The Impact of Computer-Based Trading on Market Quality

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UK Government Office for Science Foresight project on *The Future of Computer Trading on Financial Markets*

International project with hundreds of academics and practitioners involved

Some Questions our project addresses

1. What are the effects of Computer-Based trading ("CBT" including "AT" and "HFT") on market quality measures like liquidity, transaction costs, price discovery, and efficiency in normal times?
2. What are the risks associated with the changing nature of market making (which has shifted from designated providers to opportunistic HFT traders with in many cases limited capital commitment combined with ultra-fast speed) in extreme times?
3. What are the appropriate definitions of market abuse/manipulation in a high speed multi-venue multi-asset environment? Has the advent of CBT increased market manipulation?

Main complaints about HFT (from e.g., OW survey of buy-side)

- Liquidity they supply is ephemeral. Narrow bid ask spreads, but created by "flickering quotes", i.e., not accessible to humans. Pass the parcel trading between HFT. Liquidity supply evaporates during crisis times e.g., Flash Crash.
- Too much messaging, i.e., order cancellations and revisions, negative externality. Requires big investments in technology (Smart Order Routers, Co-location, Algos for order slicing) to keep up. Arms race for speed socially unproductive (Paul Krugman)
- Increase volatility
- Market abuse and manipulation: quote stuffing, spoofing, layering, smoking, etc.

Theoretical Arguments on either side

- Jarrow and Protter (2011), Biais et al. (2012), Pagnotta and Philippon (2012), Cartea and Penalva (2011), Jovanovic and Menkveld (2011).
- No dominant agreed-on theoretical model. Furthermore, in many cases, models suffer from oversimplifications either:
  - No explicit time scale, when time is the key feature here.
  - Simplified strategy space for traders (HFT contains a number of different trading styles: market making (e.g., GETCO), statistical arbitrage, directional or momentum traders. The first two typically thought to have good contribution to the markets, the third less so. Same firm can combine all strategies differently over time)
  - Simplified market structure

Caution about What we Know and What we dont Know

- The question of whether it is good or bad can only be answered with empirical evidence and with reference to some benchmark alternative universe.
- Recent phenomenon of interest. Not much published research on this. We survey what there is with an emphasis on high quality peer reviewed work.
- Field is evolving so some caution is required in making conclusions. It is not like the issue of whether smoking has negative health outcomes where there is almost universal agreement based on lots of careful research. It is also not perhaps at the same level as climate change...
- The research on CBT being so recent has not achieved that level of agreement.

System latency following Moores law or even more

System	Implementation Date	Latency (Microseconds)
SETS	$<$2000	600000
SETS1	Nov 2001	250000
SETS2	Jan 2003	100000
SETS3	Oct 2005	55000
TradElect	June 18, 2007	15000
TradElect 2	October 31, 2007	11000
TradElect 3	September 1, 2008	6000
TradElect 4	May 2, 2009	5000
TradElect 4.1	July 20, 2009	3700
TradElect 5	March 20, 2010	3000
Millenium	February 14, 2011	113

What is the Social Cost of High Frequency Trading

Costs of speed $\downarrow$; Benefits of speed are small but not zero. Race to the bottom. Krugman, Haldane, etc.

Can we bound the social cost of the socially unproductive arms race for speed?

What is the value of the Equity Trading Space?

Profitability estimated $8b-20b per year in US. Kearns et al study tries to bound profitability of omniscient HFT more like $3b.

Compare with total value of electronic order book trading $30tr in 2009

Knight Capital. US electronic market maker, 10% of total value of equity traded in US in 2011. Total revenue $1.4b, net income $114m in 2011. 1500 employees.

Not trivial, but compare with Exxon Mobile Net Income of $41billion in 2011

What Kind of Evidence?

