



High Frequency Trading and Long-Term Investors: A View from the Buy-Side

Nataliya Bershova, PhD

Dmitry Rakhlin, PhD

http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2066884

Journal of Investment Strategies, Vol. 2, No. 2, pp. 3-47, Spring 2013



Outline & A Bit of History

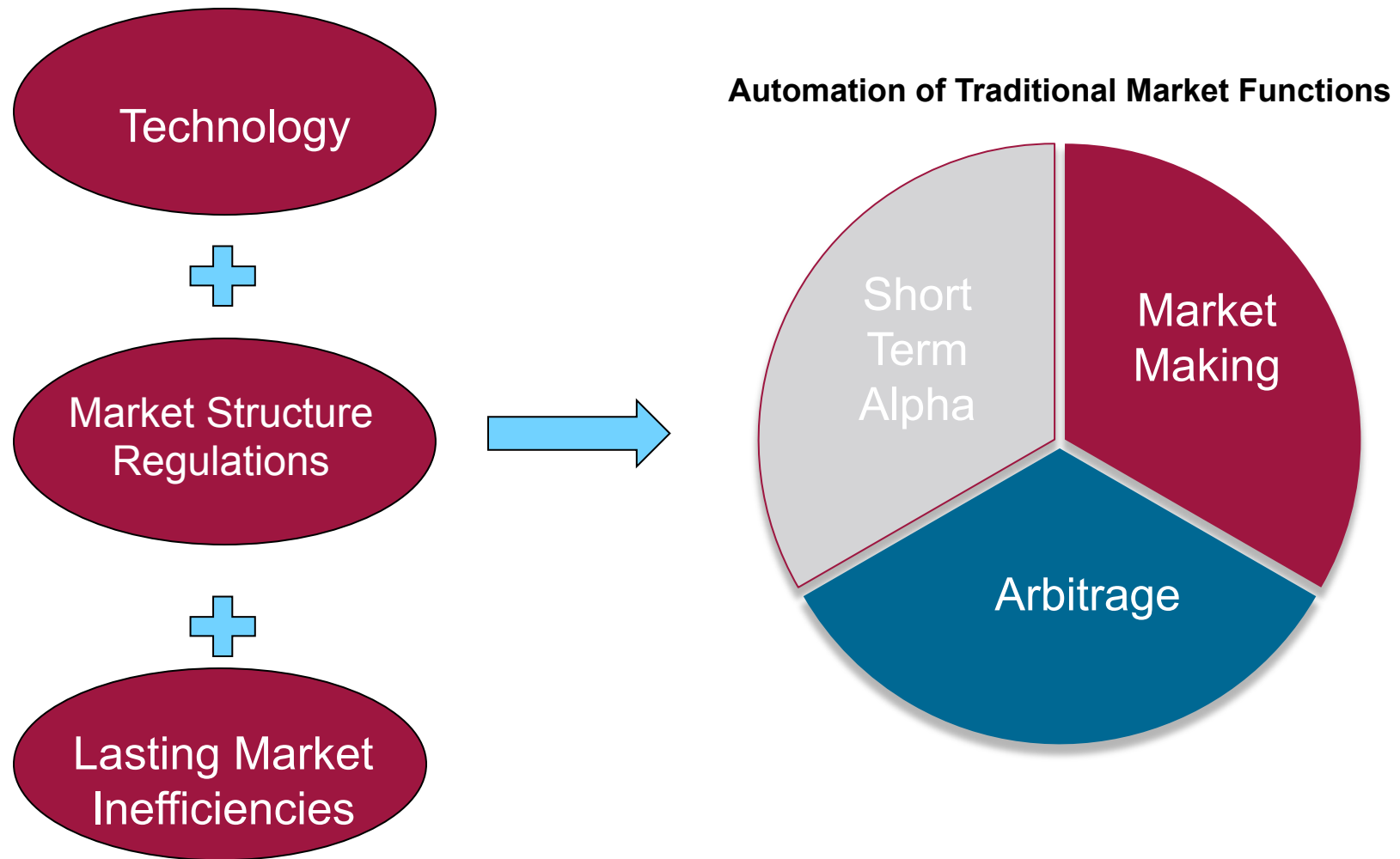
What is HFT
really?

Reasons for
Emergence
of HFT?

Market
Quality
Impact

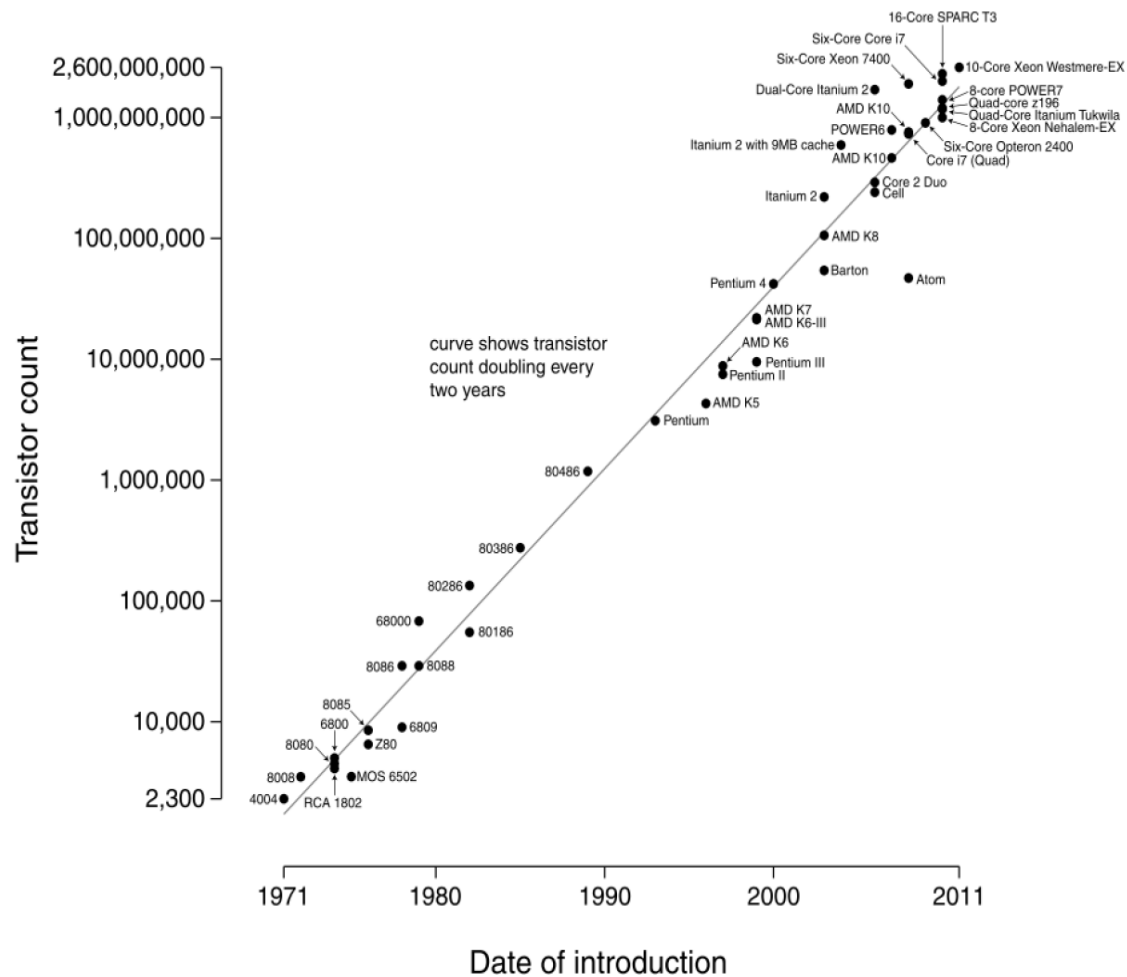
Size of HFT

The growth of High Frequency Trading



Moore's Law

Microprocessor Transistor Counts 1971-2011 & Moore's Law



Technology

Processing Power

- A. Moore's law: Transistor count has doubled every two years for decades
- B. Performance doubled every 18 months
- C. Cheap and easy to process market data for thousands of instruments in real time

Networking and Storage

- A. 10 Gigabit/sec Ethernet
- B. Connectivity across data centers
- C. Petabytes of fast, reliable data storage

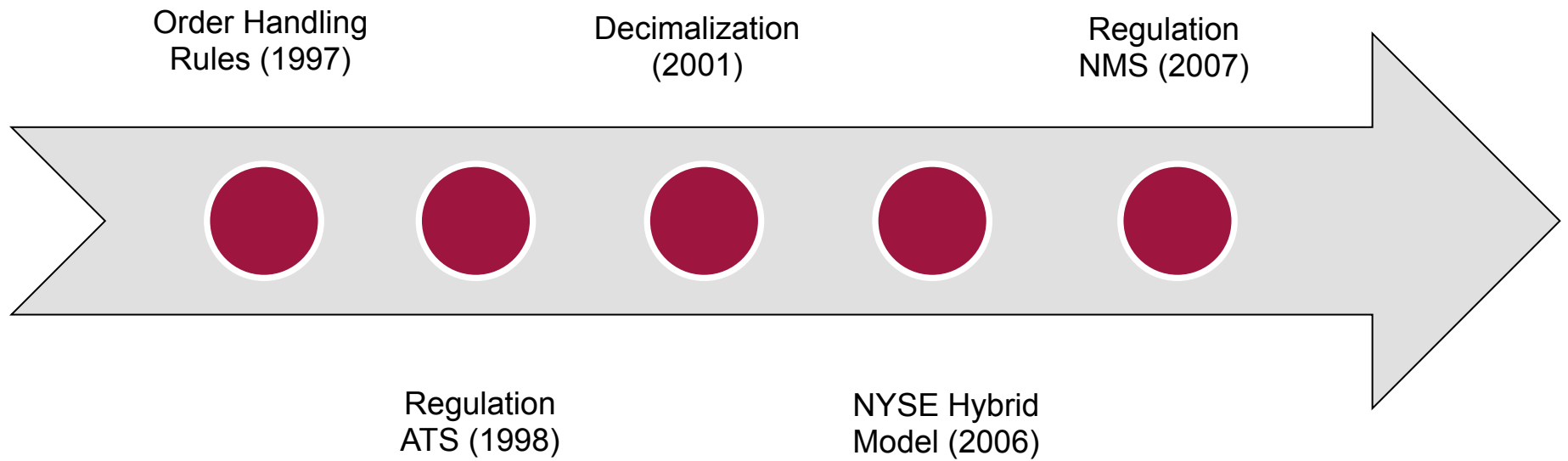
Software

- A. High level programming languages
- B. FIX and other standardized protocols

Algorithms

- A. Statistical techniques
- B. Optimal execution strategies

Market Structure Evolution



Early History

❑ **National Market System: Securities Acts Amendments of 1975**

- A. Vision of unified national market for securities
- B. Transparent pricing: the NBBO
- C. Competitive execution landscape

❑ **Order Handling Rules of 1997**

- A. Requires display of best customer price

❑ **Regulation ATS of 1998**

- A. Formalized notion of alternative trading system
- B. Encouraged proliferation of ECNs in early 2000s (INET, Island, BRUT, ARCA, etc)
- C. Island introduced two major innovations
 - a) Direct book feeds with order update: ITCH
 - b) Maker-take pricing

Decimalization (2001)

