Testimony of
Cameron Smith

Before the
House Financial Services Subcommittee on
Capital Markets and Government Sponsored Enterprises

"Market Structure: Ensuring Orderly, Efficient, Innovative and Competitive Markets for Issuers and Investors"

President
Quantlab Financial
Houston, Texas

June 20, 2012

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Introduction

Thank you Chairman Garrett, Ranking Member Waters, and Members of the Subcommittee for providing me this opportunity to participate in today's hearing. My name is Cameron Smith. I am President of Quantlab Financial, a Houston, Texas-based quantitative trading firm.

Quantlab was founded in 1998 and now employs more than 100 people. Our company does business in multiple markets around the world – not just in equities – but other asset classes such as futures, options, treasuries and foreign currencies. In addition, I have worked at the Securities Exchange Commission (SEC), an exchange, and a broker that serves institutions before arriving at Quantlab five years ago.

I am proud of the role Quantlab plays in the market and how our trading activities, in competition with other likeminded firms, lead to better prices for investors. The fact that a relatively small firm from Houston, Texas, is represented here today underscores the truly competitive, fair, and transparent nature of our equity markets.

Mr. Chairman, we trust and hope that this hearing reflects a commitment by all concerned with the quality of our financial markets to a comprehensive assessment of the strengths and weaknesses of our markets.

Modern Electronic Markets and Automated Trading Have Benefited U.S. Investors

In recent years, computer technology advancements have shifted the marketplace from an exclusive market, centered around the privileged few with seats on an exchange floor to an open, competitive electronic environment where orders are routed to exchanges and prices are communicated to the public in real-time through tele-communication lines. Virtually all trading is automated in some fashion. The result of these advancements is that professional trading can take place nearly anywhere in the country and across the globe.

Along with the technological advances, the updating of regulations over the last fifteen years has helped promote transparency and fair competition, leveling the playing field for all market participants.

As these changes have dramatically increased the efficiency of the markets, the role of traditional manual market making and specialist firms has been reduced and replaced by today's automated professional trading intermediaries. Many are calling these newer market participants "high frequency traders" or "HFTs." That is a vague label that means different things to many different people.

By whatever name, however, the market needs professional intermediaries to bridge gaps in supply and demand between investors. Historically, this function was provided by privileged intermediaries known as specialists, market makers, dealers, floor traders, or locals. Today, this function is provided by diverse, highly competitive firms that rely on technology.

It is this intense competition that has played a prominent role in reducing transaction costs for all investors, both retail and institutional. By virtually every common measure of market quality, our markets have never been healthier. This has been demonstrated in numerous empirical academic studies that show that transaction costs have come down dramatically, price discovery has improved, and short-term volatility has been reduced. I have attached a copy of a recent review of the academic literature on the topic for the record (Appendix A). The intensely competitive market is also why the U.S. equity market is the largest and most efficient equity market in the world.

While the general trend of improving market quality is clear, there still remains a great deal of misunderstanding around the role of professional trading, and so-called high frequency trading in particular. While different firms will describe their trading approach in different ways, high frequency traders generally collect and analyze publicly available data, and determine their view of the instantaneous "fair value" of whatever they are trading. Different traders use their view of fair value in different ways and at different times. Some make markets by posting prices around their idea of fair value. Others will wait until their idea of fair value allows them to trade immediately based on prices in the market. Regardless of their approach, the fierce competition between scores of professional intermediaries provides investors with the ability to buy or sell with low transaction costs. It is no coincidence that investor transaction costs dropped during the recent period of increasing competition and automation.

Further, the general approach of competitive traders identifying and trading towards fair value explains why studies that have compared high frequency trading to the rest of the market find that it tends to improve price discovery and lower, not increase, short term volatility in the market. Recently, in a working paper titled "High Frequency Trading and Price Discovery," Professor Terrence Hendershott at the University of California-Berkeley and Professor Ryan Riordan at the Karlsruhe Institute of Technology in Germany concluded that traders "play a positive role in price efficiency by trading in the direction of permanent price changes and in the opposite direction of transitory pricing errors on average days and the highest volatility days."

