Liquidity Supply across Multiple Trading Venues

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Market microstructure: confronting many viewpoints, December, 2014

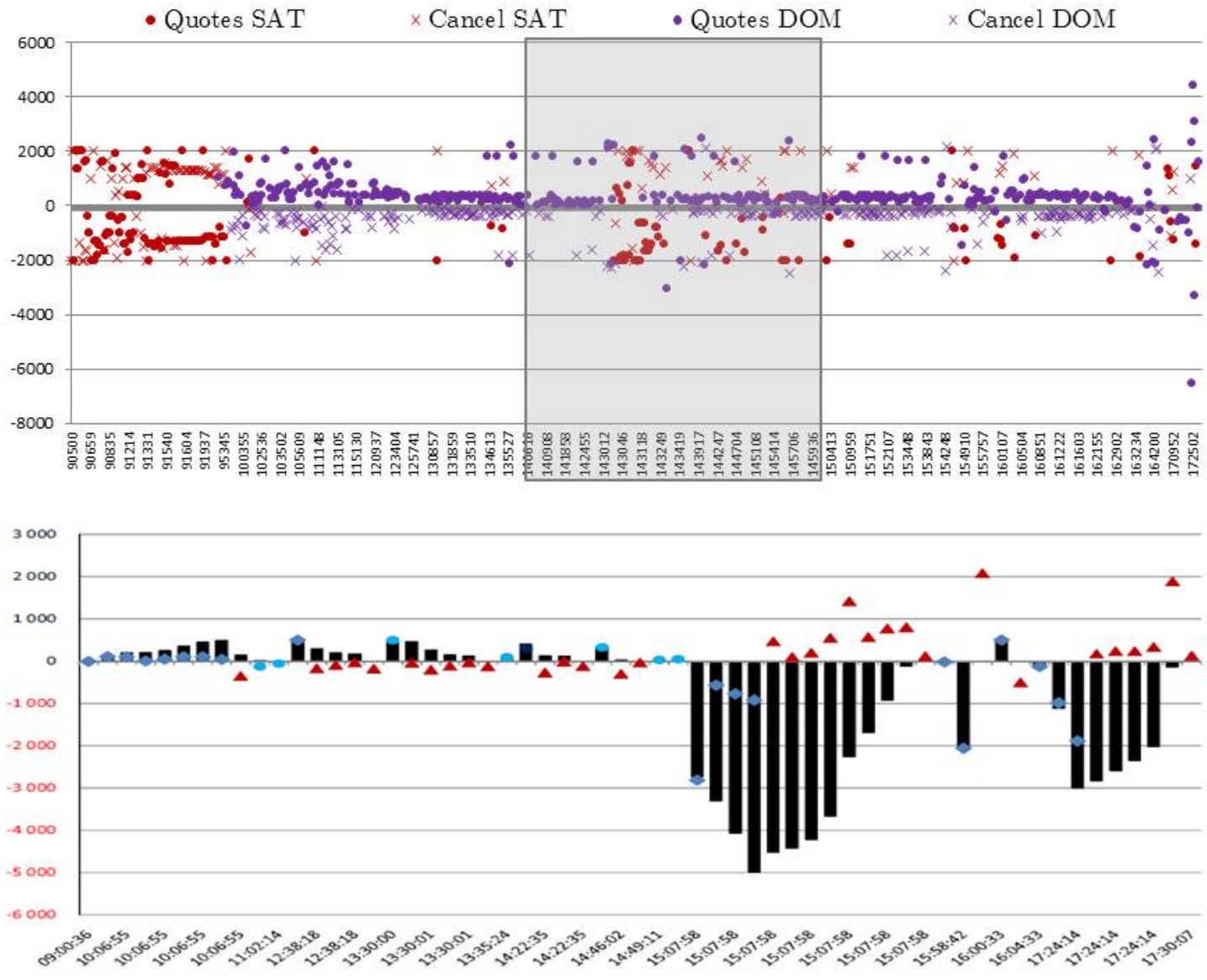
Motivation - Fragmentation and liquidity supply

Fallen technology costs + changes in regulation:

- **Proliferation of trading venues**: for the equity cash market, 27 exchanges and 19 MTFs in Europe
- Response of the trading industry
  - Buy-side: smart order routing systems, execution algorithm,...
  - Sell-side: arbitrage algorithm, **multi-venue market-making strategies**
    - Growing evidence of HFT engaged in multi-venue market-making (KCG Holdings Inc.,)
  - Renewed regulatory concerns: in the U.S. (Mary Jo White, SEC chair), in the E.U. (MiFID 2), in Australia (SCI) ;...
- **Our paper**:
  1. How do multi-venue market makers actively manage their inventories across trading venues?
  2. How does this multi-venue market-making impact liquidity characteristics across venues?