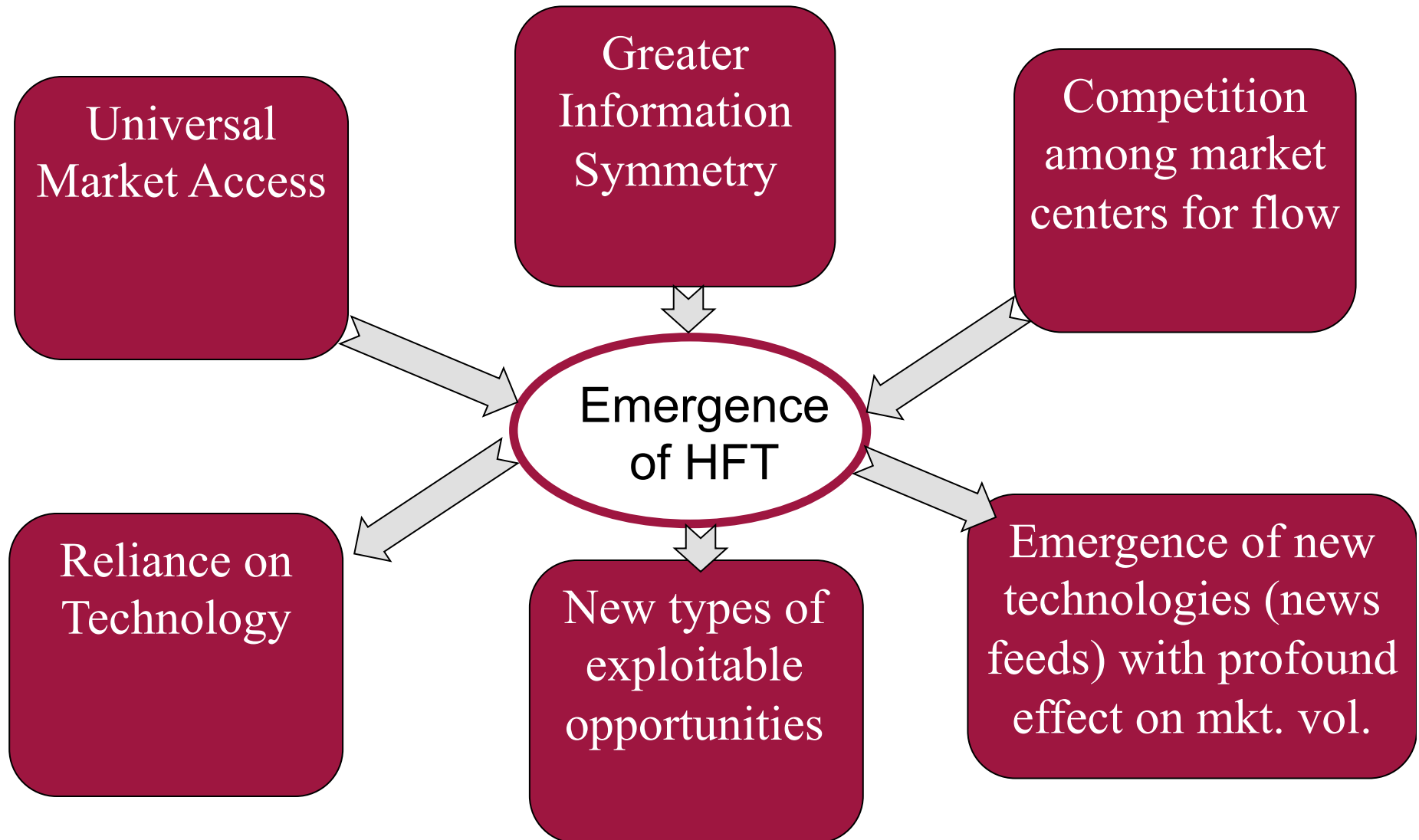
- ❑ **Definition: minimum price variant is the smallest increment in price in which an instruments can be quoted (or an order entered)**
- ❑ **Before 2001: MPV for stocks was 1/16 or 6.25 cents**
- ❑ **After 2001: MPV lowered to 1 cent**
- ❑ **Not just a cosmetic change. Implications for the market:**
 - A. Ability to improve prices by economically smaller amount discourages posting large orders
 - B. Spread narrows for small orders, but it may be harder to do larger size
 - C. Market makers want to adjust their quotes faster in response



Regulation NMS

- ❑ **Strengthened and formalized many aspects of existing market structure**
 - A. Banned trade-through, so ability to set the NBBO became paramount
 - B. Capped access fees
 - C. Standardized minimum price variants at 0.01 for order above \$1
 - D. Some market data rules..
- ❑ **Forced the hand of NYSE to adopt a more purely automated system**
 - A. We will hear about its implications later

Upshot of all this regulation:



Empirical Market Quality Measures

❑ Transaction costs

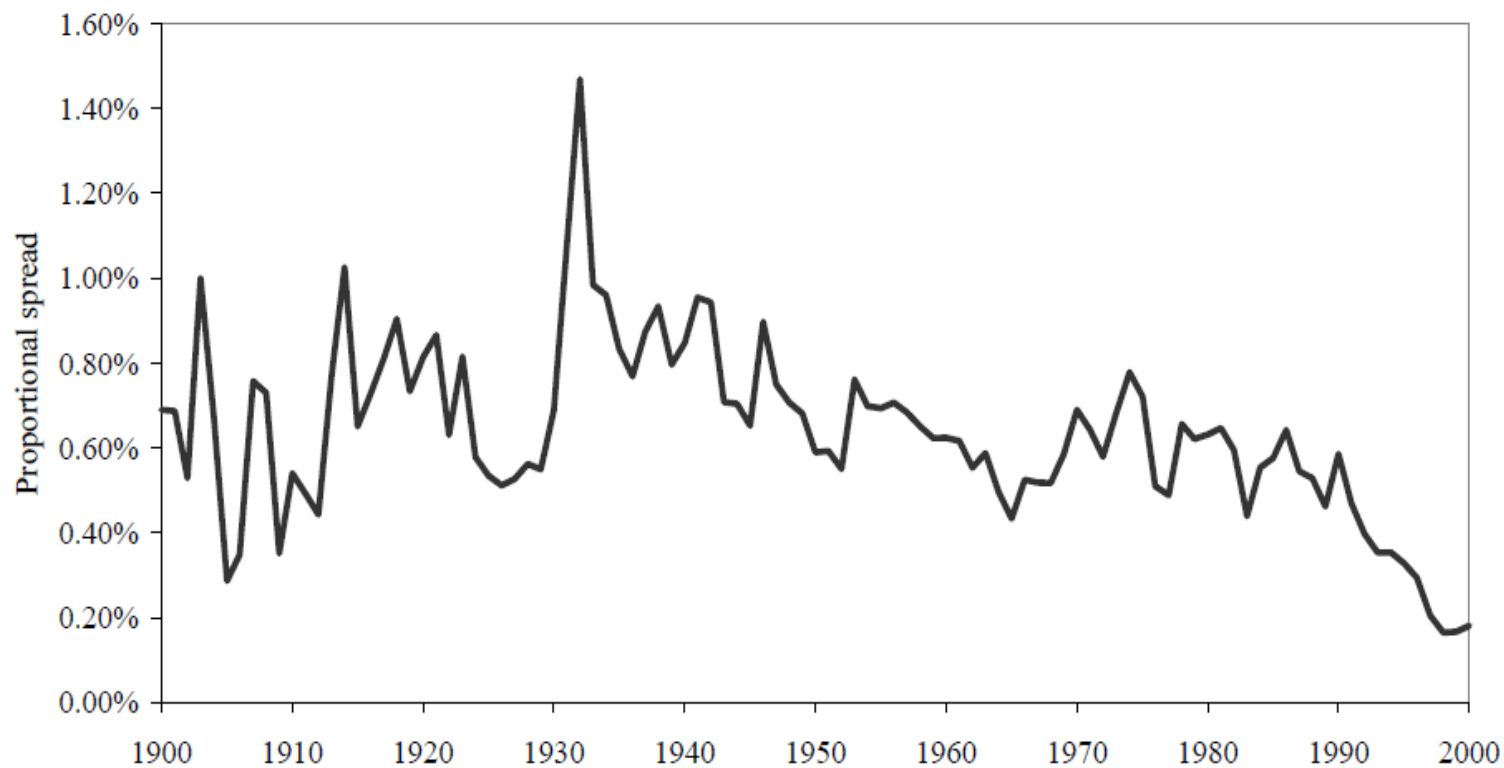
- A. Bid-Ask spread
- B. Implementation shortfall

❑ Volatility

❑ Specific Market Structure Changes

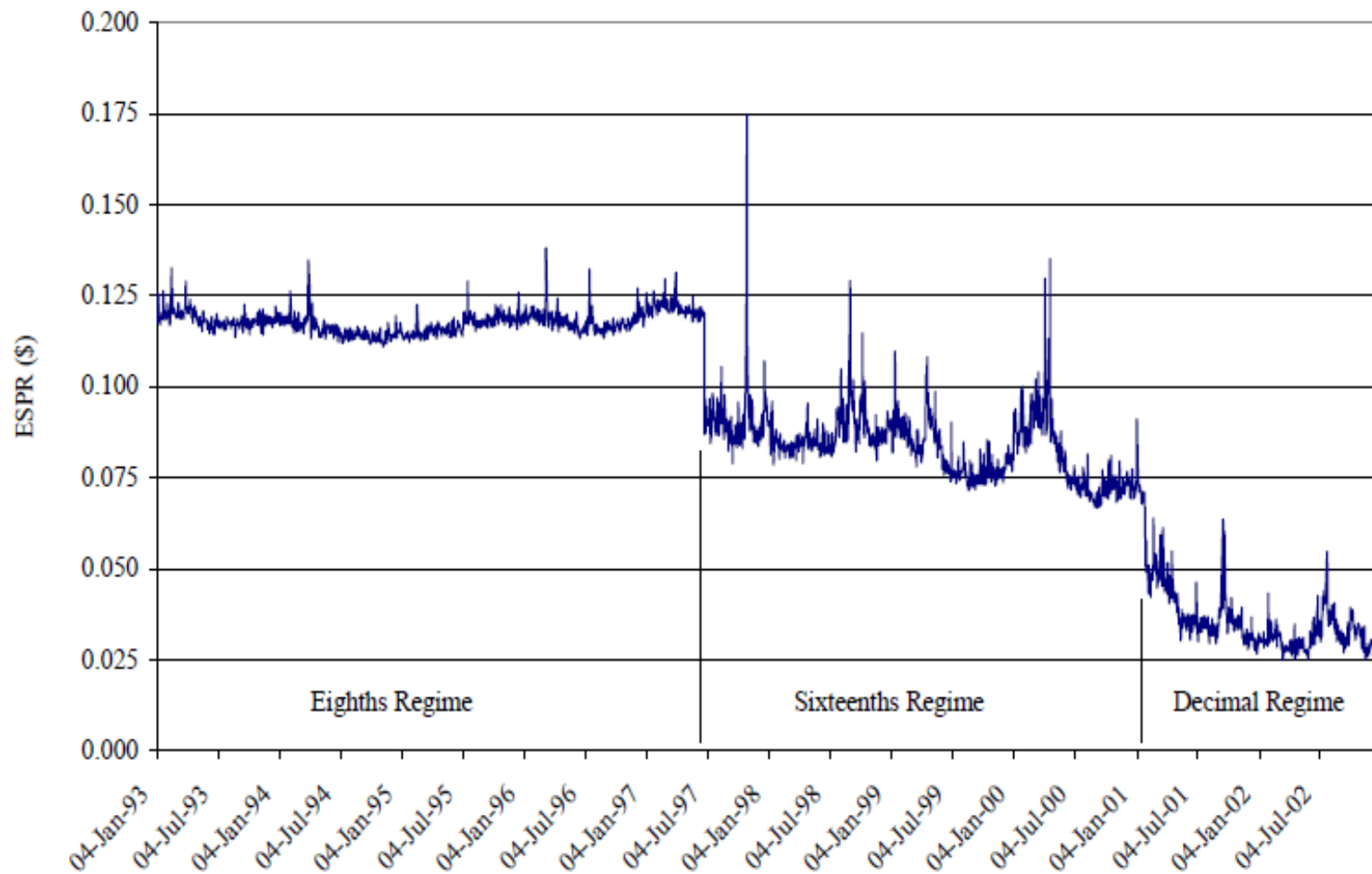
A History of Spreads

Figure 1. Bid-ask spreads on Dow Jones stocks
(all DJ stocks 1900-1928, DJIA stocks 1929-present)



