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**High-frequency trading and market implications –
an assessment from a central bank perspective**

Speech at
TradeTech DACH 2012
in Frankfurt
on 4 July 2012

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1 Introduction

Ladies and gentlemen

First of all, I would like to thank you for inviting me to speak at this year's TradeTech DACH conference. An in-depth dialogue between market participants and the Bundesbank has always been a particular priority for me. I am therefore pleased to be able to share a few thoughts on high-frequency trading (HFT) with you today.

Let us start by taking a look back to the 19th century. The 28 July 1866 marked a major milestone in the history of communications technology. On that date, following a three-week crossing by the special cable-laying vessel, the Great Eastern, the first successful transatlantic telegraph cable was put into operation, transmitting electric signals between Europe and North America. The cable weighed 9,000 tonnes and had a data transfer rate of 2 bits per second or eight words per minute. This represented a major advance in

communications between the two continents. Information that had previously taken weeks to arrive could now be transferred between Europe and the United States within a matter of minutes. Not least, the enormous saving of time brought about big changes in the capital markets of the age on both sides of the Atlantic. The markets grew much closer to each other. Price differentials for commodities and securities that were traded on both continents shrank dramatically and there was a rapid increase in transatlantic trade. None among of the commentators at the time doubted that the cable was a true blessing for mankind.

Now, 146 years later, a ship is again preparing to cross the Atlantic. On board this time, too, is a cable intended to link the two continents. But instead of transmitting telephone calls and internet data, from 2013 this cable will be carrying only financial data and price information. Thanks to optimised routing, this link from London, England to Halifax in Nova Scotia will be 570 kilometres shorter than all its predecessors. At a speed of some 200 kilometres per millisecond in the glass fibre cable, this means that the signals will take 59 milliseconds to travel a distance of 6,000 kilometres and back, which is almost six milliseconds quicker than in existing Atlantic cables. The project costs for this six milliseconds speed advantage amount to 300 million US dollars. According to the operators, it will have paid for itself within only a few years as the charges for the cable will be higher than for other links by the factor of 50. Despite the immensely higher fees, no-one is worried about the demand for this service. According to estimates in the HFT sector, every millisecond by

which a major HFT player is faster than the competition will generate several million US dollars in additional profits.

No-one should underestimate this comparatively slight speed advantage. Just like the old cable, the new one represents a major milestone in the development of technology. In 1866, it was a revolution in telecommunications. Now, it is the algorithmic revolution in securities trading for which the new cable stands.

With this algorithmic revolution, the capital markets have now arrived at a historically defining point in their development. Roughly half of the most important transactions conducted in shares and currencies on the stock market are no longer set in motion by human traders, but are the product of computer algorithms which are able to analyse large quantities of data and initiate hundreds of orders in fractions of a second. To an ever increasing extent, people are being taken out of the direct decision-making process about buying or selling an asset and being replaced by software programs. Speed in executing an order has become the most important factor and is now measured in milliseconds or microseconds. New practices, such as “co-location” and “quote stuffing” have become important instruments in the contest to execute orders most quickly. For most HFT algorithms, fundamental data on the value of the securities or currencies in question are irrelevant or play only a secondary role. In HFT, the holding periods for the positions that have been entered last between a few milliseconds and several hours. In the present-day high-speed markets, the advantage no longer lies with the investor

who can better assess the true value of an asset but with the person who is the quickest to act. For that reason, competition for human resources has also changed for many investment companies and hedge funds. Until a few years ago, it was mainly a matter of attracting the most talented economists. Now, attention is often focused on recruiting the best programmers and mathematicians.

Given the importance that HFT has gained in the capital markets and events such as the “flash crash” in May 2010, as well as the heavily polarised views on HFT among investors, the regulators have to deal with the question of what impact high-frequency trading has on the functioning of the market.

In this context, the advancing trend towards ever quicker, more complex and interlinked global financial markets is posing particular challenges for the regulators. The high speed at which information is disseminated in the capital markets means that future financial crises and systemic disruptions, like flash crashes, can occur ever more spontaneously and are becoming increasingly difficult to predict. In traditional man-machine systems, human intervention in real time is still possible in most cases if unwanted changes to the system occur within human reaction times. This minimum reaction time of about 1,000 milliseconds is many times longer than the usual critical time spans in today’s trading centres, which are increasingly measured in microseconds.