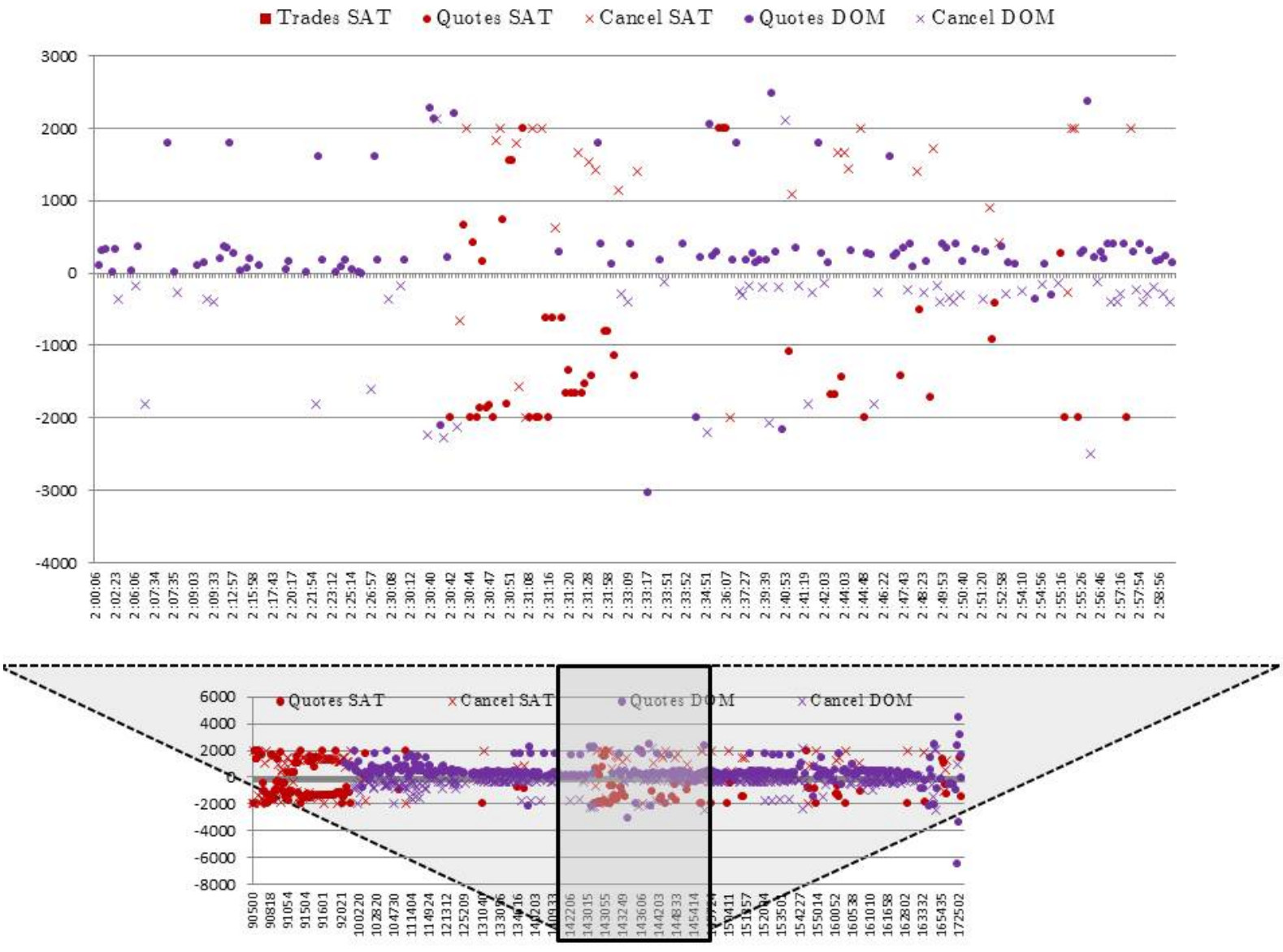
Air-France KLM on January 17, 2007

Updates in Quotes and Trades across venues in Paris and Amsterdam by a single multi-venue market-maker



Air-France KLM on January 17, 2007 - Cont'd

Updates in Quotes and Trades across venues in Paris and Amsterdam by a single multi-venue market-maker



In this paper

What we do

- A simple theoretical model of multi-venue inventory management based on a static version of Ho and Stoll (1983)
  - same pool of liquidity suppliers can trade across several venues
    - **price formation across venues**
    - policy implications: analysis in terms of transaction costs and risk sharing in presence of multi-venue liquidity suppliers
- An empirical analysis using trades and orders containing traders' ID for multi-listed stocks within Euronext (Amsterdam, Brussels, and Paris), pre-MiFID (Jan-Apr 2007)
  - Investigating the impact on venue performance of multi-venue market-making strategies

