

High-frequency trading – a discussion of relevant issues

Eurex Exchange Press Workshop

New York, Chicago
25-27 February 2013



Agenda

HFT – background

- How do you define high-frequency trading (HFT)?
- What are the most common HFT strategies?
- Why is the speed so important?
- What is the impact of HFT on market quality?

HFT – current environment

- Do HFT users cause volatility?
- Why are there critical voices on HFT from institutional investors?
- How do HFT firms (re-)act in critical times?

HFT – Eurex Exchange's/Eurex Clearing's response

- What are the key challenges for exchanges and CCPs? (VV)

Differentiation of “algorithm trading” (AT) and HFT

Common factors of AT and HFT:

- Pre-designed trading decisions
- Used by professional traders
- Observing market data in real-time
- Automated order submission, automated order management
- Without human intervention
- Use of direct market access

Specifics for AT excl. HFT

- Primary agent trading
- Minimize market impact (for large orders)
- Significant positions overnight
- Typical holding periods: days/weeks/months
- Working an order through time and across markets

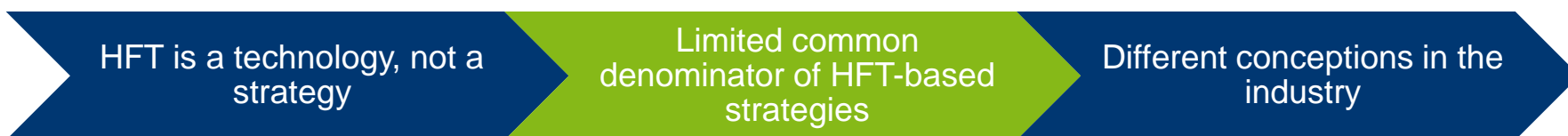
Specifics for HFT

- Proprietary trading
- Very high number of orders, rapid order cancellation
- Mainly spread and arbitrage income
- No significant position at the end of a day (flat position)
- Very short holding periods, small margin per trade
- Low latency requirement
- Focus on highly liquid instruments

Source: Gomber et al. (2011)

HFT is a technology applied to a broad spectrum of strategies

Conclusive definition of HFT is difficult as it is the technology necessary for implementing a broad range of latency sensitive strategies.



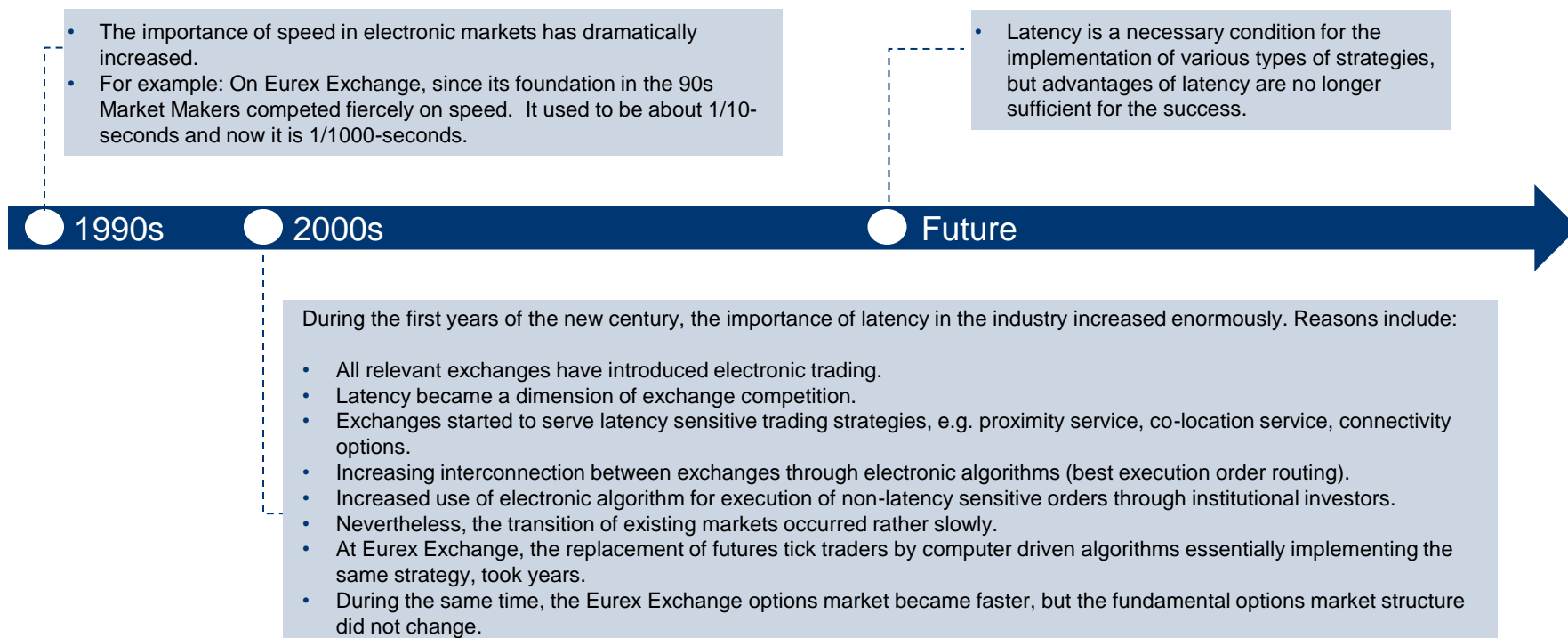
- HFT uses a wide range of strategies with very different characteristics.
- HFT is a technological approach for the realization of established trading strategies.

- HFT-based strategies have in common only the need to be competitively fast in order to address profit opportunities and, even more importantly, avoid being taken advantage of by others, i.e. avoid losses.

- Everyone in the financial industry has an individual idea of what HFT is.
- The opinions on HFT vary considerably depending on what the observer considers a typical strategy for HFT.
- The majority of Eurex Exchange's options Market Makers do not consider themselves, HFT while they would fulfill all existing HFT definition proposals.

High Frequency Trading is a natural evolution of financial markets based on technical progress and competition

- The term HFT was coined approximately in 2006.
- However there was no binary event, at which HFT strategies/firms entered the market.
- Speed has always been an essential factor for success in exchange trading e.g. 1903 pneumatic tube system of NYSE.



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The majority of HFT- based strategies belong to two types: Liquidity provision and arbitrage*

Liquidity provision

- The majority of HFT-based strategies are liquidity provision strategies as every form of liquidity provision in electronic markets requires extremely fast response times.
- The reason is all provided bids and offers are based on certain sets of information.
- When information changes, this implies different prices, bids and offers.
- Accordingly, liquidity providers need to be as fast as possible in: a) receiving the new information, b) transforming the new information into new prices, bids/offers and c) update the bids/offers provided to the exchange.
- The faster the liquidity provider can act, the lower the risk of liquidity provision and the higher the quality of provided quotes.
- **Primary source of income: Spread.**

(Statistical) arbitrage

- Take advantage of price differences (market inefficiencies) between economically identical or similar products.
- Actors calculate fair product values/spreads, and in case of any deviations, they sell the more expensive product, and purchase the cheaper product.
- This way, unjustified price differences between economically related products are eliminated.
- Arbitrage assures clients fair pricing across all markets/products and thereby reduces their information costs in fragmented markets.
- Primary source of income: Short term market inefficiency.
- **Primary source of income: Spread.**

* Hagströmer, Nordén (2012) found that 63 - 72 % of HFT trading volume is provided by liquidity provision strategies .

Also the other two strategy types exist as long as markets exist

Short term momentum-strategy

- New information leads to new price levels.
- These strategies attempt to generate profits by reacting swiftly to new information.
- As a result, new information is reflected in the market prices extremely fast.
- Besides new information, market moves can generate trading signals (“riding the short term trend”).
- **Primary source of income: Short term shift in general price level.**

Liquidity detection-strategy

- Detection of hidden orders or orders that are generated by execution algorithms.
- The aim is to gather information about the direction of the customer flow and thus the market prices.
- Often used by electronic liquidity providers in order to recognize the market direction at an early stage.
- **Primary source of income: To take advantage of short term trends or avoidance of losses when providing liquidity.**

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Speed is a risk management tool for participants

A Market Maker's quote...