In sum, regulatory changes and technology advancements have led to a higher quality market that has benefitted all classes of investors, including retail and institutional, in the form of lower transaction costs, dampened volatility, and prices that better reflect all information.

Additional Reforms Have Potential to Further Improve Market Quality

While market quality has improved and investors have benefitted over the past decade or so, there are aspects of the market that might benefit from certain regulatory initiatives.

One policy that must be implemented in the short term is a reporting regime that ensures that regulators have access to all the data they need to adequately surveil our markets and continue to ensure they operate with the highest integrity. In this regard, we have consistently supported initiatives such as consolidated audit trails and the large trader reporting system. Further, we have encouraged the formation of industry working groups to offer technical assistance to regulators that must learn to analyze the richness of data that exists in electronic audit trails.

As regulators develop more robust market surveillance tools, however, it would be a mistake to focus attention solely on one group of market participants, as now seems to be the case with efforts by some to define "high frequency trading." Instead, the programs should surveil the activities of all market participants, and then focus on specific unusual activity, regardless of their perceived strategy or use of automation.

A second area for improvement is one that the SEC is already in the process of addressing. Those are the related areas of risk management and circuit breakers or limit up/limit down protections. Many of the concerns expressed by critics of automated trading are really concerns, not about a specific trading style, but related to the threat of computer errors that undermine market integrity. While automation has improved market quality dramatically, there is no question we must vigilantly protect against its unique risks. Effective risk management by broker dealers, coupled with another line of defense at the exchanges through circuit breakers or limit up/limit down protections, are important to protect our markets from the effects of computer errors, software bugs or unintended interactions. The SEC's proposals in these areas are right on the mark and should greatly reduce the potential impacts of errors while preserving the tremendous benefits of automation for investors.

A third area that policymakers must continue to monitor and perhaps make some incremental changes involves the issue of fragmentation. This is a longstanding issue in the world of U.S. equity market structure. The challenge has long been to balance the benefits of competition against complexities from fragmenting the market between too many trading venues.

The best price discovery occurs when orders from market participants with different objectives, time horizons, and perspectives interact in open and transparent markets. It is worthwhile to explore whether, for example, different types of order flow being executed away from the public, transparent markets, such as in dark pools or in other order flow arrangements, could lead to a degradation of market quality. We must, therefore, ensure that the current regulations don't inadvertently contribute to fragmentation by hindering the ability of public markets to compete with private markets.

In this regard, two adjustments to the current regulatory scheme are worth considering. First, consider allowing "locked" markets – that is, permitting quotes to be displayed when the "bid" price and the "ask" price are the same. While Regulation NMS banned locked markets, one impact of the ban is to widen the quoted spread of the public market, thereby facilitating internalization and dark pool activity.

Second, policymakers should create categories of stocks with different quote increments. While decimalization and penny increments have saved investors hundreds of billions dollars, a one size fits all approach regardless of whether a stock trades at $5 or $500 does not make sense. Increments that are too wide reduce the efficiency of the public exchange markets relative to the private markets. For example, when Citigroup stock was trading under $5 per share, just that one stock constituted more than 30 percent of the off private market volume. When the public markets cannot arrive at efficient prices due to tick increment constraints, it is relatively easier for off-exchange venues to siphon away order flow, contributing to fragmentation.

My final suggestion involves improving our overall approach to how we monitor and evaluate market performance. Specifically, I believe it is imperative for the equity market community to develop commonly accepted measures of market quality that are monitored consistently over time and provide a common-ground for market structure discussions. Our capital markets are far too important to allow policymaking decisions to be driven by opinion and anecdote as to the current state of our markets. Certainly, discussions about market structure, including high frequency trading, could benefit from rigorous statistical analysis and greater awareness of empirical evidence on the topic. There are already many established metrics and methodologies for examining market quality, including measures of liquidity, price efficiency, market impact, volatility and cost. It should be a priority of the policymakers to develop and specify the proper metrics before taking any significant steps toward altering the current market structure that has generally served investors well.