Related literature

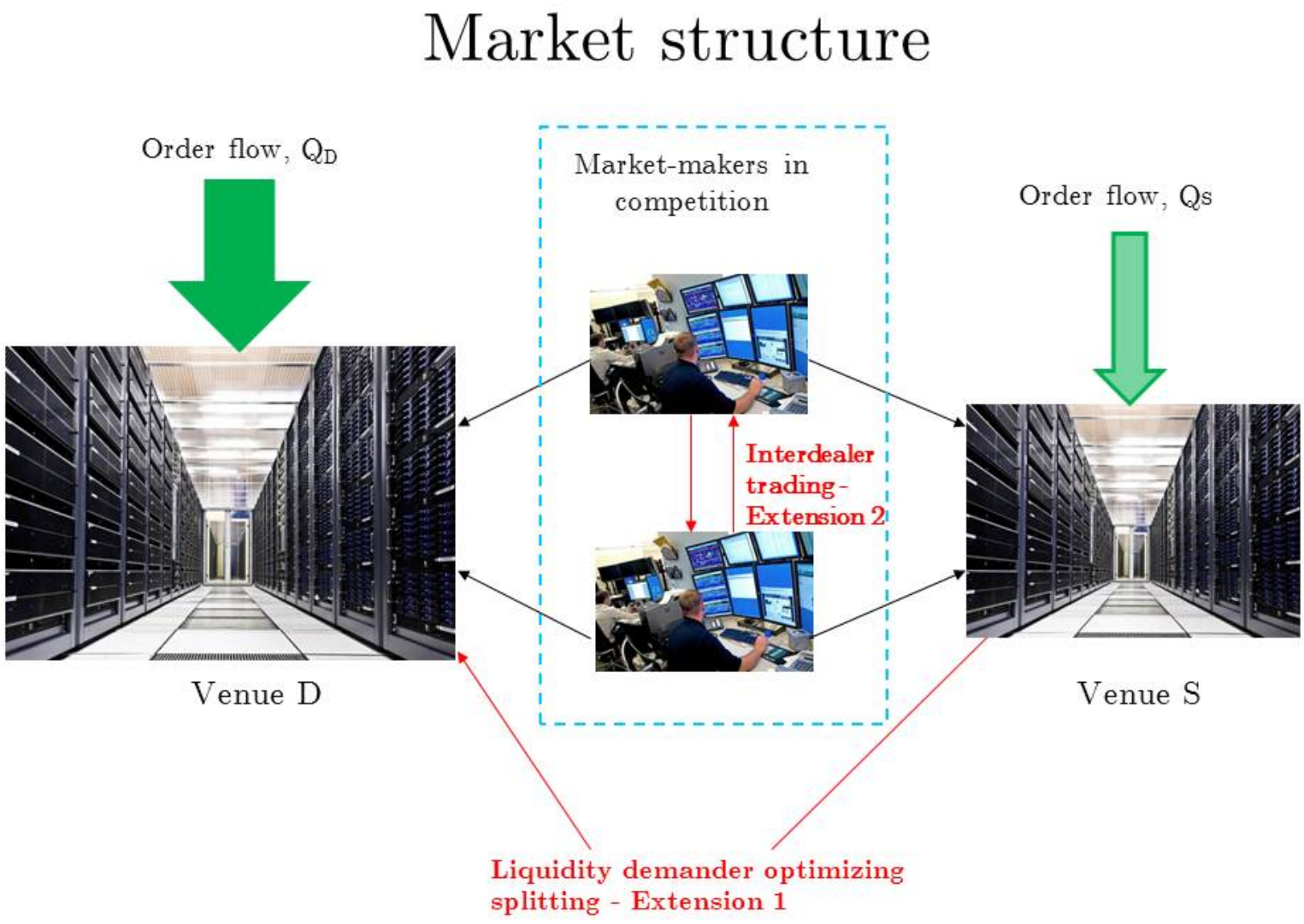
Does fragmentation harm market quality?

- Theory
  - "-": Harms welfare and risk-sharing among liquidity suppliers (Pagano, 1989), increases adverse selection (Chowdhry and Nanda, 1991)
  - "+": Lowers fees (Foucault and Colliard, 2012), fosters inter-market competition (Foucault and Menkveld, 2008)
- Vast empirical literature with mixed results (depending on the degree of transparency)
  - Negative impact of fragmentation: Lee (1993), ... Hatheway et al (2013)
  - Positive impact of fragmentation: Neal (1987), Foucault and Menkveld (2008), O'Hara and Ye (2011), Gresse (2012), Aitken et al (2013), Degryse et al (2014)

Multi-venues strategies

- Duplicate strategies (van Kervel, 2014), arbitrage strategies (Foucault et al, 2014)

The Model in a nutshell



The Model - Main assumptions

- 1 risky asset denoted $\tilde{v}$ distributed according $N(\mu, \sigma^2)$
- 2 types of agents:
  - Liquidity demanders: signed order flow, Q, known in advance
  - Liquidity suppliers: 2 risk-averse strategic dealers endowed with I_i ($U[I_d, I_u]$) such that $I_1 > I_2$. Reservation prices: $r_i(Q) = (\mu - \rho\sigma^2 I_i) + \frac{\rho\sigma^2}{2} Q$; $r_1(Q) < r_2(Q)$.
- Order flow fragments across 2 different venues, D and S. We assume $Q_D + Q_S > 0$, such that
  - $|Q_D| > |Q_S|$
  - $Q_D > 0$ and $Q_S > 0$: a cumulative effect? or $Q_S < 0$: an offsetting effect?
  - $\lambda = Pr((Q_D \neq 0) \cap (Q_S \neq 0))$ and $\gamma = Pr(\text{Same sign})$

A benchmark: batch auction

- Transparency: we assume that both venues, D and S, are visible.

- Benchmark (Batch auction): the total order flow $Q_D + Q_S$ is batch and sent to a single venue
  - The best offer price is set by the dealer with the most extreme inventory position.
  - In our case, dealer 1 posts the best ask price, equal to the reservation price of her competitor

$$a^{batch} = r_2(Q_D + Q_S) - \varepsilon$$

  - ε is equal to the minimum tick size.