Like many other complex sociotechnical systems, financial markets do not have a higher-ranking real-time controller who can intervene in trading at

lightning speed if needed. For this reason, the continuous safeguarding of an orderly functioning of the markets cannot be guaranteed solely by real-time rights of intervention (such as a circuit-breaker) or ex post powers of the supervisory authorities (such as cancellation of faulty orders after a flash crash). What is therefore needed is a comprehensive regulatory framework with its main emphasis on measures that already identify and neutralise the risks and problems of high-frequency trading ex ante. In conjunction with real-time instruments and ex post measures, such a regulatory framework for innovative markets should ensure transparency and efficiency while safeguarding financial stability. The benefits have to be identified and the risks contained without impeding progress unnecessarily. In this respect, it is important to consider not only the necessity of regulatory measures but also the direct and indirect effects of these measures. This is because regulation invariably induces changes in investors' market behaviour and may be counterproductive in terms of market quality.

To make such regulation effective and friction-free, it always has to be based on a good understanding of the matter to be regulated. Unfortunately, however, we are faced with the problem that discussion on the subject of HFT is currently often conducted on the basis of incomplete or fragmentary information.

This is due, for one thing, to conditions in the HFT sector, which is characterised by a severe lack of transparency – it is not just outsiders but also regulators who find it difficult to gain an overall perspective on it in some cases.

The major HFT participants (the five or six big players in London) prefer to go about their business without arousing great public attention. Furthermore, the population of smaller HFT firms is quite volatile and generally below the “perception threshold” of the regulators. Empirical data on HFT trading activities and the algorithms used are mostly difficult to obtain and are often not very up-to-date or accurate. Given the current data situation, it is only rarely possible to analyse individual algorithms applied in real trading. Therefore, most studies on the subject try to capture HFT activities at an aggregated level for whole indices or markets. On top of this, the rapid pace of development in this area means analyses which are older than one or two years run the risk of describing a market that now no longer exists.

Another thing is that, for a long time, regulators failed to deal more closely with developments in this area and their implications for the capital markets. It can be said, with good justification, that the flash crash of 6 May 2012 was basically the starting signal for the authorities and central banks to look into the matter in greater depth. While HFT traders were already breaking the barrier from the millisecond to the microsecond range, authorities and commissions were still discussing how to define HFT in law. It is now a matter of making up for this late start in acquiring expertise in order to put in place a moderate regulatory framework.

A further critical point is the often undifferentiated and generalised treatment of the various issues and problems surrounding HFT in the public debate and sometimes also among specialists. For example, misgivings prompted by the

existence of a specific HFT strategy that is detrimental to the market or by a certain one-off market event are often cited as points of criticism against high-frequency trading in general. Conversely, supporters like to use supposedly market-friendly effects of a single strategy, such as the lower bid-ask spreads due to HFT market making, as arguments for all HFT traders having as much unrestricted freedom to act as possible. Such an approach on both sides fails to do justice to the numerous aspects of HFT and is not helpful for an objective discussion of the pros and cons of regulation.

2 The many facets of HFT

For this reason, it is advisable to take a nuanced view in the debate in order to take better account of the various facets of the subject. The term “HFT” should be seen only as a general heading that can cover a large number of different fields of application. Some of the most important strategies are based on the provision of liquidity in equity trading (market making). Others can be classified under the heading “statistical arbitrage” and apply algorithms in order to identify and use profitable trading opportunities from the price data at lightning speed. Other strategies again belong to a category known as “liquidity detection” (spying-out the order book for hidden large orders). This is

described by many observers as “predatory trading” and is suspected of being unfair and detrimental to the market. Within the various segments, there are, in turn, further subcategories which, in principle, have to be regarded as quite autonomous areas. The variety cited here has no claims to be complete or even clearly structured. It is merely intended to illustrate that there is no single high-frequency trading entity as such, but rather a broad spectrum of HFT activities.

Given this complex background, conclusions about HFT and discussions on regulatory options should relate, as far as possible, to the specific underlying HFT strategy. Making wholesale judgements on HFT are not appropriate, nor do they help in making an improvement in the regulatory framework for transparency, stability and efficiency. This means that the advantages of HFT as well as its drawbacks have to be evaluated very specifically. Statements to the effect that HFT is either generally good or bad for a market therefore have to be viewed critically.