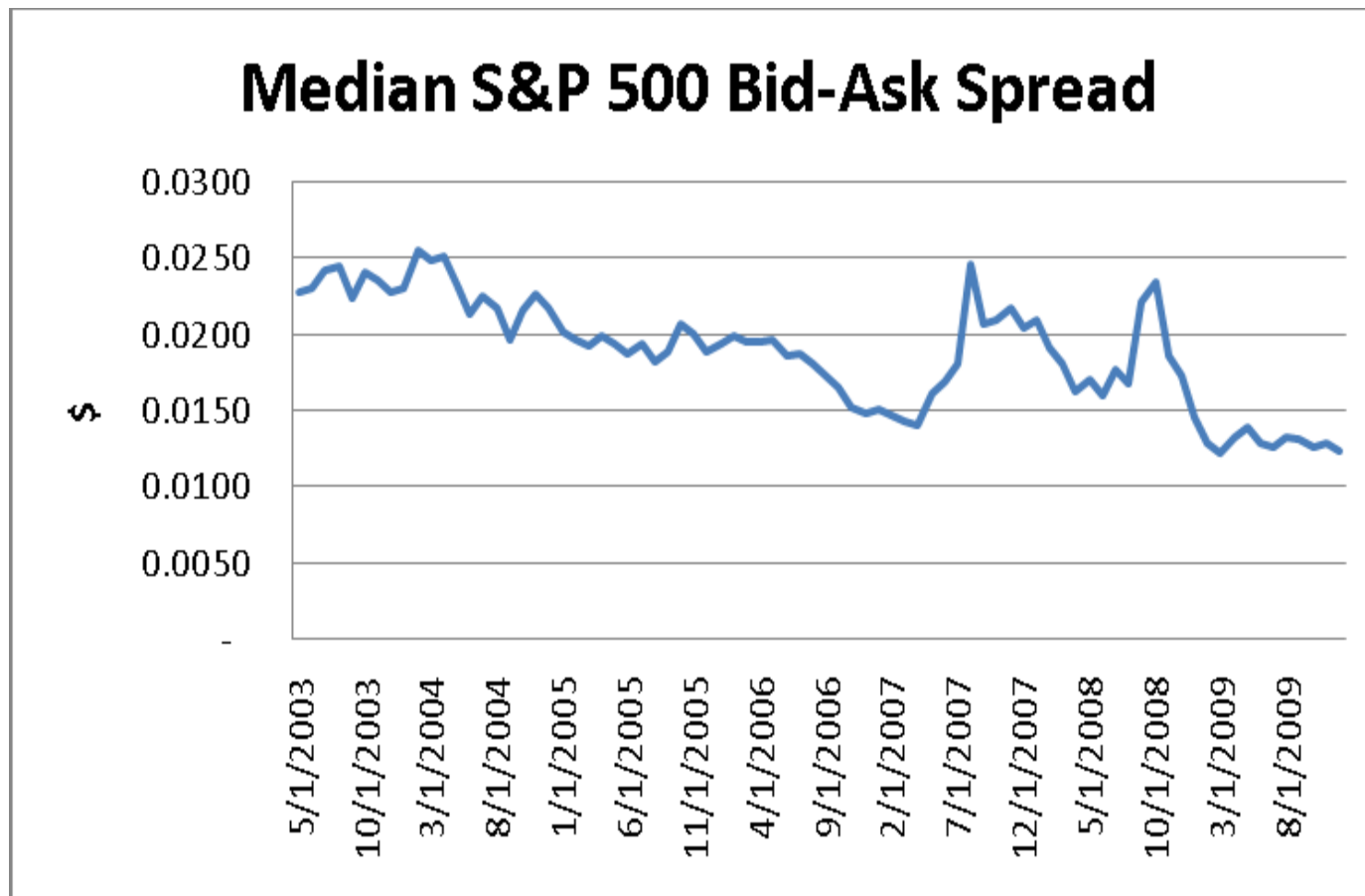
Source: Charles Jones (2002)

Spreads: Impact of MPV Regulation



Source: Chordia, Roll, Subrahmanyam (2008)

Recent Spreads: Impact of Technology



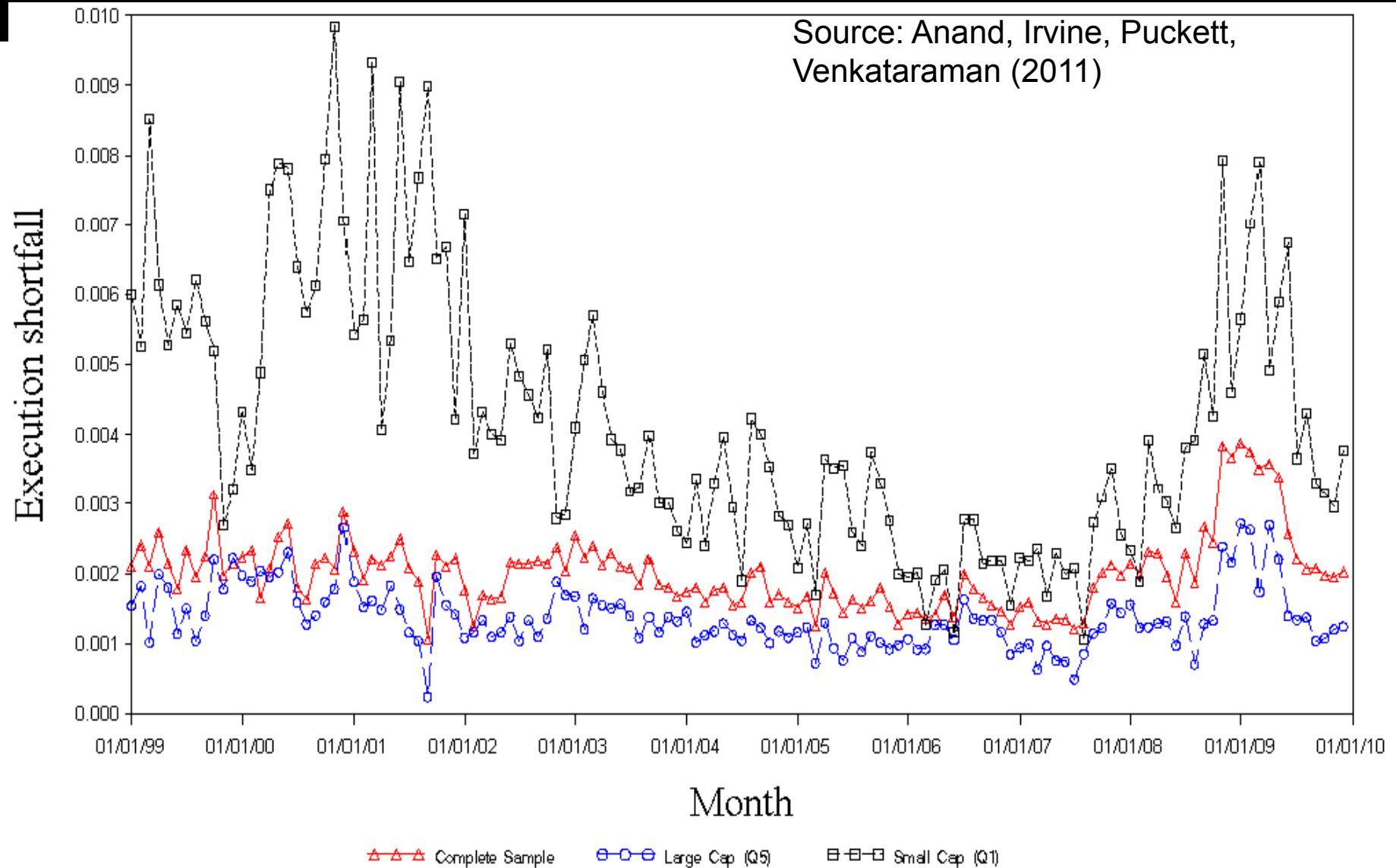
Source: Angel, Harris, Spatt (2010)

Implementation Shortfall: Institutional Flow Stats (Ancerno)

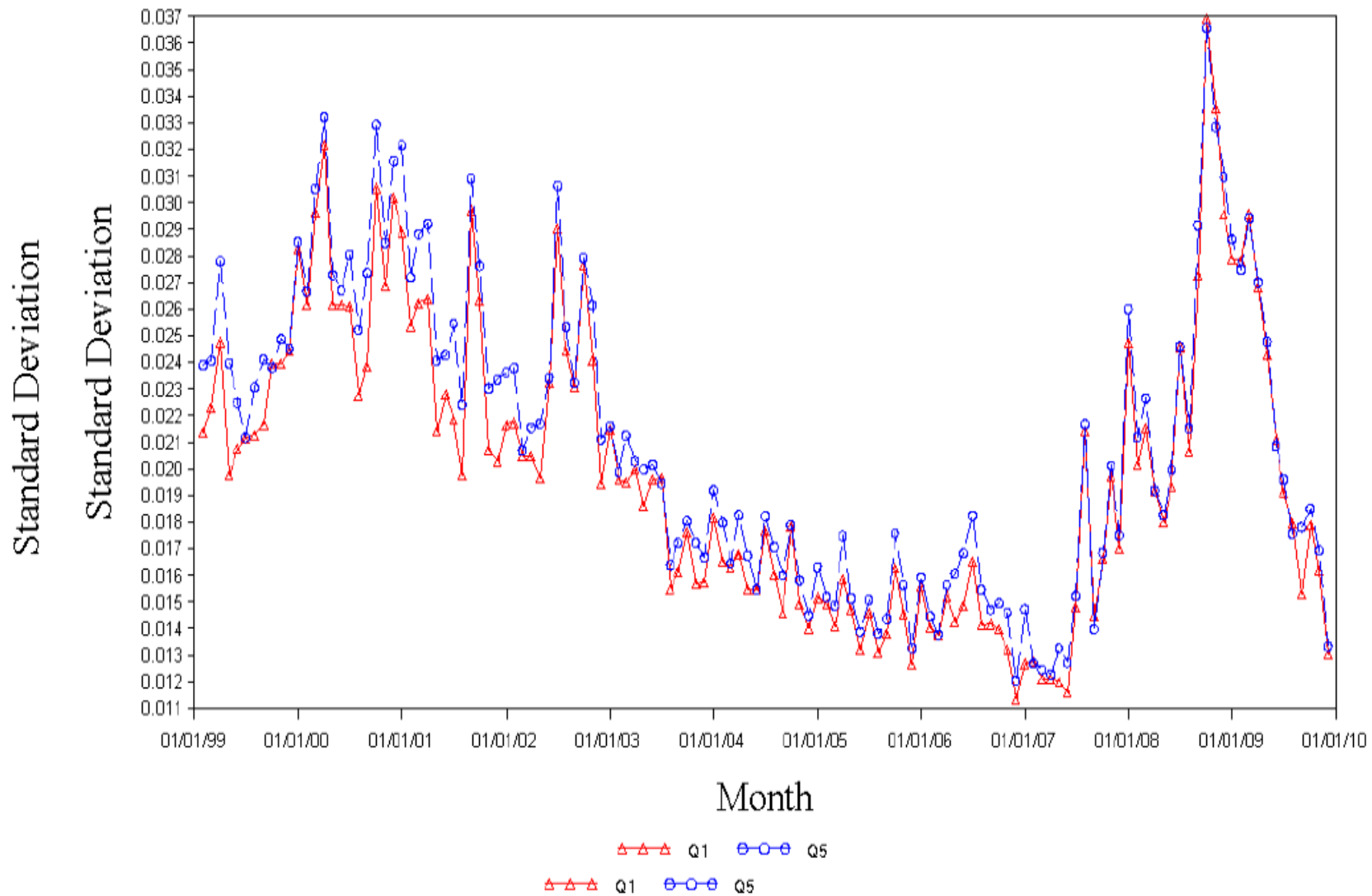
| | Number of Institutions | Number of Stocks | Number of daily orders | Daily order Size | Daily order Size/Avg. daily volume (30 days) | Buy dollar volume/Total dollar volume |
|---|---------------------------|---------------------|---------------------------|------------------|--|---|
| Panel A: Full sample | 955 | 8,514 | 43,293,870 | 16,165 | 2.9% | 50.7% |
| Panel B: By year | | | UP 244% | FLAT | DOWN 63% | |
| 1999 | 324 | 5,726 | 2,122,761 | 14,371 | 4.8% | 51.3% |
| 2000 | 322 | 5,502 | 2,509,332 | 16,189 | 3.9% | 51.4% |
| 2001 | 350 | 4,715 | 2,754,936 | 18,672 | 3.8% | 52.0% |
| 2002 | 380 | 4,383 | 3,456,098 | 19,984 | 3.7% | 51.6% |
| 2003 | 356 | 4,320 | 3,558,992 | 18,799 | 3.5% | 50.6% |
| 2004 | 367 | 4,485 | 4,497,585 | 18,658 | 3.5% | 50.9% |
| 2005 | 336 | 4,342 | 3,915,803 | 16,326 | 3.1% | 50.5% |
| 2006 | 359 | 4,321 | 4,933,460 | 14,668 | 2.5% | 50.5% |
| 2007 | 339 | 4,335 | 5,013,820 | 13,733 | 2.2% | 50.0% |
| 2008 | 296 | 4,052 | 5,347,082 | 14,636 | 1.8% | 49.8% |
| 2009 | 286 | 3,938 | 5,184,001 | 14,270 | 1.8% | 49.8% |
| Panel C: Firm size (NYSE market value quintiles) | | | | | | |
| <i>Small</i> | | | 4,471,299 | 11,418 | 11.1% | 53.5% |
| 2 | | | 6,064,350 | 12,402 | 4.4% | 52.9% |
| 3 | | | 6,699,324 | 14,298 | 2.9% | 52.2% |
| 4 | | | 8,158,691 | 17,240 | 2.0% | 50.6% |
| <i>Large</i> | | | 16,556,470 | 19,398 | 0.7% | 50.1% |