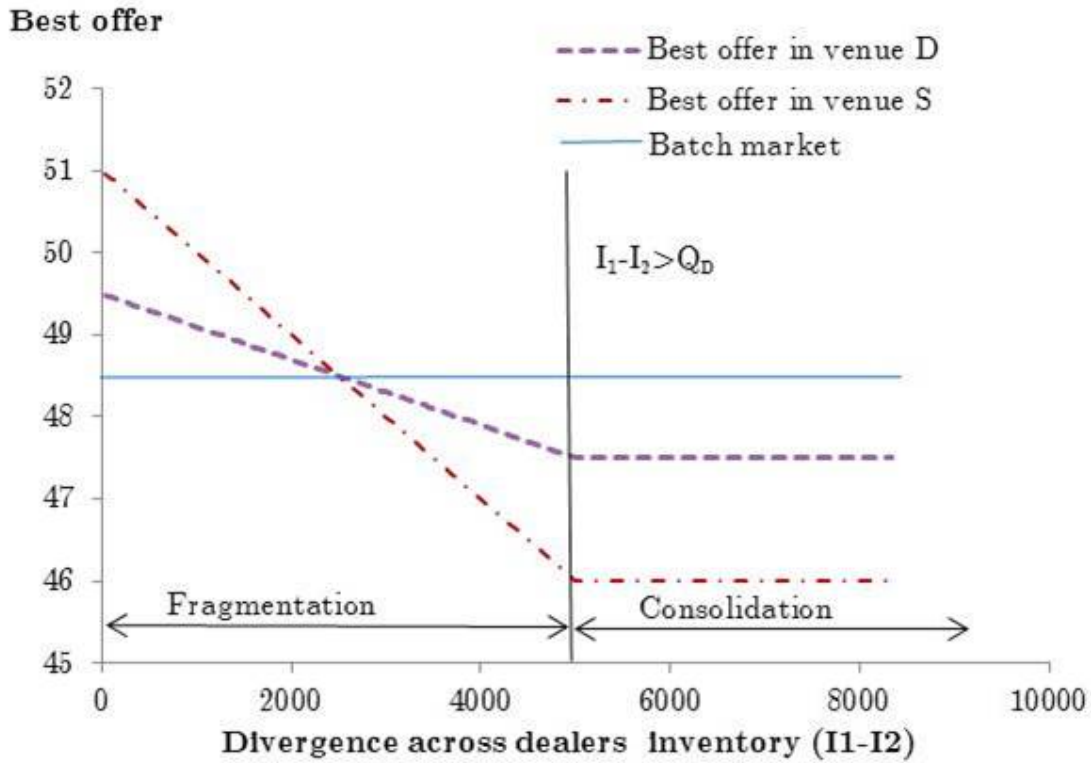
Intuitions and preliminary remarks

- Nash equilibria. Solve backward.
- Lemma 1 (necessary conditions for existence) $\longrightarrow$ 2 cases
  1. Consolidation: a single dealer consolidates the fragmented order flow through a multi-venue execution, i.e., $(I_1 - I_2 - Q_D) \times Q_S > 0$
  2. Fragmentation: the different parts Q_D and Q_S are executed by a different dealer, i.e. each dealer specializes in one venue, i.e., $(I_1 - I_2 - Q_D) \times Q_S < 0$.
- Outcome depends on
  1. the relative divergence of dealers' inventory, $I_1 - I_2$
  2. the way order flow fragments across venue
  3. the possibility of dealers to compete across all venues, or just in one of them

Proposition 1 (Price formation) - A numerical example

Best offers across venues when order flows have the same sign, the inventory divergence $(I_1 - I_2)$ varying.

($\mu = 50$, $\rho = 1$, $\sigma^2 = 0.001$, $Q_D = 5,000$, $Q_S = 2,000$, $I_u = 15,000$, $I_d = 0$, $I_2 = 5,000$ and I_1 is randomized such that $I_1 > I_2$)



