FINDINGS REGARDING THE MARKET EVENTS OF MAY 6, 2010

REPORT OF THE STAFFS OF THE CFTC AND SEC TO THE JOINT ADVISORY COMMITTEE ON EMERGING REGULATORY ISSUES

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This is a report of the findings by the staffs of the U.S. Commodity Futures Trading Commission and the U.S. Securities and Exchange Commission. The Commissions have expressed no view regarding the analysis, findings or conclusions contained herein.

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This report presents findings of the staffs of the Commodity Futures Trading Commission ("CFTC") and the Securities and Exchange Commission ("SEC" and collectively, the "Commissions") to the Joint CFTC-SEC Advisory Committee on Emerging Regulatory Issues (the "Committee") regarding the market events of May 6, 2010.[1]

This report builds upon the initial analyses of May 6 performed by the staffs of the Commissions and released in the May 18, 2010, public report entitled *Preliminary Findings Regarding the Market Events of May 6, 2010 – Report of the Staffs of the CFTC and SEC to the Joint Advisory Committee on Emerging Regulatory Issues* (the "Preliminary Report").[2] Readers are encouraged to review the Preliminary Report for important background discussions and analyses that are referenced but not repeated herein.

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[1] This report is being provided on request to the U.S. Senate Committee on Banking, Housing, and Urban Affairs, U.S. Senate Committee on Agriculture, Nutrition and Forestry, and the House Committee on Financial Services. The Committees specifically requested that the report include information relating to the business transactions or market positions of any person that is necessary for a complete and accurate description of the May 6 crash and its causes. Pursuant to these requests and section 8(e) of the Commodity Exchange Act, this report contains certain information regarding business transactions and positions of individual persons.

[2] Available at http://www.sec.gov/spotlight/sec-cftcjointcommittee.shtml.

EXECUTIVE SUMMARY

On May 6, 2010, the prices of many U.S.-based equity products experienced an extraordinarily rapid decline and recovery. That afternoon, major equity indices in both the futures and securities markets, each already down over 4% from their prior-day close, suddenly plummeted a further 5-6% in a matter of minutes before rebounding almost as quickly.

Many of the almost 8,000 individual equity securities and exchange traded funds ("ETFs") traded that day suffered similar price declines and reversals within a short period of time, falling 5%, 10% or even 15% before recovering most, if not all, of their losses. However, some equities experienced even more severe price moves, both up and down. Over 20,000 trades across more than 300 securities were executed at prices more than 60% away from their values just moments before. Moreover, many of these trades were executed at prices of a penny or less, or as high as $100,000, before prices of those securities returned to their "pre-crash" levels.

By the end of the day, major futures and equities indices "recovered" to close at losses of about 3% from the prior day.

WHAT HAPPENED?

May 6 started as an unusually turbulent day for the markets. As discussed in more detail in the Preliminary Report, trading in the U.S opened to unsettling political and economic news from overseas concerning the European debt crisis. As a result, premiums rose for buying protection against default by the Greek government on their sovereign debt. At about 1 p.m., the Euro began a sharp decline against both the U.S Dollar and Japanese Yen.

Around 1:00 p.m., broadly negative market sentiment was already affecting an increase in the price volatility of some individual securities. At that time, the number of volatility pauses, also known as Liquidity Replenishment Points ("LRPs"), triggered on the New York Stock Exchange ("NYSE") in individual equities listed and traded on that exchange began to substantially increase above average levels.

By 2:30 p.m., the S&P 500 volatility index ("VIX") was up 22.5 percent from the opening level, yields of ten-year Treasuries fell as investors engaged in a "flight to quality," and selling pressure had pushed the Dow Jones Industrial Average ("DJIA") down about 2.5%.

Furthermore, buy-side liquidity[3] in the E-Mini S&P 500 futures contracts (the "E-Mini"), as well as the S&P 500 SPDR exchange traded fund ("SPY"), the two most active stock index instruments traded in electronic futures and equity markets, had fallen from the early-morning level of nearly $6 billion dollars to $2.65 billion (representing a 55% decline) for the E-Mini

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[3] We use the term "liquidity" throughout this report generally to refer to buy-side and sell-side market depth, which is comprised of resting orders that market participants place to express their willingness to buy or sell at prices equal to, or outside of (either below or above), current market levels. Note that for SPY and other equity securities discussed in this report, unless otherwise stated, market depth calculations include only resting quotes within 500 basis points of the mid-quote. Additional liquidity would have been available beyond 500 basis points. *See* Section 1 for further details on how market depth and near-inside market depth are defined and calculated for the E-Mini, SPY, and other equity securities.

and from the early-morning level of about $275 million to $220 million (a 20% decline) for SPY.[4] Some individual stocks also suffered from a decline their liquidity.

At 2:32 p.m., against this backdrop of unusually high volatility and thinning liquidity, a large fundamental[5] trader (a mutual fund complex) initiated a sell program to sell a total of 75,000 E-Mini contracts (valued at approximately $4.1 billion) as a hedge to an existing equity position.

Generally, a customer has a number of alternatives as to how to execute a large trade. First, a customer may choose to engage an intermediary, who would, in turn, execute a block trade or manage the position. Second, a customer may choose to manually enter orders into the market. Third, a customer can execute a trade via an automated execution algorithm, which can meet the customer's needs by taking price, time or volume into consideration. Effectively, a customer must make a choice as to how much human judgment is involved while executing a trade.

This large fundamental trader chose to execute this sell program via an automated execution algorithm ("Sell Algorithm") that was programmed to feed orders into the June 2010 E-Mini market to target an execution rate set to 9% of the trading volume calculated over the previous minute, but without regard to price or time.

The execution of this sell program resulted in the largest net change in daily position of any trader in the E-Mini since the beginning of the year (from January 1, 2010 through May 6, 2010). Only two single-day sell programs of equal or larger size – one of which was by the same large fundamental trader – were executed in the E-Mini in the 12 months prior to May 6. When executing the previous sell program, this large fundamental trader utilized a combination of manual trading entered over the course of a day and several automated execution algorithms which took into account price, time, and volume. On that occasion it took more than 5 hours for this large trader to execute the first 75,000 contracts of a large sell program.[6]

However, on May 6, when markets were already under stress, the Sell Algorithm chosen by the large trader to only target trading volume, and neither price nor time, executed the sell program extremely rapidly in just 20 minutes.[7]

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[4]   However, these erosions did not affect "near-inside" liquidity – resting orders within about 0.1% of the last transaction price or mid-market quote.

[5]   We define fundamental sellers and fundamental buyers as market participants who are trading to accumulate or reduce a net long or short position. Reasons for fundamental buying and selling include gaining long-term exposure to a market as well as hedging already-existing exposures in related markets.

[6]   Subsequently, the large fundamental trader closed, in a single day, this short position.

[7]   At a later date, the large fundamental trader executed trades over the course of more than 6 hours to offset the net short position accumulated on May 6.

This sell pressure was initially absorbed by:

- high frequency traders ("HFTs") and other intermediaries[8] in the futures market;
- fundamental buyers in the futures market; and
- cross-market arbitrageurs[9] who transferred this sell pressure to the equities markets by opportunistically buying E-Mini contracts and simultaneously selling products like SPY, or selling individual equities in the S&P 500 Index.

HFTs and intermediaries were the likely buyers of the initial batch of orders submitted by the Sell Algorithm, and, as a result, these buyers built up temporary long positions. Specifically, HFTs accumulated a net long position of about 3,300 contracts. However, between 2:41 p.m. and 2:44 p.m., HFTs aggressively sold about 2,000 E-Mini contracts in order to reduce their temporary long positions. At the same time, HFTs traded nearly 140,000 E-Mini contracts or over 33% of the total trading volume. This is consistent with the HFTs' typical practice of trading a very large number of contracts, but not accumulating an aggregate inventory beyond three to four thousand contracts in either direction.

The Sell Algorithm used by the large trader responded to the increased volume by increasing the rate at which it was feeding the orders into the market, even though orders that it already sent to the market were arguably not yet fully absorbed by fundamental buyers or cross-market arbitrageurs. In fact, especially in times of significant volatility, high trading volume is not necessarily a reliable indicator of market liquidity.

What happened next is best described in terms of two liquidity crises – one at the broad index level in the E-Mini, the other with respect to individual stocks.

LIQUIDITY CRISIS IN THE E-MINI

The combined selling pressure from the Sell Algorithm, HFTs and other traders drove the price of the E-Mini down approximately 3% in just four minutes from the beginning of 2:41 p.m. through the end of 2:44 p.m. During this same time cross-market arbitrageurs who did buy the E-Mini, simultaneously sold equivalent amounts in the equities markets, driving the price of SPY also down approximately 3%.

Still lacking sufficient demand from fundamental buyers or cross-market arbitrageurs, HFTs began to quickly buy and then resell contracts to each other – generating a "hot-potato" volume effect as the same positions were rapidly passed back and forth. Between 2:45:13 and 2:45:27, HFTs traded over 27,000 contracts, which accounted for about 49 percent of the total trading volume, while buying only about 200 additional contracts net.

At this time, buy-side market depth in the E-Mini fell to about $58 million, less than 1% of its depth from that morning's level. As liquidity vanished, the price of the E-Mini dropped by an

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[8] *See* Section 1 for the context in which high-frequency trading and market intermediaries are defined for the E-Mini.

[9] Cross-market arbitrageurs are opportunistic traders who capitalize on temporary, though often small, price differences between related products by purchasing the cheaper product and selling the more expensive product.

additional 1.7% in just these 15 seconds, to reach its intraday low of 1056. This sudden decline in both price and liquidity may be symptomatic of the notion that prices were moving so fast, fundamental buyers and cross-market arbitrageurs were either unable or unwilling to supply enough buy-side liquidity.

In the four-and-one-half minutes from 2:41 p.m. through 2:45:27 p.m., prices of the E-Mini had fallen by more than 5% and prices of SPY suffered a decline of over 6%. According to interviews with cross-market trading firms, at this time they were purchasing the E-Mini and selling either SPY, baskets of individual securities, or other index products.

By 2:45:28 there were less than 1,050 contracts of buy-side resting orders in the E-Mini, representing less than 1% of buy-side market depth observed at the beginning of the day. At the same time, buy-side resting orders in SPY fell to about 600,000 shares (equivalent to 1,200 E-Mini contracts) representing approximately 25% of its depth at the beginning of the day.

Between 2:32 p.m. and 2:45 p.m., as prices of the E-Mini rapidly declined, the Sell Algorithm sold about 35,000 E-Mini contracts (valued at approximately $1.9 billion) of the 75,000 intended. During the same time, all fundamental sellers combined sold more than 80,000 contracts net, while all fundamental buyers bought only about 50,000 contracts net, for a net fundamental imbalance of 30,000 contracts. This level of net selling by fundamental sellers is about 15 times larger compared to the same 13-minute interval during the previous three days, while this level of net buying by the fundamental buyers is about 10 times larger compared to the same time period during the previous three days.

At 2:45:28 p.m., trading on the E-Mini was paused for five seconds when the Chicago Mercantile Exchange ("CME") Stop Logic Functionality was triggered in order to prevent a cascade of further price declines. In that short period of time, sell-side pressure in the E-Mini was partly alleviated and buy-side interest increased. When trading resumed at 2:45:33 p.m., prices stabilized and shortly thereafter, the E-Mini began to recover, followed by the SPY.

The Sell Algorithm continued to execute the sell program until about 2:51 p.m. as the prices were rapidly rising in both the E-Mini and SPY.

LIQUIDITY CRISIS WITH RESPECT TO INDIVIDUAL STOCKS

The second liquidity crisis occurred in the equities markets at about 2:45 p.m. Based on interviews with a variety of large market participants, automated trading systems used by many liquidity providers temporarily paused in reaction to the sudden price declines observed during the first liquidity crisis. These built-in pauses are designed to prevent automated systems from trading when prices move beyond pre-defined thresholds in order to allow traders and risk managers to fully assess market conditions before trading is resumed.

After their trading systems were automatically paused, individual market participants had to assess the risks associated with continuing their trading. Participants reported that these assessments included the following factors: whether observed severe price moves could be an artifact of erroneous data; the impact of such moves on risk and position limits; impacts on intraday profit and loss ("P&L"); the potential for trades to be broken, leaving their firms inadvertently long or short on one side of the market; and the ability of their systems to handle the very high volume of trades and orders they were processing that day. In addition, a number of participants reported that because prices simultaneously fell across many types of

securities, they feared the occurrence of a cataclysmic event of which they were not yet aware, and that their strategies were not designed to handle.[10]

Based on their respective individual risk assessments, some market makers and other liquidity providers widened their quote spreads, others reduced offered liquidity, and a significant number withdrew completely from the markets. Some fell back to manual trading but had to limit their focus to only a subset of securities as they were not able to keep up with the nearly ten-fold increase in volume that occurred as prices in many securities rapidly declined.

HFTs in the equity markets, who normally both provide and take liquidity as part of their strategies, traded proportionally more as volume increased, and overall were net sellers in the rapidly declining broad market along with most other participants. Some of these firms continued to trade as the broad indices began to recover and individual securities started to experience severe price dislocations, whereas others reduced or halted trading completely.

Many over-the-counter ("OTC") market makers who would otherwise internally execute as principal a significant fraction of the buy and sell orders they receive from retail customers (*i.e.*, "internalizers") began routing most, if not all, of these orders directly to the public exchanges where they competed with other orders for immediately available, but dwindling, liquidity.

Even though after 2:45 p.m. prices in the E-Mini and SPY were recovering from their severe declines, sell orders placed for some individual securities and ETFs (including many retail stop-loss orders, triggered by declines in prices of those securities) found reduced buying interest, which led to further price declines in those securities.

Between 2:40 p.m. and 3:00 p.m., approximately 2 billion shares traded with a total volume exceeding $56 billion. Over 98% of all shares were executed at prices within 10% of their 2:40 p.m. value. However, as liquidity completely evaporated in a number of individual securities and ETFs,[11] participants instructed to sell (or buy) at the market found no immediately available buy interest (or sell interest) resulting in trades being executed at irrational prices as low as one penny or as high as $100,000. These trades occurred as a result of so-called stub quotes, which are quotes generated by market makers (or the exchanges on their behalf) at levels far away from the current market in order to fulfill continuous two-sided quoting obligations even when a market maker has withdrawn from active trading.