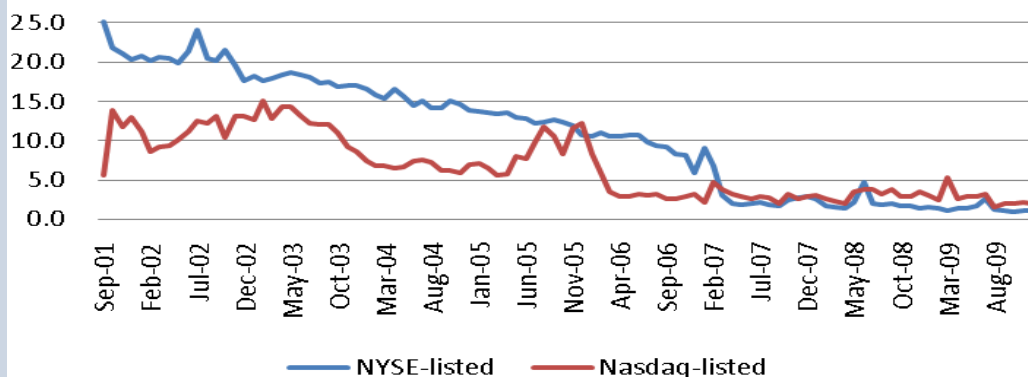
- ...is valid until canceled.
- ...needs to be updated when the information changes.
- ...results in exposure/risk for the time till the existing quote is either updated or canceled at the exchange.

The higher the speed...

- ...the more immediate the transfer of risk.
- ...the more liquidity the Market Maker is prepared to offer.
- ...the tighter the bid-ask spread the Market Maker is willing to quote.

**Reduction in
frictional
costs
to end-users**

Market Order Execution Speed



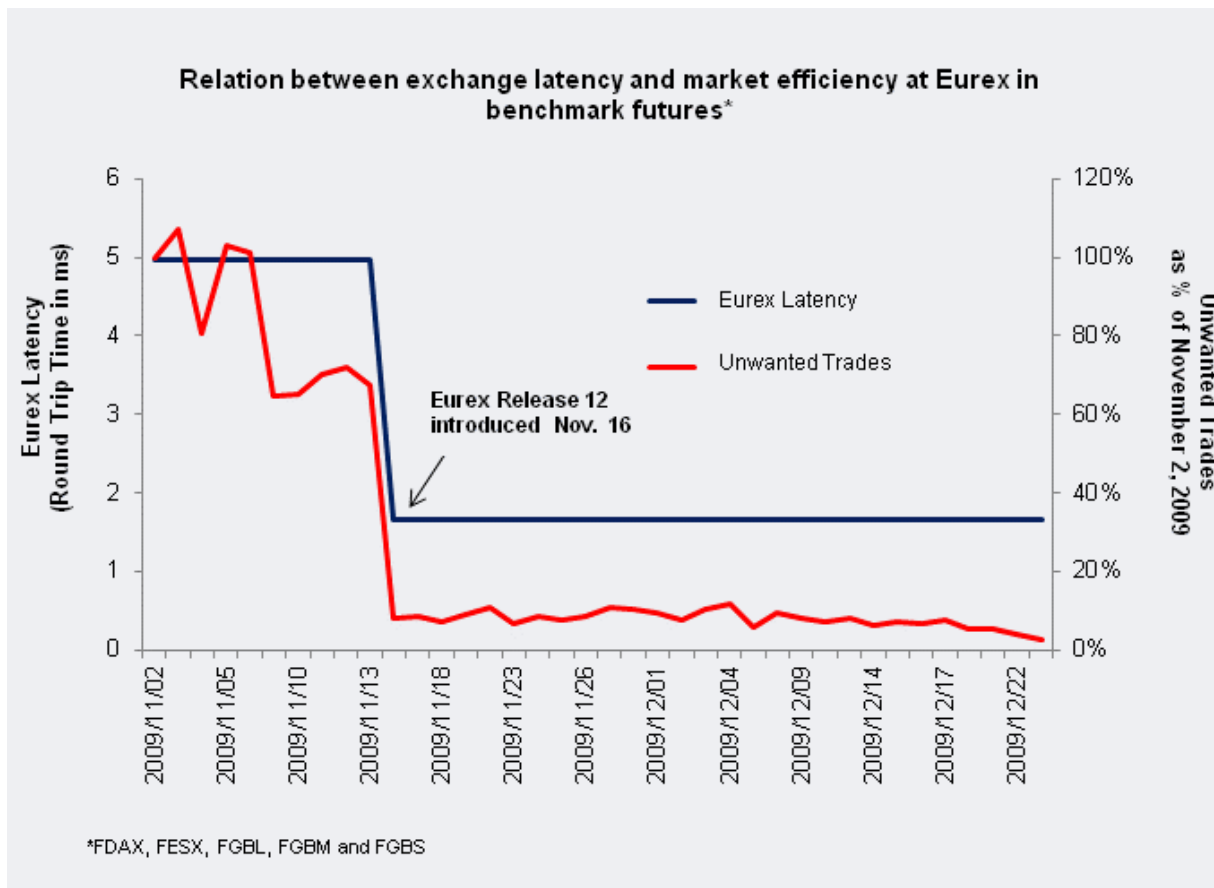
Reduction in exchange latency improves situation of liquidity providers which leads to better market quality

The biggest risk for liquidity providers is that new information imply new price levels and the liquidity provider is not able to update its quotes before others take advantage of the outdated quote.

The indicator for this is the number of "unwanted trades": We measure it by the number of times, when one party sought to modify/delete its order/quote, but it is was already matched.

Evidence from Eurex Exchange shows that a significant reduction in exchange latency in 2009 has lead to a massive reduction of the number of unwanted trades.

This enables the liquidity providers to provide higher quote quality in terms of spread and size to the market.



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Explicit transaction costs decreased substantially for European institutional investors through technical advancement

- The share of high touch order execution decreased drastically in the last few years through the increase in the availability technology. At the same time the cost of high touch executions was cut in half
- No touch (DMA) occurs at very low cost and accounts now for approximately 80% of total execution

Method of execution	2000		2005		2011	
	% trades	fee (bps)	% trades	fee (bps)	% trades	fee (bps)
High touch	100%	25-40	70%	15-20	20%	10-15
No touch (DMA)	N.A.		30%	7-8	80%	1-3

Source: IMC estimation

... part of the reduced cost results from decreasing market infrastructure fees

- Reduction in the costs of trading in all major financial centers (weighted average decrease of 21%).
- The cost of trading corresponds to the sum of fees charged by:
 - **Trading platforms**
 - **Central counter-parties (CCP's)**
 - **Central Securities Depositories (CSD's)**

Domicile of securities	Cost of trading (bp) in 2006	Cost of trading (bp) in 2009	% change
All financial centres			
Weighted average	8.9	7.0	-21
Major financial centres			
Weighted average	9.4	7.6	-19
France	11.0	9.1	-18
Germany	9.2	7.2	-21
Italy	8.0	4.1	-48
Spain	9.2	6.9	-25
Switzerland	8.2	7.4	-10
UK	9.3	8.1	-12
Secondary financial centres			
Weighted average	9.1	7.9	-13
Other financial centres			
Weighted average	10.9	8.8	-19

Source: Monitoring prices, costs and volumes of trading and post-trading services by Oxera, May 2011.

Increased economic uncertainty and the widespread algo usage has reduced resting order liquidity slightly ...

Eurex Liquidity Measure (ELM)

The ELM measures the round trip market impact cost of somebody executing a EUR 10 Million market order against the public order book.

Therefore, it is mirroring the displayed size in the order book. The larger the price impact, as measured by the ELM, the smaller the available size.

At times of crisis, the market impact cost increases, as participants scale down their risk profile, implying somewhat wider spreads and significantly reduced sizes.