Implementation Shortfall

Source: Anand, Irvine, Puckett,
Venkataraman (2011)

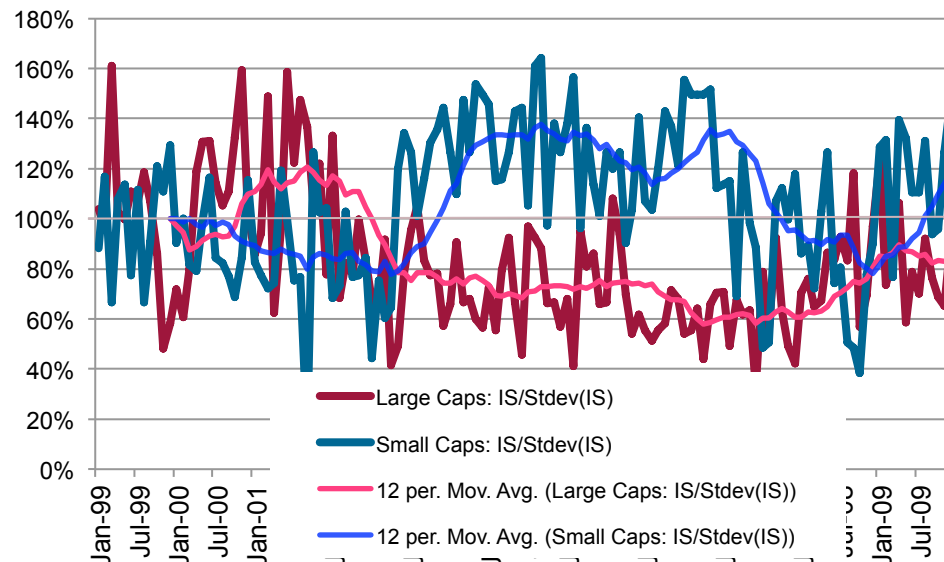
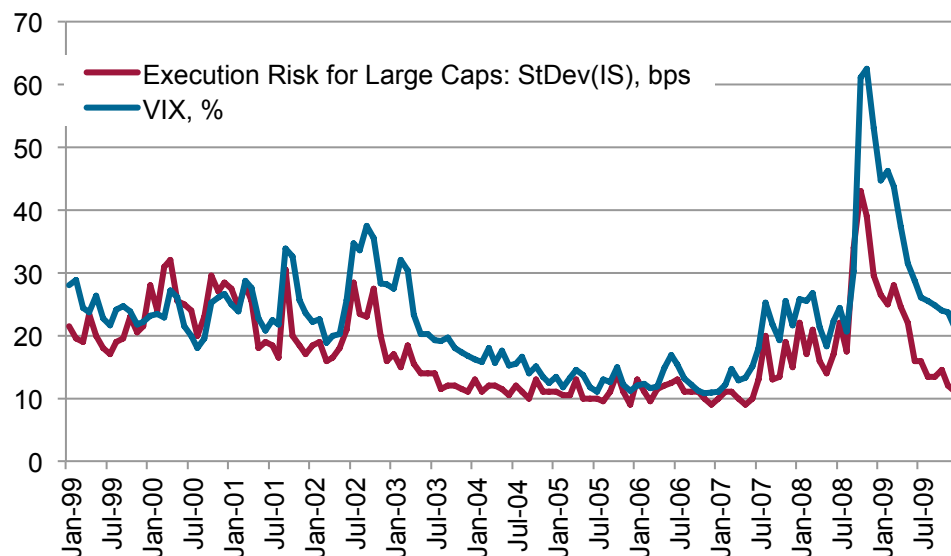
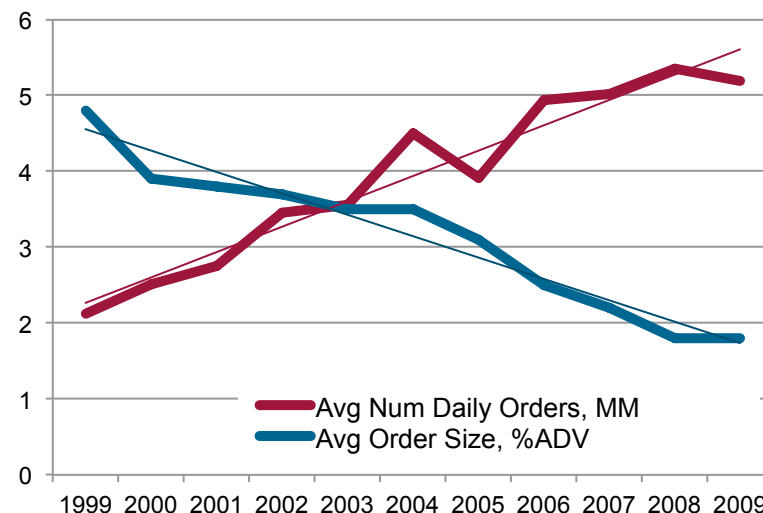


Implementation Shortfall Risk



Implementation Shortfall Normalized. Benefits of Increased Liquidity

1. (Institutional turnover) x (Order Size) \approx Const.
2. Buy-side trading is directional \rightarrow proportional increase in market making. On top increased ETF volumes, which EMMs use as hedges
3. Higher Turnover \rightarrow higher Sharpe (at least in theory). Smaller orders \rightarrow lower execution risk
4. $E(\text{Cost}) \sim \sigma \sqrt{T}$, $\text{Stdev}(\text{IS}) = \sigma \sqrt{T}$. $\text{IS}/\text{Stdev}(\text{IS})$ is more or less flat for the last decade (1999-2009)





Impact HTF on Volatility

1. **No impact on daily volatility – HTF are flat by EOD, so this result is hardly surprising**
2. **HTF increase short-term volatility (up to 10 minutes). From our own study:**
 - A. In UK short-term volatility is 30% higher for names most traded by HFT
 - B. In Japan from 1H'10 (Arrowhead implementation) to 1H'11 short-term volatility increased ~10% in the names most traded by HFT relative to names not popular with HFT

High Frequency Size and Profitability Estimates

1. Hendershott and Riordan (2011) + Brogaard (2011)

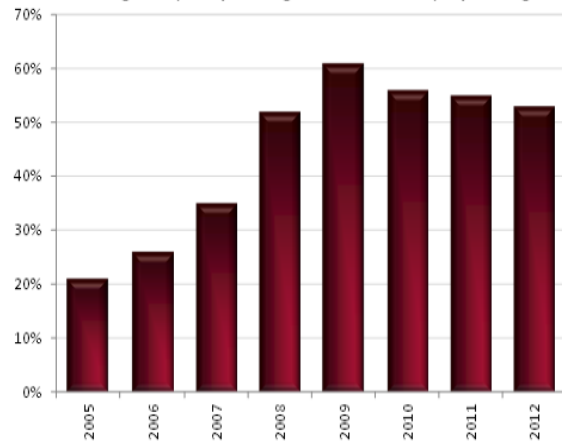
- A. Proprietary NASDAQ data set of 25 of the largest HF traders
- B. HF is 42% of (double counted) volume
- C. Collective profitability is 0.4 bps. Total revenue \$3 billion/year
- D. Not a small number, but far less than the specialist and market makers of mid 1990s (1999: Spear Leeds and Kellogg alone had revenue \$1.7B)

2. Other vague estimates

- A. Kearns et al 2010 assume “aggressive” HFTs have Oracular perfect predictive capability and bound profitability above by \$21 billion USD (probably a wild overestimate by their own admission)
- B. Tabb Group “guesstimate” \$8.5B

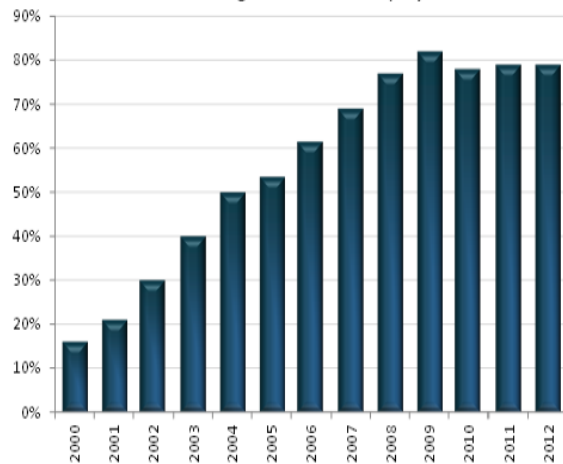
Flow Breakdown, US

Exhibit 3: Tabb survey says HFT is shrinking faster than real money trading
High Frequency Trading as a % of all US Equity Trading



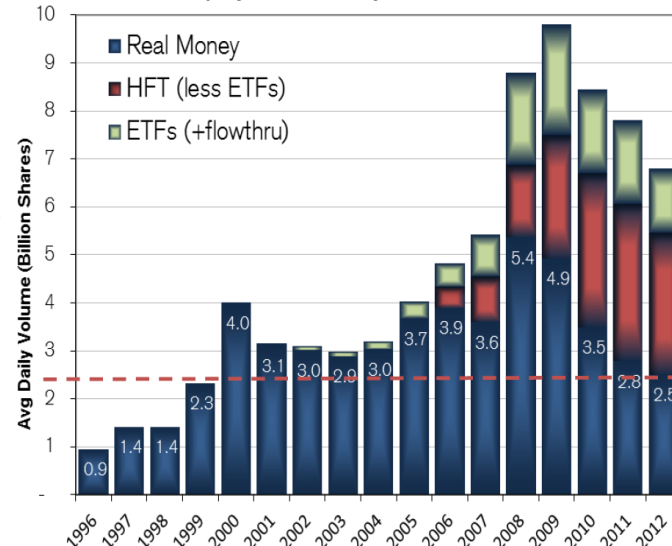
Source: Tabb

Exhibit 4: And all electronic trading has plateaued
Electronic Trading as a % of all US Equity Volume

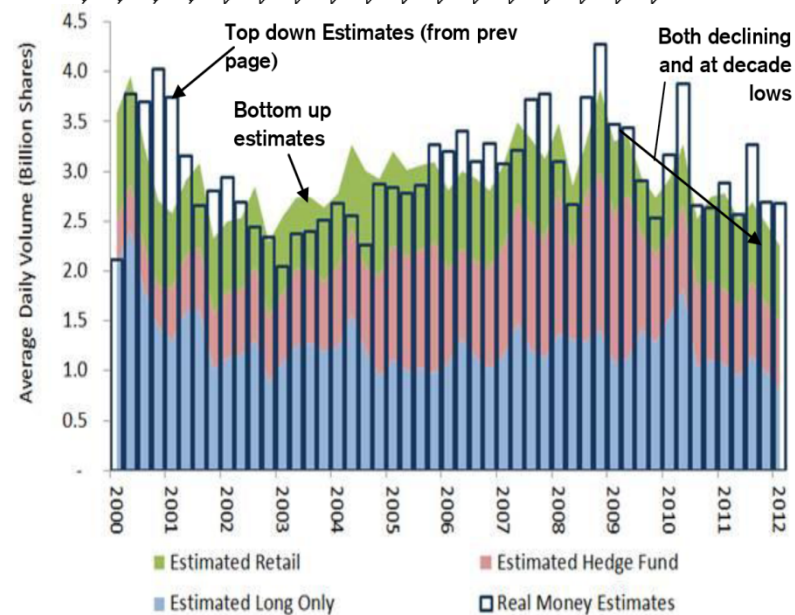


Source: Tabb

Exhibit 7: Real US equity volumes may be at Decade Lows



Source: Credit Suisse





High Frequency Trading and Long-Term Investors

PROS & CONS OF HFT

1. There is no acceptable HFT definition. Yet there is an evidence that HFT is the largest market participant trading 50-60% of reported volumes in US, 40-55% in UK and 35-40% in Japan.
2. There is also an indication that top 5 HFT firms are originating majority of HFT volumes globally.
3. There is NO consensus on the impact of HFT on the market quality.

