April 23, 2010

BY ELECTRONIC MAIL ONLY

Ms. Elizabeth M. Murphy
Secretary
Securities and Exchange Commission
100 F Street, NE
Washington, DC 20549-1090

Re: Concept Release on Equity Market Structure (File No. S7-02-10)

Dear Ms. Murphy:

This letter is submitted in response to the request of the Securities and Exchange Commission (the "Commission" or "SEC") for comments on the Concept Release on Equity Market Structure (the "Concept Release").[1] The undersigned firms[2] engage, or have affiliates that engage, in automated trading on a proprietary basis and are interested in the inquiry being conducted by the Commission with respect to U.S. equity market structure, including issues involving so-called "high frequency trading."

I.
Introduction

We agree with the Commission that, in the wake of the recent financial crisis, a broad inquiry into the functioning of the equity markets is appropriate. Indeed, we welcome an empirically driven, comprehensive inquiry into all issues related to market structure and urge the Commission to continue to support a regulatory environment that promotes fair competition; encourages innovation; enhances transparency; manages systemic risk; lowers costs for investors (whether short-term, long-term, institutional or retail); and gives regulators the tools they need to detect and deter abuses.

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[1] Release No. 34-61358, File No. S7-02-10, as published in 75 Fed. Reg. 3594, et seq. (Daily Edition, January 21, 2010).

[2] These firms include Allston Trading, LLC, Hudson River Trading LLC, Quantlab Financial, LLC and RGM Advisors, LLC.

We believe that any assessment of the current market structure or the impacts of "high frequency trading" should begin with the recognition that by virtually all measures, the quality of the markets has never been better. Indeed, one recent study noted:

> Virtually every dimension of U.S. equity market quality is better than ever. 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 . . . Market depth has marched steadily upward.[3]

The equity markets have also proven to be remarkably resilient. Despite the significant stresses that occurred during the recent financial crisis, U.S. equity markets remained open, liquid and efficient every day, while other less competitive and less transparent markets failed.

With this important background, it is critical to establish an understanding of what "high frequency trading" is, who participates in it, its evolution, the benefits it provides to investors, and the contribution that it has made to the strength and health of America's financial markets.

A. What are Automated Trading Strategies?

Over the past fifteen years, America's equity markets have evolved as the result of significant Commission reforms that have enabled the growth of electronic markets, and promoted greater transparency and competition. Over the same period, computer technology has rapidly advanced, allowing brokers, who once placed orders over the phone for manual execution on trading floors, to use computers to electronically execute the vast majority of orders for their proprietary accounts and on behalf of their clients. In fact, nearly all aspects of the equity markets have become fully automated, from order entry and exchange matching, to back-office clearing and settlement. This "electronification" facilitated the growth of automated trading, including strategies used by a wide variety of professional traders like investment funds, investment banks, market making firms and independent proprietary trading firms (including the undersigned firms).

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[3] Angel, James J., Harris, Lawrence E., and Spatt, Chester S., "Equity Trading in the 21st Century," dated February 23, 2010, at page 5, available at: http://www.knight.com/newsroom/pdfs/EquityTradinginthe21stCentury.pdf ("Angel, Harris and Spatt (2010)").

As noted in the Concept Release, the term "high frequency trading" is imprecise,[4] and does not allow for a distinction between the roles that different market participants play. We believe a more accurate description of our firms, and other independent firms with similar characteristics, is "automated professional traders" and the overall market activity we engage in can be called "automated professional trading." We believe these terms not only more accurately describe our role in the markets, but also distinguish our firms and strategies from other types of automated trading firms and strategies.

The characteristics generally shared by automated professional traders are:

- Using computers to continuously and automatically generate, submit, and adjust buy and sell orders throughout the trading day;
- Holding positions for relatively short periods of time, often going from long to short (or vice versa) multiple times per day;
- Making trading decisions based on proprietary real-time opinions of "fair value" using publicly available information;
- Trading exclusively for a firm's own account; and
- Limiting risk by taking small, quantifiable exposure on each transaction, by maintaining relatively small positions, and not carrying significant un-hedged positions overnight.

B. History of Professional Trading

Professional traders have always been a critical part of financial markets, providing liquidity and contributing to price discovery. Historically, professional trading was restricted to a few players like New York Stock Exchange ("NYSE") specialists and NASDAQ market makers. They were shielded from competition and granted special market status and order flow information advantages, enabling them to extract high profit margins from the market. This resulted in markets that were relatively inefficient and expensive for investors.

In recent years, the Commission has implemented reforms designed to increase competition and transparency in the markets and improve overall market efficiency. These reforms include the Order Handling Rules (1996), which required greater transparency from traditional market makers by requiring best priced limit orders to be reflected in the public markets;[5] Regulation ATS (1998), which facilitated the growth of

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[4] The undersigned firms believe the term "high frequency trading" is confusing and that it is not clear what "high frequency" refers to. The best guess is that it refers to the frequent turnover of the positions. Interestingly, it is not clear, if automated professional traders are turning over positions any more quickly (especially given the available technology and the significant increase in trading volumes) than the manual professional traders they supplanted. Professional traders such as specialists, market makers, dealers and floor traders have always turned over their positions frequently. See, e.g., Traders Magazine, November 1999, "Mayer Schweitzer's Black Box and New Science" ("Mayer Article") where a leading market maker that accounted for 9% of Nasdaq volume at the time, Mayer Schweitzer, states that it improved returns by increasing its holding period from *one* minute to *seven* minutes.

[5] Securities Exchange Act Release No. 37619A (September 6, 1996), 61 Fed. Reg. 48290 (September 12, 1996).

innovative competitive electronic markets;[6] decimalization (2001), which allowed for narrower spreads by requiring securities to be priced in pennies, rather than fractions of dollars;[7] and Regulation NMS (2005), which established a prohibition on trading at an inferior price to another trading center's automatic and accessible best bid or offer.[8] These SEC reforms led to the growth of open electronic markets, and, in conjunction with technology advancements, facilitated the rise of automated trading firms. We believe that other markets, such as fixed income markets (including the government and corporate bond markets) and over-the-counter derivatives markets, would benefit from similar regulatory reforms.

Today, numerous firms compete vigorously in the markets to provide liquidity and price discovery. Thanks to co-location and telecommunication, these firms no longer need to be located in traditional market centers such as New York or Chicago to be able to compete successfully on electronic exchanges and ATSs. They have established businesses all across the country and are able to compete on a level playing field against long-established Wall Street firms.

Furthermore, to a large extent, the Commission's reforms and the transition to all-electronic order books over the past 15 years effectively required the strategies used by professional traders to evolve into fast, automated strategies. With an all-electronic order book based on price and time priority, automated professional traders not only must display their trading interest if they want to trade, but, due to the intense competition between professional traders, must do so quickly. While this results in more message traffic, this has benefited investors with greater transparency, lower costs and more efficient prices.

C. Benefits of Automated Professional Trading

Automated professional traders play a critical role in the U.S. equity market, improving the effectiveness of the market both for investors (short-term, long-term, institutional and retail) and for businesses raising capital. These benefits include:

- Lower trading costs – The intense competition among automated professional trading firms significantly contributes to narrower bid-ask spreads and consequently lowers retail and institutional trading costs. (At the same time, this competition has driven down profit margins for professional traders to small fractions of a penny per share.)
- Fairer prices – Diverse automated professional trading strategies improve price discovery, ensuring prices track fair value and rapidly reflect all relevant market information.

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[6] Exchange Act Release No. 40760 (December 8, 1998), 63 FR 70844 (December 22, 1998).

[7] Securities Exchange Act Release No. 42360 (Jan. 28, 2000), 65 Fed. Reg. 5004 (Feb. 4, 2000), *et seq.*

[8] Securities Exchange Act Release No. 51808 (June 9, 2005), 70 Fed. Reg. 37496 (June 29, 2005), *et seq.*

- Resilient markets – Having a large, diverse, competitive set of automated professional traders ensures liquidity and efficient price discovery, even during market shocks such as the recent financial crisis.
- Increased liquidity – Automated professional trading activity provides substantial liquidity to investors, helping to bridge temporary gaps in supply and demand. This activity allows investors to buy or sell with less impact on market price and dampens the kind of short-term market volatility that depends on market structure (*i.e.*, "micro-volatility").

D. Executive Summary of Our Comment Letter

In our responses to questions posed in the Concept Release, in Part II, we provide commentary based on our experience in the U.S. equity markets and in other markets around the world that can be summarized as follows:

1. Market Performance. To address questions about market performance, in Part II.A, we reviewed the findings of empirical studies that have evaluated various indicators of market health. These studies found that in recent years, spreads have narrowed, the depth of the market has increased, and commissions and costs have fallen. In addition, we present the findings of an original study (attached as Exhibit A) conducted by one of the undersigned firms that examines widely-accepted measures of price efficiency over very short time frames. The study concludes that over the last four years short-term price efficiency has increased, indicating that the price discovery function in today's competitive, electronic markets is much improved. This is closely correlated with the transition to electronic markets and the emergence of automated professional traders as a significant market presence.

2. Strategies. As discussed in Part II.B, in our view, automated professional trading has contributed significantly to the positive developments in market health mentioned above. In general, automated professional traders utilize publicly available information to identify small mis-pricings in the marketplace, pushing stocks toward their equilibrium prices. While we strongly support Commission efforts to enforce clear rules against manipulative strategies and improper use of private information for trading, we believe restrictions on the way publicly available information is used to inform trading decisions would degrade market quality.

3. Tools. Part II.C discusses tools utilized by many types of market participants, including automated professional traders. Co-location allows geographically diverse market participants to compete with Wall Street firms on a level playing field. Direct exchange data feeds allow market participants to better manage trading risks, contributing to lower trading costs and improved price discovery. While we believe that all market participants currently have equal access to these tools, we support efforts by regulators and exchanges to ensure that they are available in an open, transparent and non-discriminatory manner.

4. Risk. As outlined in Part II.D, effective risk management is an essential element of market integrity. Exchanges and other market participants have developed, and must continue to develop, effective systems and procedures to manage risk. We

support regulatory and industry efforts to further reduce risk, including market access rules and consistent erroneous trade policies across market centers.

5. Fairness. We note in Part II.E that there is no conflict between the needs of long-term investors and the activities of automated professional traders and that, in fact, their interests are inextricably aligned. Long-term investors benefit from the functions provided by automated professional traders. Further, the tools that automated professional traders use, such as co-location and direct market data feeds, are readily accessible to any market participant that chooses to employ them. In our view, today's market structure is remarkably fair.

Finally, Part II.F responds to other issues raised by the Commission regarding non-displayed liquidity, tick increments and odd lots.

In Part III we provide specific policy recommendations, including: the creation of an industry working group to help identify emerging market issues and to advise on ways that technology can assist with, among other things, regulation and surveillance; greater efficiency, transparency and competition in other asset classes; and the development of a consolidated audit trail.