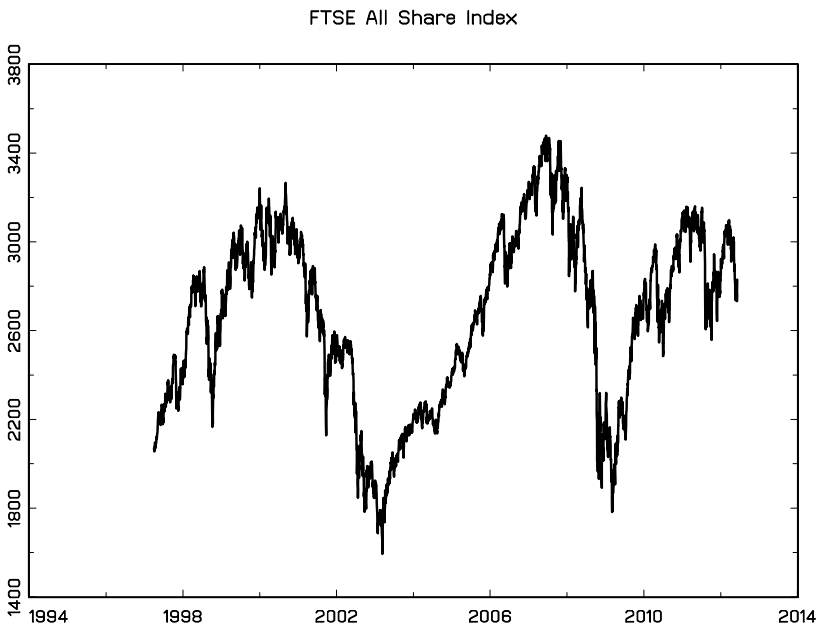
- The evidence we consider is of two types
  - Event studies/natural experiments (exogenous changes in conditions that favour HFT but do not affect directly outcome of interest)
  - Time series comparison of now and then

The main issues are:

- Measurement of HFT/AT where this is necessary. Some studies work with "trader id's" that classify traders
- Measurement of market quality in high frequency setting
- Endogeneity/causality issues. For example, HFT may cause volatility and/or volatility may cause increased trading and hence HFT.
- Time scale to do comparison. Is it meaningful to compare trading activity within a second between 2012 and 1912?

Rising Tide Lifts all Boats?

The level of the stock market has gone up and down violently over the new millenium. The macro economy has been in turmoil with dreadful performance since 2007. These are giant factors out there affecting savers and investors and any analysis that is done needs to control for this.



Liquidity

Tightness, Depth, Resilience, but difficult to define precisely. Common measures bid ask spreads, effective spreads, realized spreads, depth, trading volume etc.

- Hasbrouck and Saar (2010) Nasdaq during 2007-2008 order book. Low latency activity improves spreads and depth.
- Hendershott, Jones, and Menkveld (2011, Journal of Finance). How does CBT/HFT activity affect liquidity? They use the phased in automation of the NYSE quote system in 2003 as a natural experiment to measure the causal effect of CBT on liquidity.
- Their findings were that CBT improves liquidity and enhances the informativeness of quotes.
- Brogaard (2011) dissertation, US data. Several PhD students on market this year with new work on this data

- Castura at al. Show bid ask spreads and depth on the Russell 1000 and 2000 over the period 2006-2010. They show the improvement of bid ask spreads and depth over this time.
- Payne driver shows the same for FTSE100 stocks over the period Jan 2009 to April 2011 and finds improvements