3 Impact of HFT on the capital markets

Even if this means that making a final judgement on HFT is not an easy undertaking, sometimes heavily polarised opinions have emerged in the debate.

Many observers regard HFT as a new technological possibility of implementing existing trading strategies and not as an autonomous trading strategy per se. In their view, speed advantages have always been an essential component of many successful trading approaches. Seen from this perspective, HFT is not an entirely new phenomenon, but rather a technological evolution of the securities markets. Seen in this way, HFT plays an important role in the price-discovery process and clearly influences the level of transaction costs in securities and forex trading in favour of all market participants.

By contrast, many other investors are of the opinion that, given the market conditions created by HFT, market efficiency has declined and that “real” investment takes place increasingly rarely. They see market fairness as severely restricted and fear that HFT traders have secured systematic advantages for themselves over other market participants and are using them to the detriment of the majority of investors. A recent survey among British asset managers and pension funds as part of a government study on HFT showed that the majority of those surveyed were very sceptical about the positive impact of HFT on the market.

HFT players and stock market operators generally emphasise that HFT, on balance, brings about a perceptible improvement in market liquidity and efficiency in price discovery. They claim that the majority of investors benefit from reduced bid-ask spreads, a customary yardstick of liquidity. This assertion is supported by several economic research papers using data from the period 2001 to 2009. An economic study showed, for example, that, in the United

States, more than 50 per cent of the best bids and asks were submitted by HFT players. Nevertheless, since 2010 it has been emerging from academia that a growing number of studies – some of which are based on more recent and more extensive data – are producing results that are critical of HFT. There are increasing signs, for example, that, especially in volatile market situations, HFT might prove to be tricky – in the sense of further destabilising the market.

As long ago as the 16th century, the natural philosopher Francis Bacon wrote that the scientific attraction of extreme events lies precisely in the fact that they constitute those rare moments in which complex systems allow a brief insight into the true nature of the underlying forces driving them.

In that sense, the flash crash showed that the liquidity generated by HFT market makers, which normally keeps down transaction costs, can suddenly disappear in difficult market phases. Unlike regular human market makers who have an obligation to stay in the market even with very volatile price movements, HFT players are not, as a rule, bound by such provisions. In good times, therefore, HFT traders displace the normal market makers and often, in fact, perform their function better to the advantage of all the market players. In difficult markets, on the other hand, there is a risk of the trade flows collapsing with the attendant problems for the market as a whole if the HFT players withdraw. For many market participants, the narrowing of the bid-ask spreads generated by HFT and the higher trading volume are thus merely “pseudo-liquidity”. There have therefore been proposals from several sides to oblige HFT market makers to stay in the market even if there is high volatility. This

idea is modelled on the contractual commitment that normal market makers have, say, with Deutsche Börse. HFT market makers should therefore start to assume their share of responsibility for the markets from which, in their superior position, they have so far derived only benefit.

Besides such rare, but dramatic events with high volatility, HFT is, however, proving to be fraught with a number of problems from a regulatory perspective, even in everyday trading. While bid-ask spreads have clearly fallen in the past few years thanks to HFT market makers, the average holding period of the positions held by these players has become much shorter. According to a study on the flash crash, most HFT market makers close their positions after no more than roughly ten seconds. The stabilising effect that “normal” market makers can have on the market if there is heightened volatility has thus given way to a “hot potato effect” where the falling shares are merely handed round at cyberspeed.

With the increasing dissemination of HFT, the number of buy and sell orders has risen dramatically in the past few years. What appears at first sight to be something positive, is revealed upon closer inspection to be not entirely without problems. What is especially critical is the “quote stuffing” tactic used by some HFT algorithms. This involves the HFT trader entering a large number of orders per second for tactical reasons, only to withdraw them again unexecuted. The resulting very high annulment rate leads to a very sharp divergence between the market liquidity displayed and the actual trading

volume. It is often the case that an investor who submits an order in response to a bid or an ask cannot execute the transaction to the displayed limit.

Even though the explicit transaction costs may seem small, the implicit costs can be much higher. To sum up, it may be therefore be said that the market liquidity shown and the narrowness of the bid-ask spreads are not in themselves reliable indicators of market quality and efficiency. These are also determined by the average size of the volume of equity associated with the quotes as well as the median holding period of the quotes. Both factors have diminished in the past few years.