II.
Market Structure and Discussion of Concept Release Topics

A. Market Structure Performance and Empirical Data

We believe that any review of the current market structure must start with an appreciation that the U.S. equity markets have never been healthier. Technological and regulatory developments over the last 15 years have made these markets remarkably fair, open and competitive. Numerous studies have shown that trading costs have declined for all market participants, including retail and institutional investors, and that pricing efficiency has dramatically improved. Our firms have first-hand experience not only with the U.S. equity markets, but also with other major financial markets that have different market structures, regulatory environments and technologies. Based upon our review of the available literature and our first-hand experience, we are comfortable asserting that the U.S. equity markets are today the most cost-effective and efficient financial markets in the world.

1. U.S. Equity Market Performance. The Commission has requested comment on a variety of topics about the performance of the current equity market structure, as well as the appropriate metrics for measuring that performance. The excellent health of the U.S. equity market structure is reflected in numerous statistics from the following areas:

- Bid-ask spreads, a primary component of transaction costs, are among the lowest in the world and by any generally accepted measure have improved in recent years, significantly benefiting investors.[9] This reduction in spreads has dramatically benefited investors by significantly lowering transaction costs.

[9] See Angel, Harris and Spatt (2010) and the RGM Study (infra), and Pellecchia, Ray, "High-Frequency Trading Helps Narrow Quoted Spreads", available at: http://exchanges.nyse.com/archives/2009/08/hft.php.

- Quoted depth (the number or value of shares available for purchase at or near the best bid or ask in the market) is also plentiful and has increased substantially in recent years.[10] The empirical data contrasts markedly with critics' occasional claims that tighter bid-ask spreads have come at the expense of available liquidity.

- Trading volumes have increased. While this, in and of itself, should not be a regulatory objective, it is a positive reflection of the low costs and high levels of competition in the market. Additionally, this increased volume benefits investors, particularly institutional investors, by allowing them to buy or sell large blocks of stock with less market impact.[11]

- Retail commissions and execution costs have fallen.[12]

- Institutional execution costs have fallen.[13] The empirical data contradicts the largely anecdotal concerns expressed by some institutional investors and institutional brokers.

- Excess short-term volatility has declined significantly and price efficiency has improved dramatically, meaning prices are more quickly and accurately reflecting fair value, and that there is less "micro-volatility" attributable to the market structure.[14]

2. Academic Literature. A number of academic research papers have studied the impact of automated trading and "electronification" in a variety of markets. These papers demonstrate the beneficial impact that automated trading can bring to markets.[15] In general, they suggest that automated trading increases market quality through increased liquidity, reduction of transaction costs, and facilitation of efficient price discovery.

One line of study has focused on the impact of the introduction of automated trading. Hendershott and Riordan (2009) reported on the impact of automated trading on the Deutsche Borse's Xetra market, an equity market where automated trading activity could be distinguished.[16] The paper found that automated trading accounted for about

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[10] See Angel, Harris and Spatt (2010) and the RGM Study (infra).

[11] See, e.g., http://batstrading.com/market_data.

[12] French, Kenneth R., 2008, "The Cost of Active Investing," Journal of Finance, 63(4), 1537–1573 ("French (2008)").

[13] See, e.g., reports from Investment Technology Group or Elkins McSherry LLC.

[14] RGM Study (infra).

[15] There have been a few recent commercial studies that make claims about market quality being degraded by "high frequency trading." Some, such as white-papers released by Quantitative Services Group LLC ("QSG") in late 2009 and early 2010 purport to show that the presence of algorithmic trading increases costs to institutional investors. Despite sensational titles like "The Impact of Predatory High Frequency Trading on Institutional Equity Managers" and "Higher Trading Costs Incurred for VWAP Algorithms v. Arrival Price Algorithms, High Frequency Trading Contributing Factor", they use deeply flawed proxies for high frequency trading, provide inadequate support for their methodologies, and ultimately do not actually establish a causal link between their purported adverse findings and the activities of algorithmic traders.

[16] Hendershott, T. and Riordan, R., 2009: "Algorithmic Trading and Information", available at: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1472050## ("Hendershott and Riordan (2009)").

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. Similarly, in the foreign exchange market, Chaboud, Hjalmarsson, Vega and Chiquoine (2009) showed that an increase in automated trading was associated with less market volatility, and that automated traders tended to increase liquidity provision after exogenous market events such as macroeconomic data announcements.[17]

Another line of study has investigated the impact of improvements to a market center's trading technology. Hendershott, Jones and Mankveld (2007) examined the impact on the NYSE of their auto-quoting facility introduced in 2003.[18] This study showed that for all stocks, and particularly large-cap stocks, automated trading increased liquidity. It also demonstrates 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 Xetra trading system focused solely on latency reduction, positively affected market quality.[19] 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. The collective conclusion from these studies is that reductions in latency at the exchange level translated to better means of risk management for liquidity providers, allowing them to increase their quoted sizes and/or reduce their quoted spreads.

Yet another line of study has focused on measuring the impact of regulatory changes on equity markets. Of recent importance has been the impact of short-sale bans and restrictions that were implemented during the recent financial crisis both in Europe and in the U.S. The Boehmer, Jones, and Zhang (2008) and Boehmer, Jones, and Zhang (2008-2) studies reviewed the short-sale ban of 2008 and showed that liquidity decreased and spreads increased as a direct result of the ban.[20] Beber and Pagano (2009) similarly

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[17] 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, available at: http://ssrn.com/abstract=1501135 ("Chaboud, Hjalmarsson, Vega and Chiquoine (2009)").

[18] Hendershott, T., Jones, C.M. and Mankveld, A.J., 2007: "Does Algorithmic Trading Improve Liquidity?", available at: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1100635 ("Hendershott, Jones and Mankveld (2010)").

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

[20] Boehmer, Ekkehart, Jones, Charles, and Zhang, Xiaoyan, 2008: "Shackling Short Sellers: The 2008 Shorting Ban," available at: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1412844 ("Boehmer, Jones, and Zhang (2008)"); Boehmer, Ekkehart, Jones, Charles and Zhang, Xiaoyan, 2008: "Unshackling Short Sellers: The Repeal of the Uptick Rule," available at: http://gates.comm.virginia.edu/uvafinanceseminar/Jones%20paper%2008.pdf, ("Boehmer, Jones, and Zhang (2008-2)").

found that the short-selling bans were detrimental for liquidity, slowed price discovery, and failed to support prices.[21]

3. RGM Advisors, LLC Study. One of the undersigned firms, RGM Advisors, LLC, conducted an original study[22] of recent market data from the U.S. equity markets to address some of the questions raised in the Concept Release. The RGM Study examined trends in a number of market quality metrics over the period from January 2006 through December 2009 and examined how these metrics differ by market capitalization and by listing venue (NASDAQ and NYSE). This study is attached hereto as Exhibit A.

a. Spreads and Depth. The RGM Study presents data that confirms that over the 2006 to 2009 period quoted bid-ask spreads have declined and quoted market depth has improved across both the Russell 1000 (large and mid-cap) and Russell 2000 (small-cap) indexes for both NYSE and NASDAQ-listed stocks.

b. Price Efficiency. The RGM Study examines short-term measures of market efficiency over the same period, and shows significant improvements therein. There exists a large body of research devoted to tests of market efficiency. In a seminal 1965 paper, Samuelson[23] proved that a fairly valued stock price should resemble a random walk. Pioneering work in this area was later conducted by Lo and Mackinlay[24] who explored variance-ratio tests in 1988, and such work was extended by Chow and Denning in 1993[25] which derived a more statistically powerful test. To the best of the authors' knowledge, such tests have not previously been applied to data sampled at a high rate as is done in the RGM Study. The results indicate that, in recent years, as markets have become more electronic and competitive, they have simultaneously become more efficient. Both the variance ratios and the "Chow-Denning" test show improving price efficiency, most notably in NYSE-listed stocks. This suggests that anecdotal concerns of some market commentators about excess short-term volatility may be unfounded. We hope that this work will be helpful to the Commission in its review of equity market structure.

B. Trading Strategies

The Concept Release asks whether the implementation of certain strategies by automated traders benefits or harms market structure performance and the interests of

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[21] Beber, Allesandro, and Pagano, Marco, 2009: "Short-Selling Bans around the World: Evidence from the 2007-09 Crisis," available at: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1533163, ("Beber and Pagano (2009)").

[22] Castura, J., Litzenberger, R. and Gorelick, R., 2010: "Market Efficiency and Microstructure Evolution in US Equity Markets: A High Frequency Perspective," ("RGM Study").

[23] Samuelson, Paul, 1965: "Proof That Properly Anticipated Prices Fluctuate Randomly," *Industrial Management Review*, 6: 41–49.

[24] Andrew W. Lo and A. Craig MacKinlay, 1988: "Stock Market Prices do not Follow Random Walks: Evidence from a Simple Specification Test," *Review of Financial Studies*, Oxford University Press for Society for Financial Studies, vol. 1(1), at pages 41-66.

[25] V. K. Chow and K. C. Denning, 1993: "A Simple Multiple Variance Ratio Test: Power and Size in Finite Samples," *Journal of Econometrics*, 58, no. 3, 385–401.

long-term investors, and whether the use of allegedly "harmful" strategies is sufficiently widespread to require a regulatory initiative.

We believe that the current market environment, which encourages competition among numerous market participants engaged in a wide array of diverse trading strategies, benefits all market participants, including "long-term investors." These benefits are reflected in the many recent studies of market structure performance discussed above. While the market is fundamentally healthy, we strongly support the Commission's efforts to identify and eliminate manipulation or misuse of private information by any market participant. We do not, however, believe that it is either practical or desirable to attempt to identify and regulate otherwise legal trading strategies that rely on publicly available information.

Automated professional trading firms typically use publicly available information to identify small, perceived mis-pricings of stocks in the market, and to execute trades to eliminate and profit from those miniscule mis-pricings and maintain a stock's "fair value." Thus, automated professional traders are constantly balancing supply and demand and attempting to maintain equilibrium prices in the markets. The strategies can be implemented in numerous ways, including market making, arbitrage and statistical arbitrage approaches. In the aggregate, these strategies contribute to market efficiency.

One type of strategy specifically discussed in the Concept Release is an "order anticipation" strategy, described as "any means [used] to ascertain the existence of a large buyer (seller) that does not involve violation of a duty, misappropriation of information, or other misconduct ... such as sophisticated pattern recognition software."[26] It should be noted that nearly every strategy employed by a market participant (not just by an automated professional trader) is likely to be based, at least in part, on a judgment about supply and demand derived from publicly available information and, therefore, to some extent, could be deemed "order anticipation." As a result, it would be impractical to distinguish "order anticipation" from other trading strategies.

We also believe that it is not advisable to limit the ways that market participants use public market data to form opinions on the value of the instruments they trade. We are concerned that attempting to eliminate or curtail certain trading strategies would degrade competition and overall market quality.