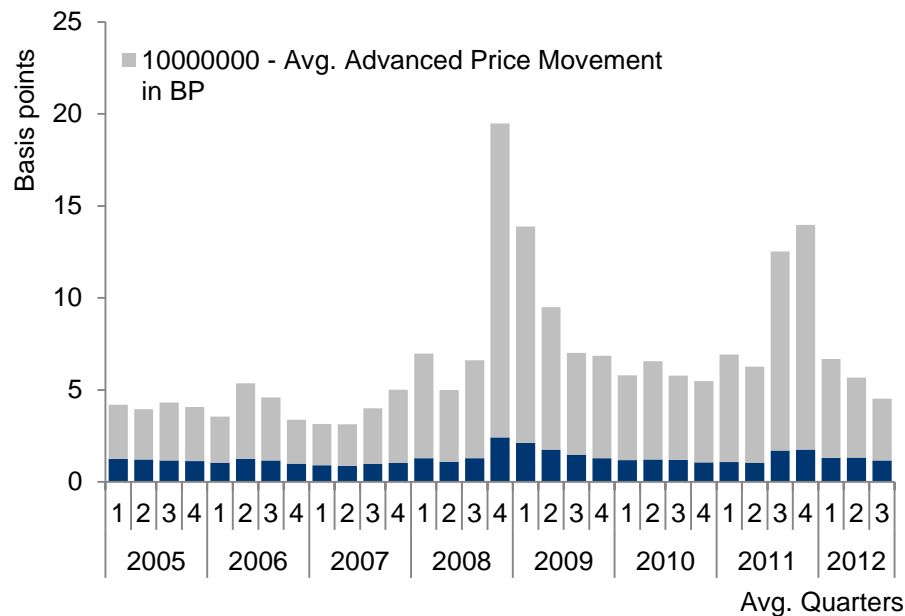
In general, the liquidity readily available in the order book looks slightly worse in Q3 2012 than in 2005.

This is a function of changed market behavior. A major driver for this is the use of execution algo by the buy-side, which has vastly reduced the placement of resting orders by the buy-side in the transparent order book.

HFT adds significant liquidity, but their order sizes are typically much smaller.

Visible liquidity decreased

Liquidity did not revert back to its high of Q2 2007.



... however, the market has become much more resilient

How to quantify liquidity resilience?

Fierce competition in liquidity provision strategies, using HFT technology, increased the resilience of liquidity in our benchmark futures.

The top chart shows a stylized example of the spread recovery following a large aggressive order. The time it takes the liquidity to recover is a function of (a) volatility (b) order size and (c) competition for liquidity provision.

By accounting for (a) and (b) it should be possible to say something about (c). The bottom graph shows average recovery paths for eight similarly volatile days; four from 2010 and four from 2012.

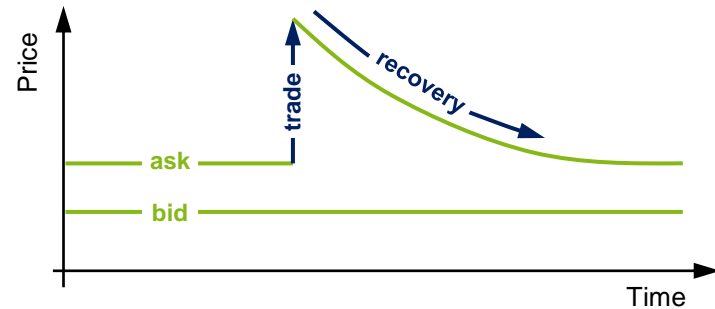
We see a tremendous increase in resiliency compared to 2010, implying increased competition for liquidity provision.

We argue that the increase in resiliency makes up for (part of) the reduction in visible liquidity.



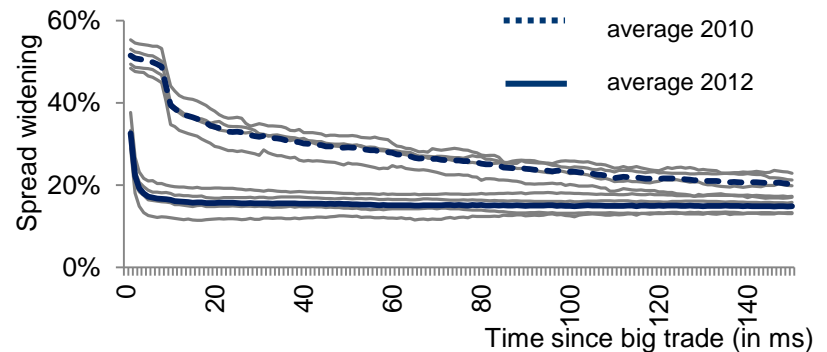
How to quantify liquidity resilience?

We focus on the recovery period after a big trade (in the case below; a buy) widened the spread.



Evidence of resilience improvement

Compared to 2010, the liquidity in the DAX30 futures became much more resilient. The averages converge around 500ms from the big trade.



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- What are the key challenges for exchanges and CCPs? (VV)

What does volatility mean and what does it cause?

Volatility is a measure of price variation of an instrument.



It reflects the uncertainty about the future price of an asset or the market as a whole.



It is **amplified** by the breadth of possible outcomes.



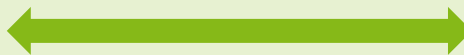
Possible outcomes

Inflation



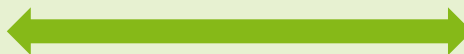
Deflation

Growth



Recession

Fiscal consolidation



Sovereign default

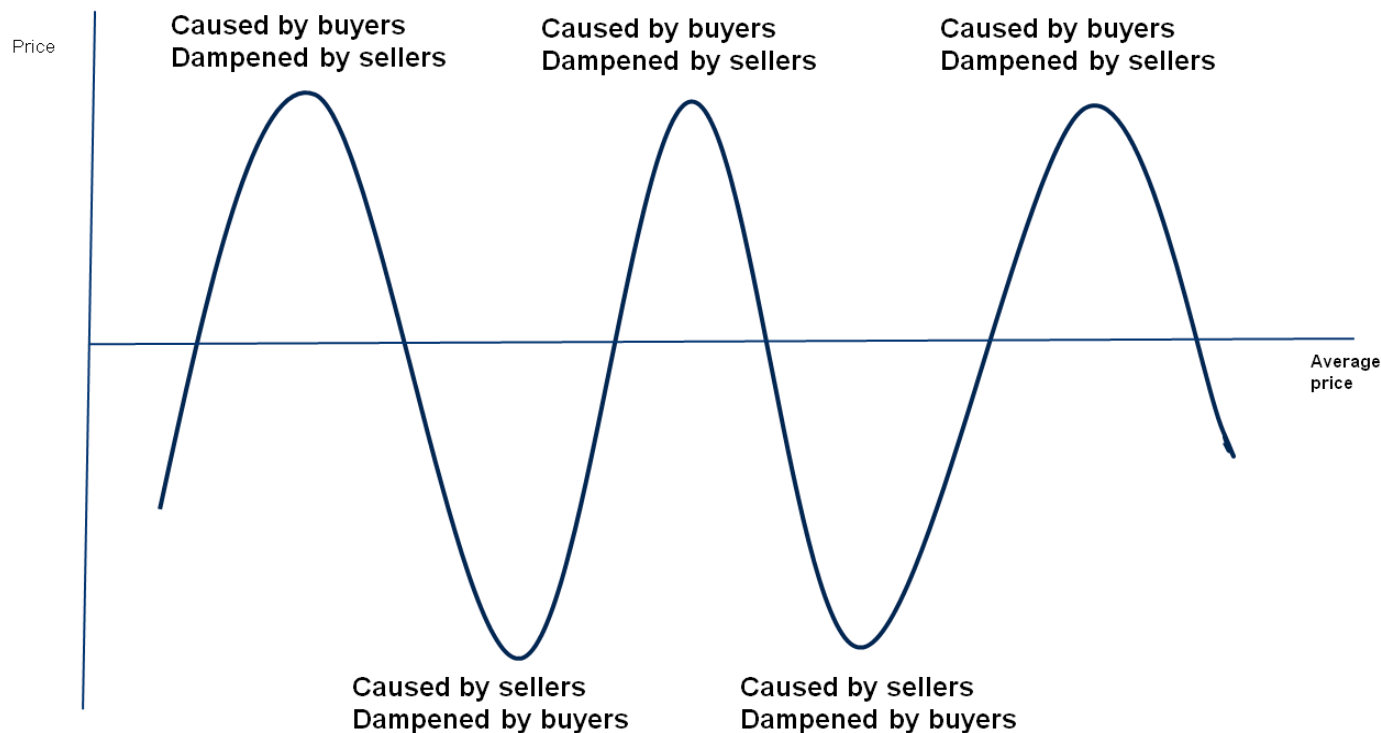
Strengthening the EUR by reforms



Breakdown of the EUR

HFT strategies typically benefit from volatility, but do not increase it

- HFT strategies are intraday strategies.
- Causing intraday volatility is a loss making business.
- Mean reversion is the basic strategy of most liquidity providers/Market Makers.