An analysis of all the trading days conducted by NANEX on the New York Stock Exchange from the beginning of 2007 to September 2011 showed that, for 535 billion quotes for all stocks listed there, there were only 35 billion genuine transactions. What is interesting here is that the ratio of quotes to genuine trades has undergone a very marked change in parallel with the growth in importance of HFT. The ratio of quotes to trades that is necessary to generate US\$10,000 in real transaction volume increased from between roughly six and seven at the beginning of 2007 to between 60 and 80 in mid-2011. A higher ratio of quotes to trades stands for a less efficient market, where more information is needed to turn over the same trading volume.

Sudden dramatic spikes in the number of quotes are increasingly being measured for individual US stocks, with individual HFT algorithms generating several tens of thousands of quotes per second for several seconds. The

current record for quotes per second generated by a single HFT player on a single stock exchange (as of 24 April 2012), is held by a US stock (PSS World Medical) and stands at 47,138. In comparison: within one second

- Google currently processes around 34,000 search queries worldwide
- there are scarcely more than 10,000 tweets on Twitter
- there are, at most, roughly 6,000 profile status updates on Facebook.

Often, such bursts of activity are accompanied by what are known as mini flash crashes, in which, without any fundamental reason, the stocks lose 20, 40 or even more than 50 per cent of their value within the space of a few seconds, only to recover again a short while later. For example, according to SEC, since mid-2010 there have been more than 100 of these unexplained crashes in the United States, of which HFT algorithms are suspected to have been the cause. But even in Germany there have been cases of sudden heavy price fluctuations occurring for no obvious fundamental reason.

One interesting example of extreme price anomalies was the recent failed stock market flotation of the BATS exchange platform. This was the shortest IPO in stock exchange history. It began at 11.14, 18 seconds and 436 milliseconds on 23 March 2012 with a starting price of US\$15.25. The end came just under 1.5 seconds later after the price had tumbled to US\$0.2848 within the space of 900 milliseconds and hit a floor at US\$0.0002 another 600

milliseconds later, with 567 trades being conducted within the first 900 milliseconds.

This incident attracted a great deal of attention and was dismissed by many as a computer glitch. A close look at the trading data reveals an interesting fact, however. Plotting the number of trades since the start of trading rather than the time on the x-axis and focusing on the logarithmic stock price suddenly produces an entirely different picture of the incident. Seen from this perspective, the obvious conclusion is that the flotation of BATS could have collapsed because of an algorithm that was specifically designed to disrupt the IPO. The experts are not in full agreement and the jury is still out concerning what really happened. Nevertheless, some market observers are asking pointedly whether BATS might have been the victim of an targeted HFT attack. If that was indeed the case, it would surely be an unprecedented occurrence for the capital markets.

Sending bids or asks has one thing in common with sending spam mails. Both cost virtually nothing for the sender, but do come at a cost for the receiver. Transmitting and processing such quantities of data create major problems and entail high costs for stock exchanges and market players. Overloading occurs frequently and is even seen by some observers as one of the contributory causes of the flash crash in May 2010.

An added difficulty is that some of these quotes are sent out by certain algorithms solely for the purpose of misleading other traders or algorithms into

performing certain actions which can then, in turn, be exploited. As a result, more and more institutional investors are transferring their transactions from normal stock exchanges to alternative off-exchange trading venues (such as “dark pools”), in which it is often more difficult for HFT to operate profitably.

Submitting a quote that facilitates a real transaction under fair conditions between two parties in the capital market is one of the core functions of a well regulated market. Some HFT players who apply such tactics thus increase the frequency of quotes at the expense of their quality. They therefore act more as an obstacle to greater market efficiency rather than a driving force behind it. As described earlier, the quote-trade ratio is now ten times higher in the US market. Given an increase of this kind, regulators are faced with the question of the real economic sense and the market impact of such excessive quote sending. Is it genuine progress? Assuming that advances are usually associated with an increase in efficiency, as is mostly the case in the history of technology, it unfortunately has to be said that it is not progress.