At the same time, we strongly support the Commission's ongoing efforts to detect and prevent manipulation. For example, the Concept Release describes "momentum ignition" strategies, stating that "[w]ith this strategy, the proprietary firm may initiate a series of orders and trades (along with perhaps spreading false rumors in the marketplace) in an attempt to ignite a rapid price move either up or down."[27] Such a strategy would be considered to be manipulative according to the rules of several exchanges.[28] While

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[26] Concept Release at pages 54-55.

[27] Concept Release at page 56.

[28] For example, BATS Rule 12.1 reads: "No Member shall execute or cause to be executed or participate in an account for which there are executed purchases of any security at successively higher prices, or sales of any security at successively lower prices, for the purpose of creating or inducing a false,

exchange rules designed to prevent this activity should be sufficient, to the extent to which such rules require strengthening, or to the extent to which regulators require additional tools to detect such abuses, we would support appropriate action by the Commission.

1. The Importance of Audit Trails. Modern electronic trading has dramatically improved regulators' ability to detect and deter abuses. Today, all trades and quotes are entered and stored in a variety of electronic databases that can be monitored and reviewed by regulators. This has created the opportunity for unprecedented transparency not only for market participants, but also for regulators.

However, there are improvements in the electronic audit trails that could be made to assist regulators in their vital surveillance functions. We believe that initiatives such as the Commission's new proposed Rule 13h-1[29] encompassing a large trader reporting system are appropriate to ensure the Commission has ready access to important trading records. However, we note that surveillance for market abuse should not be limited to large traders and should also cover automated and manual trading implemented by lower volume market participants, which in our view are at least as likely as large traders to engage in manipulative activity.

Further, we understand that the Commission is working on a project to improve the quality, accessibility, and timeliness of the trading data that is available to regulators, by means of a consolidated audit trail. We support the idea of a consolidated audit trail that would give the SEC and the self-regulatory organizations better information to detect potential problems.[30] We note that all of our businesses depend on the integrity and fairness of the markets and believe that giving regulators better tools should demystify "high frequency trading" and, ultimately, improve market quality.

2. Liquidity Rebates. The Commission has requested comment on passive market making, liquidity rebates and what types of regulatory initiatives would be the most effective for improving the quality of liquidity. As the Commission notes in the Concept Release, many firms engage in strategies that the Concept Release refers to as "passive market making" and receive liquidity rebates.[31] It is not the case, however, as some have charged, that the success of automated professional trading firms is solely, or even primarily, based on the collection of liquidity rebates. In fact, automated professional trading firms heavily participate in both equity and non-equity markets that do not offer any kind of liquidity rebates, and in many cases, in markets that charge for both sides of all trades.

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misleading or artificial appearance of activity in such security on the Exchange or for the purpose of unduly or improperly influencing the market price for such security or for the purpose of establishing a price which does not reflect the true state of the market in such security."

[29] Release No. 34-61908, File No. S7-10-10, as published in 75 Fed. Reg. 21455, et seq. (Daily Edition, April 23, 2010).

[30] We hope that this would replace the OATS system, which is antiquated and unduly burdensome.

[31] Liquidity rebates were developed by the exchanges and are innovative market driven pricing mechanisms to encourage the provision of liquidity and to compensate market participants for the adverse selection cost associated with posting publicly displayed limit orders.

Ultimately, we view exchange rebates as a competitive issue between market centers rather than between different types of market participants. Liquidity rebates are factored into the prices at which market participants are willing to quote and trade. As a result, rebates lead to tighter quoted bid-ask spreads and eliminating liquidity rebates would widen quoted bid-ask spreads. This would benefit internalizers and dark pool operators, but would increase transaction costs for investors without contributing to price discovery in the public markets.

We believe that liquidity rebates are serving their purpose of encouraging the provision of liquidity on trading venues that offer them, and that any changes in the rebates should be determined by competition among these venues, rather than by regulation. Since rebates provide exchanges with a tool to compete with off-exchange trading venues that typically have more pricing flexibility, we believe that any proposal on liquidity rebates should be considered in conjunction with pricing on ATSs, as well as payment for order flow practices to ensure a level playing field between displayed public markets and non-displayed trading centers.

C. Tools: Co-Location and Data Center Feeds

1. Co-Location. Co-location creates equal opportunity among market participants and contributes to better market quality. To impose affirmative or negative obligations upon market participants using co-location would provide no benefit and would only serve to re-create regulatory barriers that inhibit competition, harming investors.

a. Fairness of Co-Location. The Commission has requested comment on the fairness of the practice of "co-location," where market participants locate their computers in data centers that also host the exchanges' matching engines. We believe that co-location, rather than providing a small number of market participants with an unfair advantage, actually has the opposite effect of making markets fairer and leveling the playing field between market participants. It eliminates traditional geographic advantages that, for example, a Wall Street firm might have enjoyed over a firm in Nebraska, by providing all firms the opportunity to locate their computers in the same optimized environment as their competitors and to receive market data and submit orders with minimal latencies. We understand that all types of market participants use and benefit from co-location, including automated professional traders, wholesale market makers, institutional brokers and retail brokers.

Without the ability to co-locate, market participants with latency-sensitive strategies would be driven by competitive pressure to find other advantageous places to locate their servers, locations would be less regulated, have less open access and transparent pricing, and could result in large discrepancies in latencies.

We understand that all market participants that co-locate their computers in exchange data centers are subject to the same standard terms and conditions. However, to assure that this is always the case, we welcome the cooperation of the markets and regulators to assure that co-location opportunities continue to be offered in a fair, open and non-discriminatory manner.

b. Related Trading Obligations. The Commission has requested comment on whether market participants that obtain co-location services should be subject to any affirmative or negative trading obligations in connection with these services. We would be concerned about the imposition of such obligations as a condition of co-location for two reasons. First, it would not enhance liquidity. Recent increases in quoted depth and the high performance of the markets during the financial crisis demonstrate that competitive markets provide better market quality than mandated markets. Secondly, such obligations would erode the benefits of the recent regulatory reforms and would be a step back towards the less competitive days of the specialists and market makers that enjoyed time and place advantages over other market participants. Reinstituting these advantages would harm overall market quality and resiliency by creating a two-tiered market that would reduce fair competition.

2. Data Feeds. The Commission has requested comment on the latency differences between consolidated data feeds and individual trading center data feeds. We believe that the current flexible model of making both direct and consolidated data feeds available is appropriate and promotes higher market quality better than any one-size-fits-all solution. Access to fast market data allows latency-sensitive market participants to better manage their risk and therefore to better contribute to liquidity and price discovery. We note that direct data feeds are readily available to any market participant for standard and reasonable prices, and believe that products based on these data feeds are offered to retail investors by many online brokers. Moreover, we believe that an attempt to require market participants to only use a consolidated data feed would create a systemic risk by creating a single point of failure and dependency on the consolidated feed.

D. Systemic Risks

In the Concept Release, the Commission seeks general comment on "whether high frequency trading poses significant risks to the integrity of the current equity market structure".[32] We believe that reviewing potential systemic risks is entirely appropriate, especially given the recent systemic failures in other financial markets, and given the significant regulatory and technological evolution of the U.S. equity markets. We regard effective risk management as an essential requirement for successful automated professional trading, and accordingly have been focused on managing market and operational risks since the inception of our firms. We also have been working with exchanges and clearing firms to reduce a variety of risks.

1. Speed and Message Traffic. The Commission has requested comment on whether the high speed and enormous message traffic of automated trading systems threaten the integrity of trading center operations. We do not believe that this increase in message traffic poses a significant problem for the markets or a systemic risk. Exchanges and other market participants have been managing increasing message traffic for many years, and have developed tools and systems to deal with these high message volumes. These include highly scalable infrastructures, permanent or selectively applied message volume throttles, and investigations of abnormally high message traffic. The application of these methods by the exchanges has been quite effective. In addition, it is important to

[32] Concept Release at page 63.

note that the speed and capacity of the markets directly benefit investors. Specifically, the ability to adjust orders based upon current information enables automated professional traders to quote tighter and deeper markets at lower risk.

2. Similarities in Trading Strategies and Systemic Risk. The Commission has requested comment on whether similarities in strategies of proprietary firms could contribute to systemic risk. The undersigned firms believe that the risk of automated professional trading firms creating instability in the markets is unlikely for the following reasons.

Unlike hedge funds and banks, automated professional trading firms generally do not accumulate large concentrated positions. This is because the pricing inefficiencies sought after by automated professional trading firms tend to be small and fleeting and do not support a large investment capacity.

The intense competition among automated professional traders for relatively small opportunities encourages a true diversity of non-correlated trading strategies. The diversity of automated professional trading strategies is evidenced by empirical data on market efficiency, such as the variance ratio data provided earlier in this comment letter. If many traders were following identical strategies, we would expect those market efficiency measures to suffer.

Automated professional trading firms have very conservative risk profiles. Not only are their market exposures often flat at the end of each day, but their intraday exposures tend to be diffused over the market (*i.e.*, not concentrated in large positions in individual names) and/or tend to be market and sector hedged.

3. Further Steps to Address Systemic Risk. The Commission has requested comments on what further steps it should take to address systemic risk.

a. Pre-Trade Risk Checks. The Commission has identified potential ways to address some risks in its recent proposed market access rule.[33] Our views are well represented in the comments by some other market participants in response to the Commission's proposed rule. To briefly summarize, we support requiring that all trades entering the market have reasonable mandatory pre-trade risk checks, and that a broker-dealer ensures that these checks occur. However, these pre-trade checks should not need to be conducted by more than one broker-dealer prior to market entry.

b. Erroneous Trade Policies. The undersigned firms further believe that encouraging market centers to define and implement clear and consistent erroneous trade policies would help to reduce an area of risk in the U.S. equity markets.

4. Registration as Broker-Dealers and FINRA Membership. The Commission has requested comments on whether all proprietary firms should be required to register as broker-dealers and become members of FINRA to ensure that their operations are subject to full regulatory oversight. Currently, all broker-dealers are required to register with the SEC and at least one exchange (or FINRA) that acts as its Designated Examining Authority. Any broker-dealer that has customers is required to register with FINRA. Suggesting that proprietary trading broker-dealers that are not registered with FINRA are

[33] Risk Management Controls for Brokers or Dealers with Market Access, File No. 34-61379.

not subject to full regulatory oversight is inaccurate. In fact, because exchanges that act as a Designated Examining Authority only have proprietary trading firms as members, they are more specialized in proprietary firms' operations. In addition, proprietary trading firms that are registered as broker-dealers are generally members of several exchanges and are consequently subject to multiple regulators.