What do academics say?

HFT dampens volatility

- Credit Suisse (2010)
- CME Group (2010)
- Brogaard (2011)
- Castura, Litzenberger, Gorelick, Dwivedi (2009)
- Hasbrouck and Saar (2011)
- Hagströmer, Nordén (2012)

HFT has no effect on volatility

- Chaboud, Chiquoine, Hjalmarsson and Vega (2009)
- Frino, Lepone, Mistry (2010)
- Hendershott and Riordan (2009)
- UK Treasury Foresight Committee (2011)
- Groth (2010)
- Bank of international Settlements (2011)
- Jarnecic, Snape (2010)

HFT causes volatility

- Zhang (2010)
- Boehmer (2011)

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The accusation of front running is misleading and false

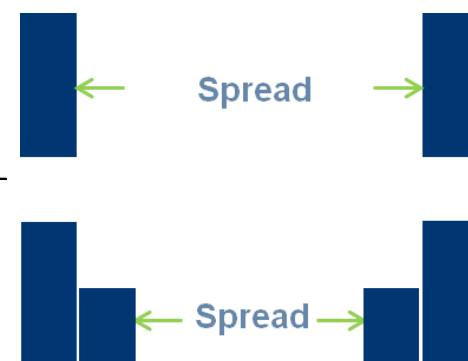
- In public discussions the accusation that HFT firms pursue front running of customer flow occurs from time to time.
- This accusation is wrong, because by definition they are not able to pursue front running: They do not have customer flow and therefore no private order flow information that they could abuse.

If the accusation of front running is incorrect, where does it come from?

- Usually institutional investors have large orders, which they execute with the help of algorithms over time to minimize the market impact (implicit transaction cost).
- In contrast, numerous HFT firms are liquidity providers.
- The greatest threat to a liquidity provider is that one or several large orders move the market. This created losses for the liquidity provider, as they are the first counterparts to the large order and thereafter the market moves against them due to the large order size.
- To compete successfully in the market, liquidity providers need to identify, as quickly as possible, when the market moves in a certain direction through large orders (usually generated by institutional customers).
- Liquidity providers may witness price changing orders through liquidity detection strategies only, after parts of this order are present in the market and have already been filled.
- This leads to a natural conflict which always existed: Large orders shift the market and institutional investors try to keep the impact as small as possible. To achieve this goal, they have to work off the orders as inconspicuously as possible. If they succeed, liquidity providers will be damaged who in turn, use liquidity detection strategies, for their protection.
- Liquidity providers at no point of time, have the knowledge about the size of the original order, not to mention any other private information necessary for front running.

Tighter spreads reduce “bid-ask sizes”, and thereby create the perception of reduced liquidity

- Ever faster electronic trading has tightened the average bid-ask spread.
- This development was amplified by a number of markets reducing the tick size in response to the tightening of spreads.
- As a result of both factors, the quantities available at the best bid-ask have become smaller in many markets. Institutional investors perceive this as a reduction of liquidity as they reluctantly trade through the best bid-ask.
- A major driver for smaller displayed size in the order book have been the institutional investors themselves as they hardly place any resting orders in the public order book due to the use of execution algorithm and dark pools.
- This negative effect on liquidity has been overcompensated for by growing HFT participation as evidenced by improved liquidity. See page 13 ff.



In futures contracts, there is no evidence of HFT orders fading away when large orders hit the market

Introduction

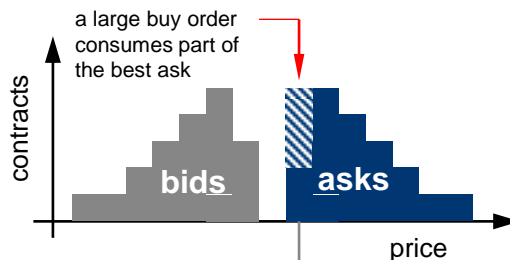
Some buy-side firms complain that the liquidity seen in the public order book is not really available to them. In this respect, HFT is also accused of front running.

This allegation is obviously related to the experience in fragmented (cash) markets, where sometimes a buy-side order, by the time it hits the second or third market, is meeting an order book where some of the liquidity providers responded faster to the fills in the first market.

Our analysis of futures revealed a) there is no evidence of HFT pulling out before large orders hit the market and b) right after a large order has hit the market, the HFT-share of the just hit best bid or just hit best offer is increasing above the average participation level.

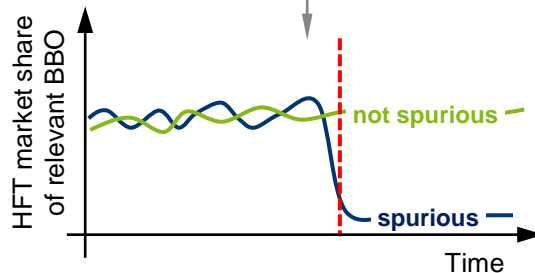
How to quantify spuriousness?

Retreating liquidity is especially painful around large trades (when liquidity is already under stress).



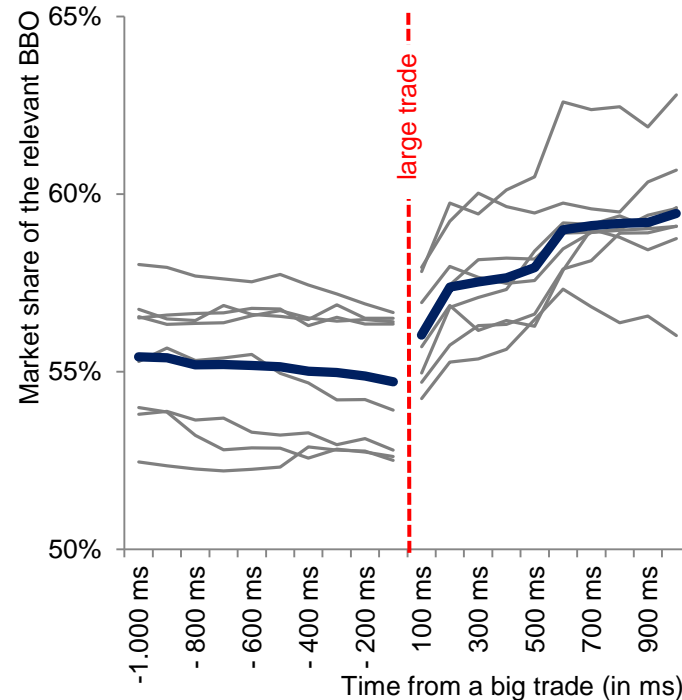
What do we expect?

Finding a liquidity reduction after a large trade is not enough. We're interested in evidence of HFTs pulling out more than non-HFTs before or after a large trade.



Actual HFT participation

The grey lines depict the daily average market share of HFTs on the relevant side of the BBO before and after a large trade (10 time the trailing 10 minute average) in the front month EURO STOXX 50@ futures.