Proponents:

- HFT are EMMs + statarb = liquidity providers, can't be harmful
- They reduce volatility, compress bid-ask spreads = reduce T-Costs for LT and retail
- It is EMMs who are adversely selected by large orders originated by informed LT investors. EMM margins are razor thin (profits are \$2-5B annually, 0.3-0.8bps/trade, 5-15% spread), so have to be quick to re-price quotes

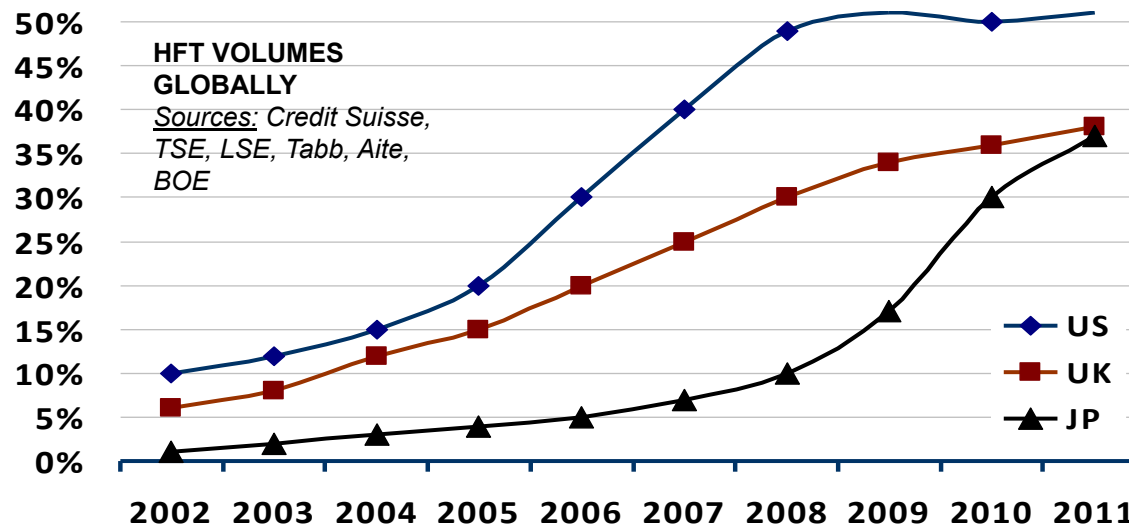
Critics:

- HFT generates most of the profits by front-running LT orders
- Provided liquidity is fictitious. This hurts confidence of slow-to-react LTs.
- HFT contribute to elevated intraday volatility and correlations
- Liquidity is being shifted toward smaller subset of investible universe (which works as self-fulfilling prophecy)


SO, IS THERE TRUTH IN ANY OF THESE STATEMENTS?



Scope



1. What are the characteristics of stocks that are actively and rarely traded by HFT?
2. How HFT daily volumes correlate with the market volumes and LT investor's volumes?
3. Is liquidity demand by LT truly matched by liquidity supply by HFT?
4. What are the factors driving daily volumes for HFTs?
5. How HFT affect trading costs for a traditional LT investor?



DATA SETS

1. AllianceBernstein's trades: orders executed by 5 regional buy-side desks, originated by ~80 PMs (both Value and Growth styles).
2. HFT & LT traded volumes for Nikkei 225 & BE500 (Bloomberg European 500), routed via a single broker between January – June 2010
 - Europe: daily volumes
 - Japan: sided volumes split into 6 intraday intervals
 - HFTs are defined as users of ultra low latency infrastructure, LTs are users of DMA/DSA/Crossing platform
3. We focus on UK (mature market) and post-Arrowhead Japan (evolving market with rapidly growing HFT presence).
4. Within each region we defined *HiVLM*, *LoVLM* subgroups – roughly top and bottom tertiles by volume traded. *HiVLM* is validated by volume consistency
5. UK 140 names, 50 in *HiVLM*, 50 in *LoVLM*, Japan 225 names – 75 & 75 names

TRADING UNIVERSE

HFT MOST TRADED: HIGHER CAPITALIZATION, HIGHER LIQUIDITY GROUP

1. UK: *HiVLM* : share float **5B**, *LoVLM*: **0.5B** shares (note, *LoVLM* stocks are not illiquid, not small caps, far from it)
2. *HiVLM* stocks form the top of major country indices (which are cap-weighted)
3. *HiVLM* stocks have significantly tighter bid-ask spread

| <i>HiVLM - UK</i> | Beta | Spread | MDV | HL |
|-------------------|------|-------------|---------------|-----|
| | | (bps) | (mln. shares) | (%) |
| Avg. | 1.1 | 6.6 | 17.3 | 2.6 |
| Median | 1.0 | 6.3 | 5.8 | 2.1 |
| Std. dev | 0.4 | 2.3 | 36.6 | 1.5 |
| <i>LoVLM - UK</i> | | | | |
| Avg. | 1.0 | 13.7 | 2.8 | 2.8 |
| Median | 1.0 | 11.2 | 1.3 | 2.3 |
| Std. dev | 0.3 | 7.4 | 4.1 | 1.6 |
| <i>HiVLM - JP</i> | Beta | Spread | MDV | HL |
| | | (bps) | (mln. shares) | (%) |
| Avg. | 1.1 | 13.1 | 8.3 | 2.2 |
| Median | 1.2 | 12.1 | 3.6 | 2.0 |
| Std. dev | 0.2 | 6.1 | 14.5 | 1.1 |
| <i>LoVLM - JP</i> | | | | |
| Avg. | 1.1 | 27.1 | 4.1 | 2.2 |
| Median | 1.1 | 25.4 | 2.5 | 2.0 |
| Std. dev | 0.2 | 12.0 | 5.0 | 1.1 |

TRADING UNIVERSE

HiVLM TRADE CONSISTENTLY, *LoVLM* TRADE OPPORTUNISTICALLY

| HiVLM - UK | Market | HFT | LT |
|-------------------|--------|------|----|
| Market | 1 | | |
| HFT | 0.40 | 1 | |
| LT | 0.50 | 0.28 | 1 |

| LoVLM - UK | Market | HFT | LT |
|-------------------|--------|------|----|
| Market | 1 | | |
| HFT | 0.25 | 1 | |
| LT | 0.37 | 0.21 | 1 |

| HiVLM - JP | Market | HFT | LT |
|-------------------|--------|------|----|
| Market | 1 | | |
| HFT | 0.39 | 1 | |
| LT | 0.31 | 0.27 | 1 |

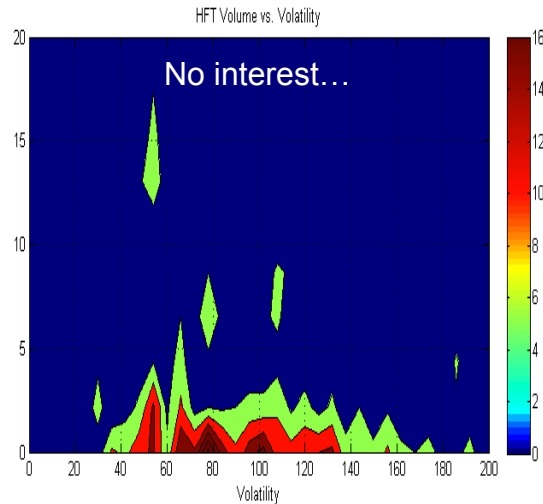
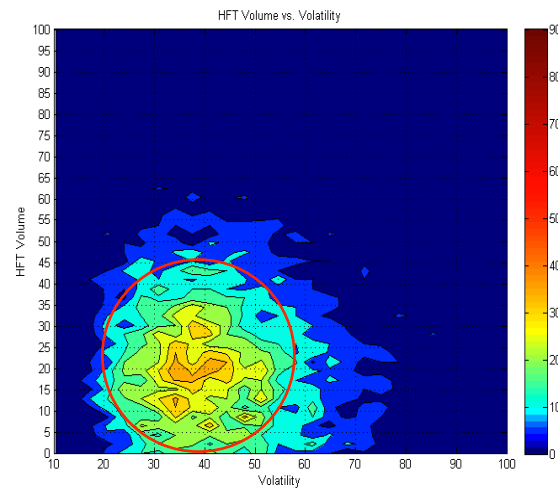
| HiVLM - JP | Market | HFT | LT |
|-------------------|--------|------|----|
| Market | 1 | | |
| HFT | 0.28 | 1 | |
| LT | 0.22 | 0.10 | 1 |

HiVLM names show much higher correlation of HFT & LT volumes with overall market volume:

- Underscores consistency of *HiVLM* flow from both HFT and LT,
- Opportunistic nature of *LoVLM* flow,
- Higher dispersion of *LoVLM* flow among brokers
- Relative to UK, Japan market shows more opportunistic nature of LT flows, but similar consistency for HFT's (similar models?)

LT vs. HFT: MISMATCHED DEMAND-SUPPLY

JAPANESE MARKET



■ *HiVLM*: HFT trade the same range %DV if volatility stays within their comfort zone

■ *LoVLM*: HFT are not there. Period.

■ LT: Trade at 5% every day (rebalances). Occasionally trade a lot more. Averse to volatility.

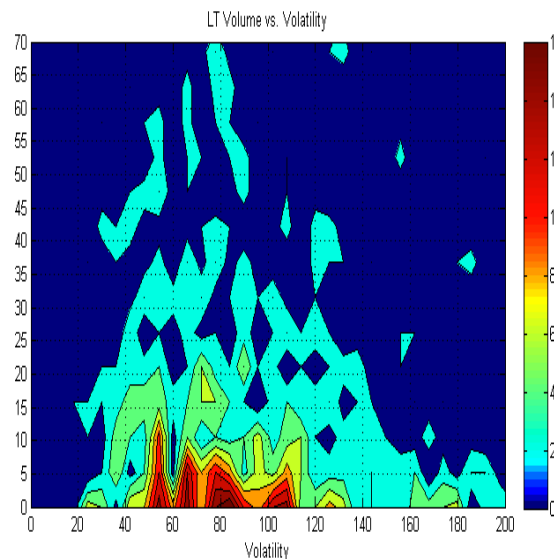
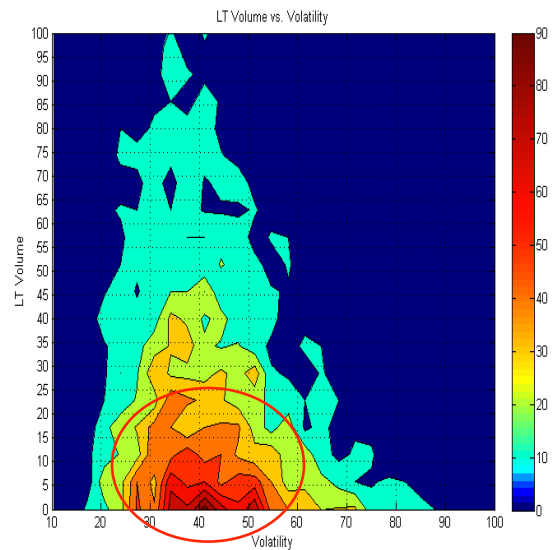
Triggers for LT and HFT volumes:

■ LT: driven by fundamentals (such as earnings)