Regulators treat proprietary trading firms that are not registered broker-dealers in the same manner as other customers such as retail investors, mutual funds or hedge funds. Any trading done by non-registered proprietary trading firms would be done through a FINRA registered broker-dealer and all of the firm's trading information would be included in audit trails. Requiring all proprietary trading firms to register as broker-dealers would create a barrier to entry for new entrants resulting in degraded competition. While this might benefit our firms that are already registered broker-dealers, we are concerned that such a rule would hurt competition and market quality.

E. Fairness

The Commission has requested comment on whether the current market structure is fair for "long-term investors." The undersigned firms believe that there is no conflict between the interests of long-term investors and of automated professional traders and that, in fact, their interests are inextricably aligned. Automated professional trading firms are not "competing" with long-term investors, rather, they are in intense competition with each other in ways that lower costs and improve price efficiency for investors who require the valuable functions. Any regulatory action that inhibits the activities of automated professional traders would necessarily increase costs and degrade price efficiency for long-term investors.

In general, the basic question of fairness to long-term investors may well stem from the mistaken, but often repeated, assertion that trading is "zero-sum." This view of transactions often leads to the conclusion that the profits made by professional traders come at the expense of other market participants.[34]

This zero-sum notion of trading is wrong. When two parties enter into a transaction, that exchange is expected to be mutually beneficial, or neither party would enter into the transaction. Similarly, when an automated professional trader trades, it means that the automated professional trader has the best price at that moment. This also means that a long-term investor on the other side of the transaction received a better price than it would have otherwise. Trading is not "zero-sum", but "positive sum," because both sides of the transaction benefit substantially from more efficient prices. As Lawrence H. Summers, Director of the National Economic Council and Assistant to the President for Economic Policy, noted on March 18, 2010, at the Pew Charitable Trusts-sponsored "Financial Reform: Too Important to Fail" conference, "one of the things that economi[sts] have that's closest to the proverbial free lunch is the reduction of bid/ask spreads."[35]

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[34] We believe that the rise of automated professional traders has only come at the expense of less efficient professional traders.

[35] See http://www.pewtrusts.org/events_detail.aspx?id=57684&selectedDate=03/01/2010&nav=past.

1. "Fairness" of Market Structure. The Commission has requested comment on whether the speed with which automated trading is done is inherently unfair to long-term investors or whether the two groups' needs are different enough to make the technology and speed differences of no consequence. As described above, automated professional traders are not in competition with long-term investors. Automated professional traders are continuously trying to capture fleeting and small deviations in stock prices from fair value. In contrast, long-term investors are entering the market at different times based on different information and with different objectives.

To the extent that long-term investors develop time-sensitive strategies or otherwise value latency, they enjoy a wide variety of choice among agency brokers ranging from the "professional" offerings of on-line brokers to full service Wall Street brokers, to boutique agency brokers, where they can obtain a technology infrastructure comparable to automated professional traders and implement their time-sensitive strategies.

In sum, every market participant has the same *opportunity* to take advantage of exchange offerings that may benefit latency sensitive strategies including co-location and direct data feeds. Regulations can play a role in ensuring that all market participants have an equal opportunity to access all exchange offerings on a fair and non-discriminatory basis.

F. Other Issues

1. Dark Pools/Undisplayed Liquidity. We believe that any market structure issues raised by "dark pool" trading venues are separate and distinct from those surrounding automated professional trading. Although dark pool-related issues have occasionally been erroneously confused with automated professional trading in the press and elsewhere, the undersigned firms note that the vast majority of automated professional trading occurs in the transparent public markets. In general, we support a flexible regulatory environment that meets the needs of diverse market participants. We urge the Commission to be mindful of principles of competition, transparency and innovation, in its regulation of dark pools and undisplayed liquidity.

2. Tick Increments. The Commission has requested comment on whether the minimum price variation is leading to distortions in order routing and internalization in low-priced stocks. We believe that the mandated penny increment leads to increased off-exchange trading activity. In fact, as we understand it, a significant percentage of dark pool and internalization volume is concentrated in highly active stocks that are artificially constrained by the penny increment. When the spread is artificially wide, it becomes easier for market participants to engage in quote matching strategies off-exchange. Accordingly, we believe that the Commission should consider proposals to reduce the minimum price variation for securities that have artificially high spreads due to the one-cent minimum price variation. Because price alone is an insufficient determinant of a stock's spread, we do not believe the Commission should simply choose a price level under which stocks will have a smaller minimum price variation. Instead, we believe that volume and volatility characteristics should also be considered. Limiting the review of tick increments to the most active stocks would address concerns by some market participants about finer quote increments.

3. Odd Lot Transactions. The Commission has noted that the current consolidated trade data does not include reports of odd lot transactions (which could equal four percent of the trading volume) and has requested comment on whether this data should be included in consolidated data. The undersigned firms believe that there is no reason to exclude this information in consolidated data, regardless of the smaller size of these orders. This data would serve to increase transparency in the markets and further level the field between market participants, ultimately resulting in healthier and more efficient markets.

III.
Specific Policy Recommendations and Conclusion

As we have emphasized throughout this comment letter, we believe that the U.S. equity markets are healthier than they have ever been and are the fairest, most efficient markets in the world. The evolution of competitive, transparent, electronic markets and automated professional trading has led to significant improvements in market quality over the past 15 years. At the same time, we recognize that there are still improvements that can be made to the markets. Given our healthy starting point, changes should be empirically driven and carefully considered. Our specific recommendations follow:

A. Industry Working Group

Given the rapid pace of change in the equity markets, we believe it would be useful for the Commission to form an Industry Working Group, including a diverse group of market participants such as automated professional traders, institutional investors, and exchanges. The purpose of the group could include:

- assistance in evaluating emerging market structure issues;
- developing and promoting best practices related to the management of both trading and operational risks in modern electronic markets; and
- providing practical advice on technology and techniques that regulators could use to analyze and interpret the large amounts of market data available to them to assist in market structure regulation and surveillance.

B. Tick Increments and Odd Lots

Given the relatively large percentage of high volume stocks that are traded off-exchange, the minimum increment should be reduced for relatively few actively traded stocks that display trading characteristics reflecting the need for sub-penny increments. Reducing tick increments in these securities would improve market efficiency and lower transaction costs for investors. Similarly, the traditional distinction between the reporting of odd and even lots no longer seems appropriate. Reporting all transactions regardless of size would improve transparency.

C. Consolidated Audit Trail

The U.S. equity markets would benefit from a project to improve the quality, accessibility and timeliness of the trading data that is available to regulators, by means of a consolidated audit trail. This new system should be viewed as a replacement for the antiquated and unduly burdensome OATS system.

D. Regulatory Reform in Other Asset Classes

We believe that other markets, including important markets under the jurisdiction of the Commission, such as government and corporate bond markets, would benefit from the kind of reforms that have been so successful in the U.S. equity markets. We believe that efforts to make those markets more competitive, transparent and fair would benefit investors in those markets with lower transaction costs, higher price efficiency and increased resiliency against market shocks.

In conclusion, we appreciate the opportunity to comment on the Concept Release and assist the Commission's efforts to improve the quality of the U.S. equity market. Please do not hesitate to contact us should you have any questions or require additional information.

Sincerely,

/s/ Liam Connell
Liam Connell
Chief Executive Officer
Allston Trading, LLC

/s/ Richard B. Gorelick
Richard B. Gorelick
Chief Executive Officer
RGM Advisors, LLC

/s/ Adam Nunes
Adam Nunes
President, HRT Financial LLC
Hudson River Trading, LLC

/s/ Cameron Smith
Cameron Smith
General Counsel
Quantlab Financial, LLC

cc: Ms. Mary L. Schapiro, Chairman
Mr. Luis A. Aguilar, Commissioner
Ms. Kathleen L. Casey, Commissioner
Mr. Troy A. Parades, Commissioner
Ms. Elisse B. Walter, Commissioner
Mr. Robert W. Cook, Director, Divisions of Trading and Markets
Mr. Donald V. Moorehead, Patton Boggs LLP
Mr. Micah Green, Patton Boggs LLP
Ms. Alexandra Metzner, Patton Boggs LLP

EXHIBIT A

RGM Study

Market Efficiency and Microstructure Evolution in U.S. Equity Markets: A High-Frequency Perspective

Jeff Castura, Robert Litzenberger, Richard Gorelick
RGM Advisors, LLC

April 22, 2010

1 Introduction

The impact of high frequency trading (HFT) on the U.S. equity markets has received considerable attention in the wake of the financial crisis of 2008. It has been asked whether the increase in the amount of automated trading as a percentage of overall trading activity over the past several years has been accompanied by degraded measures of market health such as liquidity, trading costs, volatility, etc. Uninformed answers to these important questions have the potential to influence policy makers toward actions that are not beneficial to the vitality and efficient functioning of financial markets in the U.S.

This work presents some evidence showing that the U.S. equity markets appear to have become more efficient with tighter spreads and greater liquidity over the past several years; a period that has seen a sizable increase in the prevalence of HFT, and a period during which there has been coincident growth in automation and speed on many exchanges. It has been suggested that HFT now accounts for over half of U.S. equity share volume [1]. With such a large presence in the market, it is important to understand if there are any adverse effects caused by such activity. While the existence of a causal relationship is not proven, evidence is presented which suggests that the U.S. markets have improved in several respects as HFT activity has grown.

One measure of efficiency investigated is the bid-ask spread and it is expected that the presence of more participants, algorithmic and otherwise, will drive spreads down due to competition, thereby decreasing costs to other investors. The results presented in this paper confirm the results of many other studies, showing that bid-ask spreads have come down over time for a broad range of stocks.

Another measure of efficiency is liquidity, representing the ability of investors to obtain their desired inventories with minimal price impact. Again, it is expected that more participants implies a greater amount of liquidity in the markets, a benefit to investors. This appears to be the case as this paper confirms

the results of other papers demonstrating an increase in available liquidity over time.

It was shown by Samuelson in [2] that if a stock price is efficient, i.e., the price is fairly valued with all public information, then it must follow a martingale process. As a consequence, an efficient price exhibits no serial autocorrelation, either positive (momentum) or negative (mean-reversion). Measurements are made in this paper that test how closely stock prices resemble a random walk, and improvements are seen for all segments.

A variance ratio test was developed by Lo and Mackinlay in [3] which makes use of the fact that in an efficient market, the variance per unit time of the price of a stock should be constant. This allows ratios of variances over different time horizons to be taken and compared with theoretical expectations where, in an efficient market, these tests would show that there is little or no serial autocorrelation in prices. Another advantage of this type of test is that it does not depend on a particular order of serial autocorrelation, only whether any such autocorrelation is present. These tests, a novel contribution of this paper, demonstrate that for all the data-sets investigated, there is an overall improvement in efficiency in prices over time.

The data-sets used in this study are the Russell 1000 components, consisting of 1000 large-cap and mid-cap stocks, and the Russell 2000 components, consisting of 2000 small-cap stocks. The set of components are taken as of Q4 2009, and no attempt is made to correct for survivor bias, though it may be argued that the nature of this study is not sensitive to such effects.