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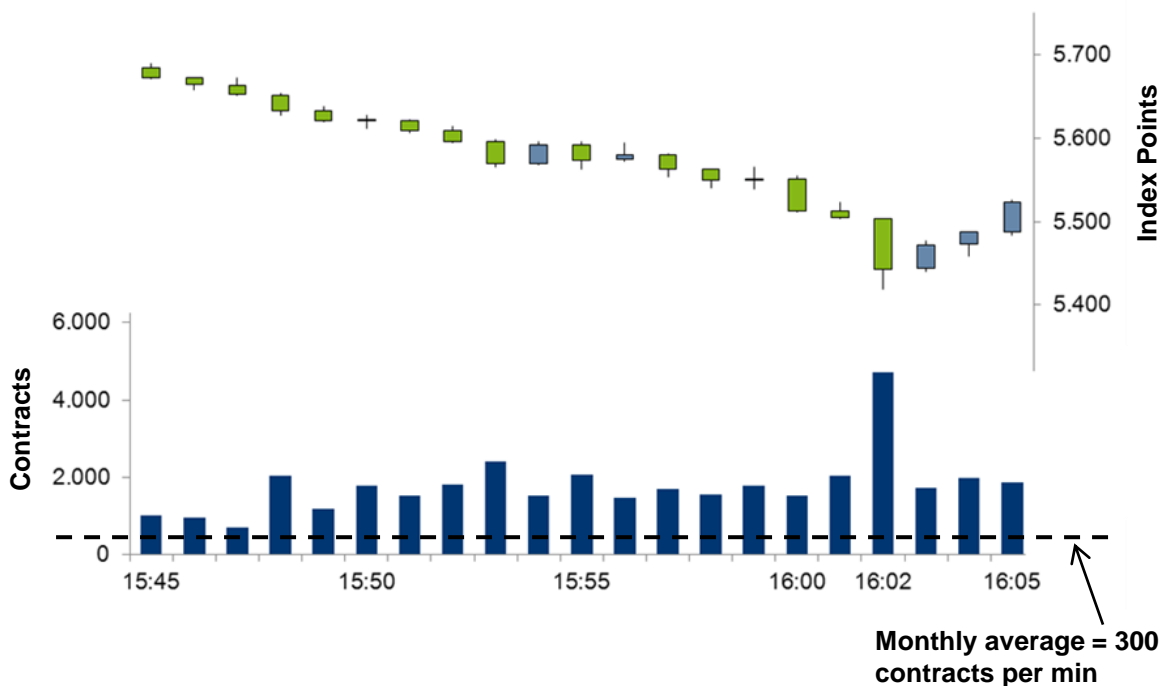
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25 August 2011: Within a few minutes institutional orders caused a rapid decline in prices: Highly liquid order book damped price impact

Trading in FDAX futures contracts on 25 August 2011 (one-minute intervals)



Description

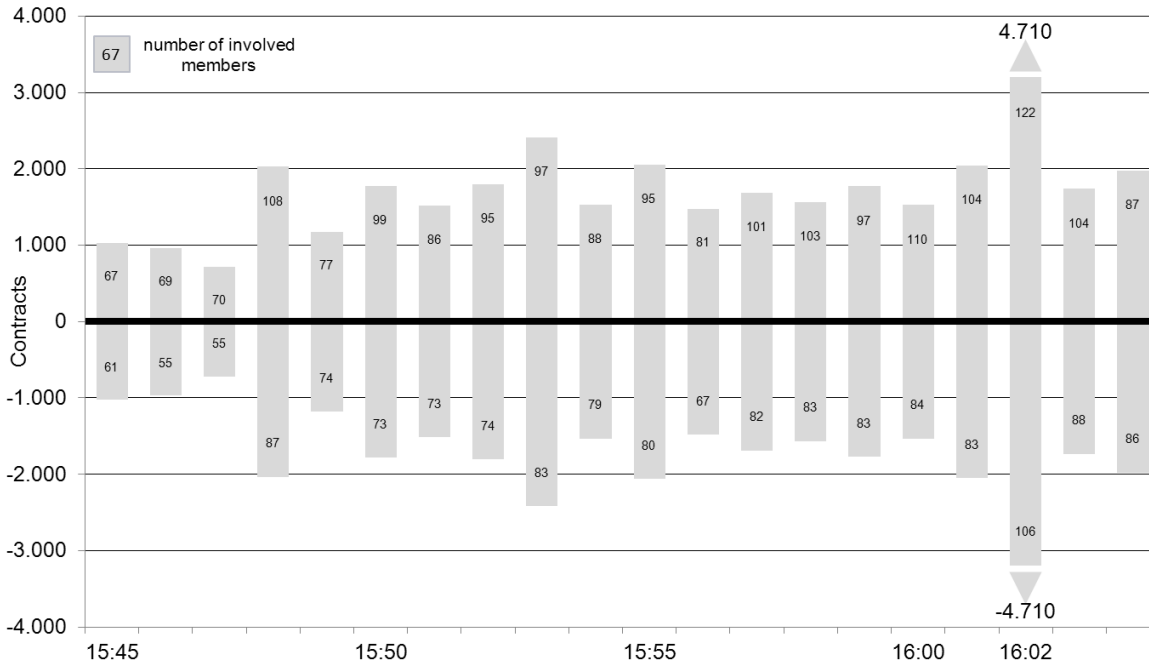
Within 17 minutes the FDAX went down by more than 4%, and came back by 2%.

Cause of the price decline: a big institutional order (6,000 contracts), which was converted by algorithms into a large number of sell orders flooding the market during that time.

Highly liquid order book prevented a greater decrease: High volume orders were processed with only small price increments- peak turnover 4,700 contracts per minute, compared to monthly average of 300 contracts per minute.

Large number of buyers absorbed the initial shock; HFTs provided liquidity, since they were buying in falling markets

Number of individual buyers and sellers per minute



Description

High number of Trading Participants involved on both sides of the market shows high variety of trading interests.

A total of around 200 different Trading Participants acted as buyers in the falling market, including but not limited to high-frequency traders.

High liquidity was in large part provided by HFTs, as these Participants initially absorbed the major sell positions and then passed them on to protect the market. The often assumed acceleration of downward movements through computer-based trading strategies was not observed.

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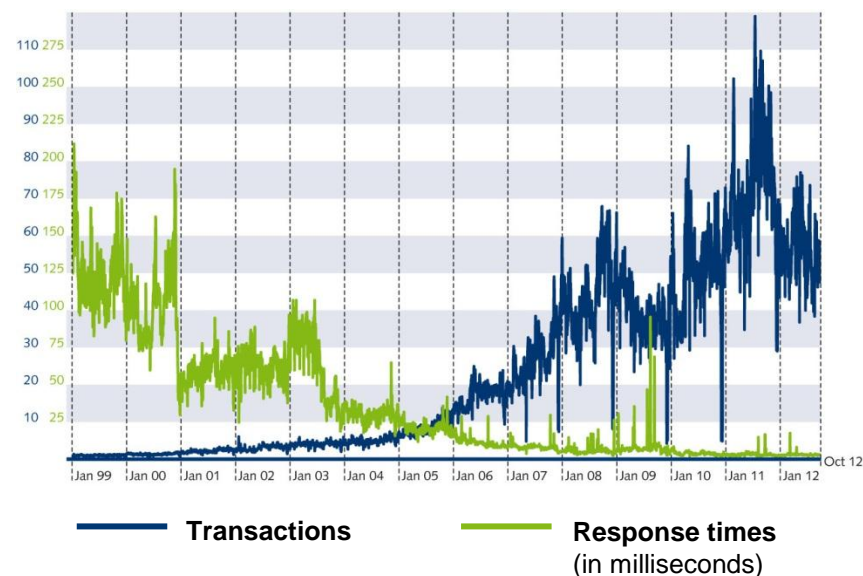
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HFT requires high investments in the exchange infrastructure

- Our trading- and clearing-systems have to process an exponentially growing number of technical transactions (message throughput).
- Eurex Exchange addresses this with the roll-out of a completely new trading architecture. The clearing architecture will be renewed as well.
- Furthermore, Eurex has massively invested in tools, which enable Eurex Exchange, Eurex Clearing, Exchange Participants and Clearing Members to identify and address problems swiftly and independently.
- In addition to our investments in infrastructure and functionalities, we also protect the integrity of our marketplaces through a “transaction limit regime”, which provides Participants with limits to their maximum system capacity usage. Violations trigger appropriate penalties.