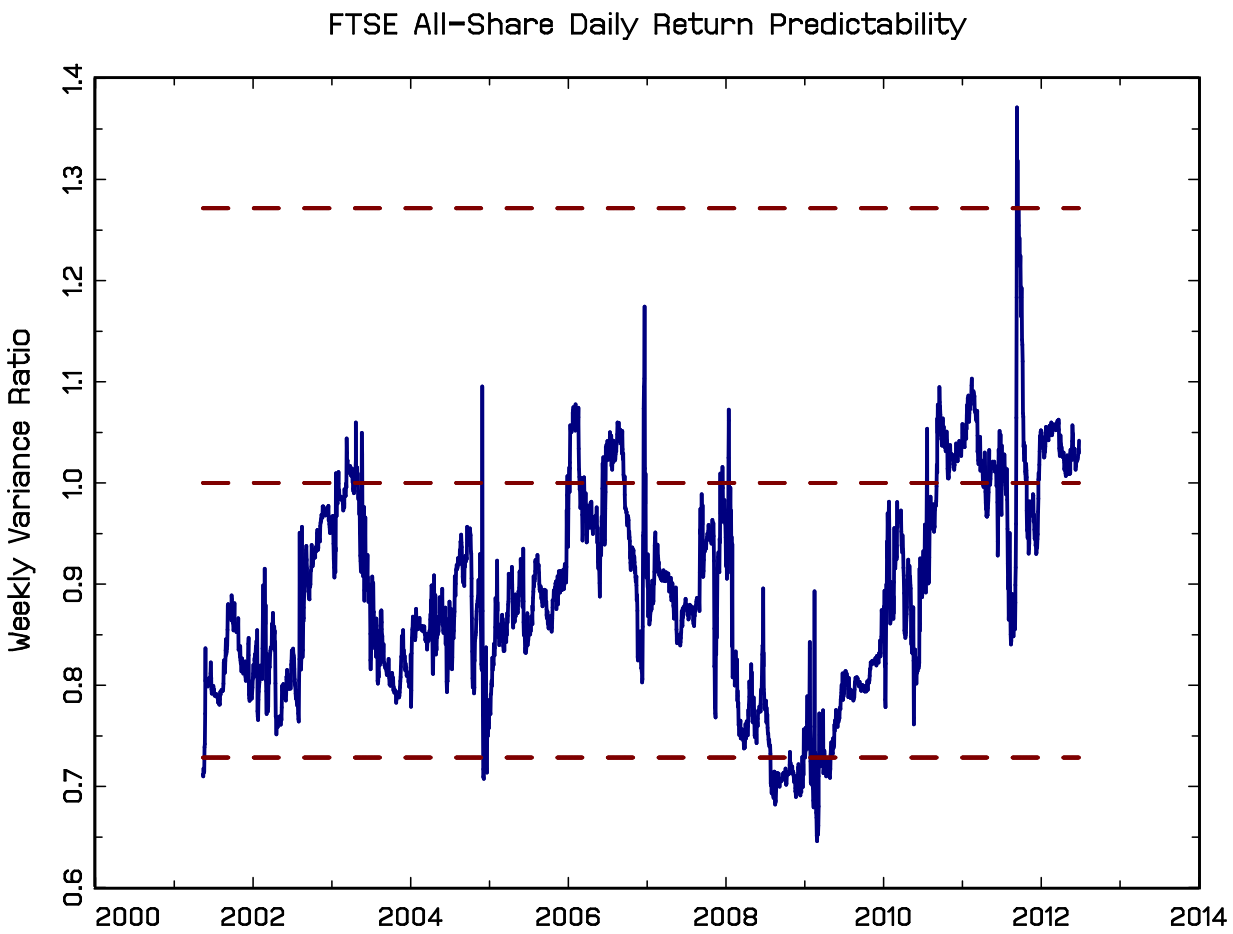
- J&M. Empirical study of the entry of a HFT player into the market for Euronext listed Dutch index stocks on Chi-X in 2007/2008.
- Compares with Belgian stocks which had no such treatment. Difference in difference analysis: before and after (it was during a busy time for markets), Dutch and Belgian
- Shows *improved* market quality metrics, *reduced* adverse selection components, and *more* trading. Chi-X quotes more responsive to futures quotes than Euronext. Consistent with the story that middleman are more active during periods of hard information
- Gresse (2011) shows that the fragmentation of trading (associated with HFT activity) after MiFID1 lead to improvements of effective and realized spreads as well as market depth especially for larger stocks in Europe.