Proposition 1 (Price formation) - A numerical example / cont'd

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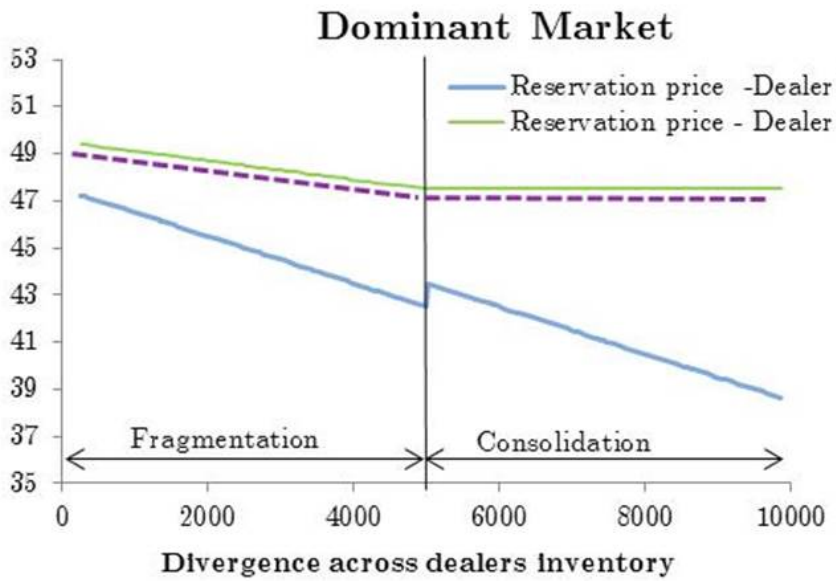
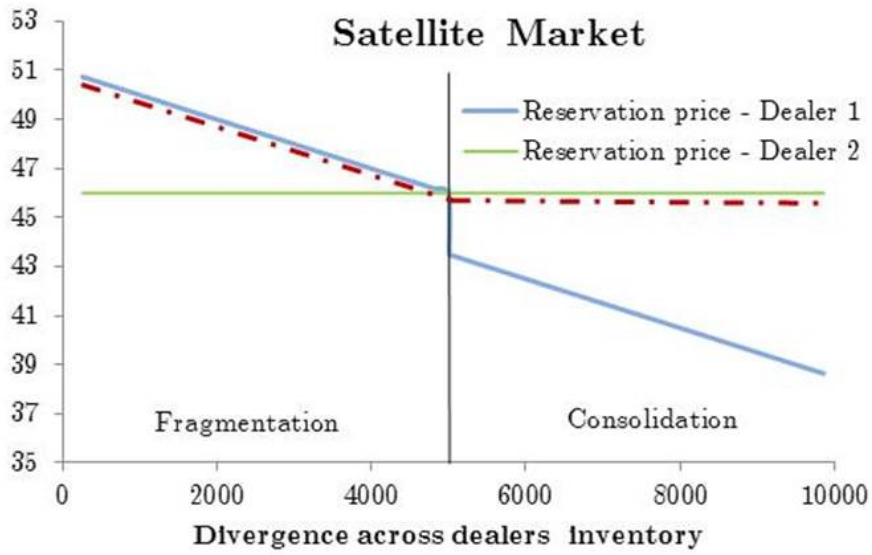
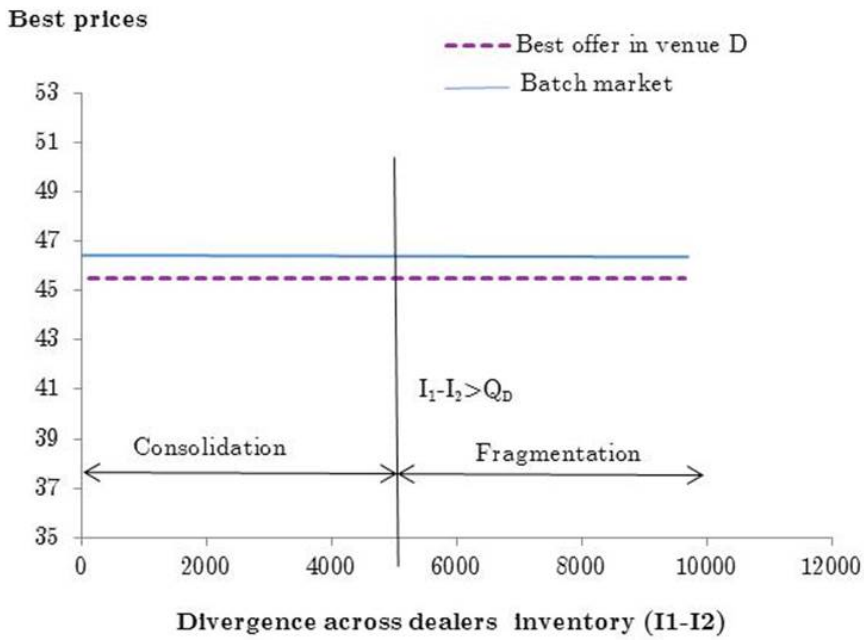


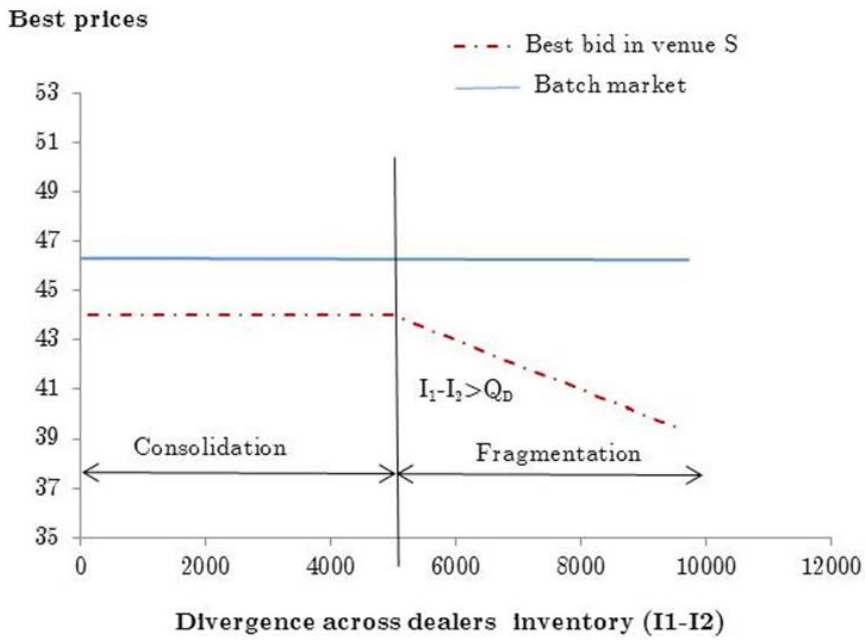


Prop 1 (Price formation) - A numerical example, cont'd

Best offers across venues when order flows have opposite signs, the inventory divergence $(I_1 - I_2)$ varying.