■ LT trade less as implied volatility increase

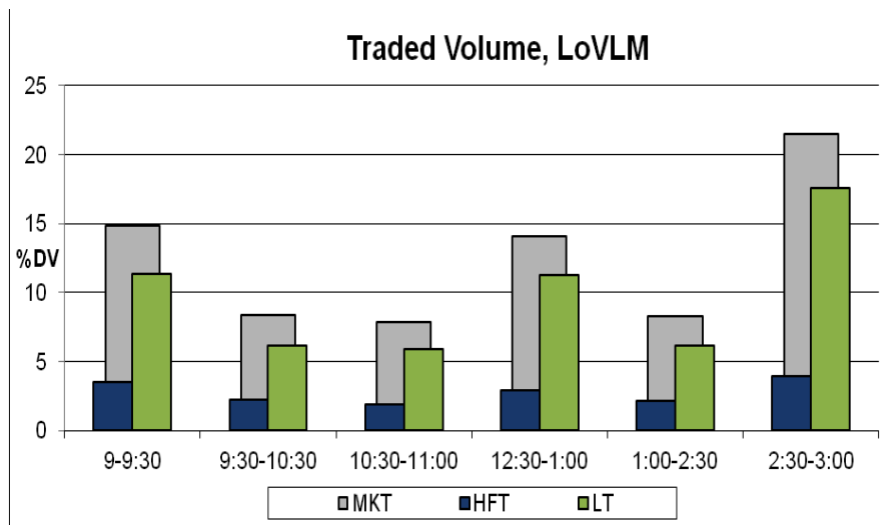
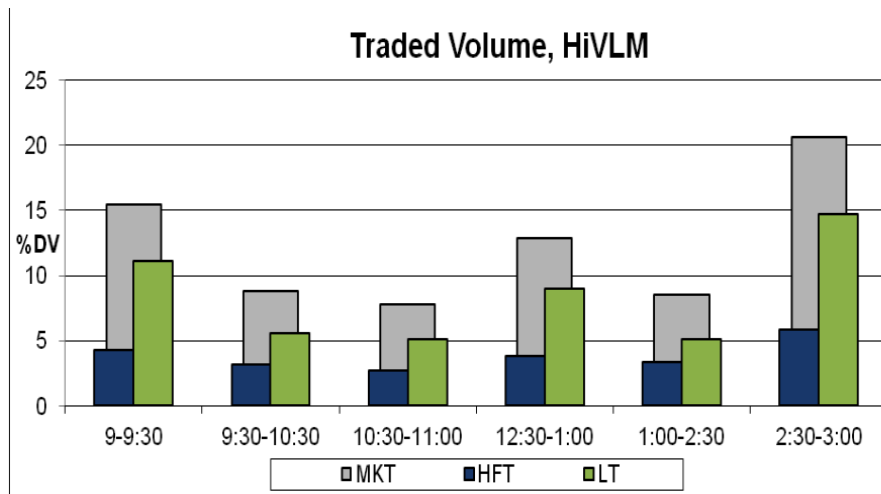
■ HFT - not driven by fundamentals, but positively correlated with implied volatility

■ Both LT and HFT volumes are highly correlated with each other in *HiVLM* (liquidity begets liquidity)



LT vs. HFT: MISMATCHED VOLUME PROFILES

JAPANESE MARKET



■ LT volume profiles are strongly W-shaped:

■ Two price discovery windows

■ High-volume closing session

■ HFT's volume profiles are significantly flatter

This means:

■ HFT doesn't aim to maximize liquidity provisioning: risk controls take prevalence, informed flow at the open of both sessions is avoided and positions are flat by EOD

■ LT may not realize how expensive it is to trade around the open given pronounced one-sidedness of the market.

TRADE “SIDEDNESS”

JAPANESE MARKET - LT TRADE IS CROWDED, HFT TRADES ON BOTH SIDES

| HiVLM | HFT BUY | HFT SELL | LT BUY | LT SELL |
|--------------|---------|----------|--------|---------|
| HFT BUY | 1 | | | |
| HFT SELL | 0.93 | 1 | | |
| LT BUY | 0.21 | 0.23 | 1 | |
| LT SELL | 0.26 | 0.25 | 0.28 | 1 |

| LoVLM | HFT BUY | HFT SELL | LT BUY | LT SELL |
|--------------|---------|----------|--------|---------|
| HFT BUY | 1 | | | |
| HFT SELL | 0.79 | 1 | | |
| LT BUY | 0.05 | 0.04 | 1 | |
| LT SELL | 0.05 | 0.04 | 0.16 | 1 |

| | HiVLM, HFT | HiVLM, LT | LoVLM, HFT | LoVLM, LT |
|----------|-------------------|------------------|-------------------|------------------|
| Avg. | 11.08 | 52.97 | 28.58 | 66.13 |
| Median | 7.50 | 53.76 | 19.64 | 74.21 |
| Std. dev | 11.96 | 30.43 | 26.05 | 31.51 |

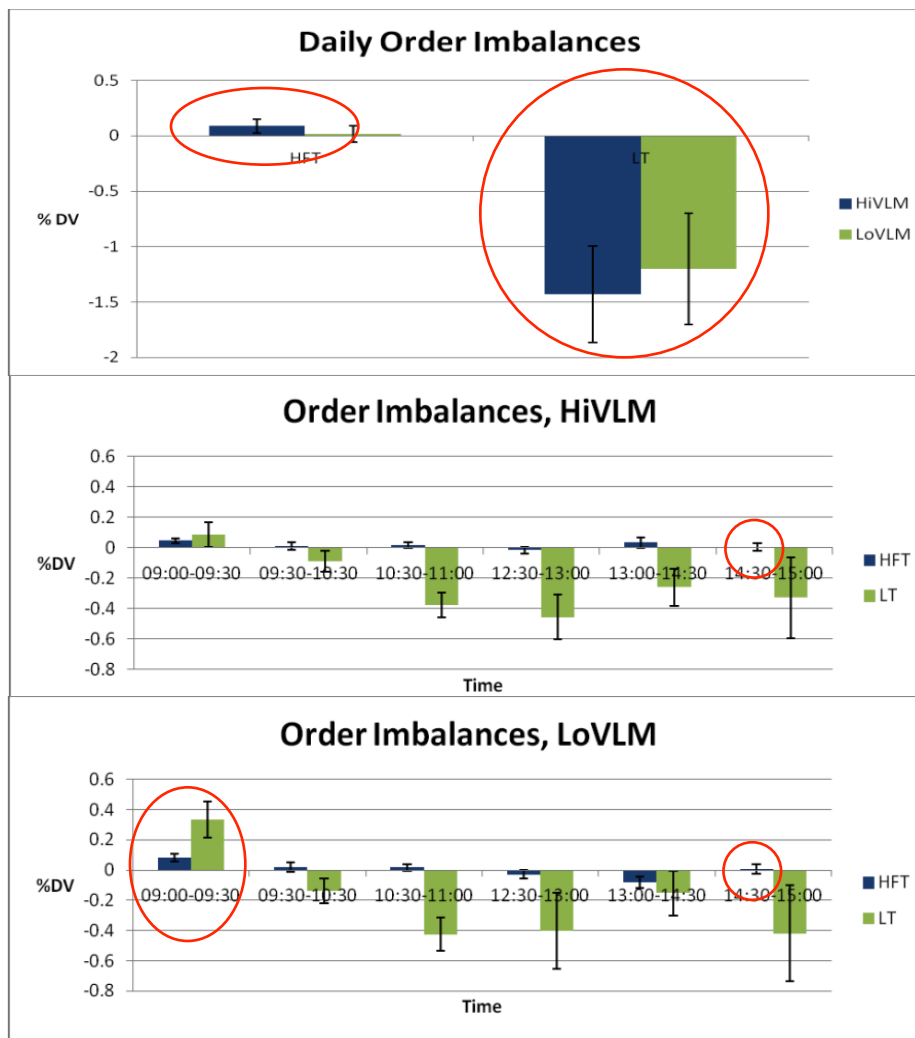
$$\text{Imbalance} = \frac{\text{Abs}(\text{Buy} - \text{Sell})}{(\text{Buy} + \text{Sell})}$$

$$10\% \approx \frac{|1.2x - x|}{(1.2x + x)} \quad 66\% = \frac{|5x - x|}{(5x + x)}$$

- HFT buy and sell volumes are highly correlated, even in *LoVLM* category
- HFT absolute daily imbalances are very tight in *HiVLM*, much less so in *LoVLM* (different strategies? low trading volumes?)
- This confirms that HFT make markets in select group of highly liquid names.
- Note: This data doesn't preclude the possibility of front-running (it only indicates that HFT are typically flat by EOD)
- As expected, LT trades are one-sided: daily imbalances are high in *HiVLM* names and even higher in *LoVLM* names - a source of adverse selection for market-makers.

INTRADAY TRADE IMBALANCE

JAPANESE MARKET – HFT FLAT INTRADAY, LT IS NOT

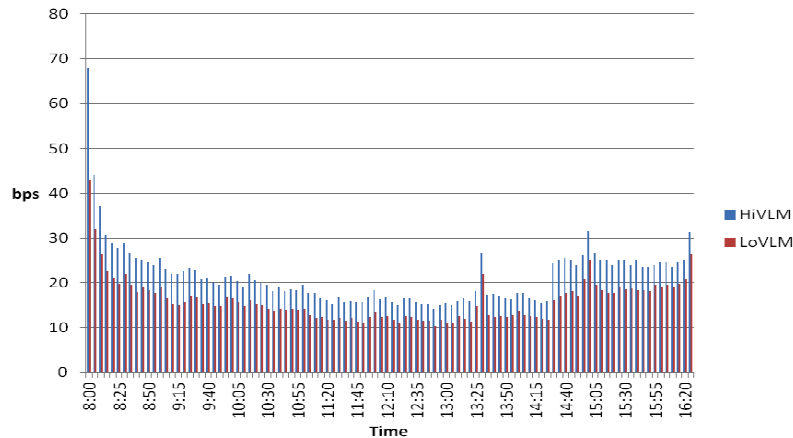


- LT were net-sellers during the 1H 2010 (outflows from Equities, from the region)
- HFT supplied liquidity in *HiVLM* (offsetting LT imbalance, perhaps hedged with futures).
- HFT keeps intraday positions flat (per ticker, making front-running of large orders difficult)
- HFT trade imbalance especially tight around the close – positions are flattened before that.
- HFT trade on the same side in the morning (front-running?), although they are late to unwind (stat-arb strategies may still be profitable)

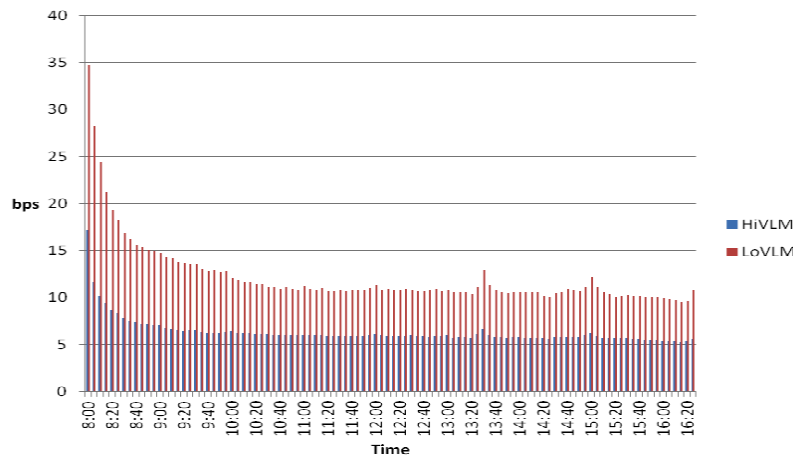
HOW HFT AFFECTS MARKET QUALITY?

UK MARKET – HFT CREATES HIGHER ST VOLATILITY & LOWER SPREADS

5 min HL, UK, 2010



5 min Spread, UK, 2010

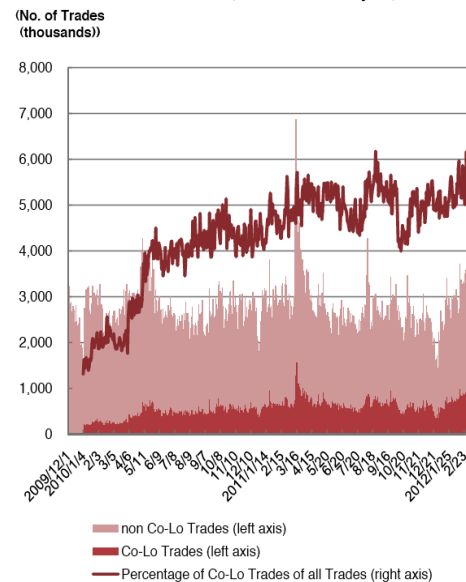


■ 5-minute HL volatility is 30% higher in HiVLM.

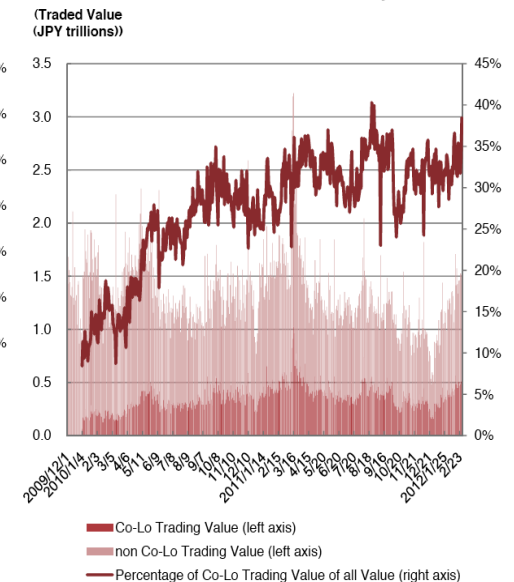
■ Bid-ask spread is twice lower.