4 What should be done?

The outlined points of criticism are intended to show that HFT is a subject on which it is quite possible to hold a wide range of different opinions and that each specific case has to be looked at and taken on its own merits. Besides fundamentally “market-friendly” strategies, like statistical arbitrage, which can be seen as positive for the market from the regulators’ point of view, there are

also “unfriendly” strategies, such as “quote stuffing” and “wash trades”, which are to be rated as dubious. Others again are basically to be welcomed, but display shortcomings in terms of their practical application in the market and are in need of improvement, HFT market making being one example of this.

Looking at the various different HFT strategies from the perspective of a potential regulator, there are strategies like “Newsreaders”, which are regarded as not being harmful to the market given moderate regulation. “Pinging” or “sniping”, on the other hand, might be seen as fraught with problems in terms of the fairness of financial markets. In specific cases, these strategies might even have to be rated as problematic. At all events, the strategies which many observers see as damaging to the market include “flash trading”; “quote stuffing” used for the purpose of influencing prices; “wash trades”, in which a false impression of liquidity is created, and “spoofing” in which an attempt is made to generate short-term momentum in an asset. Such practices have no place in a fair and efficient market.

How will it be possible to achieve the objective of a symbiotic coexistence of HFT players and other market participants while improving the quality of the market at the same time? On the part of the regulators, there are currently a whole range of initiatives and some legislative proposals which are ready and likely to be implemented in the next few months. At the European level, the new MiFID directive will introduce a series of regulations for HFT. In addition, the Federal Ministry of Finance in Germany currently has plans to take action with its own national legislative initiative.

In my following remarks, I would like to give you a brief overview of these regulatory proposals. Some of the planned new regulations are general and more concerned with market infrastructure and risk controlling requirements as well as stronger rights of regulatory oversight for the authorities such as BaFin. For instance, there is provision for the introduction of special circuit breakers which are adapted to HFT market conditions, which can interrupt trade in a specific asset when needed if the price fluctuations exceed a certain value.

Alongside this, there exists a series of proposals which can, in principle, be related directly to the individual HFT strategies. It is possible to make a distinction between regulation that enhances transparency and prohibiting regulation. The former is aimed at all HFT strategies and is intended to help the supervisory authorities to gain a better insight into what is happening in the market and, if necessary, enable them to capture and track irregularities and problematic trading activities. Trader IDs, for example, are a key requirement for being able to trace and allocate orders placed by individual HFT players in different securities and markets. This will make it possible to identify the strategies that are active in the market and make meaningful statements on how they are behaving and their implications for the market. It goes without saying that safeguards will be in place to ensure that the trader IDs behind the orders are not openly visible to other market participants.

The second category of regulations is restrictive or even prohibitive in nature. With these regulations, certain aspects and characteristics of HFT strategies which are felt to be damaging to the market are to be reduced to a tolerable

level. If this approach has little prospect of success or is not practicable, an explicit ban on the strategy can be declared. It should be noted, however, that the precise form most of the regulations will take has not yet been finalised.

5 Outlook and concluding remarks

In conclusion, allow me to highlight some fundamental points which I see as important.

With regard to the ultimate question of the relationship between HFT and market efficiency, it should be remembered that market efficiency, first and foremost, implies that the price of an asset adjusts quickly to fundamental changes in its value. It is not immediately obvious how HFT algorithms can play a part in this with their “decisions” based only on the status of the order book in the past few seconds or indicators of technical analysis. A block trade of 10,000 stocks between two informed big investors is true price discovery in the market. Shifting 100 stocks back and forth thousands of times at lightning speed between two HFT algorithms is, on the other hand, not an equivalent contribution to the efficiency of trading. Given this situation, one of the most important arguments advanced in favour of HFT is that, in effect, it operates mostly as a quasi-financial intermediary and, as a result, perceptibly improves the market conditions under which normal investors interact in a price-discovery process. Even though this may be true in some areas, it should not be overlooked that intermediation is not an end in itself. The profits earned

through financial intermediation should, in the final analysis, be justified by the benefits that they generate in the real economy. HFT strategies, like market making or Newsreader, which are employed under moderate regulation thus always have to be measured by that criterion. This means that HFT can indeed have its well-earned place in the market structure. But it should not burden, let alone dominate this structure. This is because a market overwhelmingly dominated by HFT is, at the same time, also a market in which the majority of orders have lost all connection with fundamental factors. And it is this relationship between price and fundamental value which should be the main distinguishing feature of market quality.

Thank you for your attention.

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