Conclusion

In summary, I congratulate the Subcommittee for holding this hearing and fostering discussion as to the health of our equity markets. Despite a lot of criticism from some sectors, we must not lose sight of the fact that we do have the world's leading equity market and that the empirical evidence shows they have never been healthier. The U.S. has achieved this position by adhering to certain core values: transparency, open competition and the best interests of the investing public. Accordingly, when considering any future actions we must tread carefully and make sure that any actions are consistent with these values. This can be done by ensuring that any policy decisions are firmly grounded in empirically driven understanding of the markets. While there are areas in need of improvement, we have a lot to be proud of.

I thank you for the opportunity to appear today. I look forward to answering any questions.

<u>Appendix A</u>:
Literature Review

High Frequency Trading Literature Review
June 2012

This brief literature review presents a summary of recent empirical studies related to automated or "high frequency trading" (HFT) and its impact on various markets. Each study takes a unique approach, yet all paint a consistent picture of markets being improved by competition and automation.

Author(s) / Title	Dataset	Findings
Angel, Harris, Spatt "Equity trading in the 21st century", February 2010	U.S. equities, 1993 – 2009	Trading costs have declined, bid-ask spreads have narrowed and available liquidity has increased
RGM Advisors "Market Efficiency and Microstructure Evolution in US Equity Markets: A High Frequency Perspective", October 2010 March 2012 (Update)	U.S. equities, 2006-2011	Bid-ask spreads have narrowed, available liquidity has increased and price efficiency has improved
Credit Suisse "Sizing Up US Equity Microstructure", April 2010 "Who Let the Bots Out? Market Quality in a High Frequency World", March 2012	U.S. equities, 2003-2010 U.S. equities, 2004-2011	Bid-ask spreads have narrowed, available liquidity has increased and short-term volatility (normalized by longer term volatility) has declined, and the incidence of "mini" crashes has not increased
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
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 and BATS, 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 and BATS, 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
Hirschey, Nicholas "Do High-Frequency Traders Anticipate Buying and Selling Pressure?"	HFT vs. other trades. U.S. equities on NASDAQ and BATS, various periods in 2008 – 2010	HFT trades were positively correlated with non-HFT trading, corroborating Hendershott and Riordan results
O'Hara, Yao, Ye What's Not There: The Odd-Lot Bias in TAQ Data	HFT vs. other trades. U.S. equities on NASDAQ, various periods in 2008 – 2010	Odd-lots and trades of 100 shares drive the majority of price discovery; HFT is more likely to trade with odd-lots
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
Kirilenko, Kyle, Samadi and Tuzun "The Flash Crash: The Impact of High Frequency Trading on an Electronic Market", May 2011	CME ES S&P-500 equities index futures contract, May 3 - May 6, 2010	HFT traders did not change their behavior during the flash crash; HFT was net buyer during the crash, net seller during the recovery; HFT trading may have induced more trading during the crash
Eurex AG, "Why high-frequency trading is a good thing", 2011	Eurex FDAX: DAX equities index futures contract August 25, 2011	During "FDAX flash crash", HFT acted "in a way that protects the market by placing a rapid succession of small, non-directional buy and sell orders, thus preventing abrupt price movements", improving market quality during a period of high stress
Menkveld "High Frequency Trading and the New-Market Makers", April 2011	Dutch equities traded on Chi-X and Euronext, 2007	A single high frequency trader played an important role in the development of a competitive market center, resulting in better liquidity and lower trading costs

Lepone "The Impact of High Frequency Trading (HFT): International Evidence", September 2011	HFT vs. other trades. Singapore Exchange (SGX), Australia Securities Exchange (ASX), NASDAQ and London Stock Exchange	HFT has become a major provider of liquidity, particularly during periods of market uncertainty
Hendershott, Jones, Menkveld "Does Algorithmic Trading Improve Liquidity?", February 2011	Automated quoting facility, NYSE equities, 2003	Automated trading narrowed bid-ask spreads, lowered trading costs, and improved price efficiency
Riordan, Storkenmairm "Latency, Liquidity and Price Discovery", 2009	Xetra high-speed trading system, Deutsche Börse, 2007	Higher system speeds led to increased liquidity and improved price discovery
Hendershott, Moulton "Automation, Speed and Stock Market Quality: The NYSE's Hybrid", February 2010	NYSE TAQ database plus others, June 1, 2006 - May 31, 2007	Introduction of automation via the NYSE hybrid system improved price discovery and made prices more efficient
Gomber, Arndt, Lutat, Uhle "High-Frequency Trading", March 2011	Various	Survey paper that highlights beneficial aspects of HFT, while noting that perceived problems are largely a result of U.S. market structure
Various BIS Foresight Project	Various European equities data sets	Generally stable or improving market quality over the past decade