■ These levels are observed with HFT at 40-55% of the market. What is the dynamics in Japan? (HFT grew from 10% in 2010 to

Number of Co-Lo / non Co-Lo Trades and Percentage of Co-Lo Trades
(from December 1, 2009 to February 29, 2012)



Co-Lo / non Co-Lo Trading Value and Percentage of Co-Lo Trading Value
(from December 1, 2009 to February 29, 2012)



HOW HFT AFFECTS MARKET QUALITY?

JAPANESE MARKET – HFT CREATES HIGHER ST VOLATILITY & LOWER SPREADS

| Stock Price, ¥ | Tick Size ¥, Before Revision | Tick Size ¥, After Revision |
|-----------------------|------------------------------|-----------------------------|
| Up to 2,000 | 1 | 1 |
| 2,000-3,000 | 5 | 1 |
| 3,000-5,000 | 10 | 5 |
| 5,000-30,000 | 10 | 10 |
| 30,000-50,000 | 50 | 50 |
| 50,000-300,000 | 100 | 100 |
| 300,000-500,000 | 1,000 | 500 |
| 500,000-3,000,000 | 1,000 | 1,000 |
| 3,000,000-5,000,000 | 10,000 | 5,000 |
| 5,000,000-20,000,000 | 10,000 | 10,000 |
| 20,000,000-30,000,000 | 50,000 | 10,000 |
| 30,000,000-50,000,000 | 100,000 | 50,000 |
| Over 50,000,000 | 100,000 | 100,000 |

Price Category <=2000 ¥

| % Change | Mean | Std. Err. | T-statistics |
|--|--------|-----------|--------------|
| HL5 | 9.48 | 0.28 | 33.57 |
| HL10 | 1.79 | 0.31 | 5.79 |
| HL30 | 1.47 | 0.41 | 3.59 |
| HL | 1.24 | 1.17 | 1.06 |
| CO | 4.19 | 3.18 | 1.32 |
| Quoted spread | -3.33 | 0.34 | -9.76 |
| Quoted spread improvement over tick size | -28.11 | 0.78 | -36.18 |

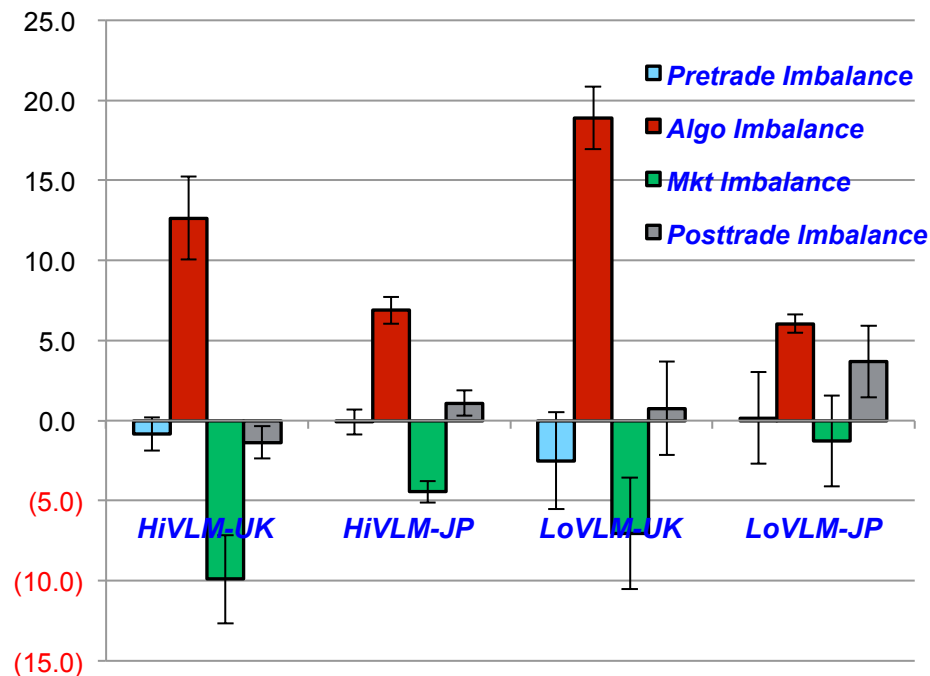
Price Category 2000-5000 ¥

| % Change | Mean | Std. Err. | T-statistics |
|--|--------|-----------|--------------|
| HL5 | 7.83 | 0.43 | 18.08 |
| HL10 | 1.20 | 0.45 | 2.67 |
| HL30 | -0.23 | 0.57 | -0.41 |
| HL | 0.03 | 1.10 | 0.02 |
| CO | 1.00 | 2.76 | 0.36 |
| Quoted spread | -11.55 | 0.68 | -16.96 |
| Quoted spread improvement over tick size | -26.48 | 0.60 | -44.06 |

- Market in flux: Arrowhead implementation, colocation facilities, minimum tick size reduction
- Same plots for UK don't work: tick size in *LoVLM* created artificially high ST- σ (bid-ask bounce) above fundamentals
- Employed DID (difference-in-difference) method: volatility in *LoVLM* is control variable, volatility in *HiVLM* is dependent variable
- 5- & 10-minute σ is up, daily volatility didn't change, quoted spread is down, quotes adjust much faster (less time spread > 1 tick)
- 8-9% increase is the slope (change in ST- σ over 1 year). In UK the difference in ST- σ is 30% between *HiVLM* and *LoVLM*

HFT: LIQUIDITY PROVISION? FRONT-RUNNING?

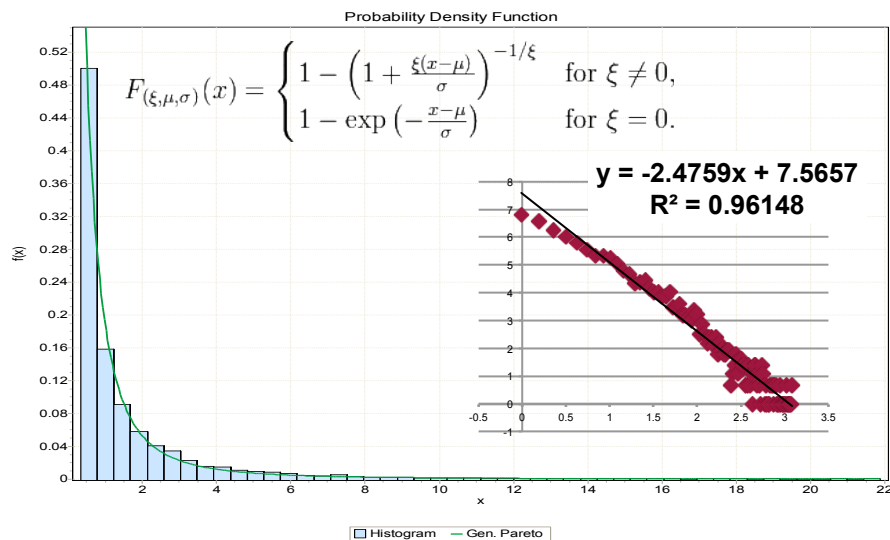
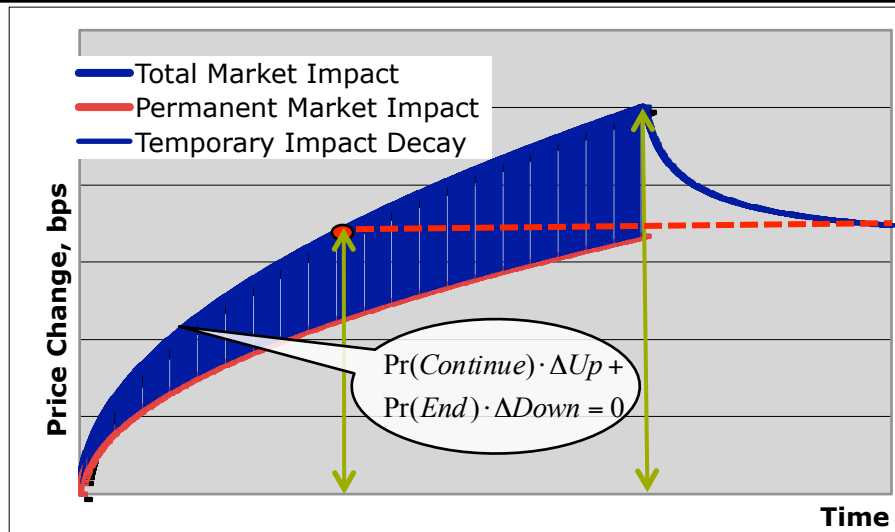
AB TRADED UNIVERSE



- Front-running: expecting same-side imbalance pre- or in-trade (first 5 min), reversal right after the trade. Observe:
- No pre-trade imbalance
- Offsetting in-trade imbalance in *HiVLM*, less so in *LoVLM*
- No post-trade imbalance
- On aggregate open-to-close return is flat (non-toxic flow) - more profitable to provide liquidity
- In general, on average LT flow is non-toxic. (ITG, AbelNoser). Intuitively: annual relative out performance in top quartile is 2-3%. Median is 0 to mildly negative (T-costs). LT tend to trade aggressively as traders are not compensated to take risk.

HFT: LIQUIDITY PROVISION? FRONT-RUNNING?

MARKET MAKING MODELS



- On average LT flow is non-toxic. (ITG, AbelNoser). Intuitively: annual relative out performance in top quartile is 2-3%. Median is 0 to mildly negative (T-costs).
- Despite low alpha, LT orders are traded aggressively (average rate 10-20%), as traders are not compensated to take risk, which causes significant temporary impact.
- Vast majority of institutional parent orders are small, market impact ~ bid-ask spread
- EMMs don't have risk appetite to carry open positions long enough to profit from front-running more than they would have profited scalping. EMMs do profit trading the reversion (which is fast ~5-10 minutes on daily orders)

HFT IMPACT ON TRADING COSTS

AB TRADED UNIVERSE

| UK | Shortfall | Pretrade | Market Return | Daily Average 5 min HL | VX2 | HFT | Time of Day |
|-----------------------------------|-----------|----------|---------------|------------------------|-------|------|-------------|
| Shortfall | 1 | | | | | | |
| Pretrade: E(Cost) | 0.08 | 1 | | | | | |
| Market Return | 0.26 | -0.02 | 1 | | | | |
| Daily average 5 min HL volatility | 0.05 | 0.15 | 0.00 | 1 | | | |
| VX2 | -0.01 | 0.19 | -0.01 | 0.30 | 1 | | |
| HFT | -0.03 | -0.25 | 0.00 | 0.11 | 0.02 | 1 | |
| Time of Day | 0.03 | -0.15 | 0.01 | -0.03 | -0.08 | 0.01 | 1 |

| Variable | Coefficient | Std. Err. | T-statistics | 95% CI | |
|-----------------------------------|-------------|-----------|--------------|---------|---------|
| Pretrade: E(Cost) | 0.0890 | 0.0158 | 5.62 | 0.0573 | 0.1208 |
| HFT presence | -0.0755 | 0.0169 | -4.45 | -0.1094 | -0.0415 |
| Market Return | 0.2933 | 0.0108 | 26.94 | 0.2715 | 0.0315 |
| Daily average 5 min HL volatility | 0.0230 | 0.0278 | 0.82 | -0.0326 | 0.0786 |
| Constant term | 0.0193 | 0.0213 | 0.91 | -0.0224 | 0.0610 |

| JP | Shortfall | Pretrade | Market Return | Daily Average 5 min HL | VXJ | HFT |
|-----------------------------------|-----------|----------|---------------|------------------------|------|-----|
| Shortfall | 1 | | | | | |
| Pretrade: E(Cost) | 0.10 | 1 | | | | |
| Market Return | 0.19 | -0.03 | 1 | | | |
| Daily average 5 min HL volatility | 0.03 | 0.30 | -0.01 | 1 | | |
| VXJ | -0.02 | 0.02 | -0.01 | 0.33 | 1 | |
| HFT | -0.04 | -0.31 | -0.02 | 0.32 | 0.02 | 1 |

| Variable | Coefficient | Std. Err. | T-statistics | 95% CI | |
|-----------------------------------|-------------|-----------|--------------|---------|--------|
| Pretrade: E(Cost) | 0.0783 | 0.0117 | 6.66 | 0.0550 | 0.1015 |
| HFT presence | -0.1023 | 0.0126 | -8.07 | -0.1274 | 0.0771 |
| Market Return | 0.2328 | 0.0163 | 14.24 | 0.2004 | 0.2652 |
| Daily average 5 min HL volatility | -0.0354 | 0.0203 | -1.74 | -0.0757 | 0.0047 |
| Constant term | -0.0558 | 0.0147 | 3.78 | 0.0269 | 0.0847 |