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[10] Some additional factors that may have played a role in the events of May 6 and that are discussed more fully in Sections 2 and 3 include: the use of LRPs by the NYSE, in which trading is effectively banded on the NYSE in NYSE-listed stocks exhibiting rapid price moves; declarations of self-help by The Nasdaq Stock Market, LLC ("Nasdaq") against NYSE Arca, Inc. ("NYSE Arca") under which Nasdaq temporarily stopped routing orders to NYSE Arca; and delays in NYSE quote and trade data disseminated over the Consolidated Quotation System ("CQS") and Consolidated Tape System ("CTS") data feeds. Our findings indicate that none of these factors played a dominant role on May 6, but nonetheless they are important considerations in forming a complete picture of, and response to, that afternoon.

[11] Detailed reconstructions of order books for individual securities are presented at the end of this report, exploring the relationship between changes in immediately available liquidity and changes in stock prices. This rich data set highlights both the broad theme of liquidity withdrawal on May 6, as well as some of the nuanced differences between securities that may have dictated why some stocks fell only 10% while others collapsed to a penny or less.

The severe dislocations observed in many securities were fleeting. As market participants had time to react and verify the integrity of their data and systems, buy-side and sell-side interest returned and an orderly price discovery process began to function. By approximately 3:00 p.m., most securities had reverted back to trading at prices reflecting true consensus values. Nevertheless, during the 20 minute period between 2:40 p.m. and 3:00 p.m., over 20,000 trades (many based on retail-customer orders) across more than 300 separate securities, including many ETFs,[12] were executed at prices 60% or more away from their 2:40 p.m. prices. After the market closed, the exchanges and FINRA met and jointly agreed to cancel (or break) all such trades under their respective "clearly erroneous" trade rules.

LESSONS LEARNED

The events summarized above and discussed in greater detail below highlight a number of key lessons to be learned from the extreme price movements observed on May 6.

One key lesson is that under stressed market conditions, the automated execution of a large sell order can trigger extreme price movements, especially if the automated execution algorithm does not take prices into account. Moreover, the interaction between automated execution programs and algorithmic trading strategies can quickly erode liquidity and result in disorderly markets. As the events of May 6 demonstrate, especially in times of significant volatility, high trading volume is not necessarily a reliable indicator of market liquidity.

May 6 was also an important reminder of the inter-connectedness of our derivatives and securities markets, particularly with respect to index products. The nature of the cross-market trading activity described above was confirmed by extensive interviews with market participants (discussed more fully herein), many of whom are active in both the futures and cash markets in the ordinary course, particularly with respect to "price discovery" products such as the E-Mini and SPY. Indeed, the Committee was formed prior to May 6 in recognition of the continuing convergence between the securities and derivatives markets, and the need for a harmonized regulatory approach that takes into account cross-market issues. Among other potential areas to address in this regard, the staffs of the CFTC and SEC are working together with the markets to consider recalibrating the existing market-wide circuit breakers – none of which were triggered on May 6 – that apply across all equity trading venues and the futures markets.

Another key lesson from May 6 is that many market participants employ their own versions of a trading pause – either generally or in particular products – based on different combinations of market signals. While the withdrawal of a single participant may not significantly impact the entire market, a liquidity crisis can develop if many market participants withdraw at the same time. This, in turn, can lead to the breakdown of a fair and orderly price-discovery process, and in the extreme case trades can be executed at stub-quotes used by market makers to fulfill their continuous two-sided quoting obligations.

As demonstrated by the CME's Stop Logic Functionality that triggered a halt in E-Mini trading, pausing a market can be an effective way of providing time for market participants to reassess their strategies, for algorithms to reset their parameters, and for an orderly market to be re-established.

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[12]   Section 2 discusses the disproportionate impact the market disruption of May 6 had on ETFs.

In response to this phenomenon, and to curtail the possibility that a similar liquidity crisis can result in circumstances of such extreme price volatility, the SEC staff worked with the exchanges and FINRA to promptly implement a circuit breaker pilot program for trading in individual securities. The circuit breakers pause trading across the U.S. markets in a security for five minutes if that security has experienced a 10% price change over the preceding five minutes. On June 10, the SEC approved the application of the circuit breakers to securities included in the S&P 500 Index, and on September 10, the SEC approved an expansion of the program to securities included in the Russell 1000 Index and certain ETFs. The circuit breaker program is in effect on a pilot basis through December 10, 2010.

A further observation from May 6 is that market participants' uncertainty about when trades will be broken can affect their trading strategies and willingness to provide liquidity. In fact, in our interviews many participants expressed concern that, on May 6, the exchanges and FINRA only broke trades that were more than 60% away from the applicable reference price, and did so using a process that was not transparent.

To provide market participants more certainty as to which trades will be broken and allow them to better manage their risks, the SEC staff worked with the exchanges and FINRA to clarify the process for breaking erroneous trades using more objective standards.[13] On September 10, the SEC approved the new trade break procedures, which like the circuit breaker program, is in effect on a pilot basis through December 10, 2010.

Going forward, SEC staff will evaluate the operation of the circuit breaker program and the new procedures for breaking erroneous trades during the pilot period. As part of its review, SEC staff intends to assess whether the current circuit breaker approach could be improved by adopting or incorporating other mechanisms, such as a limit up/limit down procedure that would directly prevent trades outside of specified parameters, while allowing trading to continue within those parameters. Such a procedure could prevent many anomalous trades from ever occurring, as well as limit the disruptive effect of those that do occur, and may work well in tandem with a trading pause mechanism that would accommodate more fundamental price moves.

Of final note, the events of May 6 clearly demonstrate the importance of data in today's world of fully-automated trading strategies and systems. This is further complicated by the many

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[13]   For stocks that are subject to the circuit breaker program, trades will be broken at specified levels depending on the stock price:

- For stocks priced $25 or less, trades will be broken if the trades are at least 10% away from the circuit breaker trigger price.
- For stocks priced more than $25 to $50, trades will be broken if they are 5% away from the circuit breaker trigger price.
- For stocks priced more than $50, the trades will be broken if they are 3% away from the circuit breaker trigger price.

Where circuit breakers are not applicable, the exchanges and FINRA will break trades at specified levels for events involving multiple stocks depending on how many stocks are involved:

- For events involving between five and 20 stocks, trades will be broken that are at least 10% away from the "reference price," typically the last sale before pricing was disrupted.
- For events involving more than 20 stocks, trades will be broken that are at least 30% away from the reference price.

sources of data that must be aggregated in order to form a complete picture of the markets upon which decisions to trade can be based. Varied data conventions, differing methods of communication, the sheer volume of quotes, orders, and trades produced each second, and even inherent time lags based on the laws of physics add yet more complexity.

Whether trading decisions are based on human judgment or a computer algorithm, and whether trades occur once a minute or thousands of times each second, fair and orderly markets require that the standard for robust, accessible, and timely market data be set quite high. Although we do not believe significant market data delays were the primary factor in causing the events of May 6, our analyses of that day reveal the extent to which the actions of market participants can be influenced by uncertainty about, or delays in, market data.

Accordingly, another area of focus going forward should be on the integrity and reliability of market centers' data processes, especially those that involve the publication of trades and quotes to the consolidated market data feeds. In addition, we will be working with the market centers in exploring their members' trading practices to identify any unintentional or potentially abusive or manipulative conduct that may cause system delays that inhibit the ability of market participants to engage in a fair and orderly process of price discovery.

ABOUT THIS REPORT

Findings for this report are presented in four sections. The first section explores the nature and sources of the selling pressure at various points during the day on May 6. The second section analyzes the impact this selling pressure had on key market participants, focusing in particular on their withdrawal from the markets and the consequent evaporation of liquidity. The third section studies additional factors that may have had a role in the events of the day. Finally, the fourth section concludes with a detailed examination of the aggregate order books for selected stocks and ETFs, illustrating how reductions in liquidity led some securities to trade at absurd prices.

I. TRADING IN BROAD MARKET INDICES ON MAY 6

The events of May 6 can be separated into 5 phases (shown in Figures 1.1 and 1.2):

- During the first phase, from the open through about 2:32 p.m., prices were broadly declining across markets, with stock market index products sustaining losses of about 3%.

- In the second phase, from about 2:32 p.m. through about 2:41 p.m., the broad markets began to lose more ground, declining another 1-2%.

- Between 2:41 p.m. and 2:45:28 p.m. in the third phase lasting only about four minutes or so, volume spiked upwards and the broad markets plummeted a further 5-6% to reach intra-day lows of 9-10%.

- In the fourth phase, from 2:45 p.m. to about 3:00 p.m. broad market indices recovered while at the same time many individual securities and ETFs experienced extreme price fluctuations and traded in a disorderly fashion at prices as low as one penny or as high as $100,000.[14]

- Finally, in the fifth phase starting at about 3:00 p.m., prices of most individual securities significantly recovered and trading resumed in a more orderly fashion.

In order to better understand the dramatic price fluctuations of broad-market indexes in phases two and three, as well as extraordinary price movements in individual securities in phase four, we begin with a brief description of the overall market conditions in the morning and early afternoon on May 6.

I.1. MARKET CONDITIONS ON MAY 6 PRIOR TO THE PERIOD OF EXTRAORDINARY VOLATILITY

As discussed in the Preliminary Report, the morning of May 6 opened to unsettling political and economic news from overseas concerning the European debt crisis. In this environment, many market participants demanded higher premiums to bear additional risk.

The broad-based increase in risk on May 6 was evidenced by a number of indicators. Premiums on credit default swaps increased for a number of European sovereign debt securities, including debt from Greece, Portugal, Spain, Italy, and Ireland. In addition, the Euro experienced downward pressure in global currency markets.

In the course of the day, the S&P 500 volatility index ("VIX"), a measure of the expected volatility of the S&P 500 Index, increased by 31.7 percent, which was the fourth largest single-day increase in VIX. Prices on gold futures rose 2.5%, while yields of ten-year Treasuries fell nearly 5% as investors engaged in a "flight to quality."

Starting at about 1:00 p.m., an overall increase in risk also began to manifest itself in the price volatility of individual equities. The number of volatility pauses, also known as Liquidity Replenishment Points ("LRPs"), triggered on the New York Stock Exchange for individual equities listed and traded on that exchange began to substantially increase above average levels.

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[14] *See* Preliminary Report, Figure 10.

By 2:30 p.m., selling pressure had pushed the Dow Jones Industrial Average ("DJIA") down about 2.5%. By this time, buy-side liquidity in the E-Mini had fallen from the early-morning level of nearly $6 billion dollars to $2.65 billion (representing a 55% decline). Buy-side liquidity in SPY had also fallen from the early-morning level of about $275 million to $220 million (a decline of 20%). Some individual stocks also suffered a decline in both buy-side and sell-side liquidity by this time.

I.2. STOCK INDEX PRODUCTS: THE E-MINI FUTURES CONTRACT AND SPY EXCHANGE TRADED FUND

The E-Mini and SPY are the two most active stock index instruments traded in the electronic futures and equity markets. Both are derivative products designed to track stocks in the S&P 500 Index, which in turn represents approximately 75% of the market capitalization of U.S.-listed equities. In order to compare trading and liquidity dynamics in these two products it is important to note their differences so that appropriate side-by-side adjustments can be made.

- The E-Mini futures contract was introduced by the CME on September 9, 1997, and trades exclusively on the CME Globex electronic trading platform 24 hours a day with the exception of short technical break periods. SPY is a registered investment company, launched in 1993, that operates as part of the SPDR family of ETFs, and trades on all large equity trading venues, including numerous alternative trading systems ("ATSs").

- The notional value of one E-Mini contract is $50 times the S&P 500 Index, and its minimum price movement (known as "tick") is 0.25 index points or $12.50 per contract. Shares of SPY trade at prices of approximately one tenth of the value of the S&P 500 Index with minimum price movements of one penny per share. One E-Mini contract is therefore approximately equivalent to 500 SPY shares. On May 6 the S&P 500 Index was about 1,100, which equates to $55,000 in notional value for one E-Mini contract, and $110 for one share of SPY.

- The number of outstanding E-Mini contracts is not fixed and there is no limit on how many contracts can be outstanding at any given time. The number of SPY shares outstanding is fixed throughout the trading day but, like other ETFs, SPY may issue its shares to, and redeem them from, specified market participants (known as authorized participants) in large aggregations or blocks (known as creation units) at the end of a trading day.

Limit orders in the E-Mini can be placed only with prices that are effectively within 12 index points (slightly over 1% on May 6) of the last transaction price. There are no bands on the prices for limit orders in SPY.

I.3. A LOSS OF LIQUIDITY

Since the E-Mini and SPY both track the same set of S&P 500 stocks, it can be expected that prices of these products would move in tandem during their rapid decline. However, a detailed examination of the order books[15] for each product reveals that in the moments before prices of the E-Mini and SPY both hit their intra-day lows, the E-Mini suffered a significant loss of liquidity during which buy-side market depth[16] was not able to keep pace with sell-side pressure. In comparison, buy-side liquidity in SPY reached its low point for the day a few minutes later, after prices in both the E-Mini and SPY began to recover.

Figures 1.3 and 1.4 present market depth of the E-Mini and SPY. For the E-Mini, depth for the entire CME Globex order book for the June 2010 E-Mini contract is included in the calculation of market depth. For SPY, total market depth includes all resting orders from the trading venues listed in Footnote 15 that are within 500 basis points on either side of the mid-quote of the then-current national best bid and national best offer ("NBBO"). This is equivalent to plus or minus 50 points on each side of the S&P 500 Index.[17] As shown, the divergence between buy-side and sell-side resting orders in the E-Mini began quite early in the day, and already by 2:00 p.m., sell-side depth was twice as large as buy-side depth. For SPY, this divergence did not begin to appear until about 1:30 p.m.

Figure 1.5 compares full buy-side depth for the E-Mini and SPY relative to their respective morning averages: between 9:30 a.m. to 10:00 a.m., the average for the E-Mini is approximately 100,000 contracts (about $5.5 billion), and the average for SPY is approximately 2.5 million shares (about $275 million). By 2:40 p.m., buy-side resting orders in the E-Mini had already declined to less than 20% of their morning average. By way of comparison, at 2:40 p.m. buy-side resting orders in the SPY were about 75% of the morning average. Then, over the next few minutes buy-side resting orders in the E-Mini were rapidly depleted whereas

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[15]   Order book data for the E-Mini is from the CME and is comprised of the total number of shares across all orders at a given price point. Order book data for SPY aggregates individual order books from Nasdaq ModelView, NYSE Openbook Ultra, NYSE ARCABook, and BATS Exchange, Inc. ("BATS"). These exchanges, combined, reflect approximately 90% of the executions on exchanges on May 6. We note that BATS data is limited to five price points on either side of the mid-quote and as a result our analysis can understate the total available liquidity for SPY.