Number of processed transactions at Eurex Exchange & response times

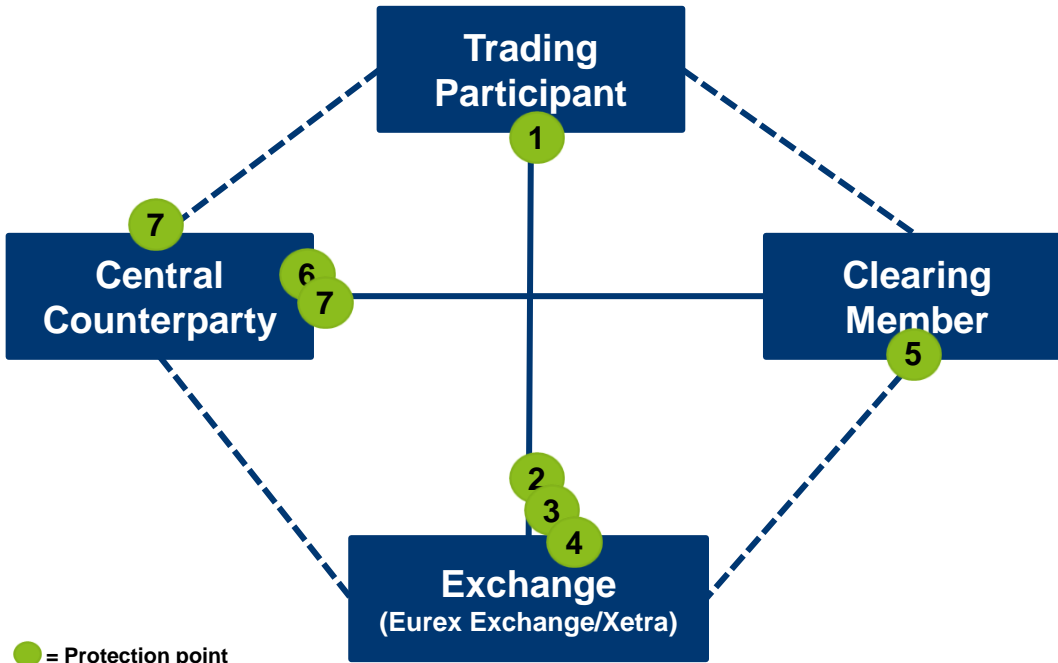


Risk of algorithms getting out-of control addressed by overlapping safety mechanism

- The overarching goal is the avoidance of a situation where an algorithm gets out of control and causes a serious market failure.
- This not only applies to HFTs but to all computer algorithms applied to our markets.
- Electronic exchanges such as Eurex Exchange have developed several tools to enable Exchange Participants, Clearing Members, Eurex Exchange itself and Eurex Clearing as the CCP, to identify and prevent possible misconduct as quickly as possible.
- In addition, Trading Participants and Clearing Members are also investing significantly into the monitoring of their algorithms in the dimensions of IT-governance, test protocols, access safety standards, risk monitoring and change management.
- HFT firms as well as exchanges such as Eurex Exchange welcome any regulatory definition regarding minimum standards for systems and controls.
- All parties have a keen interest in the integrity and efficiency of our markets.
- On the following pages there is an overview of the tools available at Eurex Exchange and Xetra.

Protection points across the value chain tackle potential risks arising from HFT

Illustration of major protection points at Eurex Exchange and Xetra



Description

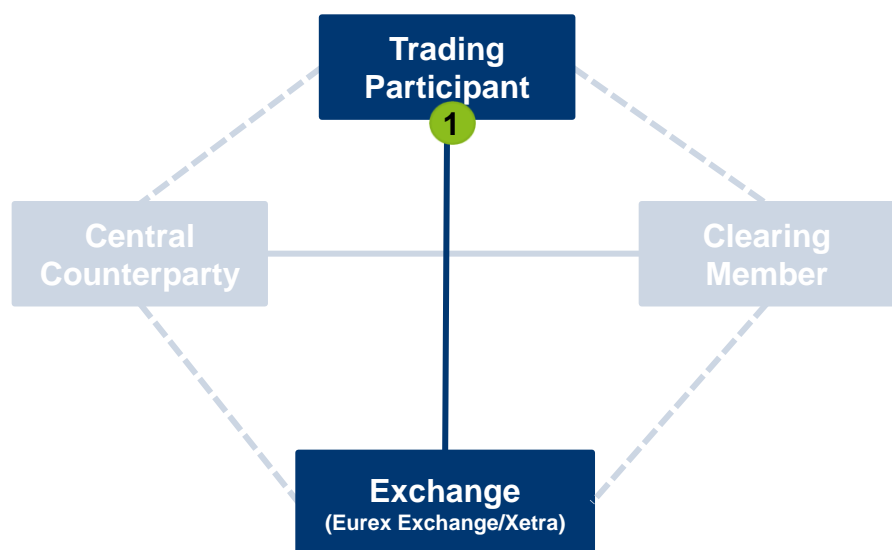
1	DMA control	<input checked="" type="checkbox"/>
2	Plausibility checks	<input checked="" type="checkbox"/>
3	Architecture throttle	<input checked="" type="checkbox"/>
4	Trading safeguards	<input checked="" type="checkbox"/>
5	Stop button	<input checked="" type="checkbox"/>
6	Real-time risk management	<input checked="" type="checkbox"/>
7	Advanced risk protection	<input checked="" type="checkbox"/>

- Protection mechanisms built into the market structure safeguard fair and orderly markets.
- Established procedures and practices exist to mitigate potential risks arising from trading / high-speed trading.
- Procedures exist along the whole value chain, involving traders, market operators, clearing firms and CCPs.
- Protection mechanisms handle errors on the level of order entry (“fat finger”), human mistakes or an erroneous algorithm.

Direct market access to Eurex Exchange/Xetra requires electronic control at the level of the firm

1 DMA control

Illustration



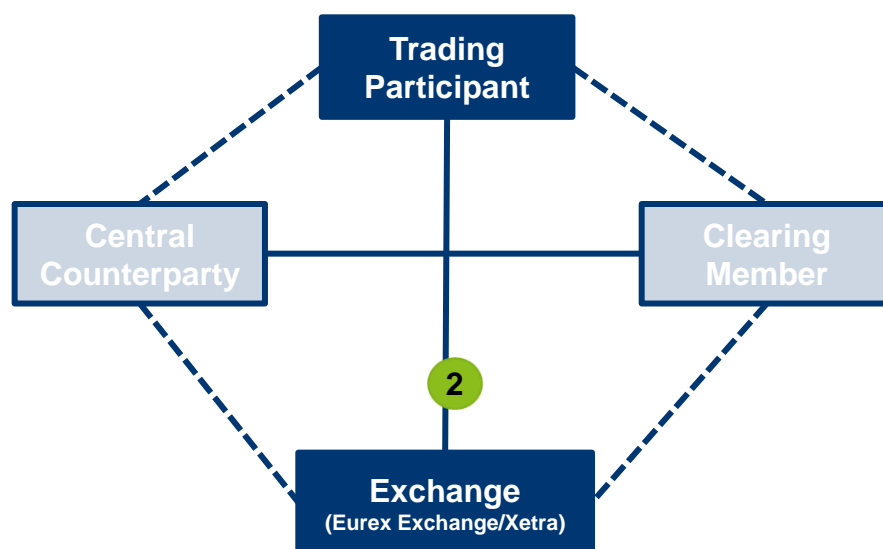
Description

- With Eurex Exchange/Xetra orders submitted by an order-routing system (DMA) pass an electronic filter installed at the company. The filter verifies all outgoing orders according to parameters pre-determined by the Exchange Participant.
- The firm has to inform the exchange (Eurex Exchange/Xetra) about the user ID of the Exchange trader under which the orders are entered.
- The exchange (Eurex Exchange/Xetra) may prohibit the connection of automated order-entry systems, if the connection jeopardizes the orderly exchange trading or system safety.