This following studies measured improvements in overall market quality:

Angel, Harris and Spatt (February 2010) examined many measures of market quality and how they have changed over time and in response to regulatory and structural changes in the U.S. equity markets.[1] Drawing from a diverse set of data sources, they show that there has been significant improvement in virtually all aspects of market quality. They stated that "execution speeds have fallen, which greatly facilitates monitoring execution quality by retail investors. Retail commissions have fallen substantially and continue to fall. Bid-ask spreads have fallen substantially and remain low, although they spiked upward during the financial crisis as volatility increased. Market depth has marched steadily upward. Studies of institutional transactions costs continue to find U.S. costs among the lowest in the world."

[1] Angel, J., Harris, L. and Spatt, C., "Equity trading in the 21st century", http://papers.ssrn.com/so13/papers.cfm?abstract_id=1584026

RGM Advisors, LLC (October 2010, Updated March 2012) studied recent data from the U.S. equity markets.[2] The authors examined trends in a number of U.S. equity market quality metrics over the period from January 2006 through June 2010 and how these metrics differed by market capitalization and by listing venue. They presented data that confirmed that over this period quoted bid-ask spreads declined, quoted market depth increased and short-term measures of market efficiency significantly improved. The updated Research Note examined the same metrics through the end of 2011, a period that included significant macro-volatility surrounding the European debt crisis and U.S. credit downgrade. The data demonstrated that trends toward improving market quality continued in recent periods, despite the macro-economic shocks.

Credit Suisse (April 2010, March 2012) released a report on related topics and showed that in recent years, bid-ask spreads declined, depth at the inside quote increased and intra-day volatility normalized by longer-term volatility declined substantially.[3] The authors concluded on this last point that "[t]his seems to be confirmation that the new market participants are successfully finding and removing mispricings, as well as dampening volatility that might otherwise be created by large institutional orders filled during the day." Credit Suisse (March 2012) released a follow-up report on the impact of HFT on market quality and found that bid-ask spreads declined and depth at the inside quote increased. They also looked at historical long-term and short-term (intraday) volatility and found that long-term volatility has remained within historical norms while short-term volatility has declined over recent years. They concluded that, with regard to high frequency traders, "markets are not worse for their presence".

Hasbrouck and Saar (October 2010) explored the nature and impact of low-latency (algorithmic) trading on the NASDAQ exchange during June 2007, a 'nominal' market period, and October 2008, a volatile, uncertain period.[4] They identified periods of high market activity due to algorithms and relate these to longer-term market quality metrics such as spread, effective spread and depth of liquidity. They observe in both periods "that higher low-latency activity implies lower posted and effective spreads, greater depth, and lower short-term volatility."

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[2] Castura, J., Litzenberger, R., Gorelick, R., and Dwivedi, Y., 2010: "Market Efficiency and Microstructure Evolution in US Equity Markets: A High Frequency Perspective", http://www.rgmadvisors.com/docs/MarketEfficiencyStudyOct2010.pdf

Castura, J., Litzenberger, R., Gorelick, R. 2012: "Market Efficiency and Microstructure Evolution in US Equity Markets: A High Frequency Perspective: Update March 2012", http://www.rgmadvisors.com/docs/MarketQualityStudyMarch2012.pdf

[3] Credit Suisse, 2010: "Sizing Up US Equity Microstructure", https://tradeview.csfb.com/edge/Public/Bulletin/Servefile.aspx?FileID=14377&m=1337434953