[16]   We use the term market depth throughout this report to refer to resting orders that market participants place to express their willingness to buy or sell at prices equal to, or outside of (either below or above), current market levels. These orders are referred to as "buy interest" and "sell interest", and the number of shares of each type of order interest represent "buy-side market depth" and "sell-side market depth." Collectively, buy-side and sell-side resting orders form a "liquidity pool" against which incoming sell or buy orders can be executed.

   Normally, the rate at which resting orders within a liquidity pool are being depleted by incoming orders requiring immediate execution is approximately the same as the rate at which new buy and sell interests replenish the pool. However, imbalances can develop if the rate at which incoming orders requiring immediate execution outpaces the rate buy and sell interest is replenished, or if market participants reduce, or even halt, their replenishment thereby withdrawing their liquidity. A liquidity crisis can ensue if this imbalance becomes so severe that new orders requiring immediate execution cannot be matched with resting orders at near-market prices, which in turn can lead to extreme prices moves and volatility.

[17]   Additional liquidity in SPY existed at even wider levels but was not included in analyses that compare SPY market depth to E-Mini market depth since, as discussed above, limit orders in the E-Mini are price-banded to within about 100 basis points of the last transaction price.

resting orders in SPY remained at between 20% and 40% of its morning average until 2:50 p.m., when they fell to about 9%.

A closer examination of the E-Mini order book offers additional evidence that in the very short term liquidity dynamics in the E-Mini differed somewhat from that in SPY.

Figure 1.6 presents buy-side resting orders for the E-Mini on a second-by-second basis from 2:40 p.m. through 2:46 p.m. At 2:42:40, buy-side resting orders in the E-Mini rapidly went down to 15,000 contracts, and then steadily declined over the next three minutes. By 2:45:28 there were less than 1,050 contracts of buy-side resting orders for the E-Mini, representing less than 1% of buy-side market depth observed at the beginning of the day. In comparison, during that same time, buy-side resting orders in SPY fell to about 600,000 shares (the equivalent of 1,200 E-Mini contracts[18]), representing approximately 25% of its depth at the beginning of the day. Importantly, as illustrated in Figures 1.7 and 1.8, these erosions in buy-side liquidity did not affect near-inside market depth.[19]

Trading in the E-Mini was paused for 5 seconds at 2:45:28, when the CME Stop Logic Functionality was triggered to prevent the execution of the series of stop-loss losses that, if executed, would have resulted in a cascade in prices outside a predetermined "no bust" range.[20] Trading in SPY did not pause during the 5-second pause in the E-Mini.

As the data shows, buy-side liquidity in the E-Mini declined significantly faster than in SPY. However, according to Figures 1.6 and 1.9, buy-side liquidity in the E-Mini order book was quickly refilled during the 5-second pause and aggressive buy-side orders began to lift prices as soon as the trading resumed.

In comparison, it was sell-side depth in SPY that nearly vanished at 2:46 p.m. while the buy-side depth remained steady at about 600,000 shares (see Figure 1.10). Furthermore, SPY buy-side depth within 500 basis points of the mid-quote reached minimums of about 225,000 shares four minutes later at 2:50 p.m. and 2:51 p.m. even though prices in the E-Mini and SPY were recovering.[21] These 225,000 shares in the SPY (equivalent to 450 contracts in the E-Mini) represent approximately 9% of its early morning depth.

In summary, since the E-Mini and SPY both track the same set of S&P 500 stocks, cross-market arbitrage (discussed at the end of this section) between these two products kept their prices closely aligned during their rapid declines. However, as demonstrated above, in the moments before prices of the E-Mini and SPY both hit their intra-day lows, the E-Mini

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[18]   Recall that additional liquidity in SPY existed at even wider levels but was not included in analyses.

[19]   For SPY, near-inside market depth includes all resting quotes within 10 basis points on either side of the mid-quote of the then-current NBBO. For the E-Mini, near-inside market depth includes all resting quotes within $1.00 on either side of the last transaction price. On May 6 this was approximately equivalent to 10 basis points.

[20]   The "no bust" range is currently set at six index points for the E-Mini, or about 0.6% (60 basis points) of price on May 6.

[21]   After 2:45 p.m., as prices in the E-Mini and SPY were recovering from their rapid declines, severe reductions in the liquidity of many individual securities and ETFs, triggered by these rapid declines, were causing even more severe price dislocations in those individual securities and ETFs – a topic that will be discussed in detail throughout subsequent sections of this report.

suffered a significant loss of liquidity during which buy-side market depth was not able to keep pace with sell-side pressure.   Four minutes later, when prices in the E-Mini and SPY were recovering, buy-side market depth for SPY reached its daily low.

I.3. AUTOMATED EXECUTION OF A LARGE SELL ORDER IN THE E-MINI[22]

In order to examine what may have triggered the dynamics in the E-Mini on May 6, over 15,000 trading accounts that participated in transactions on that day were classified into six categories: Intermediaries, HFTs, Fundamental Buyers, Fundamental Sellers, Noise Traders, and Opportunistic Traders.

For classification purposes, both Intermediaries and HFTs were treated as "market makers."[23] As such, these traders would normally be active in the market every day, including the days prior to the events of May 6. Thus, the classification of HFTs and Intermediaries was based on trading data for May 3-5, 2010. Data for May 6, 2010 was used to designate traders into other trading categories.

Intermediaries are defined as "market makers" who follow a strategy of buying and selling a large number of contracts, but hold a relatively low level of inventory. This trading strategy manifests itself in both a low standard deviation of position holdings and a low ratio of overall net holdings to trading volume.

HFTs are defined as "market makers" with very large daily trading frequency. For classification purposes, the top 3% of the Intermediaries sorted by the number of trades were designated as HFTs.

Fundamental Traders are defined as those who were either buying or selling in one direction during the trading day and held a significant net position at the end of the day. Fundamental Traders are further separated into Fundamental Buyers and Sellers depending on both the direction of their trade and the trading volume associated with the accumulation of their net positions.

Noise Traders are defined as those traders who traded fewer than 10 contracts on May 6.

Opportunistic Traders are defined as those traders who do not fall in the other five categories. Traders in this category sometimes behave like the intermediaries (both buying and selling around a target position) and at other times behave like fundamental traders (accumulating a directional long or short position). This trading behavior is consistent with a number of trading strategies, including momentum trading, cross-market arbitrage, and other arbitrage strategies.

The behavior of these categories of trading accounts was examined before and during the period of extreme volatility on May 6. Summary statistics for each category of E-Mini market participants are presented in Table I.1.

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[22]   This section is based in part on a paper by Kirilenko, Kyle, Samadi, and Tuzun (2010).

[23]   For the purpose of this report the term "market maker," when used only in the context of the E-Mini, reflects a style of trading, not a formal registration requirement.

Against a backdrop of negative market sentiment and thinning liquidity, at 2:32 p.m., a large Fundamental Seller (a mutual fund complex) initiated a program to sell a total of 75,000 E-Mini contracts (valued at approximately $4.1 billion) as a hedge to an existing equity position.

Generally, a customer has a number of alternatives in how to execute a large trade. First, a customer may choose to engage an intermediary, who would, in turn, execute a block trade or manage the position. Second, a customer may choose to manually enter orders into the market. Third, a customer can execute a trade via an automated execution algorithm, which can meet the customer's needs by taking price, time or volume into consideration.[24] Effectively, a customer must make a choice of how much human judgment is involved while executing a trade.

This large Fundamental Seller chose to execute this sell program via an automated execution algorithm ("Sell Algorithm") that was programmed to feed orders into the June 2010 E-Mini market to target an execution rate set to 9% of the trading volume calculated over the previous minute, but without regard to price or time.

The execution of this sell program resulted in the largest net change in daily position of any trader in the E-Mini since the beginning of the year (from January 1, 2010 through May 6, 2010). Only two single-day sell programs of equal or larger size – one of which was by the same large Fundamental Seller – were executed in the E-Mini in the 12 months prior to May 6. When executing the previous sell program, this large Fundamental Seller utilized a combination of manual trading entered over the course of a day and several automated execution algorithms which took into account price, time, and volume. On that occasion it took more than 5 hours for this large trader to execute the first 75,000 contracts of a large sell program.[25]

However, on May 6, when markets were already under stress, the Sell Algorithm chosen by the large Fundamental Seller to only target trading volume, and not price nor time, executed the sell program extremely rapidly in just 20 minutes.[26]

HFTs and Intermediaries were the likely buyers of the initial batch of orders submitted by the Sell Algorithm, and, as a result, these buyers built up temporary long positions. Specifically, HFTs accumulated a net long position of about 3,300 contracts. HFTs, therefore, initially provided liquidity to the market.

However, between 2:41 p.m. and 2:44 p.m., HFTs aggressively sold about 2,000 E-Mini contracts in order to reduce their temporary long positions. Thus, at this time, HFTs stopped

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[24] Specifically, automated execution algorithms generally target execution profiles defined in terms of time, price or volume (or any combination of the three). For example, some traders feed orders into the market based on volume-weighted average price ("VWAP") algorithms that are designed to obtain an average price over a specified period of time and therefore have a built-in time throttle that prevents an unexpectedly fast execution that can cause significant market impact. Other such throttles include a limit price that would prevent executions at unfavorable prices.

[25] Subsequently, the large Fundamental Seller closed, in a single day, this short position.

[26] At a later day, it took the large Fundamental Seller more than 6 hours to offset the net short position accumulated on May 6.

providing liquidity and instead began to take liquidity. At this time, HFTs were competing with the large Fundamental Seller for the liquidity expected to be provided by Fundamental Buyers who would hold their positions, or by Opportunistic Buyers who would trade based on their ability to hedge their positions in the equity markets.

At the same time, HFTs traded nearly 140,000 E-Mini contracts or over 33% of the total trading volume. This is consistent with the HFTs' typical practice of trading a very large number of contracts, but not accumulating an aggregate inventory beyond three to four thousand contracts in either direction.

The Sell Algorithm used by the large Fundamental Seller responded to the increased volume by increasing the rate at which it was feeding the orders into the market, even though orders that it already sent to the market were arguably not yet fully absorbed by fundamental buyers or cross-market arbitrageurs. In fact, especially in times of significant volatility high trading volume is not a reliable indicator of market liquidity.

In a day of very negative market sentiment and high volatility, the combined selling pressure from the Sell Algorithm, HFTs and other traders drove the price of the E-Mini down approximately 3% in just four minutes from the beginning of 2:41 p.m. through the end of 2:44 p.m.

As discussed below, during this price decline, Opportunistic Buyers (and some Fundamental Buyers) were indeed purchasing the E-Mini (and contemporaneously selling SPY or baskets of individual securities), but not in sufficient quantity nor at a fast enough pace to keep up with the selling pressure in the E-Mini.

Furthermore, 16 (out of over 15,000) trading accounts that were classified as HFTs traded over 1,455,000 contracts on May 6, which comprised almost a third of the total daily trading volume. Yet, net holdings of HFTs fluctuated around zero so rapidly that they rarely held more than 3,000 contracts long or short on that day. Moreover, compared to the three days prior to May 6, there was an unusually high level of "hot potato" trading volume – due to repeated buying and selling of contracts – among the HFTs, especially during the period between 2:41 p.m. and 2:45 p.m. Specifically, between 2:45:13 and 2:45:27, HFTs traded over 27,000 contracts, which accounted for about 49 percent of the total trading volume, while buying only about 200 additional contracts net.

At this time, buy-side market depth in the E-Mini fell to about $58 million, less than 1% of its depth from that morning's level. As liquidity vanished, the price of the E-Mini dropped by an additional 1.7% in just these 15 seconds, to reach its intraday low of 1056. In fact, in the four-and-one-half minutes from 2:41 p.m. through 2:45:27 p.m., the prices of the E-Mini had fallen by more than 5%. This sudden decline in both price and liquidity may be symptomatic of the notion that prices were moving so fast, Fundamental or Opportunistic Buyers were either unable or unwilling to supply enough buy-side liquidity.

Between 2:32 p.m. and 2:45 p.m., as prices of the E-Mini rapidly declined, the Sell Algorithm sold about 35,000 E-Mini contracts (valued at approximately $1.9 billion) of the 75,000

intended.[27] During the same time, all Fundamental Sellers combined sold more than 80,000 contracts net, while all Fundamental Buyers bought only about 50,000 contracts net, for a net fundamental imbalance of 30,000 contracts. This level of net selling by Fundamental Sellers is about 15 times larger compared to the same 13-minute interval during the previous three days, while this level of net buying by the Fundamental Buyers is about 10 times larger compared to the same time period during the previous three days.

At 2:45:28 p.m., trading on the E-Mini was paused for five seconds when the CME Stop Logic Functionality was triggered in order to prevent a cascade of further price declines. In that short period of time, sell-side pressure in the E-Mini was partly alleviated and buy-side interest increased. When trading resumed at 2:45:33 p.m., prices stabilized and shortly thereafter, the E-Mini began to recover.

Data from the E-Mini order book reveal that a significant amount of additional orders from Opportunistic and Fundamental buyers began arriving sometime during and after the 5 second pause in trading. These buy orders initially neutralized the fall in prices and then sent prices up. While the HFTs did not significantly alter their trading strategy during the rebound in prices, nearly half of Intermediaries withdrew from the market.

The Sell Algorithm continued to execute the sell program until about 2:51 p.m. as prices were rising in both the E-Mini and SPY. Between 2:45 and 2:51 p.m., the Sell Algorithm sold the remaining 40,000 E-Mini contracts or so (valued at approximately $2.2 billion) of the 75,000 intended.[28]

Between 2:45 p.m. and 3:08 p.m., the 23-minute period during which E-Mini prices rebounded, Fundamental Sellers sold more than 110,000 contracts net and Fundamental Buyers bought more than 110,000 contracts net. The large fundamental trader sold the remaining 40,000 contracts or so of its program during this period. This level of net selling by Fundamental Sellers is about 10 times larger compared to the same 23-minute interval during the previous three days, while this level of buying by the Fundamental Buyers is more than 12 times larger compared to the same time period during the previous three days.

By 3:08 p.m., accelerating demand from both Opportunistic and Fundamental Buyers, attracted by the significant price concessions, and lifted the E-Mini prices back to nearly their pre-drop level.

I.5. CROSS-MARKET PROPAGATION

In order to assess how the liquidity shock may have propagated across securities and markets on May 6, staff spoke with 15 cross-market trading firms that collectively represented net buying of more than 100,000 June 2010 E-Mini contracts (approximately $5.6 billion in notional value) between 2:00 p.m. and 3:00 p.m. on May 6.