Plausibility checks at the exchange entry to prevent “fat finger errors”

2 Plausibility checks

Illustration



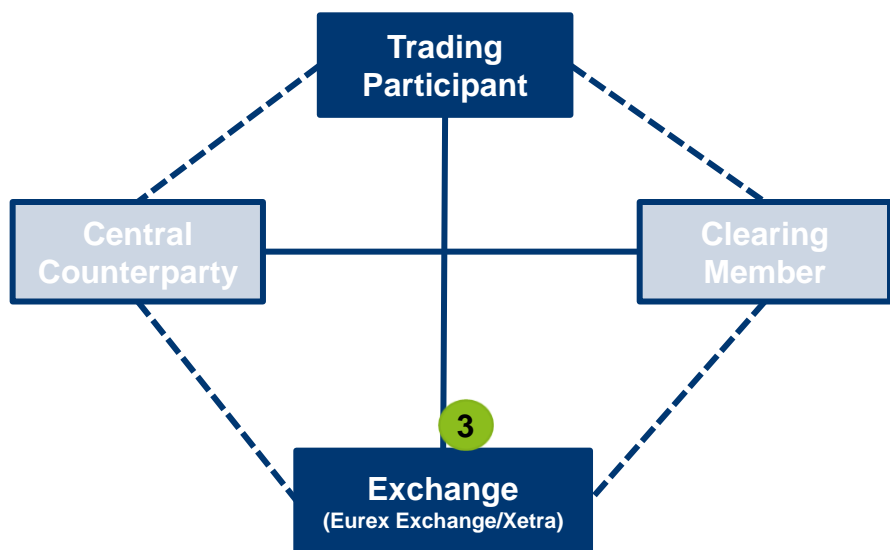
Description

- A fat finger error describes errors when inputting text via keyboard (typo).
- When entering an order, typos can have massive economic consequences (e.g. adding a “zero” to the order size will tenfold increase the size), if they are not prevented.
- Eurex Exchange/Xetra check for maximum order quantities upon reception of each order.
- Furthermore, Eurex Exchange/Xetra perform a mandatory check and offers an optional price reasonability check.

Architecture throttle limits the maximum message to avoid traffic congestion and resulting slow-down

3 Architecture throttle

Illustration



Description

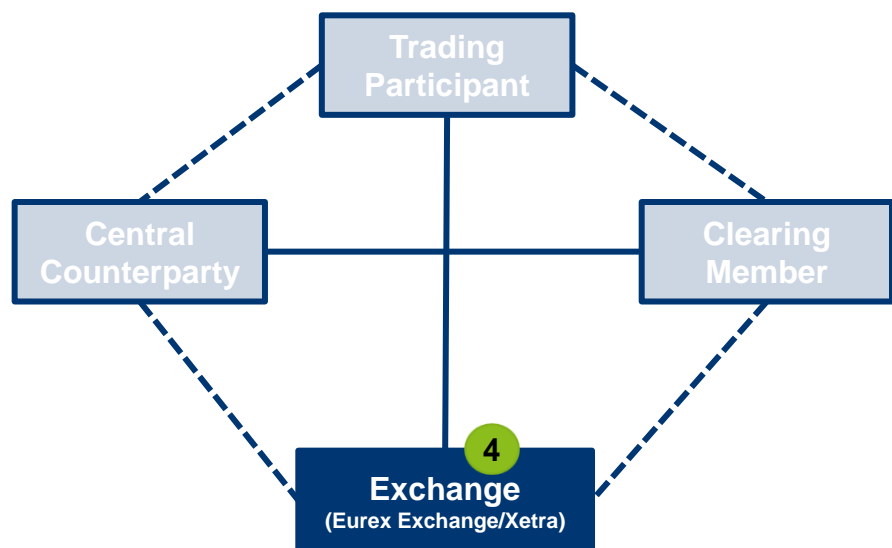
- Each trading session of a Participant includes a technical architecture throttle mechanism that limits the maximum throughput per second.
- The architecture throttle limits the transaction rates submitted per session. It avoids applications with extremely high transmission rates from endangering the overall integrity of the Eurex Exchange/Xetra trading system.
- The rate can be changed intraday, if market conditions require*.

* In addition to these measures, there are also limits for capacity usage rate for the members. They are enforced by an excessive usage fee. However, violations of the capacity usage limits are rare.

Trading safeguards as protection against extreme, unreasonable price moves

4 Trading safeguards

Illustration



Description

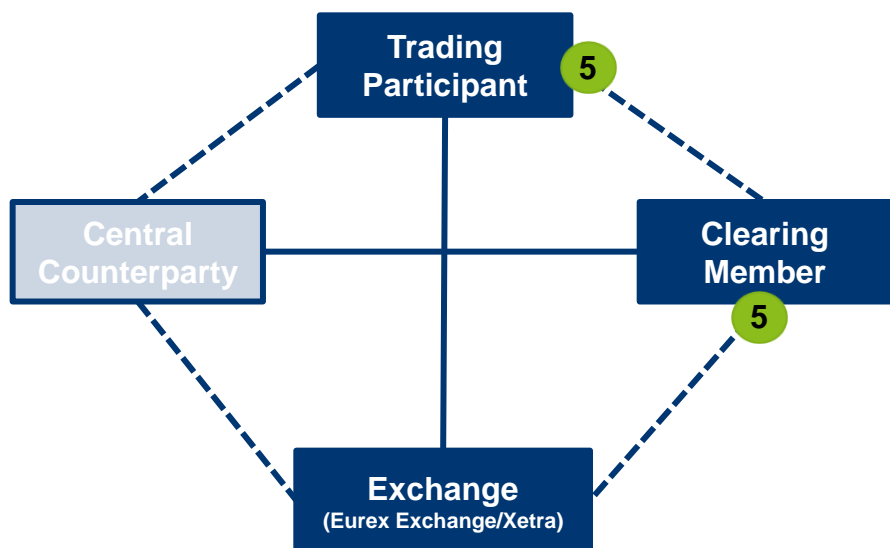
- Trading safeguards exist to protect the orderly price formation process.
- Trading safeguards at Eurex Exchange and Xetra are called “volatility Interruptions”.
- Trading is interrupted* “before the damage is done” – i.e. before a trade is made at volatile prices.
- For options markets, Eurex Exchange offers Market Maker protection tools to limit their risks.

* From a technical perspective, trading is not interrupted. Instead, the market model is merely switched from “continuous trading” to “call auction”. Therefore, the process of trading still resumes, as Participants can still delete, modify and enter orders in anticipation of the auction price.

Stop button enables Clearing Members to discontinue all trading activities of a Trading Participant

5 Stop button

Illustration



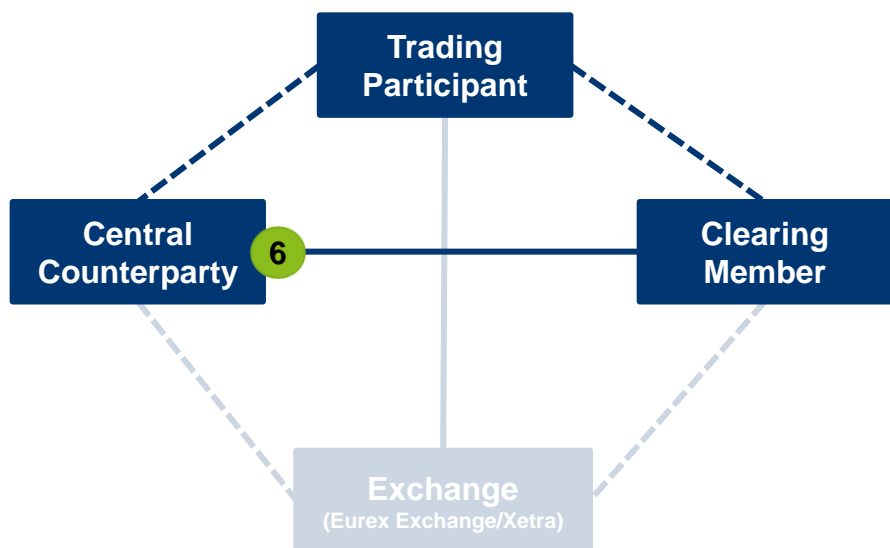
Description

- The stop button functionality enables Clearing Members to control (discontinue or release again) the transactions of their Trading Participants.
- At Eurex Exchange, this is also possible for Trading Participant.