Credit Suisse, 2012: "Who Let the Bots Out? Market Quality in a High Frequency World", https://edge.credit-suisse.com/edge/Public/Bulletin/Servefile.aspx?FileID=21352&m=2100222725

[4] Hasbrouck, J. and Saar, G, "Low-Latency Trading", http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1695460

The following studies examined market data sets that distinguished between automated trades and other trades:

Hendershott and Riordan (August 2009) reported on the impact of automated trading on the Deutsche Börse's Xetra market, an equity market where automated trading activity could be distinguished.[5] The paper found that automated trading accounted for about half of the total volume in the top 30 volume stocks, and that automated trading was better than non-automated trading at driving prices toward efficiency. The authors also showed that automated trading "contributes more to the discovery of the efficient price than human trading." Furthermore, they find there is "no evidence of [automated trading] behavior that would contribute to volatility beyond making prices more efficient."

Similarly, in the foreign exchange market, **Chaboud, Hjalmarsson, Vega and Chiquoine (October 2009)** used a dataset that separately identified computer generated trades from human generated trades and showed that an increase in automated trading may be associated with less market volatility, and that automated traders tend to increase liquidity provision after exogenous market events such as macroeconomic data announcements.[6]

The Bank for International Settlements (September 2011) released a related study on the impact that growing HFT participation has had on the foreign exchange market.[7] The authors based their findings on observations made from several banks and other foreign exchange markets, in addition to using historical data from Reuters and EBS, two of the largest FX trading platforms. They cited a general consensus that HFT benefits the markets under normal conditions, and therefore focused on two significant FX shocks: May 6, 2010 and March 17, 2011. In both cases, they found evidence suggesting that HFT did not withdraw from trading during the shocks, and that they may have been quicker to resume normal trading as the shocks stabilized than traditional market participants.

Brogaard (August 2010) investigated the impact of "high frequency trading" or "HFT" on US equity trading on the NASDAQ and BATS exchanges.[8] Using a data set provided by the exchanges that labeled all activity as either 'HFT' or 'everything else', Brogaard examined the exact impact that HFT participants have on the market. His analysis used a well-known regression framework to isolate various factors in the market and how HFT impacts each of these. In particular, he shows that HFT activity contributes more to price discovery than other activity, that HFT quotes are at the best bid or best ask price about 50% of the time, that HFT reduces price impact (an important component of trading costs) for other participants, and that HFT activity reduces volatility.

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[5] Hendershott, T. and Riordan, R., 2009: "Algorithmic Trading and Information", http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1472050

[6] Chaboud, Alain, Hjalmarsson, Erik, Vega, Clara and Chiquoine, Ben, "Rise of the Machines: Algorithmic Trading in the Foreign Exchange Market" (October 2009). Federal Reserve Board International Finance Discussion Paper No. 980, http://ssrn.com/abstract=1501135

[7] Bank for International Settlements, "High-frequency trading in the foreign exchange market" (September, 2011), http://www.bis.org/publ/mktc05.pdf

[8] Brogaard, J., "High frequency trading and its impact on market quality", www.futuresindustry.org/ptg/downloads/HFT_Trading.pdf

Brogaard (October 2011) used the same data set to investigate the impact of HFT on volatility. [9] He performed a series of measurements in an attempt to determine the causal nature of the relationship between HFT activity and volatility. He found evidence that HFT liquidity provision increases during times of short-term volatility, but decreases during periods of long-term volatility. Using the 2008 short-sale ban as an exogenous control variable of HFT activity levels, Brogaard found that restrictions that reduced HFT participation lead to higher volatility.

Hendershott and Riordan (2011) examined the impact of HFT on the price discovery process using the same NASDAQ dataset used in Brogaard (2010).[10] Overall they found that HFT trades are positively correlated with permanent price changes and are negatively correlated with temporary pricing errors, thereby improving the price discovery process. By distinguishing trades initiated by HFT, the authors found that marketable high frequency trades actively drive prices towards fair value.