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[27] Approximately 18,000 out of the 35,000 orders (or about 51 percent) were executed aggressively, i.e., removed resting liquidity from the market, while about 17,000 were executed passively (i.e. provided resting liquidity to the market).

[28] Approximately 24,000 out of the 40,000 orders (or about 60 percent) were executed aggressively and the remaining 16,000 or so passively .

Cross-market strategies primarily focus on the contemporaneous trading of securities-related products in the futures and securities markets. The objective of these strategies is to capture temporary price differences between any two related products, but with limited or no exposure to subsequent price moves in those products.

The specific nature of cross-market trading strategies varies widely. Some firms focus on "one-way" strategies by acting as a liquidity provider (i.e., trading passively by submitting non-marketable resting orders) primarily in one product, and then hedging by trading another product (often by submitting marketable limit or market orders to trade aggressively in the hedging product). Other firms run "two-way" strategies that provide liquidity in multiple products and then hedge as necessary in another product.

In addition, according to the interviews, some firms focus on derivative index products such as futures, ETFs, and listed options, and do not trade the basket of underlying stocks. Other firms, in contrast, attempt to take advantage of the increased difficulty of trading baskets of underlying stocks by specializing in strategies that trade such baskets. With respect to these basket strategies, some firms engage in "pure" arbitrage by trading/hedging in substantially the full basket of underlying stocks, while other firms use "optimized baskets" that are designed to reduce hedging costs or otherwise improve the profitability of their cross-market strategies.

Although the specific nature of cross-product strategies can vary widely, they all start from the basic objective to "buy low, sell high" – that is, to buy the product (whether futures, ETF, or basket of underlying stocks) that is (relatively) cheap and to sell the product that is (relatively) rich. Moreover, cross-product trading firms reported that they incorporate these relative price differences among products in determining their quoted prices. For example, if the E-Mini moved down in comparison with SPY, they would immediately lower their bids and offers in SPY to reflect the price difference, even prior to those bids and offers being executed by incoming contra side orders.

These firms interviewed reported that the products they most consistently used for cross-market trading strategies on May 6 and other trading days were the E-Mini, SPY, and the basket of underlying stocks in the S&P 500 Index.

Consistent with the E-Mini's very high trading volume, most of the interviewed cross-market trading firms reported that they viewed the E-Mini as the primary price discovery product for the S&P 500 Index. While some firms noted that SPY has increased in importance in recent years as its trading volume has expanded, the firms agreed that price changes in the E-Mini generally lead price changes in SPY and in the basket of underlying stocks. The interviewed firms reported that on May 6, E-Mini prices also led the decline and that they were purchasing the E-Mini during this period.

Moreover, nearly all of the interviewed large net buyers in the E-Mini market, which were engaged in cross-market arbitrage strategies, reported that during the decline in prices of the E-Mini and SPY, the E-Mini was relatively cheaper than either SPY or baskets of individual securities. These same firms reported that they therefore purchased the E-Mini and contemporaneously sold SPY, baskets of individual securities, or other equity index products.

Many cross-market trading firms reported that, by 2:45 p.m., they had ceased operating their cross-market strategies because of the highly abnormal price changes in the market.

Nevertheless, those firms that continued to operate cross-market strategies during this period reported that the E-Mini generally led the recovery of prices across all three products.

I.6. LIQUIDITY IN THE STOCKS OF THE S&P 500 INDEX

In order to control for a possibility of a fundamental liquidity event that may have started in stocks underlying the E-Mini and SPY, thereby affecting their prices, we compared the order books of the E-Mini and SPY to that of a basket of large-cap stocks. To do so, an aggregate order book was re-created for the 500 stocks comprising the S&P 500 Index. To account for the wide range of price levels among these 500 stocks, shares of each were standardized to a split-adjusted price of $50 at the open.

The aggregate order book for the S&P 500 out to 500 basis points is plotted in Figure 1.11. Buy and sell market depth is approximately level and balanced throughout most of the day at about 70 million standardized shares. At 2:00 p.m. both the buy and sell order books begin to decline, and then rapidly fall just after 2:30 p.m. Of note is that the buy and sell order books remained mostly balanced even throughout the decline. At 2:45 p.m., buy-side depth was about 20 million standardized shares, or 28% of its early-afternoon value, reaching a low of 14 million shares, or 20% at 2:49 p.m., before rebounding.

Since the pattern of changes in the order books during the day for the E-Mini, SPY, and S&P 500 are characteristically different we normalized each of their values to 2:30 p.m. for the purposes of comparison.[29] As shown in Figure 1.12, the decline in full-depth buy-side liquidity for the E-Mini precedes that of the SPY and the S&P 500. In addition, E-Mini liquidity recovers sooner than either the SPY (which reached its daily low at 2:50 p.m.) or the S&P 500.

In sum, there does not appear to have been a fundamental liquidity event in S&P 500 stocks that preceded and drove price declines in the E-Mini and SPY.

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[29]   In particular, 2:30 p.m. represents reasonably level points for the E-Mini, SPY, and S&P 500 order books.

E-Mini Volume and Price
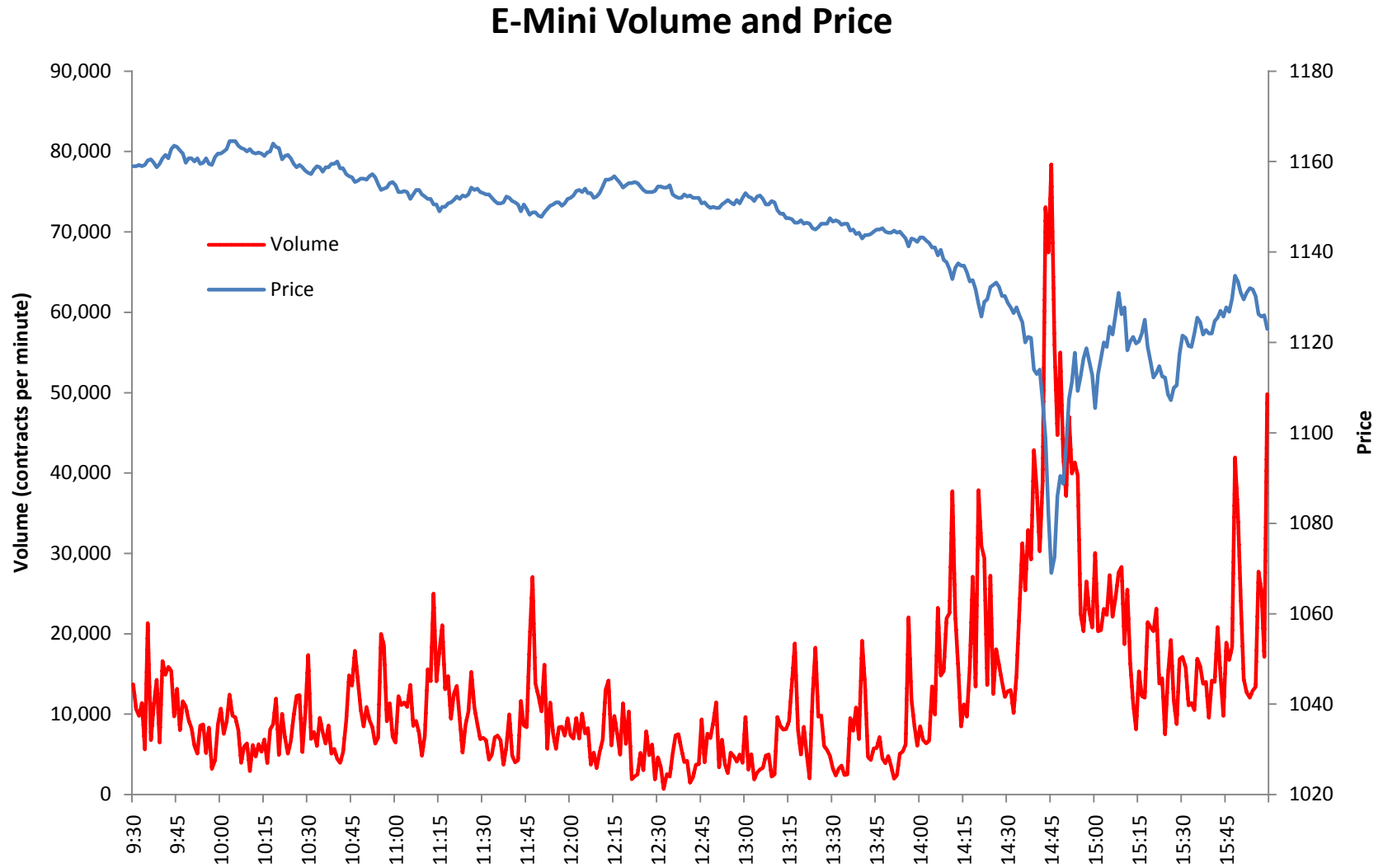
FIGURE 1.2: SPY Volume and Price
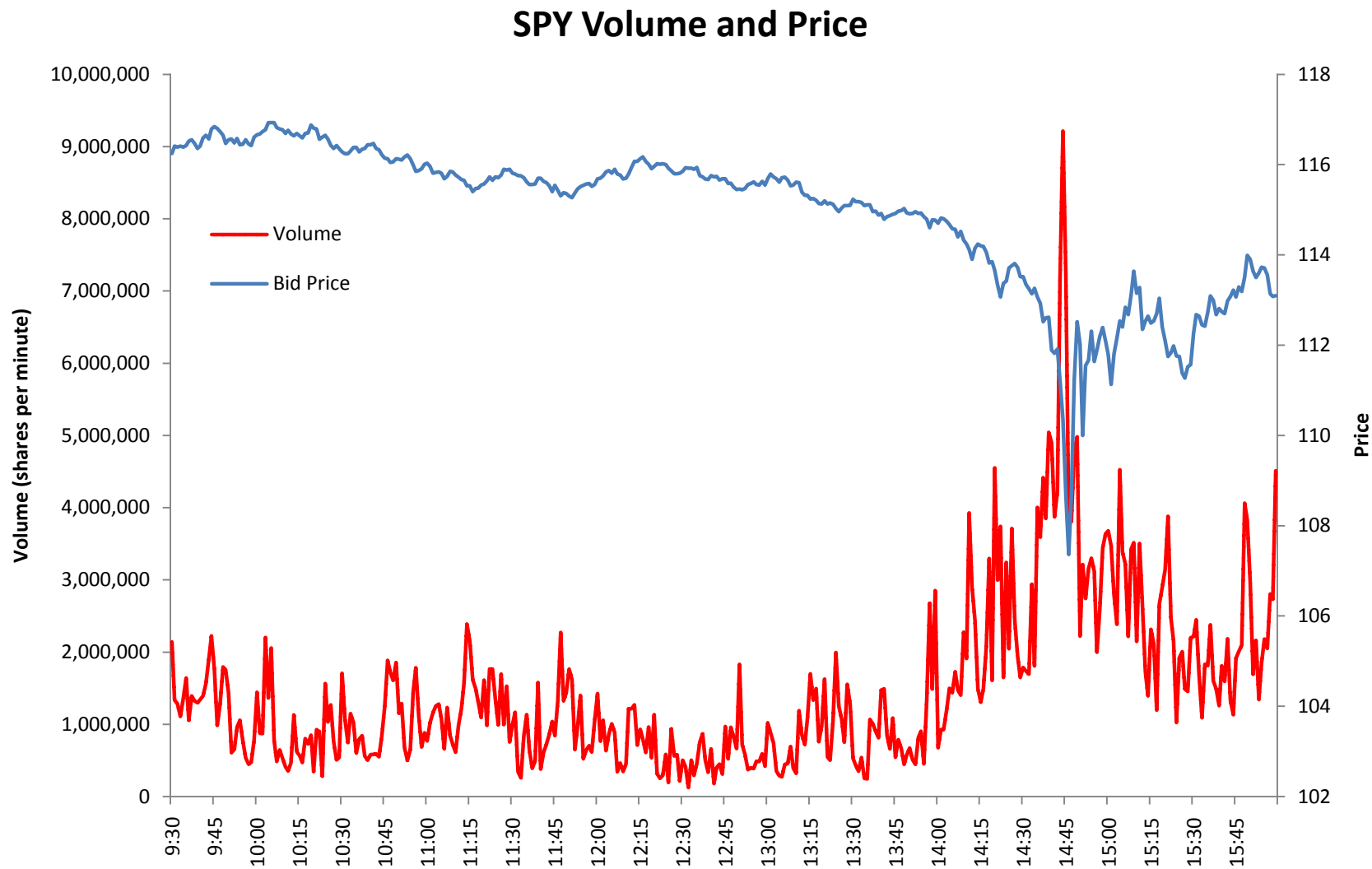
SPY Volume and Price