($\mu = 50$, $\rho = 1$, $\sigma^2 = 0.001$, $Q_D = 5,000$, $Q_S = -2,000$, $I_u = 15,000$, $I_d = 0$, $I_2 = 5,000$ and I_1 is randomized such that $I_1 > I_2$)





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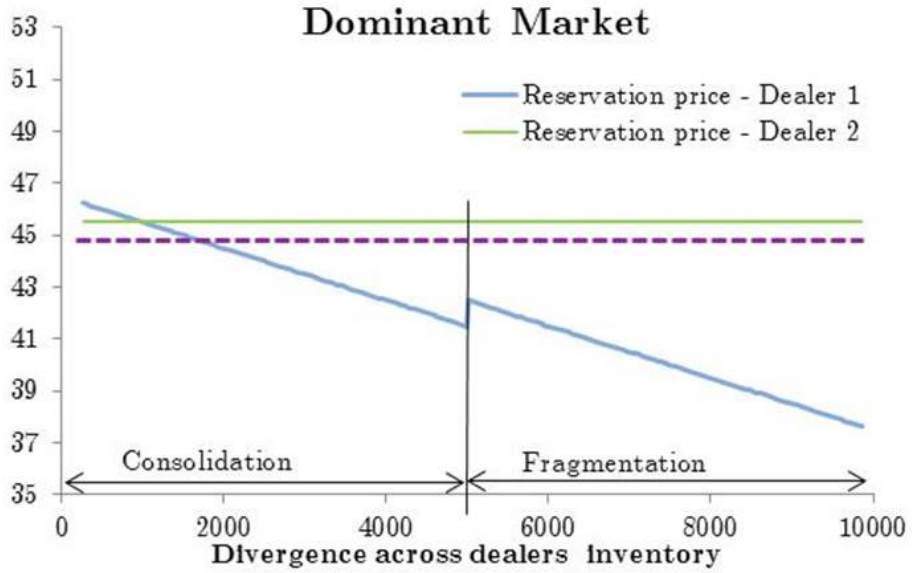
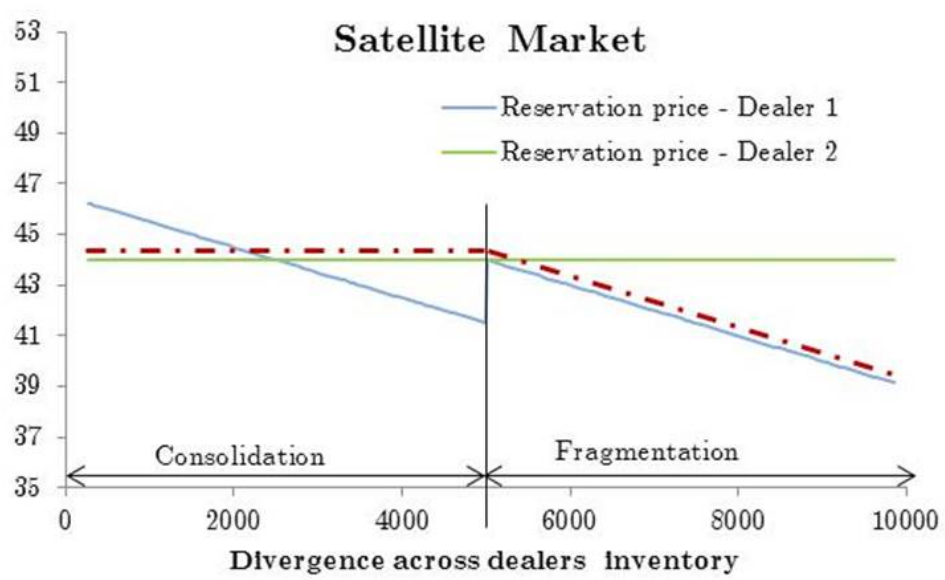




Market quality

- Corollary 1: Risk sharing is more efficient in fragmented markets.
- Corollary 2: Expected transaction costs may be lower in fragmented markets.

- Proposition 2: The expected (half-) spreads in venues D and S write:

$$E(s^m) = \frac{\rho\sigma^2}{2}\left(\frac{2I_d+I_u}{3}\right) + \underbrace{\frac{\rho\sigma^2}{2}q_m}_{\text{Direct impact}} + \underbrace{\lambda_{-m}\rho\sigma^2 q_{-m} f\left(\frac{q_D}{I_u - I_d}, \gamma\right)}_{\text{Indirect impact}}.$$

  Note that $\lambda_D > \lambda_S$.
- Proposition 3: Expected spreads co-vary jointly and covariance increases with γ.

Testable implications

Hypotheses formulated in the context of our experiment, i.e., the limit order book environment of Euronext.

At the liquidity supplier level,

- **H1:** Multi-venue market-makers should update existing limit orders or submit new orders in one venue after a trade in another venue, in a direction that is associated with inventory changes.

At the venue level,

- **H2:** Variation in spreads in one venue depends on both the directions of order flows across venues (identical or opposite) and the divergence between market-makers' inventory.