Hirschey (2011) used the same HFT-labeled NASDAQ dataset of Hendershott and Riordan (2011) to investigate how HFT used marketable orders.[11] He found that HFT traded with marketable orders in the direction of previous, contemporaneous and future non-HFT orders. This corroborates the Hendershott and Riordan results, showing that HFT trades in the direction of permanent price impact.

O'Hara, Yao and Ye (2011) used the same HFT-labeled dataset of Hendershott and Riordan (2011) to investigate the use of odd-lots in trading.[12] They found that that odd-lots contribute to 30% of the price discovery process, and that such trading can represent a significant fraction of all trades, particularly for higher priced stocks. They showed that HFT was more likely to trade with odd-lots. Finally, they raised the concern that the consolidated pricing feed does not account for odd-lots, and as such may not be as useful as it was intended.

A similar study done by **Jarnecic and Snape (June 2010)** used data provided by the London Stock Exchange (LSE).[13] Like the NASDAQ data set, this set labeled all activity by participant type; HFT, investment bank, retail, etc., providing a finer granularity of participation rates and behaviors. The authors used a similar regression framework as Brogaard in order to isolate the impact of HFT on various market metrics. They found that HFT participants tend to provide liquidity when spreads are wide, demand liquidity when spreads are narrow, that they are more likely to "smooth out liquidity over time and are unlikely to exacerbate stock price volatility".

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[9] Brogaard, J., "High frequency trading and volatility", http://papers.ssrn.com/so13/papers.cfm?abstract_id=1641387

[10] Hendershott, T. and Riordan, R., 2011: "High Frequency Trading and Price Discovery", http://faculty.haas.berkeley.edu/hender/HFT-PD.pdf

[11] Hirschey, N. "Do High-Frequency Traders Anticipate Buying and Selling Pressure?", https://www2.bc.edu/~taillard/Seminar_spring_2012_files/Hirschey.pdf

[12] O'Hara, M. Yao, C. and Ye, M. "What's not there: The odd-lot bias in TAQ data", http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1892972

[13] Jarnecic, E. and Snape, M., "An analysis of trades by high frequency participants on the London Stock Exchange", http://mfs.rutgers.edu/MFC/MFC17/MS/MC10~447_Snape_Jarnecic.pdf

The CME Group (July 2010) released a report on automated trading activity on the CME futures exchange.[14] They labeled all participants as either "ATS" (automated trading system) or "non-ATS." They compared trade volume and messaging rates for each participant against market measures such as liquidity and volatility. ATS's impact on these measures varies by futures contract, but as a whole, they concluded that ATS-based "volume and message traffic tend to be associated with enhanced liquidity and reduced volatility".

Kirilenko, Kyle, Samadi and Tuzun (May 2011) investigated the role that HFT played in the flash crash on May 6, 2010.[15] With access to all trades and accounts for the S&P 500 e-mini futures contract that trades on the CME, they classified all participants by activity patterns, including a group of participants that they characterized as "HFT". They found that these participants accounted for a large portion of trading and that they did not change their trading behavior before or during the flash crash. HFT participants were net buyers during the crash and net sellers during the recovery. The authors suggest that HFT trading during a brief period of the crash may have induced other participants into thinking there was more liquidity than was truly available.

Backes (2011), representing the Eurex futures group, performed a similar investigation around the flash crash of the FDAX futures contract on August 25, 2011, which shared many characteristics of the May 6, 2010 flash crash in the U.S.[16] Analysis of the trading behavior of HFT during this time found that HFT played an important role in maintaining and providing liquidity during the sharp drop in the FDAX contract. The author stated that HFT acted "in a way that protects the market by placing a rapid succession of small, non-directional buy and sell orders, thus preventing abrupt price movements".

Menkveld (April 2011) studied the development of the Chi-X European stock MTF in 2007 and the simultaneous entry of a large high frequency trading participant on Chi-X.[17] He found that this new participant was largely responsible for the increase in market share of Chi-X and ultimately led to reduced spreads for the stocks that it traded.

