled (or repriced outside normal bands) after an order is hit on another venue.
- **Cancellations in reaction to trades on other venues**
  - Van Kervel's (2015)
    - A trade on one venue, within 100 milliseconds, is followed by cancellations of limit orders on the same side of competing venues with a value of 29 to 67% of the trade size.
    - **Quote updating** in reaction to new information / High-frequency market makers supply liquidity across venues / After a trade on one venue they **cancel the liquidity** on the other venue **and reprice it to reflect the information content of trades**
  - Chen, Foley, Goldstein, and Ruf (2018): cancellations by fast traders when see executions on other platforms.

## Paper motivation and research questions – cont'd

- **1) Empirical strategy to measure GL** not related to quote updating upon new information in trades
  - Measure at the trader level
  - Following the same trader across venues
  - Member IDs are key
- **2) Estimate the importance of GL** in fragmented markets and its impact on competition benefits
- **3) Identify the economic determinants of GL**
- **4) Investigate the impact of GL on trading costs**

## Data (kindly provided by ESMA)

- Proprietary dataset collected by ESMA and several National Competent Authorities for the month of May 2013.
- Order book and trade information on 91 stocks that are trading on their primary exchange and the three largest “alternative venues” at that time, i.e., BATS, Chi-X, and Turquoise.
  - The sample was built by using a stratified sampling approach taking into consideration market capitalization, value traded, and fragmentation.
  - More stocks from larger countries (9 different European countries).
- **IDs of 388 members that we can track across all platforms**
  - Key for identification of behavior of the same member across platforms  $\neq$  van Kervel (RFS 2015)
- Trade data are timestamped to the millisecond.
- Order book information recorded every 10-milliseconds.

# Market members

Trading scope	Trading aggressiveness	Trading speed	Capacity	Number of member/stock combinations	% in trading volume				
					Total	Primary exchange	BATS	Chi-X	Turquoise
Local trader	Liquidity taker	Slow	A	3,259	15.80%	15.72%	0.01%	0.06%	0.01%
			P	1,241	4.88%	4.31%	0.02%	0.37%	0.18%
		AT	A	247	3.79%	3.78%	0.00%	0.01%	0.00%
			P	105	0.39%	0.30%	0.00%	0.03%	0.06%
	Liquidity supplier	HFT	P	34	0.35%	0.19%	0.00%	0.16%	0.00%
		Slow	P	545	0.99%	0.81%	0.01%	0.10%	0.07%
			AT	P	122	0.50%	0.36%	0.01%	0.12%
		HFT	P	61	0.48%	0.29%	0.01%	0.18%	0.01%
Global trader	Liquidity taker	Slow	A	527	3.23%	1.87%	0.24%	0.89%	0.22%
			P	817	20.22%	11.70%	1.13%	5.27%	2.12%
		AT	A	189	3.18%	1.82%	0.18%	0.63%	0.55%
			P	231	7.37%	4.19%	0.42%	1.59%	1.18%
	Liquidity supplier	HFT	P	305	15.31%	8.34%	0.94%	4.11%	1.93%
		Slow	P	441	9.69%	5.73%	0.57%	2.42%	0.98%
			AT	P	218	7.75%	3.13%	0.64%	2.44%
		HFT	P	226	6.06%	1.81%	0.76%	2.54%	0.94%
Total				8,568	100%	64.35%	4.92%	20.91%	9.82%

Global = 73% of total trading

ATs = 23% of total trading (26% of trading on alt. venues)

HFTs = 22% of total trading (32.5% of trading on alt.venues)

Liquidity suppliers = 25.5% of total trading (37.5% on alt. venues)

# Measuring Ghost Liquidity (GL)

- We compute GL by member  $m$  on venue  $qv$ , following a trade on venue  $tv$  in stock  $i$  at a time  $t$  in between  $t-x$  and  $t+y$  ( $x+y=10\text{ms}$ )

$$GL_{tv \rightarrow qv}^{ask}(t; i; m) = \underset{\substack{\uparrow \\ \text{Quantity on } qv \\ \text{immediately before} \\ \text{the trade on } tv \\ \text{(time } t-x\text{)}}}{PREQTY_{qv}^{ask}(t; i; m)} - \underset{\substack{\uparrow \\ \text{Quantity on } qv \\ \text{immediately after} \\ \text{the trade on } tv \\ \text{(time } t+y\text{)}}}{POSTQTY_{qv}^{ask}(t; i; m)} - \underset{\substack{\uparrow \\ \text{Executions on } qv \\ \text{within the same} \\ \text{time window} \\ \text{(} x+y=10\text{ms)}}}{\sum_{t; \Delta t} Volume_{qv}^{buy}(i; m)}$$