Additionally, each index is partitioned into two sets; NYSE-listed stocks and NASDAQ-listed stocks. For much of the time period studied, NASDAQ-listed stocks traded primarily on automated, electronic exchanges while NYSE-listed stocks have transitioned from being primarily traded manually on the NYSE to being traded on a more competitive, automated group of electronic exchanges. Therefore the data essentially represents four distinct subsets of stocks, at least from an historical context: large-cap stocks largely traded automatically (approximately 200 NASDAQ-listed stocks in the Russell 1000), large-cap stocks largely traded manually (approximately 800 NYSE-listed stocks in the Russell 1000), small-cap stocks largely traded automatically (approximately 1300 NASDAQ-listed stocks in the Russell 2000), and small-cap stocks largely traded manually (approximately 700 NYSE-listed stocks in the Russell 2000). This partition allows comparisons to be made that help more clearly identify the impact of automation and technology advances on the health of the market.

The raw data is sampled at 1 second intervals for each stock during the period Jan 1, 2006 to Dec 31, 2009 inclusive, representing 16 quarters of data. The first 10 minutes and last 10 minutes of each day are omitted to prevent opening and closing activities from influencing the results. Inside values are used across the NASDAQ, NYSE, NYSE ARCA and BATS exchanges. This represents a significant fraction of all shares traded in the U.S. and so is taken to be representative of overall market activity.

With this data-set a series of statistical tests and measurements are run, designed to reflect the health of the market. Spreads, available liquidity, and

transient volatility in the form of variance ratio tests are presented here as these are commonly cited metrics of market efficiency and market quality.

2 Bid-Ask Spreads

Spreads are a cost to trading and, all else being equal, smaller spreads are evidence of a better cost structure for investors. Conversely, market makers and other liquidity providers earn profits through the spread. To that extent smaller spreads imply not only smaller revenues for market makers but also that these participants, by quoting smaller spreads, are more competitive; a sign of a healthy market.

Bid-ask spreads are presented as the mean absolute spread of each of the components of the index, where the absolute spread is defined as the best ask price less the best bid price. There are other common ways to present bid-ask spread data including the use of relative spreads. This formulation is meant to more directly reflect transaction costs for investors caused by the bid-ask spread. Market makers and other liquidity providers commonly adjust their quotes based on market volatility in order to compensate for their increased risk of holding inventory [4]. Therefore a volatility adjustment is commonly done to remove the impact of volatility from spreads, typically making it easier to spot trends in spreads over time. Dollar-value weighting is also sometimes used in an effort to better reflect costs of the spread paid by investors. Equal weighting is chosen here because many of the largest and most liquid stocks are pinned at a spread of one penny.

Each of these adjustments will alter the results to some degree though overall trends are expected to remain, and this is confirmed in the appendix which contains some results with these adjustments made. Also available in the appendix are some bid-ask spread results for the NASDAQ-100 index, consisting of many of the largest stocks listed on the NASDAQ.

Figure 1 presents the mean of the absolute spread over time for the Russell 1000 stocks partitioned into its NYSE-listed and NASDAQ-listed components. This is done to try to isolate differences in behavior over the period studied that may be attributable to structural changes on each of these exchanges. Both groups have seen a reduction in spreads over the period investigated, dropping by about 1.5 pennies for the NYSE-listed stocks and about 1 penny for the NASDAQ-listed stocks. By the end of 2009 it appears the the mean spread of the two groups has converged to approximately the same value, something that could not be said previously.

It is known that the rate of adoption of automated trading on NYSE-listed stocks lagged behind that of NASDAQ-listed stocks. As the NYSE moved to an electronic system to catch up technologically with the NASDAQ, and as other electronic venues began taking market share from the NYSE, spreads in the Russell 1000 dropped more dramatically for the NYSE-listed stocks than the NASDAQ-listed stocks. This also suggests a relationship between the entrance of algorithmic trading with a reduction in spreads, something that is noted for

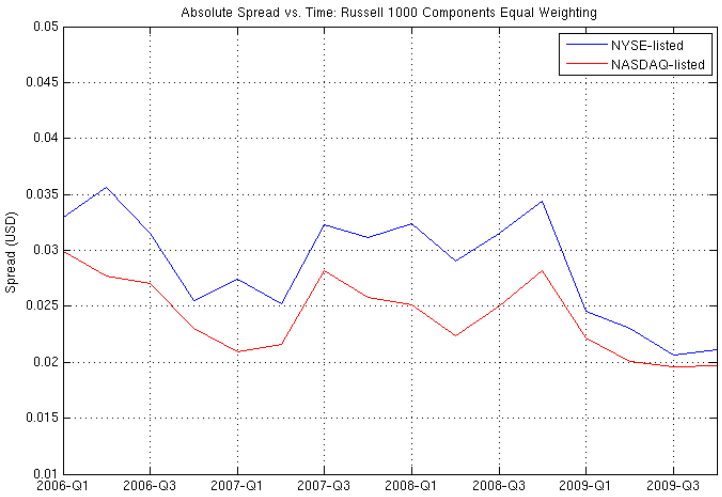

Figure 1: Mean bid-ask spread for Russell 1000

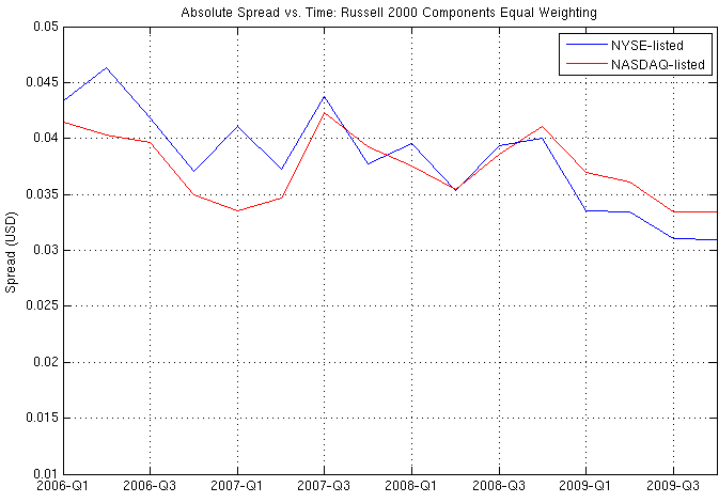

Figure 2: Mean bid-ask spread for Russell 2000

the German DAX in [5].

The same information for the Russell 2000 index is presented in Figure 2. Like the Russell 1000, these stocks have seen a reduction in mean spreads by about a penny, with the NYSE-listed symbols showing a more dramatic reduction than the NASDAQ-listed symbols.

3 Available Liquidity

Liquidity is an important part of a vital market. It is often loosely defined as the ability of participants to trade the amount that they wish at the time they wish. One measure of liquidity is the amount of size offered for sale or for purchase by market makers and other liquidity providers at a given point in time. If more shares are available to be bought and sold at any given time, then market participants have a greater ability to get into or out of positions based on their needs or desires and are less dependent on either waiting for sufficient size to become available or to seek an alternative execution venue.

Available liquidity is measured as the dollar value available to buy or sell at any instant in time at the inside bid and ask, and time averages over an entire quarter are taken. Each stock in an index is weighted by its capitalization reported for the quarter to produce a single capitalization-adjusted available liquidity metric. The motivation for weighting by capitalization is that it more closely reflects the available fraction of a company's total value that can be transacted at any given time which may be more representative of the limitations to investors. Additional available liquidity data is presented in the appendix, including results for the NASDAQ-100.

Figure 3 presents the adjusted available liquidity for the Russell 1000 components partitioned into NYSE-listed and NASDAQ-listed stocks. Between 2006 and the end of 2009, the available liquidity of both groups of stocks increased significantly, by about a factor of two, though all of that gain appears to have taken place in 2009. Similar results are seen for the two groups of stocks in the Russell 2000 which is shown in Figure 4.

It is plausible that the increase in liquidity can be explained, at least in part, by the presence of HFT participants. Since the data used in this work is sampled at a high rate, one can also claim that this liquidity measure is representative of the immediacy that is available to market participants. This immediacy is a type of option that is available to market participants providing them with more flexibility than may otherwise be available.

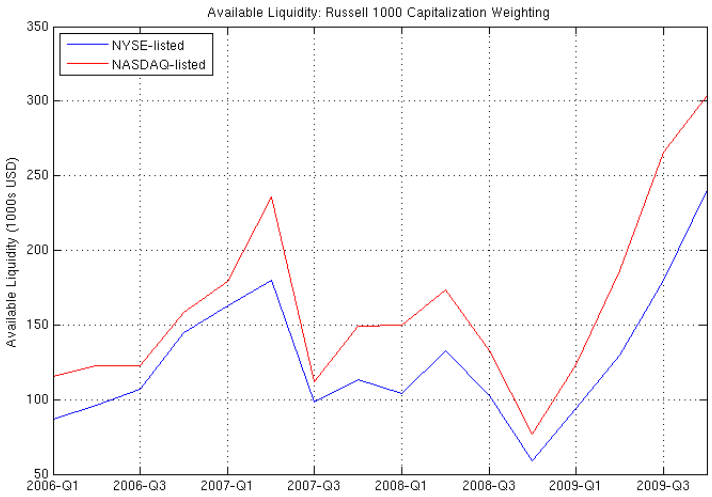

Figure 3: Mean available liquidity for Russell 1000

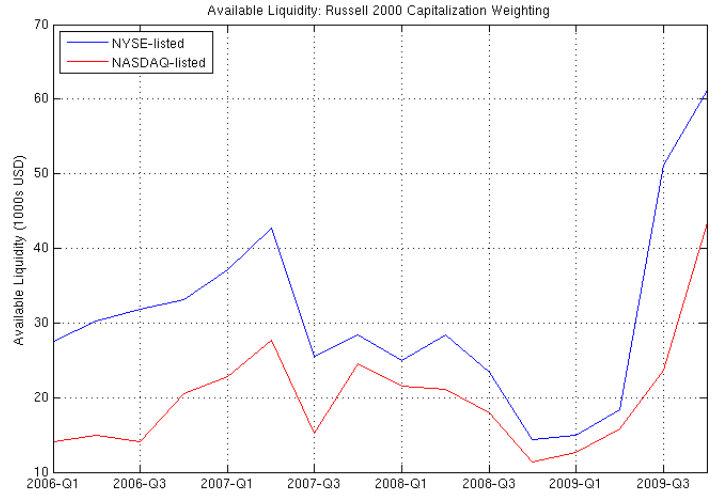

Figure 4: Mean available liquidity for Russell 2000

4 Market Efficiency Tests

There exists a large body of research devoted to tests of market efficiency. In this context, efficiency typically refers to the degree to which the price time-series of a stock resembles a random walk. The theoretical foundation for this was laid out by Samuelson in [2] which proves that a properly anticipated stock price should fluctuate randomly with no serial autocorrelation. Pioneering work in this area in the form of a variance ratio test was presented by Lo and Mackinlay in [3], in which they show with some level of statistical confidence that the NYSE stock-price time-series do not appear similar to a random walk, suggesting inefficiency in the markets. The data used in their paper is sampled daily and ends in 1988, prior to a significant number of structural and regulatory changes that have dramatically changed the nature of U.S. equity markets.