E-Mini Market Depth
All Quotes
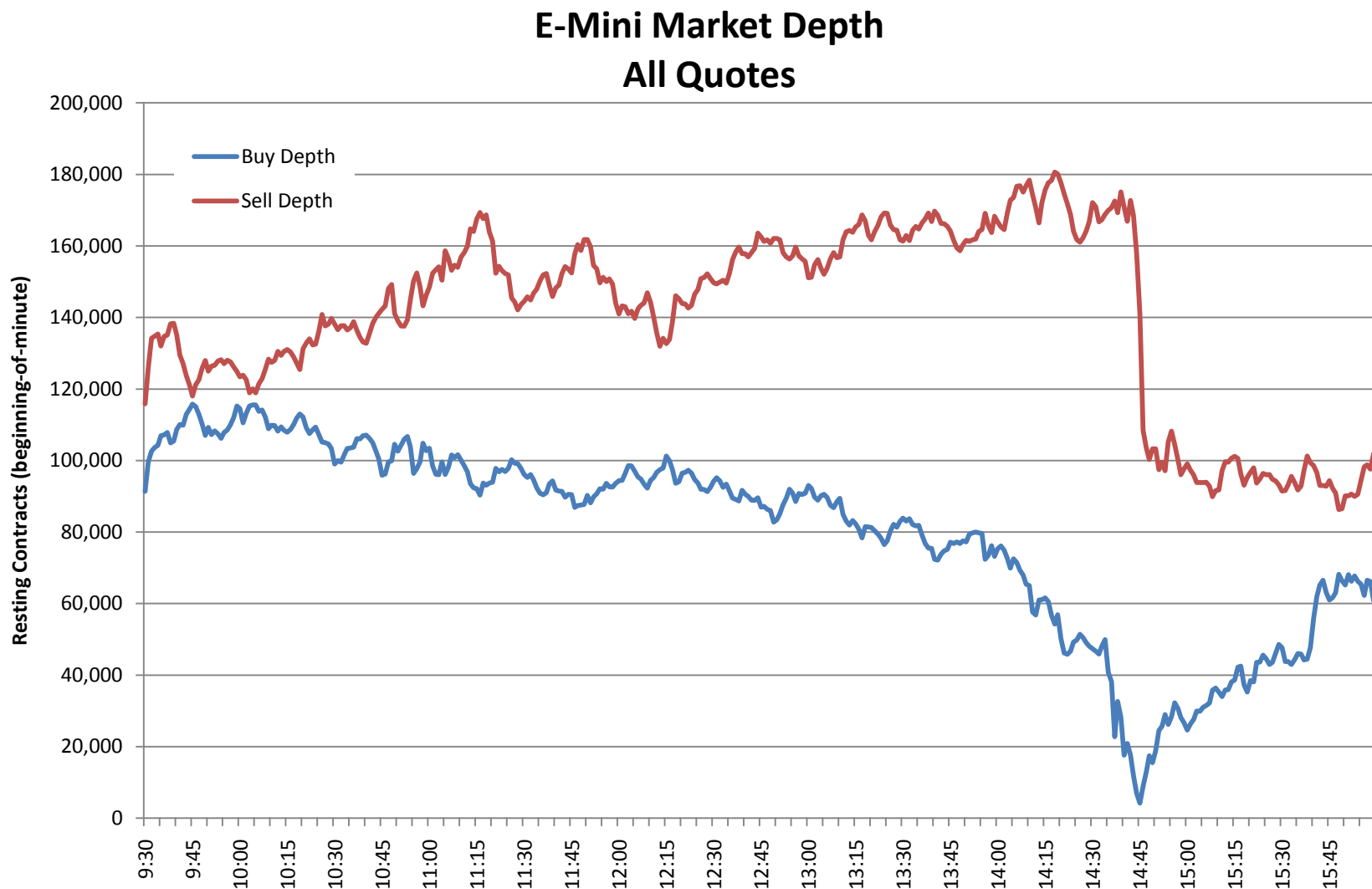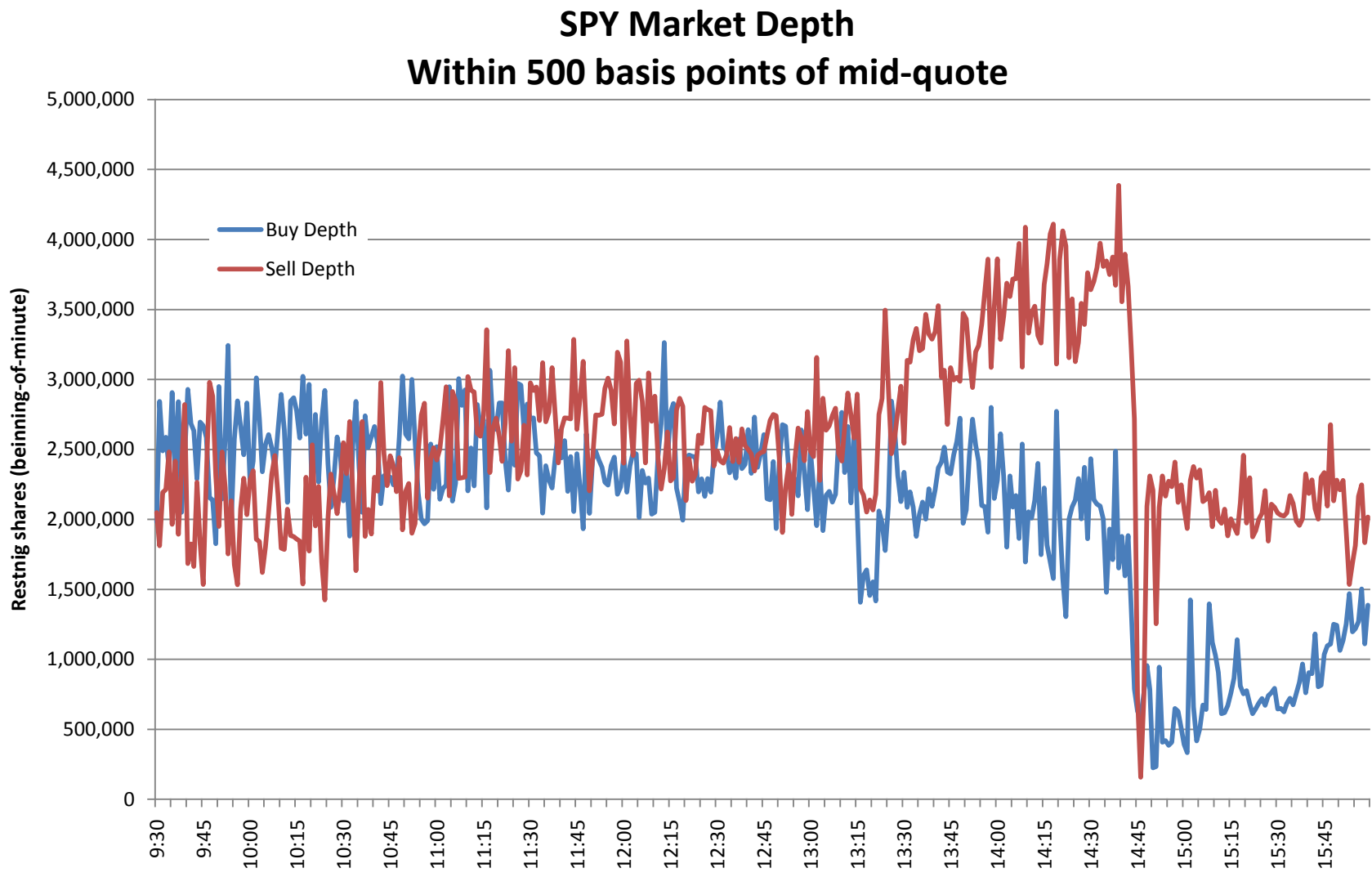
SPY Market Depth
Within 500 basis points of mid-quote

E-Mini vs. SPY Buy-Side Market Depth
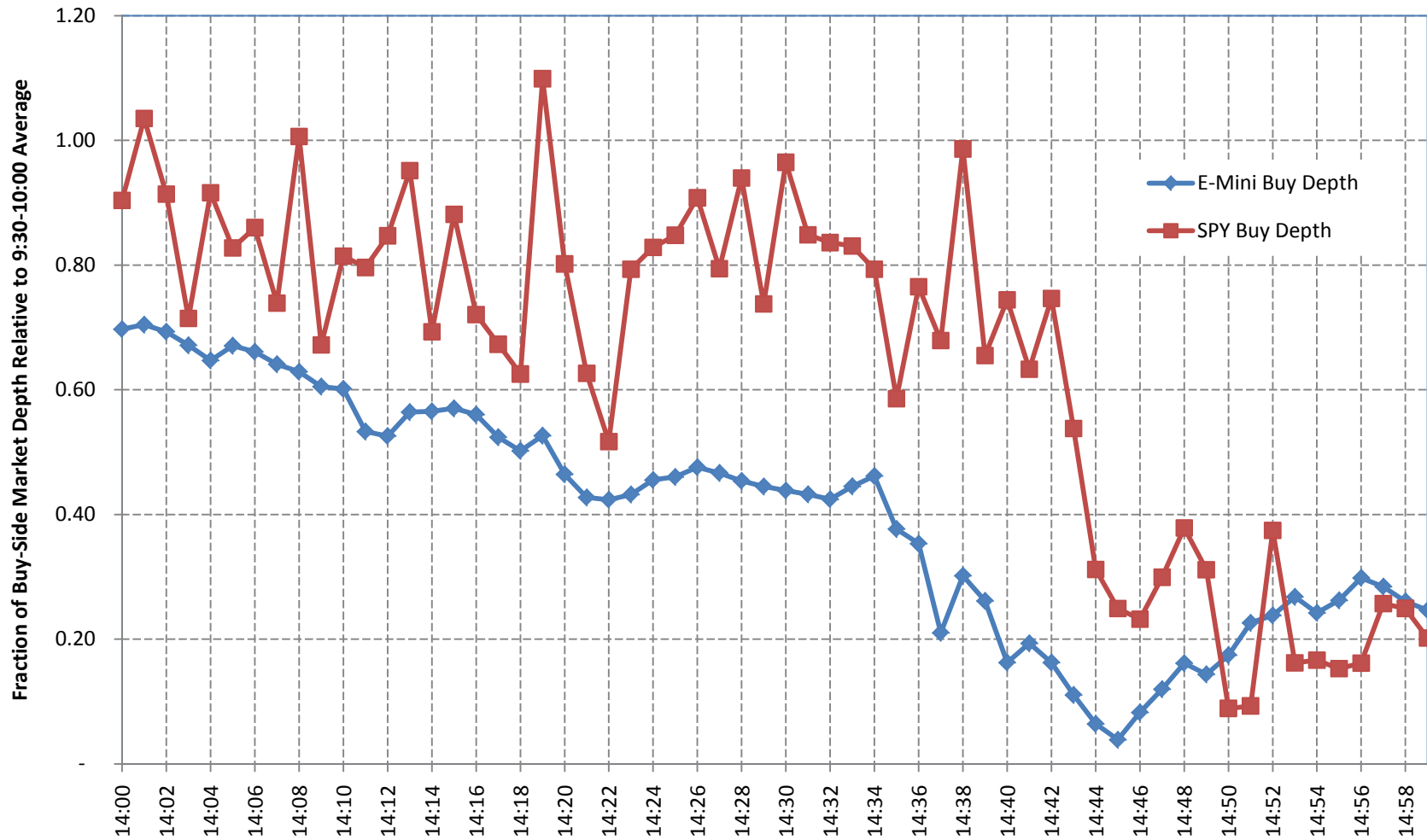
FIGURE 1.6: E-Mini Buy-Side Market Depth, Second-by-Second (note time is in CT)

E-Mini Total Buy Depth
Second-by-Second (Time in CT)

FIGURE 1.7: E-Mini Buy-Side and Sell-Side "Near-Inside" Market Depth within $1.00 of best-offer and best-bid (approximately 10 basis points from the "mid-quote")