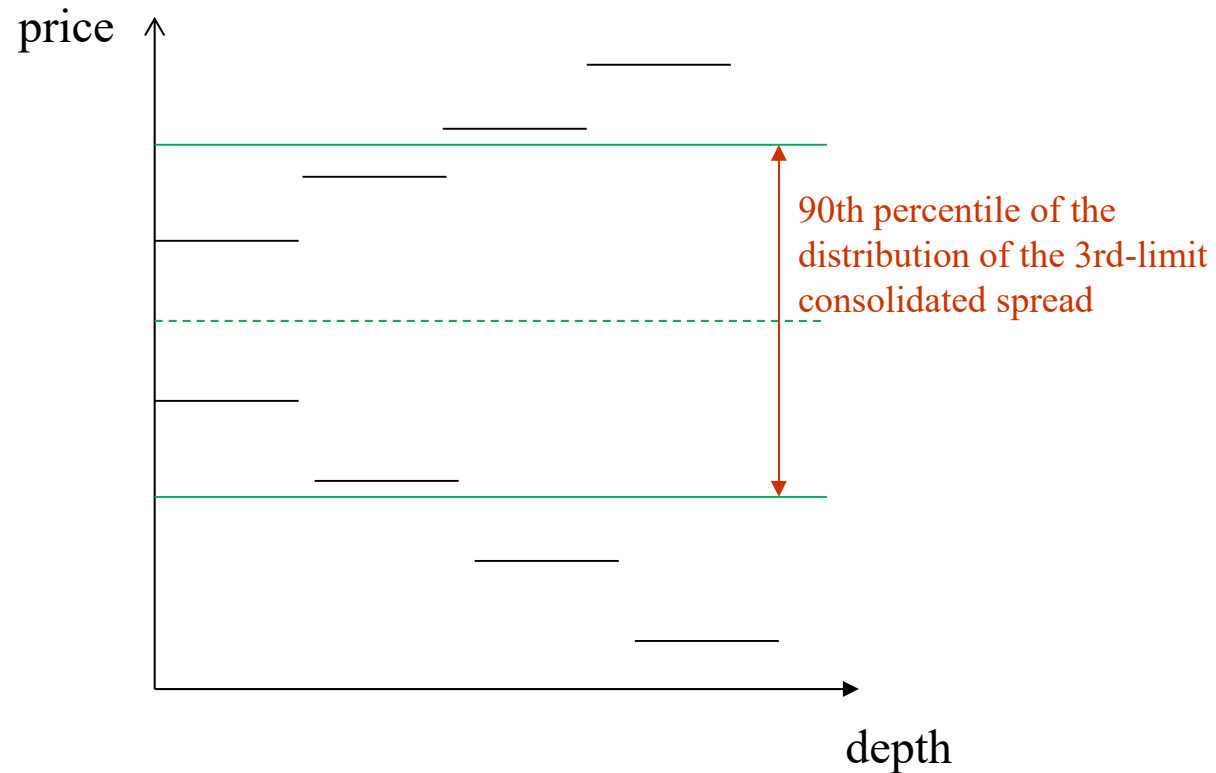
- GL at day  $d$  as a percentage of pre-trade liquidity

$$GL_{tv \rightarrow qv}(i; d; m) = \frac{\sum_{t \in d} GL_{tv \rightarrow qv}^{bid}(t; i; m) + \sum_{t \in d} GL_{tv \rightarrow qv}^{ask}(t; i; m)}{\sum_{t \in d} PREQTY_{qv}^{bid}(t; i; m) + \sum_{t \in d} PREQTY_{qv}^{ask}(t; i; m)}$$

- GL at day  $d$  as a percentage of trade size on  $tv$



# Depth measure



We compute GL considering only orders within a certain distance of the midquote “**stock-specific price range**”.

## Measuring Ghost Liquidity (GL) – cont'd

- **Refill rate** in the next 10 ms

$$Refill_{tv \rightarrow qv}^{ask}(t+10ms; i; m) =$$

$$\left( POSTQTY_{qv}^{ask}(t+10ms; i; m) - PREQTY_{qv}^{ask}(t+10ms; i; m) + \sum_{t+10ms} Volume_{qv}^{buy}(i; m) \right) / GL_{tv \rightarrow qv}^{ask}(t; i; m)$$

- Observations are at member×stock×day×tv×qv.
- Averages
  - per stock×day×tv×qv weighted by members' weights in qv's book
  - per stock for the whole period
  - across stocks for the whole sample / by sub-samples