Transaction costs

- Angel et al (2010) show that average retail commissions in the USA have decreased between 2003 and 2010. Impact costs also less evidenced from bid ask spreads.
- Menkveld (2011) investigates the effect of the entry of Chi-X into the market for Dutch index stocks. Had an immediate and substantial (negative) effect on trading fees for investors through
  - The lower fees that Chi-X charged
  - The lower fees that Euronext then charged
  - The reduction in clearing and settlement fees that followed

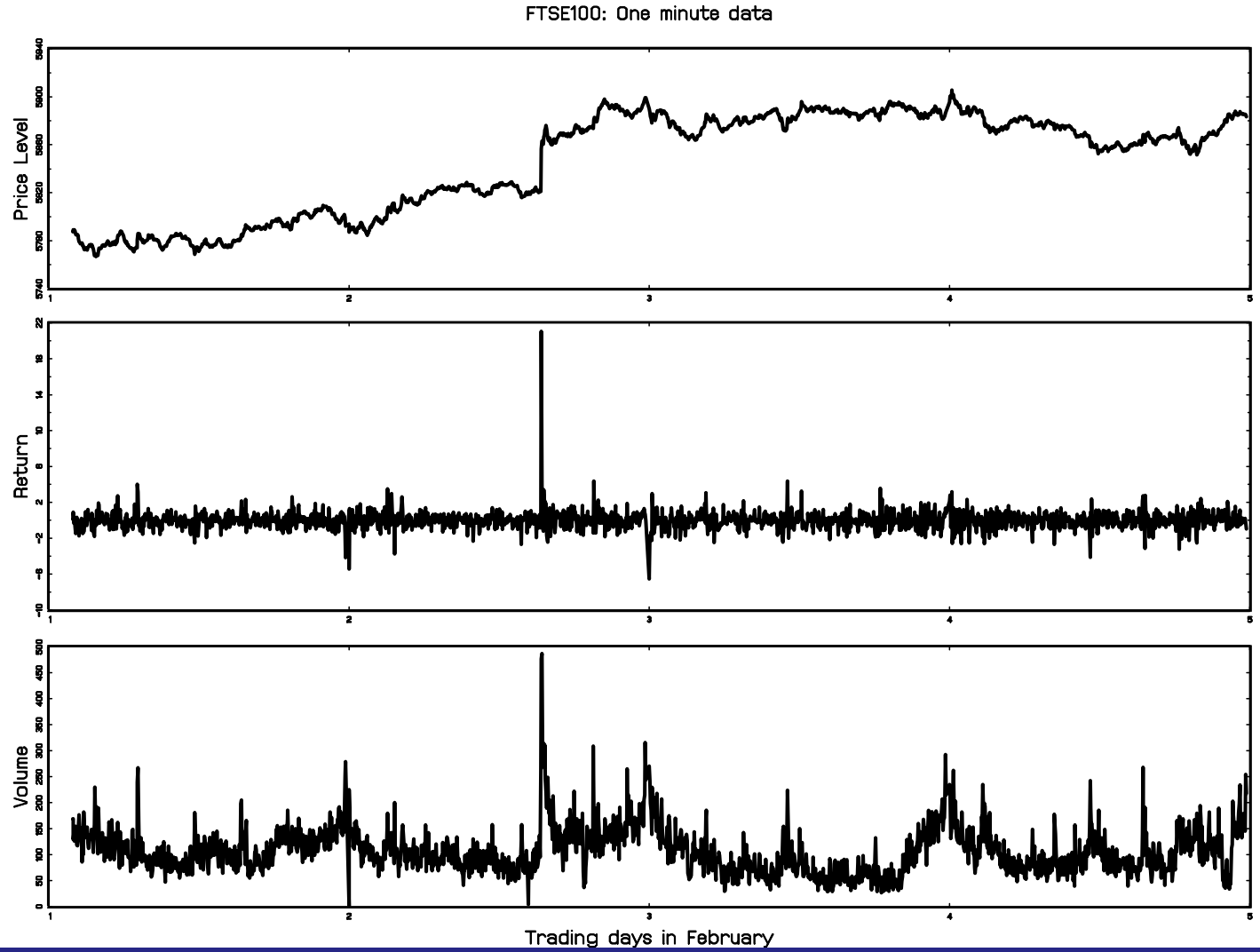
Price Efficiency/Discovery

- Hendershott driver reviews the arguments why HFT may improve efficiency by bringing into line prices of correlated securities, buying low and selling high.