Real-time risk and position information facilitate highly efficient risk management

6 Real-time risk management

Illustration



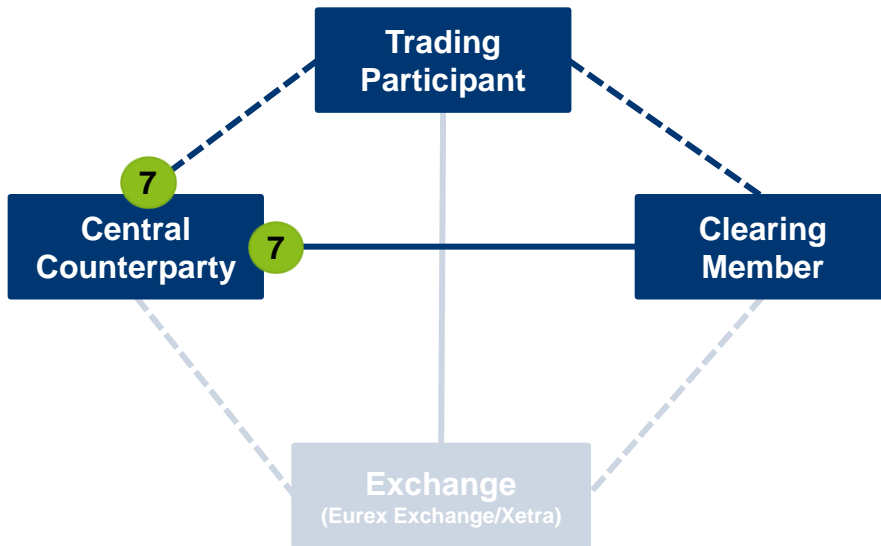
Description

- Real-time information on positions and resulting margin requirements is calculated and distributed throughout the trading day to Trading Participants and Clearing Members.
- Intra-day margining is an important feature of the risk management framework. It reduces the counterparty credit risk of the CCP because the intra-day margin call allows the CCP to quickly respond to increased price volatility or the growing positions of Clearing Members.

Protection mechanisms built into the market structure safeguard fair and orderly markets

7 Advanced Risk Protection

Illustration



Description

- Advanced risk protection functionality enables Trading Participants and/or Clearing Members to set up to three limits on aggregate risk metrics, such as the total margin requirement.
- Upon breach of the first limit, an alert message is sent.
- At the second limit, the system automatically throttles orders and quotes.
- At the third limit, the “stop button” functionality is automatically triggered, thus halting all trading activities.

Advanced Risk Protection: examples of risk limits and associated actions



Summary

HFT is a natural evolution resulting from technological developments and competition

- HFT is a natural reflection of competition between market participants using the advances in computer technology.
- HFT is a technology that enables for the implementation of a wide range of trading strategies.
- All actors in financial markets need to address this natural development
 - Proprietary traders/ Market Makers: Implementation of speed-sensitive strategies requires constant and significant technology investment.
 - Brokers: Address customer needs for faster and more advanced execution of customer orders in a growing number of electronic markets.
 - Exchanges: Invest in faster systems with larger capacity and a variety of safety mechanisms.
 - Regulators: Provide a framework for fair and transparent markets. Receive more information than ever to monitor the markets. Challenge is the efficient use of the large amount of data.
- A “deceleration of the markets” by regulatory intervention is not a solution.
 - Either the markets go somewhere else or the actors find ways of bypassing.
- As a result of public pressure the risk of over-regulation for HFT is high, as exemplified by the multitude of regulatory initiatives (MIFID, ESMA Systems & Control, National Rules).

Thank you for your attention

Backup

Literature review (I/III)

Author(s) / Title	Dataset	Findings
Markets Committee, Bank for International Settlements (BIS) "High-frequency trading in the foreign exchange market", September 2011	Various FX venues, notably Reuters and EBS, and various dates, notably May 6, 2010 and March 17, 2011	HFT is found to be beneficial during normal market periods, with similar behavior to traditional market participants during high volatility periods
Brogaard "High frequency trading and its impact on market quality", August 2010	HFT vs. other trades. U.S. equities on NASDAQ, various periods in 2008 – 2010	HFT helped to narrow bid – ask spreads, improved price discovery and may have reduced volatility
Brogaard "High Frequency Trading and Volatility", October 2011	HFT vs. other trades. U.S. equities on NASDAQ, various periods in 2008 – 2010	HFT activity tends to decrease idiosyncratic and intraday volatility.
Hendershott, Riordan "High Frequency Trading and Price Discovery" (working paper)	HFT vs. other trades. U.S. equities on NASDAQ, various periods in 2008 – 2010	HFT trades were positively correlated with permanent price changes and negatively correlated with transitory price changes, Suggesting that HFT improves price discovery
Jarnecic, Snape "An analysis of trades by high frequency participants on the London Stock Exchange", June 2010	HFT vs. other trades. LSE equities, April – June, 2009	HFT improved liquidity and was unlikely to have increased volatility
CME Group "Algorithmic trading and market dynamics", July 2010	Automated vs. other trades. CME futures, May 2008 – May 2010	Automated trading was associated with improved liquidity and reduced volatility
UK Treasury Foresight Committee (2011) "The Future of Computer Trading in Financial Markets"	Literature review of computer based trading developments	Economic research thus far provides no direct evidence that high frequency computer based trading has increased volatility.

Literature review (II/III)

Author(s) / Title	Dataset	Findings
Credit Suisse “Sizing Up US Equity Microstructure”, April 2010	U.S. equities, 2003 - 2010	Bid -ask spreads have narrowed, available liquidity has increased and short-term volatility (normalized by longer term volatility) has declined
Hasbrouck, Saar “Low-Latency Trading“, May 2011	U.S. equities, full NASDAQ order book June 2007 and October 2008	Low latency automated trading was associated with lower quoted and effective spreads, lower volatility and greater liquidity
Hendershott, Riordan “Algorithmic Trading and Information”, August 2009	Automated vs. other trades. Deutsche Börse equities, January 2008	Automated trades made prices more efficient and did not contribute to higher volatility
Chaboud, Hjalmarsson, Vega and Chiquoine “Rise of the Machines: Algorithmic Trading in the Foreign Exchange Market”, October 2009	Automated vs. other trades. EBS forex market, 2006-2007	Automated trades increased liquidity and may have lowered volatility
RGM Advisors (Castura, Litzenberger, Gorelick, Dwivedi) “Market Efficiency and Microstructure Evolution in US Equity Markets: A High Frequency Perspective”, October 2010	U.S. equities, 2006 - 2010	Bid-ask spreads have narrowed, available liquidity has increased and price efficiency has improved
X. Frank Zhang “The Effect of High-Frequency Trading on Stock Volatility and Price Discovery” November 2010	Firms from the Center for research in security prices (CRSP) and the Thomson Reuters Institutional Holdings databases during 1985–2009.	This study examines the effect of high-frequency trading on stock price volatility and price discovery
Boehmer, Fong, Wu (2012) “International evidence on algorithmic trading”	Large sample from 2001 – 2009 that incorporates 39 exchanges and an average of 12,800 different common stocks	We find that greater AT intensity is, on average, associated with more liquidity, whether measured at the transaction level or at the daily level, faster price discovery, and greater volatility

Literature review (III/III)

Author(s) / Title	Dataset	Findings
Hagströmer, Nordén (2012) “The diversity of high frequency traders”	NASDAQ OMX Stockholm, equity market, August 2011, February 2012	Market maker cause the biggest amount of HFT trading volume (63-72%) and limit order traffic (81-86%). Further Market maker have higher order-to-trade ratios, lower latency, lower inventory and provide liquidity more often than opportunistic traders

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