Data - Euronext

Merge of 4 local exchanges: Amsterdam, Brussels, Lisbon and Paris

- Comprehensive data: Jan-April 2007 (79 trading days)
  - Time-stamped (to the second) trade and order details of all multi-listed firms within Euronext across all Euronext venues
  - **Order and trade code**: client, proprietary trading, DMM
  - **Order and trade identifier**: members' ID codes for each side of the trade, unique across all venues

$\Rightarrow$ "Unique features ": pre-MiFID fragmentation $\rightarrow$ trading in Euronext only, same IDs across platforms and same market structure (trading systems, trading rules, clearing house, settlement system, and trading hours)

Our sample

- 20 multi-listed firms (Air France-KLM, ING Groep, etc.)
- 46 multi-venue market-makers (178 couples stock-dealer)
  - members acting as a principal (prop trading or formally regulated MM) posting order messages and trade at least once in each of the two exchanges.

Methodology

- Identify the **dominant** market vs. the **satellite** market

Construction of the variables

- The daily **equally-weighted relative bid-ask spread**: *RBAS*
- The (standardized) **inventory** measure: $I^j_{i,t} = \frac{IP^j_{i,t} - \overline{IP}^j_i}{\sigma^j_i}$
- The **divergence between dealers' inventory** position, using the relative inventory position to the median inventory position: *RI*
- Measure of the sign of order flows across venues

Methodology, cont'd

Control variables

- Cross-venue arbitrage activity
  - Buy/sell order submissions strategies empirically similar to inventory-driven strategies $\rightarrow$ Trade aggressiveness as a way to distinguish them
  - Control for arbitrage opportunities (d_AO), passive transactions vs. aggressive transactions

Other control variables

- Trade size, pending time to the next market close

Summary statistics

- 10 multi-venue market-makers (on average) per firm
- 3 AO taken per day (on average)
- Order flow with same direction: 59% in average

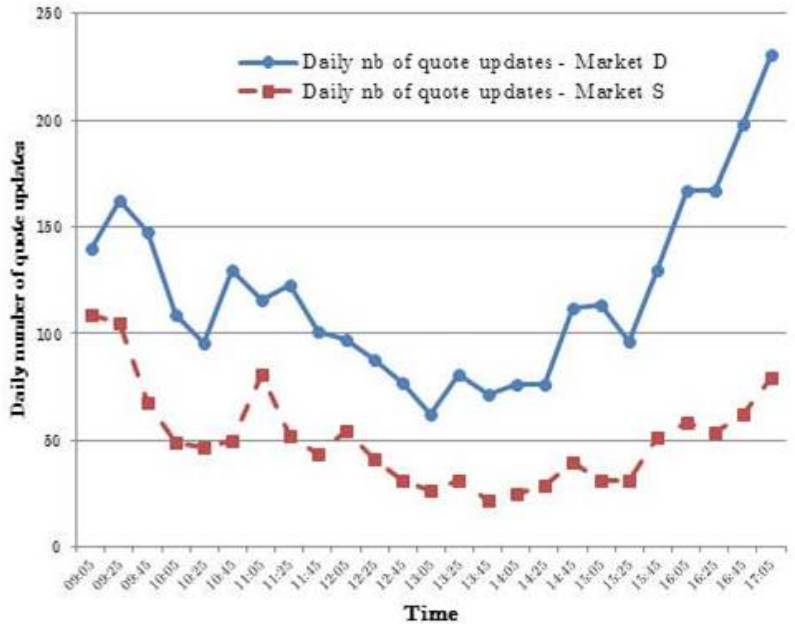
Panel A. Summary statistics by stock

	N	Mean	Std. Dev.	Q1	Median	Q3
Market Capitalization (in billion)	2628	31491	32882	129	23151	84201
Bid-Ask Spread	3449	0,680	1,723	0,014	0,119	2,413
Time-weighted Daily Bid-Ask Spread	3449	0,610	1,629	0,013	0,108	2,003
Relative Bid-Ask Spread	3449	1,070	2,383	0,048	0,271	3,648
Price (Midpoint)	3449	53,30	36,40	9,58	50,09	113,38
Number of Trades	3476	2656	3352	0	1380	9235
Number of Messages	3476	10622	10379	65	8229	29907
Trade Size	2884	491	576	33	304	1617
Number of Arbitrage Opportunities per day	3476	3	9	0	0	18
Number of Multi-venue Market-Makers	3476	10	9	1	6	22
Average inventory divergence, RI_m	3470	0,63	0,36	0,07	0,61	1,20
d_POS	2743	0,59	0,29	0,00	0,60	1,00

Summary statistics (cont'd)

△ Differences between the **dominant** and the **satellite** venue

- smaller b/a spread in the dominant venue (0,11 vs. 1,23)
- larger transaction size in the dominant venue (620) compared to the satellite venue (349)
- more modifications in the satellite venue ; more new submissions and more cancellations



Multi-venue market-makers

△ summary statistics

Panel C. Summary statistics by global dealer

	N	Mean	Std. Dev.	Q1	Median	Q3
Percentage of Trades in D	187	17	23	0	8	71
Number of Trades in D	187	70	131	0	8	377
Trade Size in D	187	724	656	92	579	2136
Percentage of Trades in S	178	7	17	0	1	40
Number of Trades in S	178	9	28	0	1	69
Trade Size in S	178	599	679	38	352	1881
Percentage of Messages in Direction of Inventory	110	66	30	0	66	100
Percentage of Passive Transactions in S	178	53	30	0	52	98
Delay to submit a message in Direction of Inv.	110	3	2	0	3	8
Dummy for Dedicated Market-Maker	178	0,19	0,39	0,00	0,00	1,00
Average Mean Reversion of Inventory	178	-0,073	0,150	-0,314	-0,013	0,001

Do multi-venue market-makers actively manage their inventory across venues?