If stock price time-series truly followed random walks, it is expected that the variance ratio computations would have values close to one. A variance ratio's deviation from unity can then be considered to be proportional to the amount of inefficiency present in that stock or index. Values greater than one imply a momentum process, equivalently a positive serial autocorrelation, while values less than one imply mean-reversion, or negative serial autocorrelation.

Subsequent research extended the variance ratio tests in [3] to provide alternative methods to test market efficiency. In particular Chow and Denning in [6] extend the work of [3] to provide a more statistically powerful test procedure and it is this "Chow-Denning" test that is used as a metric of market efficiency in this section. To the best of the authors' knowledge, such tests have not previously been applied to data sampled at a high rate as is done here.

It is important to note that at this sampling rate micro-structural effects are expected to be present. In particular, bid-ask bounce and statistical influences caused by the discrete nature of price values will tend to skew the results toward appearing mean-reverting. These effects are expected at high sampling rates and are expected to decay as the sampling rate is decreased. However, for a given sampling interval, the effect is expected to be roughly constant over time, and thus the interesting aspect of the results is how they have changed over time and whether they have converged toward a value of one. An attempt has been made in the variance calculations to account for the discrete price values and midpoint prices are used rather than last trade prices to minimize the effect of bid-ask bounce. More details are available in the appendix, along with some results based on last trade prices.

Raw variance ratio tests are applied to the Russell 1000 and Russell 2000, partitioned into NYSE-listed and NASDAQ-listed stocks. Three ratios are chosen to be representative of what may be typical HFT holding periods; 10 seconds over 1 second, 60 seconds over 10 seconds, and 600 seconds over 10 seconds.

Figures 5 and 6 show the raw variance ratios of 10 seconds over 1 second for midpoint price data from the Russell 1000 and 2000, respectively. These indexes are partitioned into NYSE-listed and NASDAQ-listed stocks. At this high frequency, it is seen that the Russell 1000, NASDAQ-listed stocks show a high degree of efficiency, and have been relatively efficient throughout the entire

period investigated, with some improvement seen over time. As these stocks have largely been traded electronically for the entire period, such results are expected. The NYSE-listed components, by contrast, show a relatively large amount of inefficiency in 2006, but have increased to over 0.95 by 2009 and now appear to be at least as efficient as the NASDAQ-listed stocks.

The Russell 2000 index in Figure 6 shows the same general trends, though the overall efficiency is lower than the Russell 1000. This is to be expected since the smaller-cap stocks of the Russell 2000 do not have the same amount of trading activity as large-cap stocks. The NYSE-listed symbols show a greater degree of improvement in efficiency than the NASDAQ-listed symbols, again coinciding with improvements in automation and increased participation in these stocks by automated trading firms.

The same results are presented for the variance ratios of 1 minute over 10 seconds in Figures 7 and 8 for the Russell 1000 and Russell 2000, respectively. Similar conclusions hold when comparing these results with the 10 seconds over 1 second variance ratios. The degree to which the variance ratio of NYSE-listed stocks in the Russell 1000 has improved of the period studied is dramatic, and has largely converged to be identical to the NASDAQ-listed components of the index. A similar trend is seen with the Russell 2000 components.

A large variance ratio of 10 minutes over 10 seconds is presented to provide a picture of market efficiency over larger time-scales. Figures 9 and 10 show the results for the Russell 1000 and Russell 2000, respectively, and the same general trends seen in the previous plots of variance ratios are present in these figures.

The Chow-Denning method tests the null hypothesis that a price time-series is drawn from a random walk, and produces a single test statistic. This value can be compared to a threshold for a certain significance level. In this study 5% was chosen as the significance level.

The test was applied over each of the 16 quarters, individually to each stock in the data-set with the input to the test being the logarithm of the midpoint price. Sampling was done at 10 minute intervals and 10 second intervals. At 5% significance, if this test were run on 100 truly random time-series, one would expect to see about 5 test outcomes reject the null hypothesis. That is to say, due to the statistical nature of this test, it may produce false positives about 5% of the time.

Results for the 10 minute sampling Chow-Denning tests are presented in Figures 11 and 12 for the Russell 1000 and 2000 data-sets, respectively. These figures show the fraction of stocks in the index that the Chow-Denning test reported as not being drawn from a random walk at a 5%-significance level. Figure 11 shows that at 10 minute sampling, the number of such occurrences has dropped over time and has largely been below 5% since the beginning of 2009, suggesting that there is no statistically significant inefficiencies at this sampling interval that this test detects. The NYSE-listed stocks appear to have a more dramatic improvement, in agreement with the variance ratio results presented above.

Similar results are seen for the Russell 2000 in Figure 12 with a general improvement in efficiency over the time period investigated although it appears