- Main evidence is from Castura et al. study. High Frequency Variance ratios (They look at 10:1 second variance ratios as well as 60:10 and 600:60 second ratios) on Russell 1000 and 2000 over the period 2006 to 2010 have come closer to one, meaning less linear predictability.
- Low frequency efficiency metrics show no trend towards improvement or disimprovement. Daily FTSE all share data from 2000-2012: variance ratios fluctuate over the business cycle and there was more evidence of predictability during the 2007/2008 period but that lack of efficiency has declined since then.

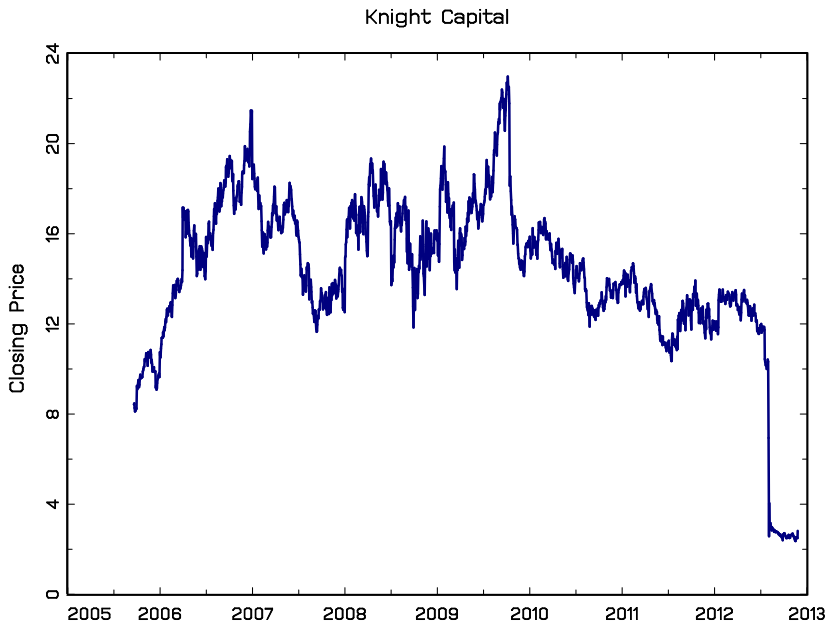


Rolling window (annual) VR(5) with iid confidence bands

Some evidence that announcement effects are much faster impacted into prices. A positive US non-farm payroll day in 2012