Lepone (2011) summarized the results of a series of research conducted by the Australian organization Capital Markets Cooperative Research Centre (CMCRC).[18] These papers examined the impact of HFT on market quality for exchanges based in Singapore, Australia, the U.S., and the United Kingdom. Their data allowed them to identify trading participants and classify them into HFT and non-HFT groups. Following a methodology similar to Brogaard (2010), each of these papers measured the impact of HFT on market quality metrics. The findings showed a consistent pattern of improved market quality coinciding with growing

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[14] The CME Group, "Algorithmic trading and market dynamics", http://www.cmegroup.com/education/files/Algo_and_HFT_Trading_0610.pdf

[15] Kirilenko et al., "The Flash Crash: The Impact of High Frequency Trading on an Electronic Market", http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1686004&rec=1&srcabs=2013789

[16] Backes, "High-frequency trading in volatile markets - an examination", http://www.eurexchange.com/download/documents/publications/factsheet_highfrequency.pdf

[17] Menkveld, A., 2011: "High Frequency Trading and the New-Market Makers", http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1722924

[18] Lepone, A., 2011: "The Impact of High Frequency Trading (HFT): International Evidence", http://www.cmcrc.com

HFT participation. They also demonstrated that HFT is active during all volatility conditions and "become the primary providers of liquidity" in periods of high uncertainty.

These event studies investigated the impact of improvements to a market center's trading technology:

Hendershott, Jones and Menkveld (2007) examined the impact on the NYSE of their auto-quoting facility introduced in 2003.[19] This study showed that for all stocks, and particularly large-cap stocks, automated trading increased liquidity. It also demonstrated that the increase in automated trading caused a reduction in effective spreads, thereby reducing costs to investors.

Similarly**, Riordan and Storkenmairm (2009)** reported on how a 2007 upgrade to the Deutsche Börse's Xetra trading system focused solely on latency reduction, positively affected market quality.[20] After latency reductions in the exchange's trading systems, liquidity increased across market capitalization and trade sizes, and adverse selection and permanent price impact were dramatically reduced.

Hendershott and Moulton (February 2010) studied the introduction of the NYSE hybrid system in 2006, which moved the NYSE to a faster and more automated matching system. [21] They found that prices became more efficient due to faster price discovery and reduced noise in prices.

These papers provided an overview of "high frequency trading" and related market structure issues:

Gomber et al. (March 2011) presented background information on HFT. Their paper analyzed HFT and "certain proposed regulatory measures."[22] They claimed that HFT is a technology rather than a strategy, and is a natural evolution in the market place. They highlighted the beneficial aspects that HFT can provide, and noted that perceived problems with HFT are largely a result of U.S. market structure rather than anything inherent in HFT itself. They provided several recommendations for policy makers that would maintain the beneficial aspects of HFT while providing markets with additional safety.

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[19] Hendershott, T., Jones, C.M. and Menkveld, A.J.,: "Does Algorithmic Trading Improve Liquidity?", Journal of Finance, Volume LXVI, No. 1, February 2011

[20] Riordan, R. and Storkenmairm, A., 2009: "Latency, Liquidity and Price Discovery", http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1247482

[21] Hendershott, T. and Moulton, P., February 2010: "Automation, Speed, and Stock Market Quality: The NYSE's Hybrid", http://www.hotelschool.cornell.edu/research/facultybios/research-papers/documents/AutomationSpeedHybrid_accepted.pdf

[22] Gomber, P., Arndt, B., Lutat, M., and Uhle, T., March 2011: "High-Frequency Trading", http://www.frankfurt-main-finance.com/en/data-facts/study/High-Frequency-Trading.pdf

The **Foresight Project** by the BIS was a study intended to "explore how computer generated trading in financial markets might evolve in the next ten years or more", with a particular emphasis on stability, integrity, competition, efficiency and costs.[23] Most of the supporting papers were policy driven and speculative in the sense that they were not data-driven. One paper examined the changes in broad market quality in U.K. equities over the past decade and found that there are few trends of statistical significance. Volatility appeared to have peaked in 2008/2009, but had no discernable long-term trend. Liquidity and efficiency metrics appeared to have no significant trends, and there may be a positive link between competition and market quality.

[23] BIS Foresight Project: http://www.bis.gov.uk/foresight/our-work/projects/current-projects/computer-trading