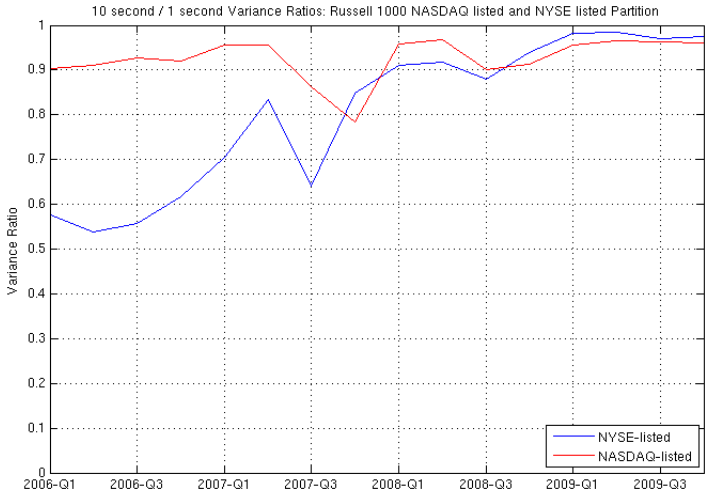

Figure 5: Variance Ratios, Russell 1000, 10 seconds / 1 second

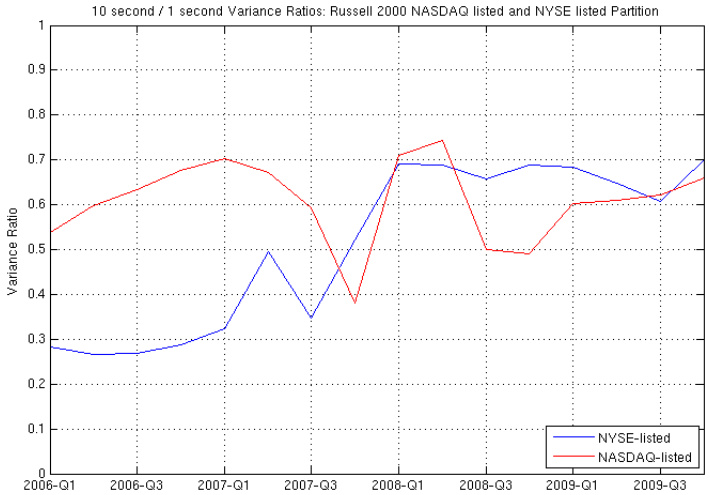

Figure 6: Variance Ratios, Russell 2000, 10 seconds / 1 second

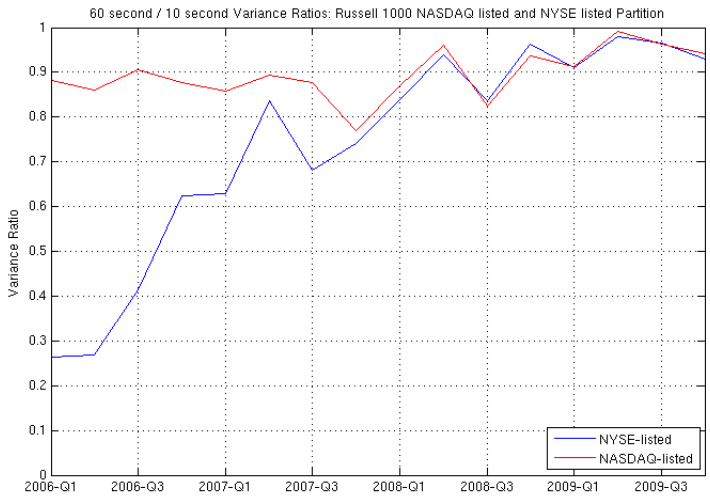

Figure 7: Variance Ratios, Russell 1000, 1 minute / 10 seconds

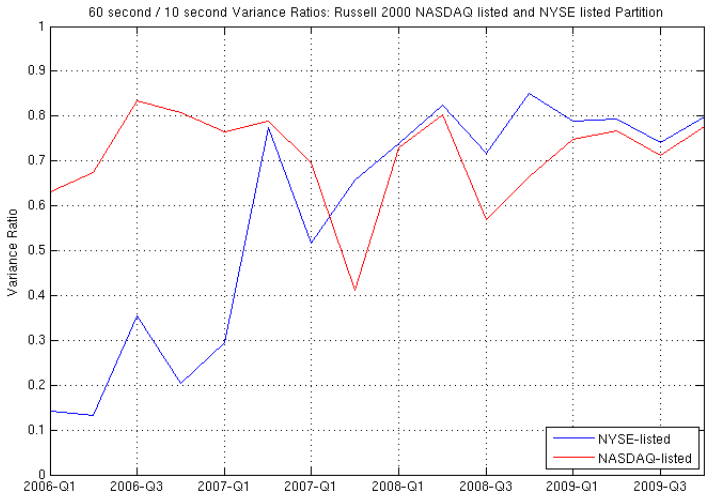

Figure 8: Variance Ratios, Russell 2000, 1 minute / 10 seconds

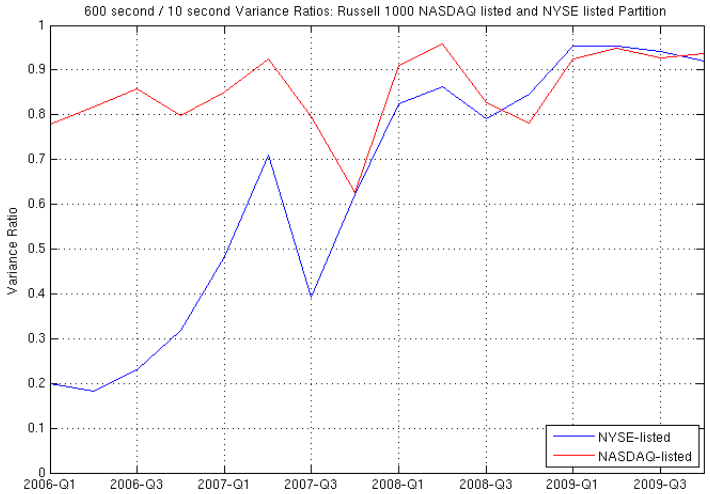

Figure 9: Variance Ratios, Russell 1000, 10 minute / 10 seconds

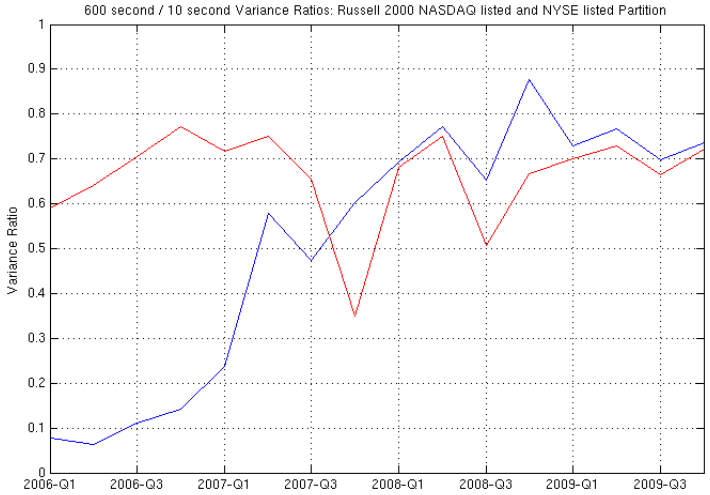

Figure 10: Variance Ratios, Russell 2000, 10 minute / 10 seconds

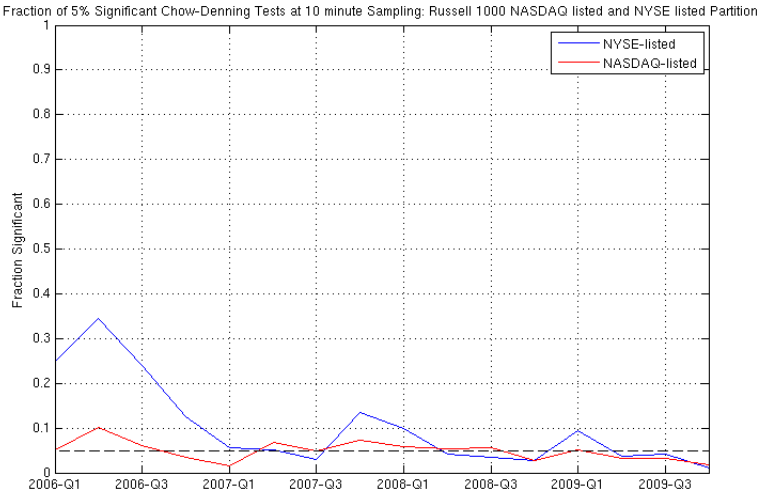

Figure 11: Chow-Denning test results for the Russell 1000, 10 minute sampling

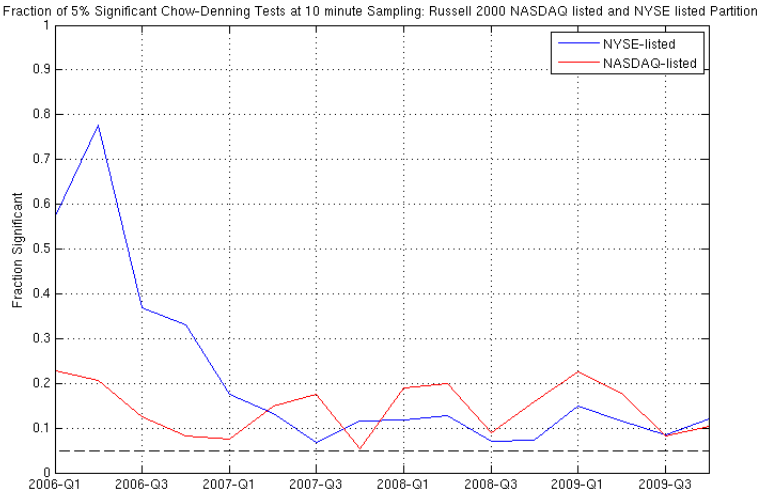

Figure 12: Chow-Denning test results for the Russell 2000, 10 minute sampling

that there remains some degree of inefficiency at this time scale that the Chow-Denning test is detecting. As expected, the large-cap stocks in the Russell 1000 exhibit a smaller number of significant events than the Russell 2000.

A smaller sampling interval of 10 seconds is also used for the Chow-Denning tests, and the results of these computations are presented in Figures 13 and 14 for the Russell 1000 and Russell 2000, respectively. At this sampling rate the impact of microstructural noise is expected to have a more significant impact than at 10 minute sampling. Despite a higher degree of apparent inefficiency, Figure 13 demonstrates that even at such fine sampling, the Russell 1000 appears to have improved over the four years studied, and that the NYSE-listed symbols have shown a more dramatic improvement in that time, largely converging with the NASDAQ-listed symbols. Similar observations are made for the Russell 2000 index in Figure 14.

An alternative interpretation of these results is that of an increase in the speed of mean-reversion over time. As mentioned, mean-reversion is present in this data due in part to micro-structural effects, and as the rate of trading and market activity increases, the impact of such noise on these variance ratio-based tests become less prevalent. Therefore one can conjecture that the decrease in the Chow-Denning test statistics may be as a result of an increased rate of reversion of prices to their mean. This is also an indication of an increasing competitive landscape and increasing efficiency in the market.

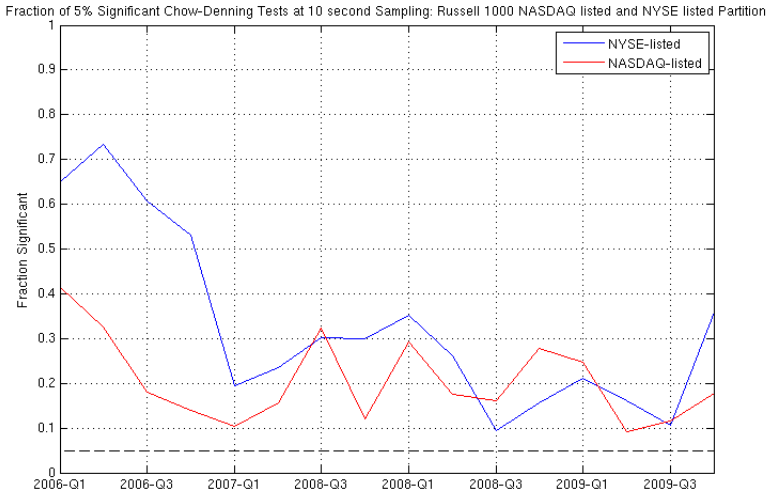

Figure 13: Chow-Denning test results for the Russell 1000, 10 second sampling

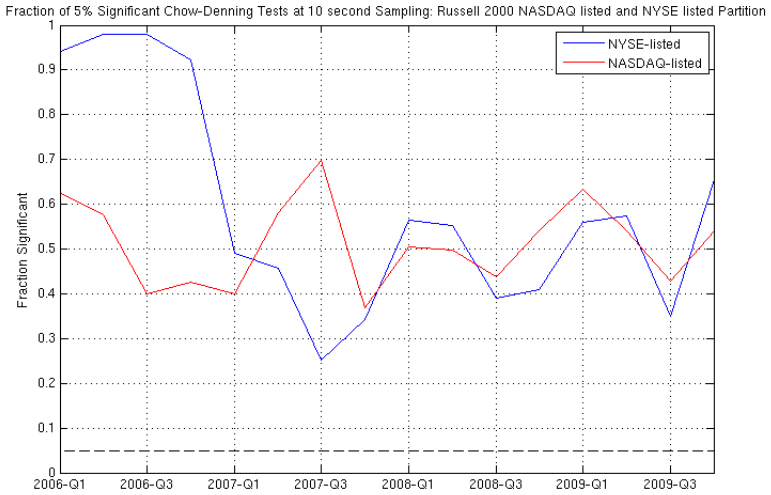

Figure 14: Chow-Denning test results for the Russell 2000, 10 second sampling

5 Summary

The presented data is suggestive that the U.S. equity markets have become more liquid and efficient over the past four years, despite macro-economic shocks. As the ratio of HFT activity to total market activity has grown, there appears to be no evidence that short-term volatility, liquidity or spreads have risen for the bulk of market participants. To the contrary, the evidence presented here suggests a continued improvement in each of these factors, implying a sympathetic relationship between HFT and the health of the overall markets.

The partitioning of data into the Russell 1000 and Russell 2000 shows that there has generally been a larger degree of improvement in efficiency metrics in the Russell 1000. The difference in trends observed between NYSE-listed and NASDAQ-listed stocks also supports the hypothesis that increased automation and the presence of HFT that has come with it has improved the market quality metrics investigated in this paper.

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6 Appendix

6.1 Bid-Ask Spreads

Absolute spreads are computed as follows. An individual stock i has a spread at time t of $S_i(t) = a_i(t) - b_i(t)$. The spread over a quarter q is defined as

$$\langle S_i(q) \rangle = \frac{\sum_{t \in q} S_i(t)}{\sum_{t \in q} 1}.$$

The spread S_q^N over an index N is the weighted average over all components, where w_i represents the weighting of stock i. The spread is then

$$S_q^N = \frac{\sum_{i \in N} w_i \langle S_i(q) \rangle}{\sum_{i \in N} w_i}.$$

The choice of equal weighting sets all $w_i = 1$. Dollar value weighting is determined by setting the weight for each stock to the total dollar value of all transactions for that stock in the quarter.

Relative spread can be computed in a similar manner, with the relative spread $S_R(t)_i = \frac{a(t)_i - b(t)_i}{p(t)_i}$ replacing the absolute spread above, and where $p_i(t)$ represents price. A common adjustment made to bid-ask spreads is a volatility adjustment [4]. The VIX is used for this purpose and its value relative to the mean of its value over the time period studied is chosen as the deflator. The value of the VIX over the period studied is given in Figure 15.

VIX-adjusted spread data is presented in Figures 16 and 17 showing the Russell 1000 and Russell 2000 relative spreads over time. Similar to the results presented in the main body of this paper, the relative spreads have been stable or falling over time, with a much larger reduction seen when adjusting for the VIX.

For comparison, spread data is also presented for the NASDAQ-100 index. Absolute spreads, both unadjusted and VIX-adjusted are given in Figure 18. The trend for this index is consistent with that seen in the Russell data-sets. Relative spreads are presented in a number of ways in Figure 19 and these adjustments do not change the overall trends presented in the body of the text.