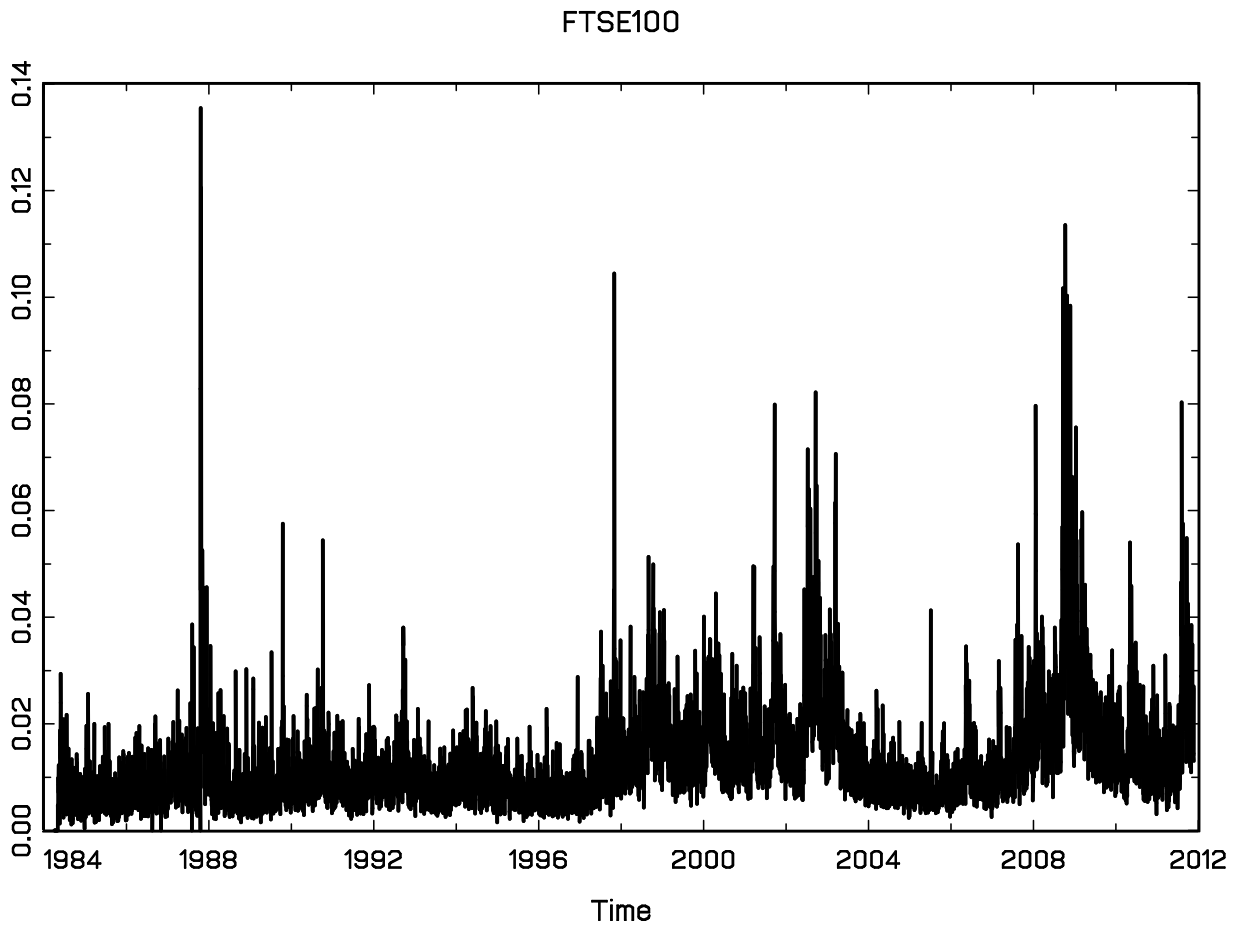
Knight Capital. US market maker. Listed on NYSE. August 1, 2012 trading error caused widespread disruption on NYSE. They lost $450m in a few minutes.
Their own share price reflected that disaster, over the day and overnight. 20120801 open 10.33 close 6.94, 20120802 open 3.30 close 2.58



Volatility

Not necessarily a good or a bad except makes life difficult for some investors. Financial stability.
Some studies show slight increase in volatility due to HFT activity (messaging) - Zhang (2010), Boehmer (2011), and OHara and Ye (2011).
Other studies show decreases, Brogaard (2011), Brogaard et al (2012). Hasbrouck and Saar (2010) Low latency activity reduces volatility. Chaboud et al. (2009) (xrates) CBT associated with slightly lower volatility.