E-Mini Near-Inside Market Depth
Within $1.00 of best-offer / best-bid

May 6, 2010 Market Event Findings

**SPY Near-Inside Market Depth
Within 10 basis points of mid-quote**
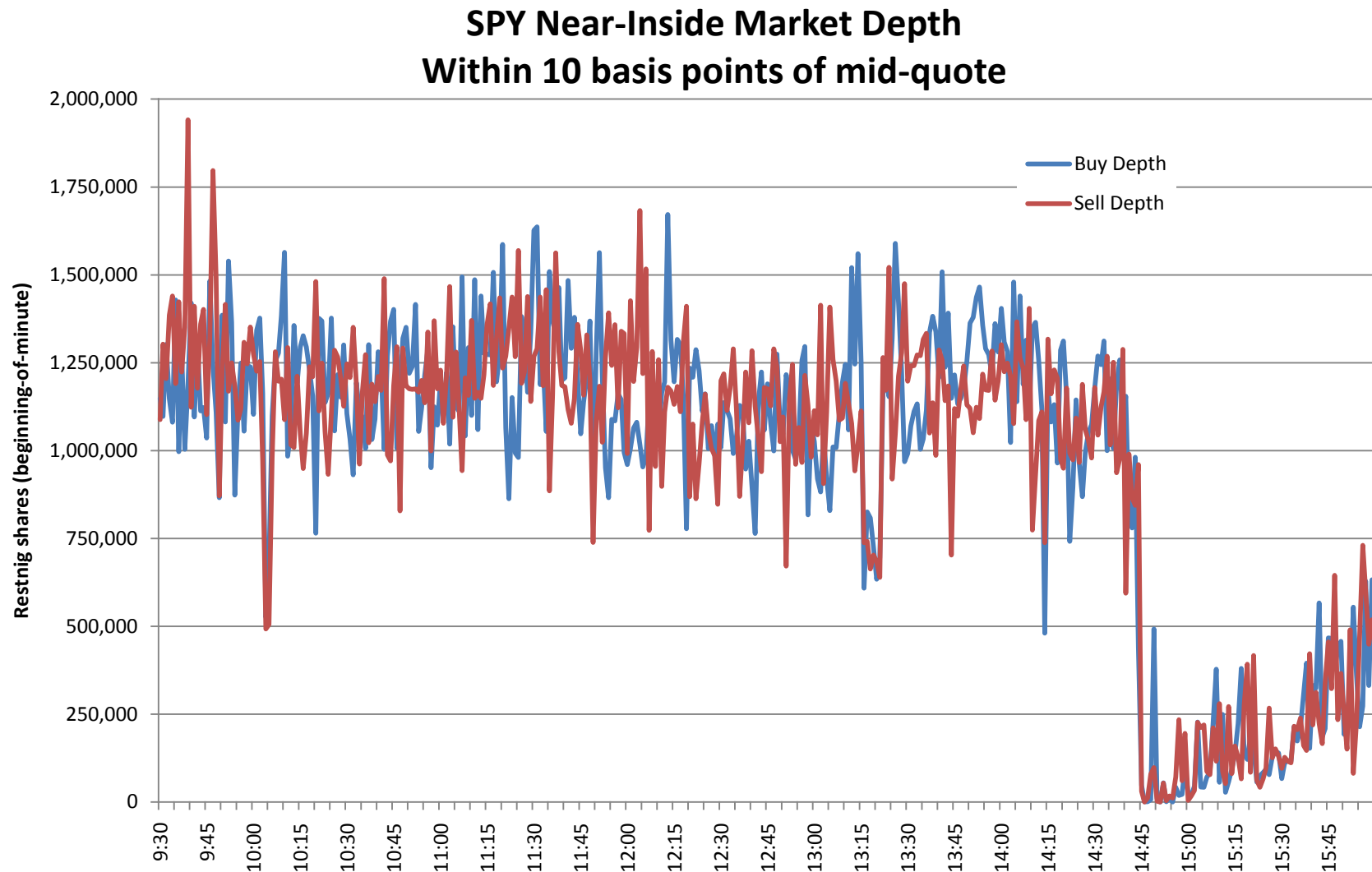
E-Mini Buyer and Seller Initiated Volume
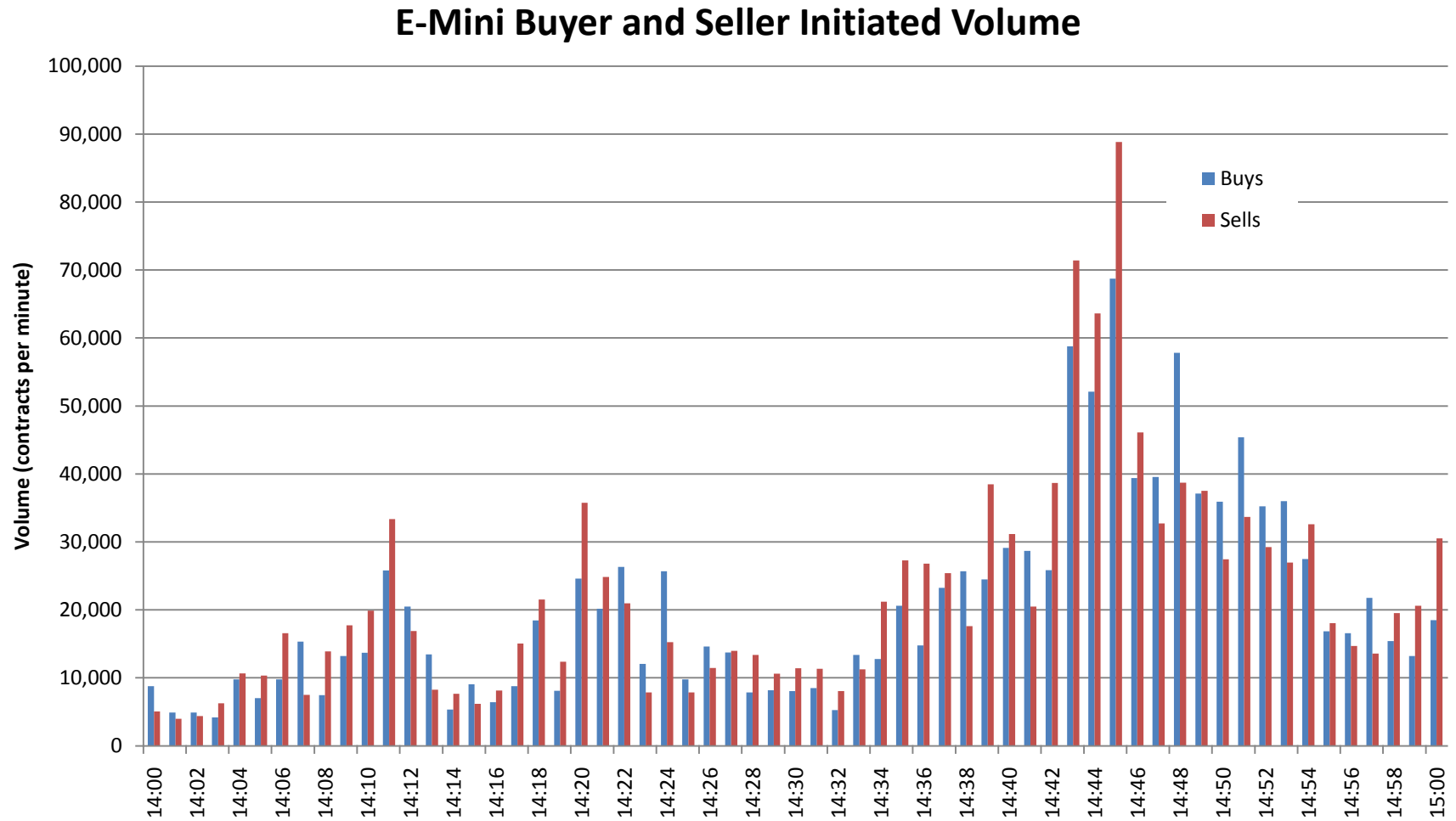
SPY Price and Market Depth
Within 500 basis points of mid-quote
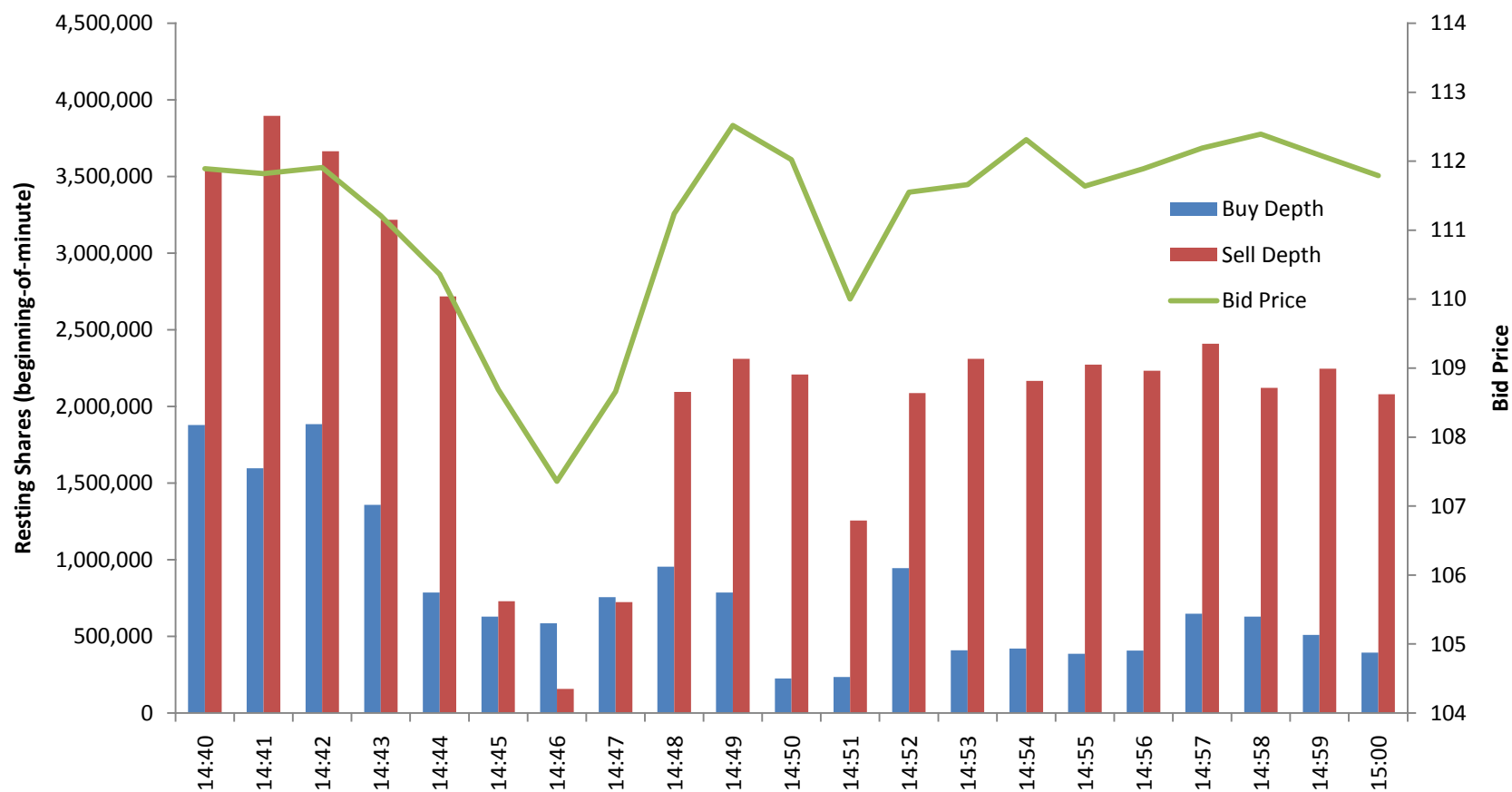
Table I.1: Summary Statistics of E-Mini Trader Categories

Panel A: May 3-5

Trader Type	% Volume	% of Trades	# Traders	Avg Trade Size	Limit Orders % Volume	Limit Orders % Trades
High Frequency Trader	34.22%	32.56%	15	5.69	100.000%	100.000%
Intermediary	10.49%	11.63%	189	4.88	99.614%	98.939%
Buyer	11.89%	10.15%	1,013	6.34	91.258%	91.273%
Seller	12.11%	10.10%	1,088	6.50	92.176%	91.360%
Opportunistic Trader	30.79%	33.34%	3,504	4.98	92.137%	90.549%
Noise Trader	0.50%	2.22%	6,065	1.22	70.092%	71.205%
All	2,397,639	446,340	11,875	5.41	95.45%	94.36%

Panel B: May 6

Trader Type	% Volume	% of Trades	# Traders	Avg Trade Size	Limit Orders % Volume	Limit Orders % Trades
High Frequency Trader	28.57%	29.35%	16	4.85	99.997%	99.997%
Intermediary	9.00%	11.48%	179	3.89	99.639%	99.237%
Buyer	12.01%	11.54%	1,263	5.15	88.841%	89.589%
Seller	10.04%	6.95%	1,276	7.19	89.985%	88.966%
Opportunistic Trader	40.13%	39.64%	5,808	5.05	87.385%	85.352%
Noise Trader	0.25%	1.04%	6,880	1.20	63.609%	64.879%
All	5,094,703	1,030,204	15,422	4.99	92.443%	91.750%
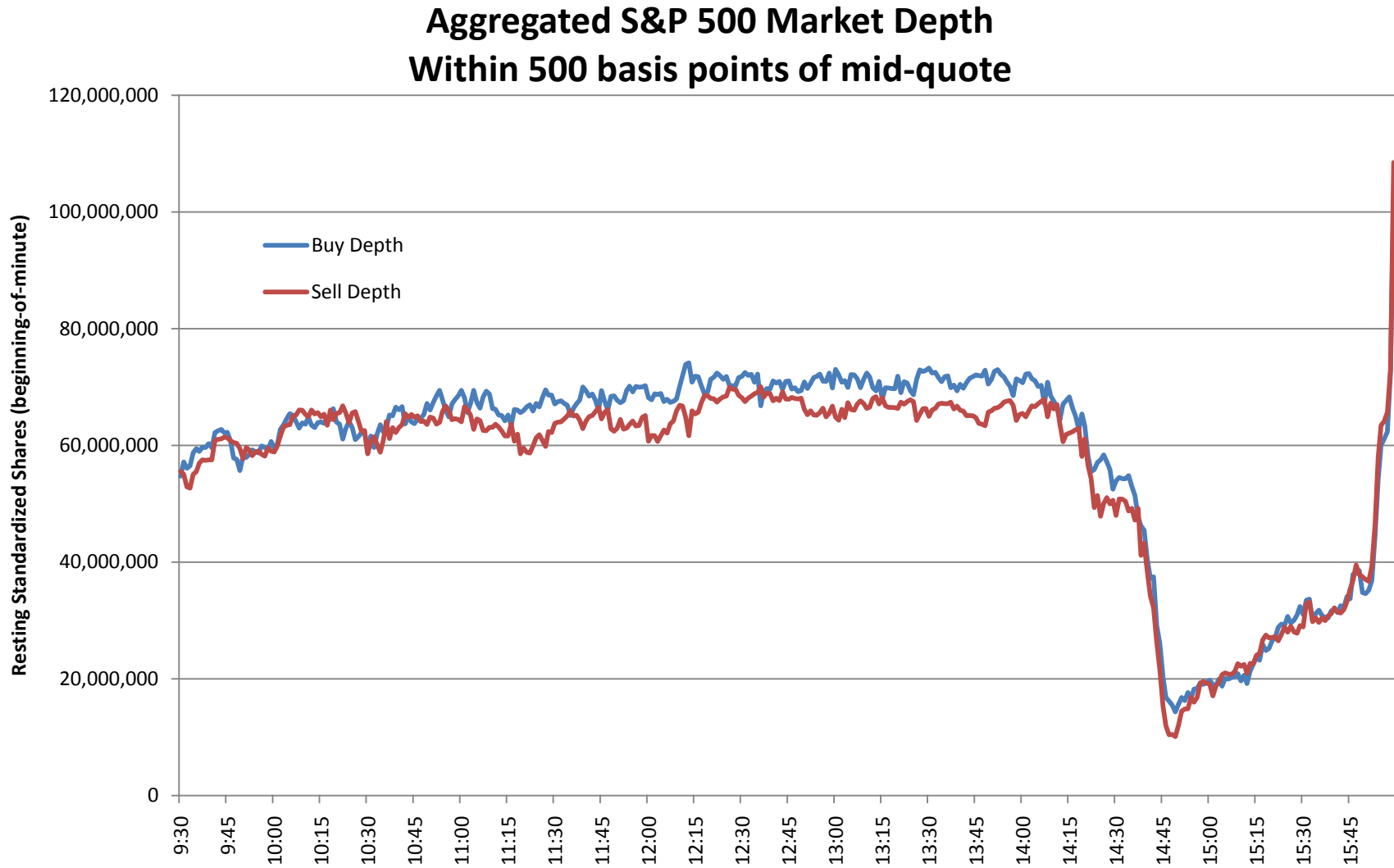
Aggregated S&P 500 Market Depth
Within 500 basis points of mid-quote