# GL as a percentage of pre-trade liquidity

		10ms	Refill rate in the next 10ms	20ms	50ms	100ms
All stocks		4.04%	-0.34%	4.20%	4.26%	4.34%
<b>By pair of platforms</b>						
<i>GL venue</i>	<i>Trade venue</i>					
Primary exchange	Chi-X	3.74%	-0.48%	3.87%	3.92%	4.02%
	BATS	1.96%	-0.19%	2.00%	1.69%	1.50%
	Turquoise	3.30%	-0.57%	3.38%	3.34%	3.37%
Chi-X	Primary exchange	6.61%	-0.86%	7.11%	7.58%	7.80%
	BATS	5.25%	-1.03%	5.56%	5.48%	4.97%
	Turquoise	6.31%	-0.31%	6.51%	6.63%	6.60%
BATS	Primary exchange	6.19%	-0.68%	6.82%	7.54%	7.93%
	Chi-X	8.50%	-1.41%	9.39%	9.77%	9.72%
	Turquoise	8.55%	-0.86%	8.79%	9.02%	9.21%
Turquoise	Primary exchange	5.86%	0.65%	6.07%	6.45%	6.73%
	Chi-X	5.99%	-0.33%	6.28%	6.34%	6.30%
	BATS	4.94%	-0.89%	5.13%	5.03%	5.17%

## GL as a percentage of trade size

		10ms	20ms	50ms	100ms
All stocks		18.89%	20.11%	20.34%	21.07%
<b>By pair of platforms</b>					
<i>GL venue</i>	<i>Trade venue</i>				
Primary exchange	Chi-X	22.87%	24.11%	22.61%	23.49%
	BATS	19.02%	21.32%	21.91%	22.28%
	Turquoise	19.43%	20.16%	21.13%	21.78%
Chi-X	Primary exchange	16.62%	17.81%	19.53%	20.31%
	BATS	30.67%	32.38%	35.42%	36.10%
	Turquoise	25.91%	27.85%	29.54%	31.25%
BATS	Primary exchange	12.84%	14.41%	16.89%	17.30%
	Chi-X	30.29%	33.05%	34.93%	35.60%
	Turquoise	30.81%	31.69%	33.76%	35.90%
Turquoise	Primary exchange	16.60%	17.48%	18.31%	19.55%
	Chi-X	26.62%	28.38%	29.04%	30.48%
	BATS	27.30%	28.58%	27.38%	30.26%

# GL by stock terciles

		Average GL as a % of pre- trade liquidity (10ms)	Refill rate in the next 10ms	Average GL as a % of trade size (10ms)	
Market value tercile	Market value range (EUR Mn)				
1	195 to 1,833	3.45%	0.39%	16.17%	
2	1,989 to 5,846	3.86%	-0.50%	17.98%	
3	6,152 to 118,942	4.79%	-0.88%	22.42%	
Volatility tercile	Daily volatility range				
1	0.0706% to 0.1253%	4.96%	-0.52%	22.74%	
2	0.1266% to 0.1549%	3.97%	-0.22%	18.78%	
3	0.1549% to 0.3266%	3.17%	-0.26%	15.04%	
Fragmentation tercile	Fragmentation index range				
1	1.0604 to 1.5520	1.68%	0.42%	7.18%	 13
2	1.5553 to 2.0663	3.35%	-0.27%	15.10%	
3	2.0831 to 3.0714	7.00%	-1.13%	33.90%	

## GL by member category

		Average GL as a % of pre- trade liquidity (10ms)	% of cases with duplication	Refill rate in the next 10ms	Average GL as a % of trade size (10ms)
<b>Trading aggressiveness</b>	Liquidity Taker	3.69%	34.42%	1.34%	13.53%
	Liquidity Supplier	3.81%	54.84%	-0.02%	18.43%
<b>Trading scope</b>	Local	2.11%	3.31%	0.26%	11.59%
	Global	3.80%	57.81%	0.38%	16.50%
<b>Trading speed</b>	Slow	2.70%	32.60%	0.06%	12.32%
	AT	3.76%	56.84%	0.81%	12.52%
	HFT	5.75%	53.65%	0.09%	16.87%
<b>Capacity</b>	Agent	1.94%	16.78%	3.16%	5.48%
	Principal	3.93%	51.23%	0.42%	17.56%

# GL determinants – Tested hypotheses

- **Main hypo.:** GL = tool used by fast traders when providing liquidity to increase expected profits by reducing execution delays & non-execution risk
  - **H1.** GL increases with order flow **fragmentation**.
  - **H2.** GL increases with **tick size**.
  - **H3.** LS post more GL.
  - **H4.** More GL when trading as **principal**
  - **H5.** GL increases with **inventory** (in excess, in absolute terms).
  - **H6.** GL greater with **trading speed** advantage (HFT, AT)
  - **H7.** GL decreases with **SOR**.
  - **H8.** GL greater on **alternative venues**.
- **Control for**
  - GL of others
  - Liquidity determinants (*volume, volatility, price level, trade size*)
  - Informational content of trades proxied by order imbalance