Cross venue expected message in D (within 10 seconds) after a limit order hit in S

Panel A. Passive Transactions

Dependent variable:	Indicator of Expected Message			
	(1)		(2)	
Log Trade Size	0.032		0.032	
	(1.05)		(1.05)	
Standardized Inventory	0.018		-0.02	
	(0.56)		(-0.55)	
DMM	1.522	***	1.377	***
	(3.70)		(3.42)	
Arbitrage Opportunity	-0.310	***	-0.309	***
	(-3.31)		(-3.33)	
Time to close	0.025		0.025	
	(1.38)		(1.36)	
DMM × Standardized Inventory			0.187	**
			(2.33)	
Intercept	0.217		0.243	
	(0.66)		(0.74)	
Firm FEs	Yes		Yes	
N	18,022		18,022	
Pseudo R^2	0.06		0.06	

△ Designated market-makers post cross-venues orders in direction of inventory management (consistent with H1).

Robustness check: After an aggressive transaction

Cross venue expected message in D (within 10 seconds) after an aggressive transaction in S triggered by multi-venue MM

Panel B. Active Transactions

Dependent variable:	Indicator of Expected Message			
	(1)		(2)	
Log Trade Size	-0.015		-0.014	
	(-0.45)		(-0.45)	
Standardized Inventory	-0.005		0.043	
	(-0.08)		(0.59)	
DMM	0.646	**	0.733	***
	(2.44)		(3.76)	
Arbitrage Opportunity	0.597	***	0.603	***
	(4.46)		(4.58)	
Time to close	0.013		0.014	
	(0.80)		(0.81)	
DMM × Standardized Inventory			-0.125	
			(-0.67)	
Intercept	1.402	**	1.348	**
	(2.30)		(2.10)	
Firm FEs	Yes		Yes	
N	9,100		9,100	
Pseudo R^2	0.06		0.06	

Multi-venue inventory management: impact on market spreads

Dependent variable:	Change in Relative Spread of Market S			
	(1)		(2)	
Same Direction	0.108	**	0.105	**
	(2.14)		(2.13)	
Lag Absolute RI	0.087		0.076	
	(1.14)		(1.34)	
Same Direction × Lag Absolute RI	-0.12	**	-0.119	**
	(-2.00)		(-2.01)	
Number of Trades in Market S	-0.050		0.004	
	(-1.30)		(0.12)	
Intercept	-0.078		-0.065	
	(-0.93)		(-1.03)	
Time FEs	Yes		Yes	
Firm FEs	No		Yes	
N	11,172		11,172	
Adjusted R^2	0.01		0.03	

△ As uniquely predicted by our model, when order flows have the same sign and market-makers' inventory divergence is high, they post very aggressive prices in the satellite market resulting in lower spreads (consistent with H2).

Summary of main findings

- Cross-venue inventory model to analyze how risk-averse market-makers strategically set their quotes in a multi-venue environment.
- Multi-venue market-making strategies may result in the consolidation of the fragmented order flow and may lower bid-ask spreads. They cause spreads to be inter-connected across venues.
- Using unique proprietary data, we find cross-venue inventory effects consistent with the model. We also find that bid-ask spreads vary with the divergence between multi-venue market-makers in a way which is uniquely predicted by our model.

Appendix

△ Differences between the **dominant** and the **satellite** venue

Panel B. Summary statistics by type of market

B.1 Dominant market

	N	Mean	Std. Dev.	Q1	Median	Q3
Bid-Ask Spread	1580	0,11	0,13	0,01	0,06	0,39
Relative Bid-Ask Spread	1580	0,28	0,37	0,04	0,12	1,08
Number of Best limits Updates	1580	6063	5901	52	4853	16963
Number of Trades	1580	2577	3108	10	1457	8563
Percentage of Messages	1578	64	27	15	66	100
Percentage of Active Trades	1338	44	26	8	39	100
Percentage of Passive Trades	1338	56	26	0	61	92
Percentage of Cancellations	1410	12	13	0	9	39
Percentage of Revisions	1410	33	36	0	16	100
Percentage of New Submissions	1410	22	17	0	25	47
Transaction Size	1578	620	684	52	360	2305

B.2 Satellite market

	N	Mean	Std. Dev.	Q1	Median	Q3
Bid-Ask Spread	1567	1,23	2,37	0,03	0,33	4,91
Relative Bid-Ask Spread	1567	1,87	3,28	0,10	1,00	6,61
Number of Best limits Updates	1554	2624	3797	3	794	10626
Number of Trades	1580	99	402	0	3	534
Percentage of Messages	1578	33	27	0	27	85
Percentage of Active Trades	1109	31	28	0	30	100
Percentage of Passive Trades	1109	69	28	0	70	100
Percentage of Cancellations	1395	8	11	0	4	26
Percentage of Revisions	1395	79	26	0	90	99
Percentage of New Submissions	1395	8	12	0	4	29
Transaction Size	1112	349	369	18	250	1000