E-Mini, SPY, and S&P 500 Buy-Side Market Depth
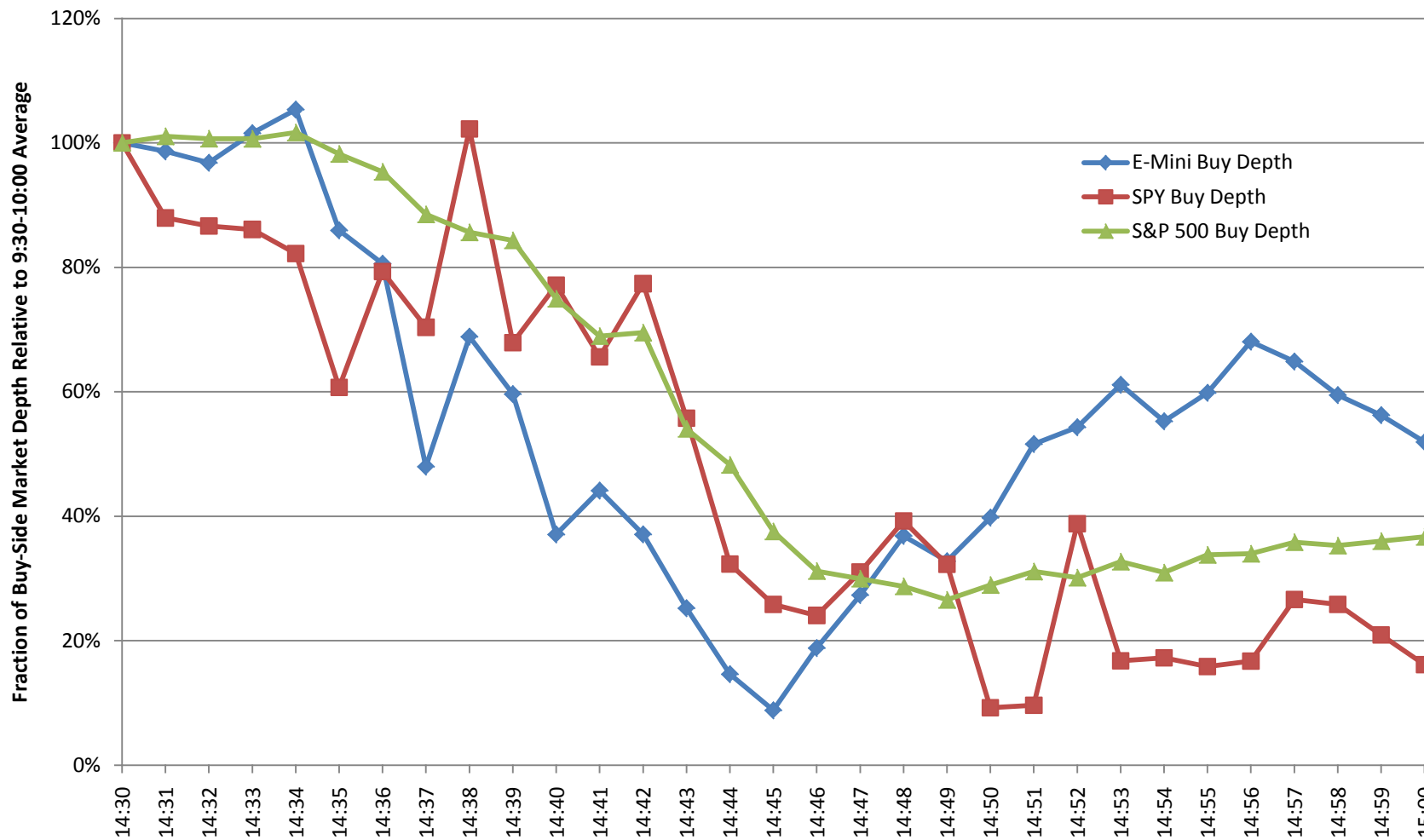
II. MARKET PARTICIPANTS AND THE WITHDRAWAL OF LIQUIDITY

II.1. OVERVIEW

In the previous section we explored the liquidity of the E-Mini and SPY, and discussed the behavior of cross-market arbitrage participants on May 6 during the decline of the broad markets. Among our findings was that even though volume spiked that afternoon, the markets suffered significant reductions in liquidity as prices fell.

Charts 1.A and 1.B on the next two pages illustrate the extent to which large capitalization stocks lost liquidity. The four panels of the first chart display progressively narrower slices of time within which a more detailed view of the aggregate order books for stocks comprising the S&P 500 is shown. This is the same data as plotted in Figure 1.12, but in this case different color bands are used to represent liquidity at different depths from the mid-quote, from 10 basis points through 500 basis points. We note that between 2:35 p.m. and 2:46 p.m., buy-side depth falls to about 25% of its mid-day value, and sell-side depth falls even further to about 15% of its mid-day value. Resting liquidity near the inside of the market at 10 basis points virtually disappears, indicative of spreads widening as liquidity (and prices) fell.

The second chart repeats the data from the first chart but adds additional bars revealing the extent to which resting orders existed beyond 500 basis points from the mid-quote. The graphs show a significant reduction in buy-side market depth, but sell-side depth is only slightly affected. This suggests that resting buy-side interest even beyond 500 basis points was being hit (or canceled) as prices fell.

Chart 1.A: S&P 500
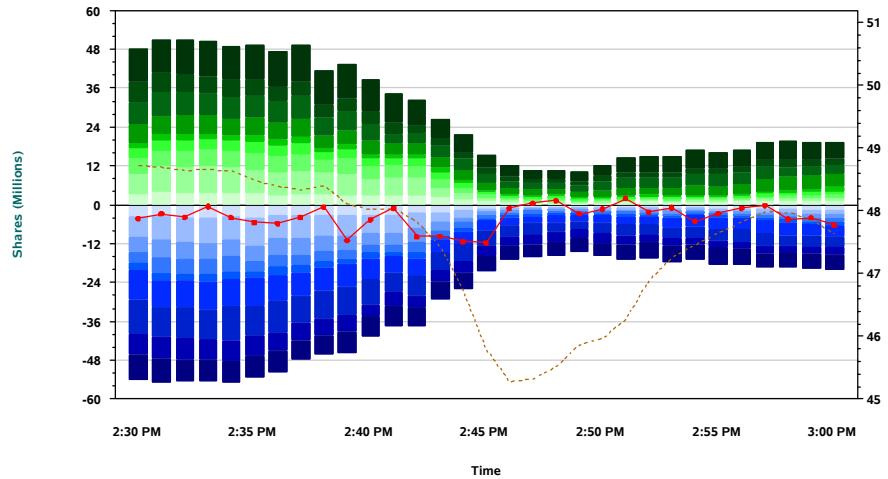## Market Depth (within 500 basis points) and Net Aggressive Buy Volume
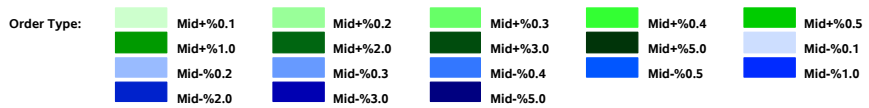
9:30am - 4:00pm

2:00pm - 3:30pm

2:30pm - 3:00pm
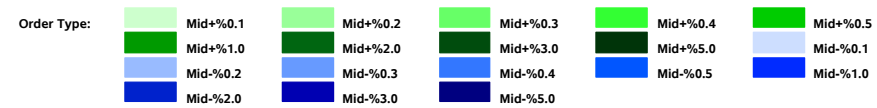

2:40pm - 2:55pm

Order Type:
- Mid+%0.1
- Mid+%0.2
- Mid+%0.3
- Mid+%0.4
- Mid+%0.5
- Mid+%1.0
- Mid+%2.0
- Mid+%3.0
- Mid+%5.0
- Mid-%0.1
- Mid-%0.2
- Mid-%0.3
- Mid-%0.4
- Mid-%0.5
- Mid-%1.0
- Mid-%2.0
- Mid-%3.0
- Mid-%5.0

Price: Minimum Executed Price   Net Aggressive Buy Volume

The order book depth reflects the total number of shares in unfilled limit orders, by ticker and minute. The data combines the information from NYSE Openbook, ArcaBook, NASDAQ ModelView, and BATS order book data.
Net Aggressive Buy Volume is defined as executed shares associated with aggressive buy orders minus executed shares associated with aggressive sell orders.
Aggressive buy orders are market buy orders and buy orders at or above the offer price. Aggressive sell orders are market sell orders and sell orders at or below the bid price.

Chart 1.B: S&P 500
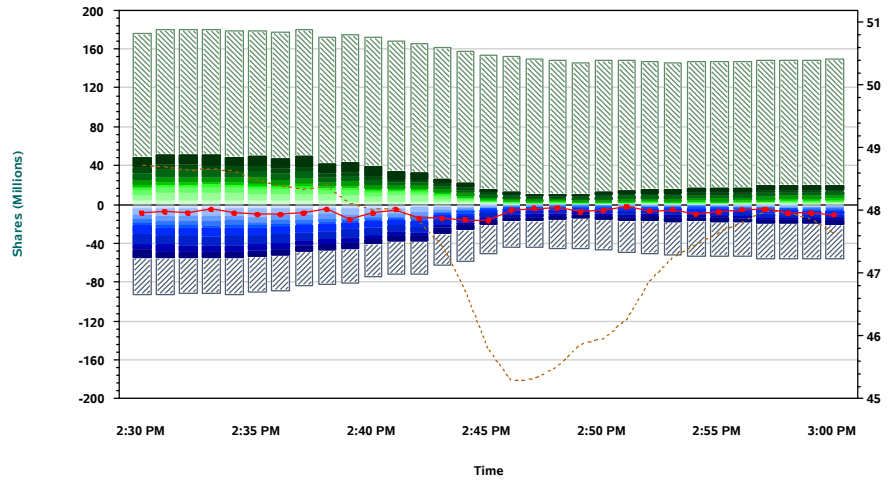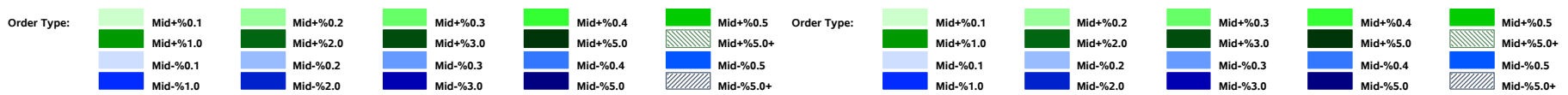## Full Market Depth and Net Aggressive Buy Volume

9:30am - 4:00pm

2:00pm - 3:30pm

2:30pm - 3:00pm

2:40pm - 2:55pm

Order Type:
Mid+%0.1 Mid+%0.2 Mid+%0.3 Mid+%0.4 Mid+%0.5
Mid+%1.0 Mid+%2.0 Mid+%3.0 Mid+%5.0 Mid+%5.0+
Mid-%0.1 Mid-%0.2 Mid-%0.3 Mid-%0.4 Mid-%0.5
Mid-%1.0 Mid-%2.0 Mid-%3.0 Mid-%5.0 Mid-%5.0+

Order Type:
Mid+%0.1 Mid+%0.2 Mid+%0.3 Mid+%0.4 Mid+%0.5
Mid+%1.0 Mid+%2.0 Mid+%3.0 Mid+%5.0 Mid+%5.0+
Mid-%0.1 Mid-%0.2 Mid-%0.3 Mid-%0.4 Mid-%0.5
Mid-%1.0 Mid-%2.0 Mid-%3.0 Mid-%5.0 Mid-%5.0+

Price: — — — Minimum Executed Price   ●●● Net Aggressive Buy Volume

Price: — — — Minimum Executed Price   ●●● Net Aggressive Buy Volume

The order book depth reflects the total number of shares in unfilled limit orders, by ticker and minute. The data combines the information from NYSE Openbook, ArcaBook, NASDAQ ModelView, and BATS order book data.
Net Aggressive Buy Volume is defined as executed shares associated with aggressive buy orders minus executed shares associated with aggressive sell orders.
Aggressive buy orders are market buy orders and buy orders at or above the offer price. Aggressive sell orders are market sell orders and sell orders at or below the bid price.

II.2. MARKET PARTICIPANTS

To better understand this reduction in liquidity and how it affected market participants, we conducted a series of extensive interviews across a wide range of firms[30] that typically provide market liquidity, beyond those involved in cross-market arbitrage, including:

- traditional equity market makers;
- high-frequency traders;
- internalizers; and
- options market makers.

Each interview was conducted in two parts. In the first half, firms outlined their trading strategies and business models. In the second half, we discussed their actions on May 6, paying special attention to what caused each firm to act in a particular way. Guidelines for the interview process were created to ensure all relevant topics, as applicable to each type of market participant, were covered. In some cases, second rounds of interviews were scheduled to follow-up on specific details not covered during the first interview.

In general we found that many (though not all) firms we interviewed significantly curtailed or completely halted their trading activities at some point during the afternoon of May 6. The specifics of their strategies and the relative size of their trading activities dictated the extent to which this had an impact on the rest of the market. We note that even within the broad categories defined above, each firm has a unique way of trading, and their specific responses to the rapid market changes observed on May 6 are quite nuanced. Nevertheless, a number of common themes emerged that help explain the actions of the day.

II.2.a. GENERAL WITHDRAWAL OF LIQUIDITY

Almost all of the firms we interviewed use a combination of automated algorithms and human traders to oversee their operations. As such, data integrity was cited by the firms we interviewed as their number one concern. To protect against trading on erroneous data, firms implement automated stops that are triggered when the data received appears questionable.

One way of identifying potentially erroneous data is to screen for large, rapid price moves. For example, it was reported that the rapid decline in prices of the E-Mini, starting around 2:40 p.m. triggered data-integrity pauses in trading across a number of automated algorithms. Rapid declines in individual securities also contributed to data-integrity concerns and triggered trading pauses. Collectively we refer to these as "price-driven integrity pauses." It is important to note these types of pauses are not necessarily the result of erroneous price data, but instead are based on prudential checks into the *possibility* that large, observed price changes are the by-product of a system error. In fact, the large price declines simultaneously observed across securities and the E-Mini contract during the afternoon of May 6 were indeed real.

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[30] The staff held extensive interviews with over three dozen firms who traded in significant size on May 6, ranging from liquidity providers to traders, and asset managers. We believe this sample contains a sufficiently large number of key firms to reliably represent the behavior and actions of most of the large market participants that afternoon. We also held extensive interviews with exchanges that inform other sections of this report. Note that a number of market participants engage in multiple strategies throughout the course of a trading day and the discussions that follow are therefore based on strategy type as opposed to firm.

Some firms use multiple data sources as inputs to their data-integrity checks, and when those sources do not agree, a pause can be triggered. As discussed in Section 3, latency issues regarding a subset of pricing data on the consolidated market data feeds for NYSE-traded stocks[31] triggered data-integrity checks in the systems of some firms. We refer to these as "feed-driven integrity pauses."

Whenever data integrity was questioned for any reason, firms temporarily paused trading in either the offending security, or in a group of securities. As a firm paused its trading, any liquidity the firm may have been providing to the market became unavailable, and other firms that were still providing liquidity to the markets had to absorb continued order flow. To the extent that this led to more concentrated price pressure, additional rapid price moves would in turn trigger yet more price-driven integrity pauses.

Some firms experienced their own internal system capacity issues due to the significant increase in orders and executions they were initiating that afternoon, and were not able to properly monitor and verify their trading in a timely fashion. When that occurred, trading was paused and sometimes halted for an extended period of time.

Another reason cited for withdrawing from the market was a belief that trades in individual securities at prices representing a 10% or greater short-term move would later be canceled, leaving a firm inadvertently and excessively long or short the market. We note that this particular concern was not necessarily due to uncertainty in whether or not a trade was going to be canceled, but rather the belief that they were indeed going to be canceled.

A number of firms reported on their use of internal risk limits based on a variety of metrics, including intraday P&L, overall volume of executions, price volatility, and absolute long or short exposure to a security, group of securities, or the overall market. Triggers in one or more of these risk limits during the afternoon of May 6 caused some firms to curtail, pause, and sometimes completely halt, their trading activities, thereby depriving the markets of liquidity they otherwise would have been providing.