- How HFT presence and ST- σ affect [IS-E(cost)], adjusted by broad market momentum?
- Side-adjusted market return is the largest factor positively correlated with [IS-E(cost)]
- HFT presence is negatively correlated with [IS-E(cost)] reducing T-costs through compressed realized spread and reduction of relative price dislocations.
- ST- σ adversely affects [IS-E(cost)] in UK. On our sample its impact is not statistically significant

CONCLUSION

- HFT activity is concentrated in a subset of liquid mega-cap names. This creates a self-fulfilling prophecy:

JP, \$10M positions (\$0.5-1B portfolio). Tracking to Topix/Nikkei ~4-5%

| | Cost | Risk | RiskAdjCost | Risk Bid | %ADV |
|--------------|-----------|------|-------------|-----------|------|
| <i>HiVLM</i> | 48 | 91 | 96 | 97 | 20 |
| <i>LoVLM</i> | 101 | 146 | 178 | 158 | 79 |
| delta | 53 | | 81 | 61 | |

JP, \$50M positions (\$2.5-5B portfolio). Tracking to Topix/Nikkei ~4-5%

| | Cost | Risk | RiskAdjCost | Risk Bid | %ADV |
|--------------|------------|------|-------------|------------|------|
| <i>HiVLM</i> | 164 | 139 | 237 | 230 | 102 |
| <i>LoVLM</i> | 305 | 212 | 417 | 407 | 395 |
| delta | 141 | | 180 | 177 | |

UK, \$10M positions (\$0.5-1B portfolio). Tracking to FTSE100/250 ~4%

| | Cost | Risk | RiskAdjCost | Risk Bid | %ADV |
|--------------|-----------|------|-------------|-----------|------|
| <i>HiVLM</i> | 18 | 63 | 51 | 72 | 12 |
| <i>LoVLM</i> | 42 | 178 | 135 | 114 | 74 |
| delta | 24 | | 84 | 42 | |

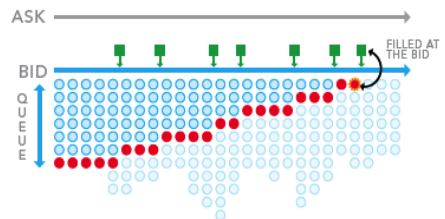
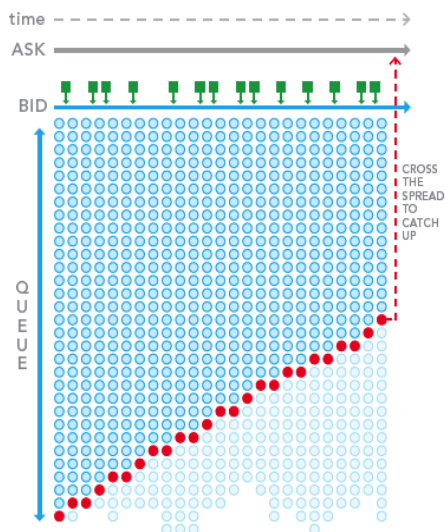
UK, \$50M positions (\$2.5-5B portfolio). Tracking to FTSE100/250 ~4%

| | Cost | Risk | RiskAdjCost | Risk Bid | %ADV |
|--------------|-----------|------|-------------|------------|------|
| <i>HiVLM</i> | 40 | 105 | 96 | 101 | 60 |
| <i>LoVLM</i> | 132 | 278 | 278 | 235 | 368 |
| delta | 92 | | 182 | 134 | |

- HFT is predominantly involved in market making. We didn't find any evidence of front-running.
- HFT is not serving liquidity on LT terms: mismatch between liquidity demand and supply.
- Smaller players are displaced by a few large EMMs. HTF liquidity is not additive – there is only so much LT: (1H'10-1H'12: TSE volumes down 17-20%, inline with 15% weight drop of Japan in MSCI)
- This environment heightens liquidity risk for LT. Leads to compressed bid-ask spreads/higher ST-volatility. Net outcome for T-cost depends on the type of the flow.
- Our own trades: net cost reduction due to liquidity provisioning. This should be the outcome for majority of LT, although certain strategies are disadvantaged: Value orders, larger high-alpha orders. Retail benefits.
- How LT should adopt? Align order sizing and aggressiveness with underlying alpha. Optimize interaction with uncorrelated (non-EMM) liquidity. Be flexible in less liquid names.

Passive Trading in Mega-Liquid names

This schematic shows a limit order's journey through the time priority queue of a limit order book, and how longer queues can interfere with passive trading.



- █ MARKET ORDER FROM OPPOSING SIDE
- POSTED ORDER AHEAD OF ALGO ORDER
- POSTED ALGO ORDER
- ORDERS POSTED BEHIND ALGO ORDER

| TICKER | ADV (MSHARES) | QUEUE LENGTH (SHARES) | SPREAD (CENTS) | 15-MIN VOLATILITY (%) | QUEUE DEPLETION TIME (S) |
|--------|---------------|-----------------------|----------------|-----------------------|--------------------------|
| BAC | 190.3 | 558,925 | 1.0 | 0.41 | 138 |
| SPY | 161.1 | 30,237 | 1.0 | 0.12 | 9 |
| XLF | 89.6 | 2,574,847 | 1.0 | 0.19 | 1345 |
| FB | 74.5 | 22,296 | 1.3 | 0.91 | 14 |
| EEM | 60.9 | 82,727 | 1.0 | 0.16 | 64 |
| JPM | 56.8 | 13,250 | 1.0 | 0.30 | 11 |
| VXX | 56.4 | 11,852 | 1.0 | 0.57 | 10 |
| SIRI | 53.8 | 1,021,571 | 1.0 | 0.45 | 920 |
| QQQ | 50.2 | 63,295 | 1.0 | 0.15 | 59 |
| IWM | 48.7 | 15,158 | 1.0 | 0.19 | 15 |
| CSCO | 47.3 | 84,527 | 1.0 | 0.23 | 85 |
| MSFT | 45.6 | 40,857 | 1.0 | 0.20 | 42 |
| F | 43.8 | 132,213 | 1.0 | 0.31 | 141 |
| GE | 43.8 | 89,467 | 1.0 | 0.20 | 96 |
| S | 43.5 | 422,473 | 1.0 | 0.58 | 456 |
| C | 41.9 | 14,347 | 1.0 | 0.37 | 16 |
| CHK | 38.6 | 10,778 | 1.0 | 0.52 | 13 |
| INTC | 36.9 | 35,485 | 1.0 | 0.22 | 45 |
| NOK | 32.2 | 430,861 | 1.0 | 0.37 | 627 |
| PFE | 30.9 | 58,008 | 1.0 | 0.19 | 88 |
| MS | 29.7 | 24,323 | 1.0 | 0.43 | 38 |
| WFC | 29.4 | 14,728 | 1.0 | 0.26 | 23 |
| ORCL | 29.3 | 22,414 | 1.0 | 0.26 | 36 |
| MU | 27.9 | 94,524 | 1.0 | 0.52 | 159 |
| ZNGA | 25.7 | 16,315 | 1.0 | 0.82 | 30 |
| T | 25.4 | 33,937 | 1.0 | 0.14 | 63 |
| DELL | 23.6 | 53,863 | 1.0 | 0.26 | 107 |
| VWO | 22.8 | 43,736 | 1.0 | 0.15 | 90 |
| VALE | 21.9 | 23,396 | 1.0 | 0.31 | 50 |
| TZA | 21.8 | 11,200 | 1.1 | 0.56 | 24 |
| EFA | 21.8 | 34,171 | 1.0 | 0.14 | 73 |
| EMC | 21.7 | 23,829 | 1.0 | 0.25 | 52 |
| SDS | 21.0 | 316,091 | 1.0 | 0.24 | 706 |
| AA | 21.0 | 100,122 | 1.0 | 0.32 | 224 |
| HPQ | 20.7 | 20,302 | 1.0 | 0.27 | 46 |
| GDX | 20.3 | 4,984 | 1.1 | 0.32 | 11 |
| EWZ | 20.3 | 5,748 | 1.0 | 0.22 | 13 |
| RF | 20.2 | 134,203 | 1.0 | 0.45 | 311 |
| LOW | 20.0 | 11,869 | 1.0 | 0.26 | 28 |
| FAZ | 19.3 | 7,236 | 1.1 | 0.50 | 18 |
| FXI | 19.2 | 22,049 | 1.0 | 0.17 | 54 |
| YHOO | 18.9 | 36,246 | 1.0 | 0.29 | 90 |
| XLI | 17.7 | 169,464 | 1.0 | 0.16 | 447 |
| NWSA | 17.5 | 26,692 | 1.0 | 0.24 | 71 |
| AAPL | 17.5 | 416 | 14.3 | 0.25 | 1 |

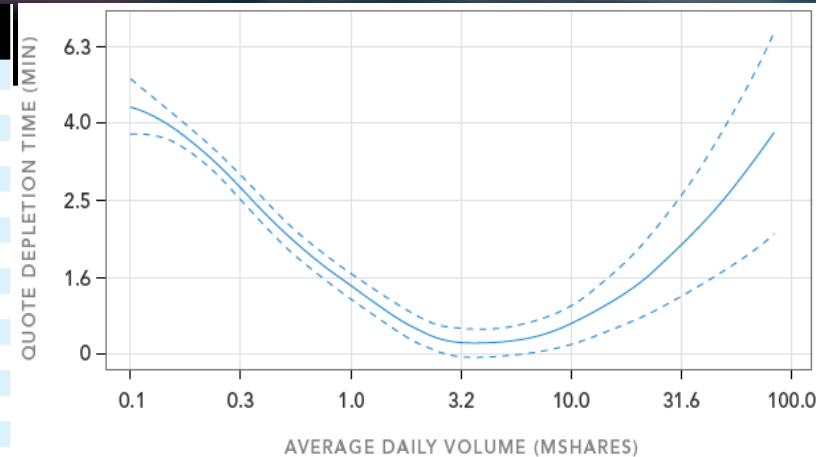


FIGURE 2
Average queue depletion time versus ADV*.

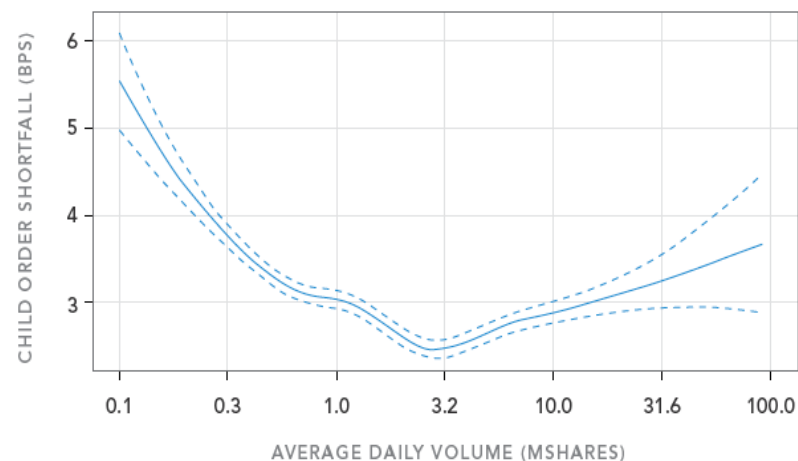


FIGURE 3
Average child order shortfall versus ADV*.

Source: PragmaTrading (Dr. Eran Fisher)



Literature

Good Overview of Existing Literature:

Charles M Jones “What do we know about high-frequency trading”

http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2236201

Interesting Recent Paper:

Johannes Breckenfelder “Competition of High-Frequency Market Makers and Market Quality”

<http://people.stern.nyu.edu/jhasbrou/SternMicroMtg2013/Papers/CompetHFMktMkrs.pdf>