6.2 Available Liquidity

The available liquidity for a stock i at time t is given as

$$L_i(t) = p_i(t) \left(s_i^a(t) + s_i^b(t) \right),$$

where $s_i^a(t)$ and $s_i^b(t)$ are the inside size at the ask and bid, respectively. In a quarter q, the average available liquidity of a stock is

$$\langle L_i(q) \rangle = \frac{\sum_{t \in q} L_i(t)}{\sum_{t \in q} 1}.$$

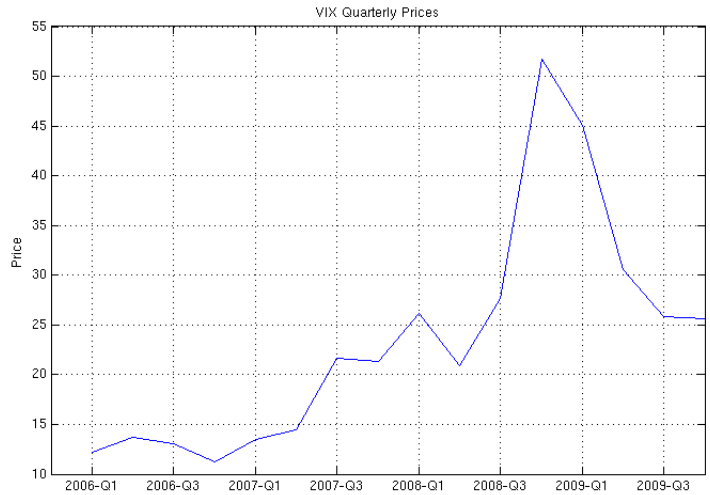

Figure 15: Quarterly VIX prices

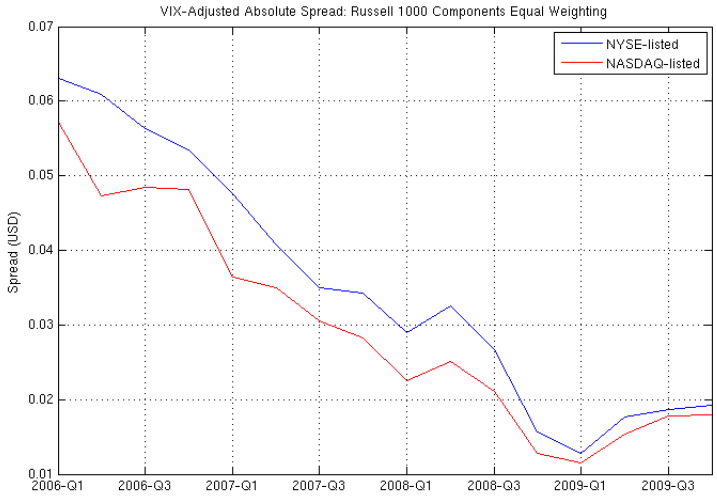

Figure 16: Mean bid-ask spread for Russell 1000, VIX-adjusted

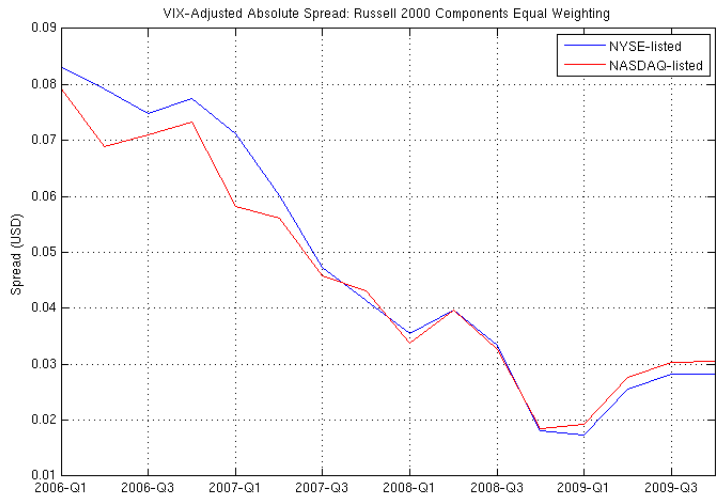

Figure 17: Mean bid-ask spread for Russell 2000, VIX-adjusted

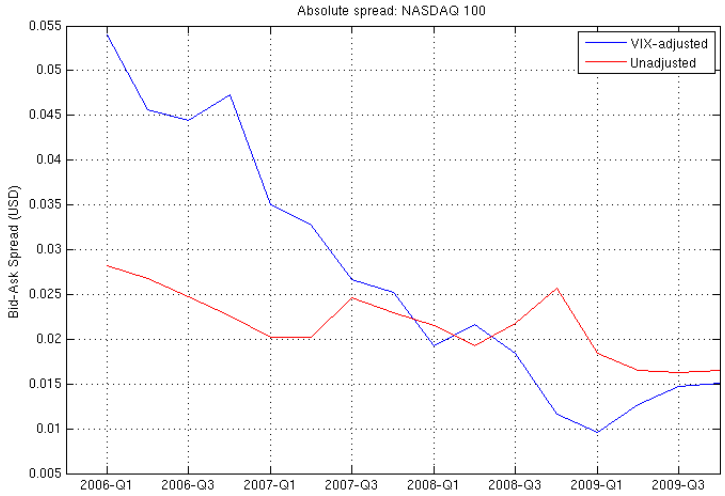

Figure 18: Absolute equal-weighted bid-ask spread for NASDAQ 100

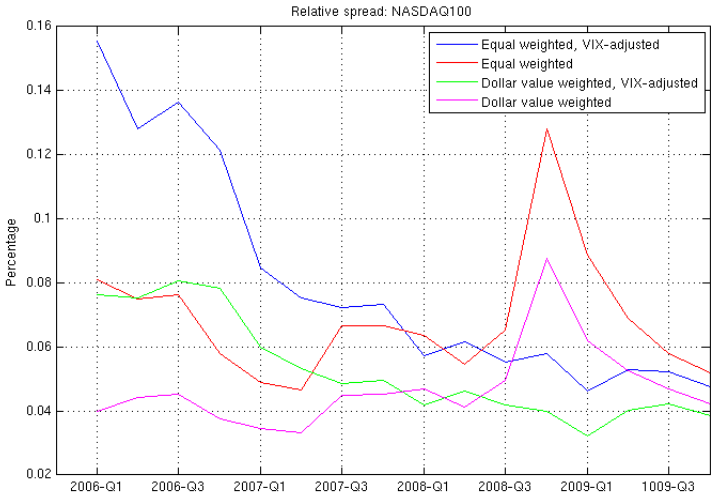

Figure 19: Bid-ask spread for NASDAQ 100

The available liquidity over an index N is the weighted average over all components, such that

$$L_q^N = \frac{\sum_{i \in N} w_i \langle L_i(q) \rangle}{\sum_{i \in N} w_i},$$

where w_i is the weighting for stock i. A common adjustment made is a capitalization adjustment, which is done by setting w_i to the market capitalization of a stock i in quarter q.

The main body of this paper presents results for the Russell 1000 and Russell 2000. For comparison, the available liquidity for the NASDAQ-100 is presented in Figure 20, showing both a capitalization-weighting and an equal-weighting. In both cases, the general trend of increasing available liquidity over the period studied is seen.

6.3 Market Efficiency

The methodology used to compute the variance ratio values follows that presented in [3]. In particular, equations (12a) and (12b) are used. Sheppard's correction [7] is applied to the variance estimates in order to reduce the discrete values of prices (log-midpoint prices) used in the computation.

The raw variance ratio r_i for a stock i with time-ratio D is given by

$$r_i = \frac{v_i^{s_1}}{D v_i^{s_2}},$$

where v^{s_1} is the variance for sampling rate s_1 and v^{s_2} is the variance for sampling rate s_2 and by convention, $\frac{s_1}{s_2} = D > 1$.

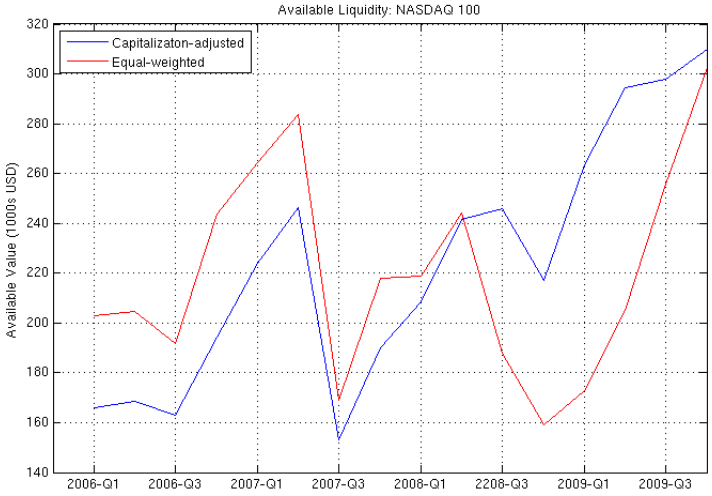

Figure 20: Mean available liquidity for NASDAQ 100

In order to gain a sense of the impact of bid-ask bounce and spreads on variance ratios, Figure 21 presents the raw variance ratios for the NASDAQ 100 using the last traded price and the midpoint price in the same figure. From the left panel, showing a fine sampling rate, it is seen that the impact of the bid-ask bounce on last trade prices results in a smaller variance ratio than when midpoint prices are used. As the sampling rate is decreased to longer time periods, the impact of bid-ask bounce becomes less pronounced. This is demonstrated in the right panel of Figure 21, where the difference between the variance ratios using trade prices and midpoint prices is much smaller.

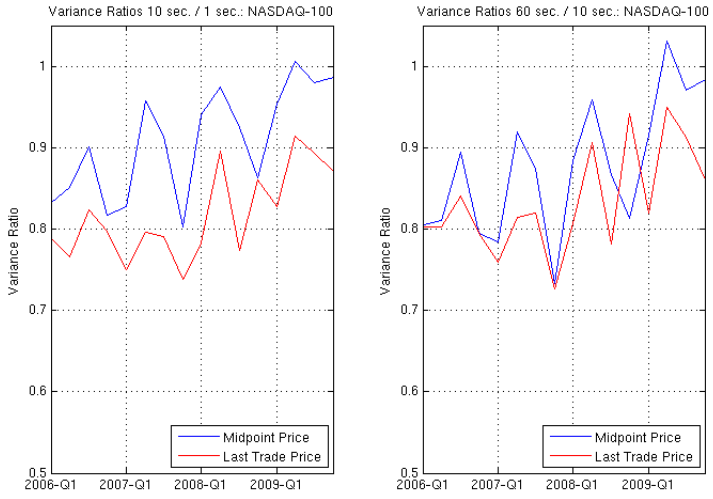

Figure 21: Mean Variance Ratios of Midpoint Prices vs. Trade Prices, NASDAQ 100. Left: 10 seconds / 1 second. Right: 1 minute / 10 seconds