- Time series graph of FTSE100 share index daily volatility measure 1984-2012.
- High minus low measure of volatility takes account of all values that price takes within a day so that extreme movements are not missed. Really an ultra high frequency measure.
- This graph shows that volatility has gone up and down over the last twenty years. In 2007 it started picking up and increased to a peak in 2008, after which it lowered throughout 2010.


FTSE100
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
1984
1988
1992
1996
2000
2004
2008
2012
Time

FTSE100 Top 20 Most Volatile days since 1984 (- means $P_C < P_O$, + means $P_C > P_O$)

Date	Volatility
19871020	0.131-
19871022	0.115-
20081010	0.112-
19971028	0.096-
20081024	0.096-
20081006	0.094-
20081008	0.094-
20080919	0.093+
20081124	0.090+
20081015	0.084-
19871019	0.081-
20020920	0.080+
20081013	0.076+
20010921	0.076-
20081029	0.075+
20110809	0.074+
20090114	0.074-
20080122	0.074+
20020715	0.071-
20081016	0.070-

S&P500 Top 20 Most Volatile (high-low/close) days since 1960

Date	Volatility
19871019	0.257-
19871020	0.123+
20081010	0.107-
20081009	0.106-
20081113	0.104+
20081028	0.101+
20081015	0.100-
20081120	0.097-
20081013	0.094+
20080929	0.093-
19871026	0.092-
20100506	0.090-
20081201	0.089+
19620529	0.089+
19871021	0.087+
20081016	0.087+
20081006	0.085-
20081022	0.085-
20020724	0.081+
19980831	0.080-

US market more volatile than UK. Both sides of Atlantic dominated by 2008 and 1987

Crashes or Market Behaviour in Extreme Times

Many financial time series are subject to large movements, i.e., have heavy tails relative to the normal distribution. Mandelbrot (1963). The biggest crashes have usually been caused by fundamental events, e.g., the Russian revolution effect on the Russian stock market.
Emerging market exchange rates: Russian ruble after default, Thai Baht during Asian crisis.
Electricity prices can be subject to large spikes due to supply shortfalls, Weron (2008).
Gopikrishnan et al. (2000) find that trading volumes for the 1,000 largest U.S. stocks have Pareto tail with exponent around 3/2
Sornette and his dragon klingons

The Flash crash was relatively small, and not contagioned to outside world unlike the 1929 and 1987 crashes
But at least part of it was driven by purely technological/trading structure failure, which is of concern. Endogenous risk.
Kirilenko and Kyle study of futures markets during flash crash.
Shows fragility of liquidity provision in the presence of order flow toxicity (Easley and OHara)
Our study did not focus on flash crash and its causes - no comparable event (in impact) in European equity markets and market structure here different
But it could happen here and we comment later on some policy measures designed to mitigate risks.

Concluding Remarks

1. A lot of negative articles and comments about HFT. Despite this, the best evidence we have today suggests that CBT in general and HFT in particular have several beneficial effects on routine market quality
    1. They have contributed to improvements in the Liquidity of markets as measured by bid-ask spreads and other metrics
    2. They have contributed to improvements in Transaction costs both for retail investors and for institutional investors mostly due to changes in market structure which are related to the developments of HFT
    3. They have contributed to improvements in Market efficiency by impacting new information into prices faster and by linking fragmented market places together

1. However, while liquidity has improved overall, there appears to be the potential for increased periodic illiquidity or liquidity crises such as the US flash crash of May 6th 2010 and various other smaller events since then (predominantly in the US)
2. This can arise through feedback loops generated within the computerized trading process itself that once started can amplify over time even within well intention management and control processes

1. There is no direct evidence that computer based trading has increased market abuse
2. However, defining and detecting market abuse in todays environment requires more and better data than is currently available
3. The perception of abuse itself may harm market quality through investor withdrawal and this needs to be countered by regulators demonstrating a firm commitment and ability to counter market abuse in todays fragmented and high speed trading environment