# GL determinants (Tobit regressions)

GL as fraction of	pre-trade liquidity	trade size	
<b>Fragmentation</b>	0.0020***	0.0060***	GL increases with fragmentation.
<b>Tick size</b>	-15.1442***	-128.6595***	H2 rejected
<b>Trading speed advantage</b>			
HFT	0.0788***	0.2197***	Fast traders exhibit higher GL than other members.
AT	0.0280***	0.0547***	
PE-to-alternative	-0.0183***	-0.0611***	Trading on PE generates less GL than trading on ALT.
Alternative-to-PE	0.0267***	0.1100***	
<b>Trading strategy</b>			
Agent	-0.0203***	-0.0522***	LS/trading as principal
Liquidity supplier	0.0258***	0.0851***	→ more GL
<b>Trader's inventory</b>			
Average inventory $_{t-1}$	-0.0009***	-0.0041***	H5 rejected : more GL when inventories are small
<b>Over-execution risk</b>			
SOR $_{t-1}$	0.3755***	1.2192***	Non-linear relation with SOR
$(\text{SOR}_{t-1})^2$	-0.8473***	-3.1961***	GL decreases with SOR over a certain level.
<b>Informational impact of trades</b>			
Order imbalance $_t$	-0.0092***	-0.0383***	Not information-based <sup>16</sup>
Order imbalance $_{t-1}$	-0.0009	0.0009	



# GL determinants (Tobit regressions)

GL as fraction of	Fast traders only	ATs only	HFTs only	Liquidity suppliers only	Fast liquidity suppliers only
<b>Trading speed advantage</b>					
HFT	0.0551***			0.0782***	0.0465***
AT				0.0332***	
PE-to-alternative	-0.0240***	-0.0132***	-0.0363***	-0.0080***	-0.0060***
Alternative-to-PE	-0.0033***	0.0284***	-0.0430***	0.0137***	-0.0178***
<b>Trading strategy</b>					
Agent	-0.0161***	-0.0075***			
Liquidity supplier	0.0280***	0.0440***	0.0199***		
<b>Trader's inventory</b>					
Average inventory $_{t-1}$	H5 -0.0020***	-0.0016***	-0.0026***	-0.0011***	-0.0023***
<b>Over-execution risk</b>					
SOR $_{t-1}$	0.3389***	0.4541***	0.1731***	0.3948***	0.3193***
(SOR $_{t-1}$ ) <sup>2</sup>	-0.9354***	-1.1113***	-0.5573***	-0.9429***	-0.8731***

# Alternative explanations – Is GL really ghost?

- Reshuffling of liquidity towards the trading venue?
  - Refill rates on the TV in the next 10ms close to zero
- Shifting limit orders to other venues?
  - GL consolidated across venues in the same time window exceeds GL on the quote venue.
  - Refill rate in the consolidated order book over the next 10ms = negative
- => Rejection of alternative explanations

# Impact of GL on trading cost

- Impact of GL on the **effective spreads** of
  - 1) Slow liquidity traders
  - 2) Fast liquidity traders
    - ATs
    - HFTs
- **Findings**
  - **Effective spreads paid by slow LT on the PE increase with GL.**
    - Greater economic impact when GL posted by HFTs.
  - Effective spreads paid by algo LTs increase with GL on all venues.
  - **No impact on the trading costs of HFTs**

# Conclusions

- **GL is economically significant** and true consolidated liquidity is overestimated, but limit order duplication not always GL
  - For 100 shares traded on one venue, 19 on average disappear from another order book.
- At market level
  - Over 4% of the consolidated liquidity available at the best limits is “ghost”
  - Around 7% on alternative venues
  - Not sizeable enough to create instability/challenge fragmentation liquidity benefits
- **Determinants of GL**
  - Greater for larger and less volatile stocks / Increasing with fragmentation
  - Liquidity Suppliers / Principal traders / HFTs post more GL
  - Greater on ALT venues / Highest for HFTs between ALT venues
  - Concave relation with SOR / Decreases with SOR only when SOR is very large
  - Not used to reduce extreme inventories but rather to build up inventories
- **Impact on trading costs**
  - Adverse effect on the trading costs of slow liquidity traders on the PE
  - No impact on the trading costs of HFTs

Merci de votre attention.