We also asked firms to comment on three specific external factors first highlighted in the Preliminary Report and in subsequent presentations: (i) delays in consolidated market data for NYSE-traded stocks; (ii) the declarations of self-help by Nasdaq and BATS on NYSE Arca; and (iii) the use of LRPs by NYSE.

Most of the firms we interviewed that are concerned with data latency in the milliseconds (such as market makers, internalizers, and HFTs) subscribe directly to the proprietary feeds offered by the exchanges. These firms do not generally rely on the consolidated market data to make trading decisions and thus their trading decisions would not have been directly affected by the delay in data in this feed. However, some of these firms do use the consolidated market

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[31] The consolidated market data feeds disseminate real-time quotation and trade information for exchange-listed stocks, as required by the federal securities laws and rules. The data reflected on the consolidated market data feeds derives from various market centers, including all securities exchanges, ECNs, and OTC broker-dealers. There are three different networks that distribute information for exchange-listed stocks: Network A for stocks primarily listed on the NYSE; Network C for stocks primarily listed on Nasdaq; and Network B for stocks primarily listed on exchanges other than the NYSE and Nasdaq.

data feeds for data-integrity checks, and delay-induced data discrepancies certainly contributed to the general sense of unease experienced that day.

Other firms that are not concerned with data latency in the milliseconds (such as many asset managers and other lower-frequency traders) tend to rely on the consolidated market data feeds for trading decisions. A number of those interviewed reported pulling back from the market as general volatility increased, and those seeing delays and price-discrepancies on the consolidated market data feeds did report that was a contributing factor in their decision to curtail or halt further trading. The source and potential implications of data delays in the consolidated market data feeds will be explored further in Section 3.

On the afternoon of May 6, Nasdaq and BATS declared self-help against NYSE Arca during which neither Nasdaq nor BATS were required to route orders to NYSE Arca or honor NYSE Arca's quote.[32] However, most of the large market participants we interviewed route orders directly to each individual exchange based on their own algorithms, and told us that they were generally unaffected by these self-help declarations. Furthermore, though these firms noted that Nasdaq and BATS declared self-help on NYSE Arca that afternoon, they continued to route their own orders to NYSE Arca based on NYSE Arca's quotes and trades. At the end of this section and in Section 3 we further explore the issue of self-help and conclude that, consistent with our interview findings, self-help was not a significant factor on May 6, nor did it contribute to the severe price dislocations observed in many securities.

As discussed in the Preliminary Report, NYSE's LRP mechanism effectively banded the trading range on NYSE for many NYSE-listed securities during the periods of extreme volatility observed on the afternoon of May 6. Market participants we interviewed had mixed reactions to NYSE's use of LRPs. Since most of the firms we spoke with route their own orders, they were able to make their own real-time decisions on whether to include or exclude NYSE in their routing algorithms. Thus these firms did not think LRPs had a direct impact on their ability to trade. Rather, firms reported that they were more concerned with general market volatility and the integrity of prices.

However, a number of firms did report that they considered the triggering of a relatively large number of LRPs indicative of system-wide liquidity issues, which added to their sense of unease, and perhaps influenced decisions to withdraw from trading. A detailed discussion of the role of LRPs on the events of May 6 is provided in Section 3.

II.2.b. TRADITIONAL EQUITY AND ETF MARKET MAKERS

In general, the rules of national securities exchanges allow a member to voluntarily register as a market maker on a security-by-security basis and subject to certain obligations. These exchange rules require members to maintain a continuous two-sided quotation in the security or securities for which they are registered as a market maker. While the strategies of equity and ETF market making firms may differ, we classify "traditional" market makers as firms with business models that attempt to profit primarily from trading passively by submitting non-marketable "resting" limit orders and capturing a bid-ask spread. Typically, traditional market

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[32] Nasdaq declared self-help against NYSE Arca at approximately 2:37 p.m. (5 minutes prior to the main market disruption). BATS declared self-help against NYSE Arca at approximately 2:49 p.m. (after the E-Mini and SPY had reached their intra-day lows at 2:45 p.m.). *See* Section 3 for further details.

makers are "non-directional" or "market neutral" with respect to the securities for which they post quotations; however, a number of market makers utilize ETFs and other securities in order to hedge market exposure they may accumulate during imbalances in buy and sell order flow.[33]

On May 6, market makers reported that rapid price movements and market volatility occurring at about 2:45 p.m. caused internal risk limits to be breached. This in turn triggered their automated trading systems to widen the bid-ask spread of their quotes, as well as reduce the number of shares offered at these levels. For some market makers, self-imposed limits to trading during rapid market moves led to an immediate pause in providing liquidity in lieu of – or soon after – widening quotes.

Most market makers cited data integrity as a primary driver in their decision as to whether to provide liquidity at all, and if so, the manner (size and price) in which they would do so. On May 6, a number of market makers reported that rapid price moves in the E-Mini and individual securities triggered price-driven integrity pauses. Some, who also monitor the consolidated market data feeds, reported feed-driven integrity pauses. We note that even in instances where a market maker was not concerned (or even knowledgeable) about external issues related to feed latencies, or declarations of self-help, the very speed of price moves led some to question the accuracy of price information and, thus, to automatically withdraw liquidity. According to a number of market makers, their internal monitoring continuously triggered visual and audio alarms as multiple securities breached a variety of risk limits one after another.

Some market makers also experienced internal systems problems on May 6. Such problems tended to stem from difficulties in processing "overwhelming" external information wrought by the unique conditions of the day. In some cases, market makers that would have otherwise manually overridden their systems and continued providing liquidity were simply incapable of doing so in a timely manner due to the tremendous pressure caused by a flood of orders, executions, and market data that needed to be manually checked. As the majority of market makers required some form of human intervention to reenter the marketplace once automatic pauses were triggered, the time needed by the various market participants to reenter the market ranged from as short as a few seconds to as long as several hours.

In order to comply with their obligation to maintain continuous two-sided quotations, market makers utilize stub quotes if they choose to discontinue actively quoting.[34] Thus, on May 6, while in the process of reassessing whether to reenter the market, some market maker quotations had extended to stub quote levels – for market makers on Nasdaq or NYSE Arca such stub quotes could be automatically generated upon a market maker's withdrawal from the market.[35] When available liquidity for an ETF or stock was exhausted, marketable orders executed against stub quotes, and such executions ultimately represented a significant

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[33]   Some market makers reported that they did not commonly use futures for equity hedging purposes.

[34]   Stub quotes are quotes at unrealistically low or high prices that fulfill a market maker's obligation to provide continuous bids and offers, but at levels that the market maker does not expect to be reached under ordinary market conditions.

[35]   *See infra* at Section 2.C for a discussion of generation of and executions against stub quotes.

proportion of broken trades. We discuss market participants' use of stub quotes and their experience with broken trades in greater detail at the end of this section.

II.2.c. ETFs AND MAY 6

In our Preliminary Report, we noted that many of the securities experiencing the most severe price dislocations on May 6 were equity-based ETFs.[36] We therefore spent considerable time with ETF market makers to understand why this was the case. Some ETF market makers and liquidity providers treat ETFs as if they were the same as corporate stocks and do not track the prices of the individual securities underlying the ETF. Instead, this group bases its market making on immediate buy and sell interest, subject to trends in broad market indicators, including the E-Mini, that may affect a bias in their bids and offers. Others heavily depend upon the tracking of underlying securities as part of their ETF pricing and algorithmic modeling. And yet others trade in individual securities at the same time they trade ETFs. For the latter two categories, changes in the prices of individual securities that are components of an ETF directly affect the manner in which such market makers trade those ETFs.

For instance, market makers that track the prices of securities that are underlying components of an ETF are more likely to pause their trading if there are price-driven, or data feed-driven, integrity questions about those prices.[37] Moreover, extreme volatility in component stocks makes it very difficult to accurately value an ETF in real-time. When this happens, market participants who would otherwise provide liquidity for such ETFs may widen their quotes or stop providing liquidity (in some cases by using stub quotes) until they can determine the reason for the rapid price movement or pricing irregularities.[38] A large majority of ETF market makers with whom we spoke, and particularly those that value underlying stocks as part of their normal market making activities, paused their market making for considerable periods of time starting at about 2:45 p.m. on May 6. We believe this is one of the reasons equity-based ETFs were disproportionately affected by the extreme price volatilities of that afternoon. We further note that ETFs that do not derive their value from the prices of domestic equity securities were not disproportionately affected.

Anecdotally, market makers in ETFs reported that ETFs trade distinctly from individual securities, which often results in more concentrated liquidity on exchange order books. Specifically, they considered ETFs a "professional's market," where depth of book is more limited compared to individual stocks, and there are little, if any, resting retail orders far from the mid-quote. Sell pressure that overwhelms immediately-available near-inside liquidity is less likely to be "caught" by resting orders farther from the mid-quote in an ETF versus an individual stock.

To test this hypothesis we aggregated the liquidity books for the 100 largest ETFs (by market capitalization) into a single order book and compared that with an aggregate order book for

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[36]   *See* Preliminary Report, at Figure 18 and accompanying text.

[37]   The design of ETFs is intended to ensure that the market price of an ETF's shares generally track the ETF's net asset value (the value of its assets minus its liabilities), which can often be represented by a basket of securities. *See* Preliminary Report, Overview of ETFs, Appendix A at A-23.

[38]   The sensitivity of a market maker's model to an underlying stock movement will dictate the speed at which a firm widens and/or pauses its quotations.

the largest 100 individual stocks. These order books are presented in Charts 2.A, 2.B, 3.A, and 3.B.

The differences are significant. Market depth for the top 100 individual stocks is well-distributed from 10 through 500 basis points (Chart 2.A). In contrast, market depth for the top 100 ETFs is highly concentrated - approximately half of all liquidity is within 30 basis points of the mid-quote (Chart 3.A). At the peak of the decline, buy-side liquidity for the ETFs seems to suffer more severely, falling to 10% of their mid-day value compared to 20% for stocks.

When depth beyond 500 basis points is added to the charts the results are even more striking. For stocks, market depth at those levels doubles on the buy side and triples on the sell side (Chart 2.B). For ETFs the increase is much more modest (Chart 3.B). These results are consistent with the hypothesis that relative to the liquidity of large-cap stocks, much more of the liquidity in ETFs is provided by market professionals, such as market makers and HFTs, who tend to quote much closer to the inside of the market than do non-professional investors who may have price targets much further from the mid-quote. Therefore, when professionals pulled out because of data-integrity concerns, ETFs may not have had the same level of resting liquidity far from the mid-quote as did large-cap stocks, allowing a disproportionate number of ETF orders to hit stub-quote levels.

Of final note, several market makers indicated that they experienced some form of data latency from one or more of the exchanges, most notably NYSE Arca. However, though most ETFs are listed on NYSE Arca, only a few of the ETF market makers we interviewed raised this latency, or the declaration of self-help by other exchanges against NYSE Arca because of this latency, as an issue of concern on May 6. We explore this topic in further detail at the end of this section and in Section 3.

Chart 2.A: Non-ETF Top 100
Market Depth (within 500 basis points) and Net Aggressive Buy Volume
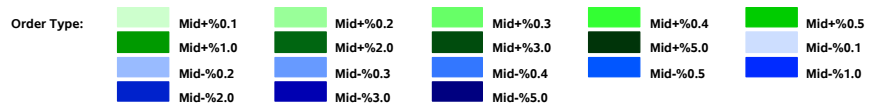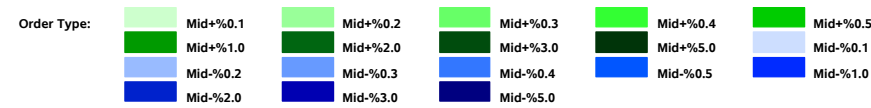

9:30am - 4:00pm

2:00pm - 3:30pm

2:30pm - 3:00pm

2:40pm - 2:55pm

Order Type:
Mid+%0.1 | Mid+%0.2 | Mid+%0.3 | Mid+%0.4 | Mid+%0.5
Mid+%1.0 | Mid+%2.0 | Mid+%3.0 | Mid+%5.0 | Mid-%0.1
Mid-%0.2 | Mid-%0.3 | Mid-%0.4 | Mid-%0.5 | Mid-%1.0
Mid-%2.0 | Mid-%3.0 | Mid-%5.0

Price: — — Minimum Executed Price ●●● Net Aggressive Buy Volume

The order book depth reflects the total number of shares in unfilled limit orders, by ticker and minute. The data combines the information from NYSE Openbook, ArcaBook, NASDAQ ModelView, and BATS order book data.
Net Aggressive Buy Volume is defined as executed shares associated with aggressive buy orders minus executed shares associated with aggressive sell orders.
Aggressive buy orders are market buy orders and buy orders at or above the offer price. Aggressive sell orders are market sell orders and sell orders at or below the bid price.

Chart 2.B: Non-ETF Top 100
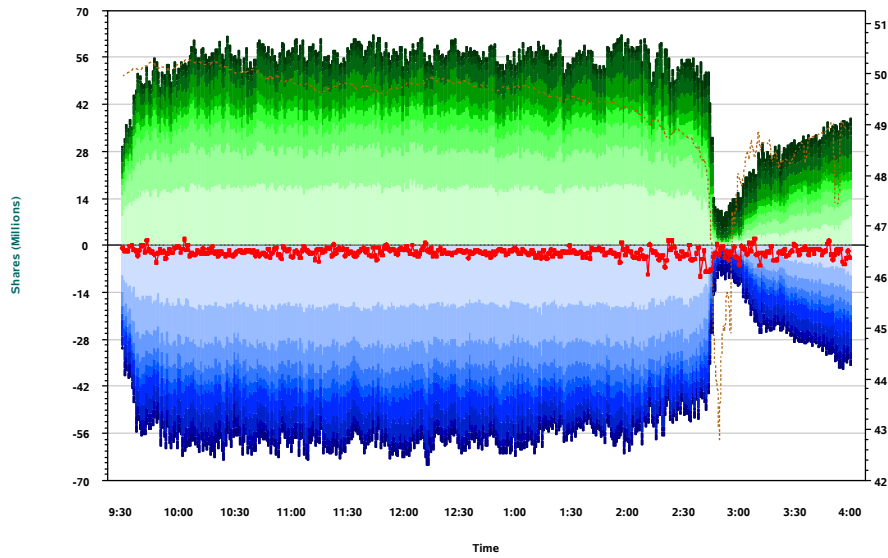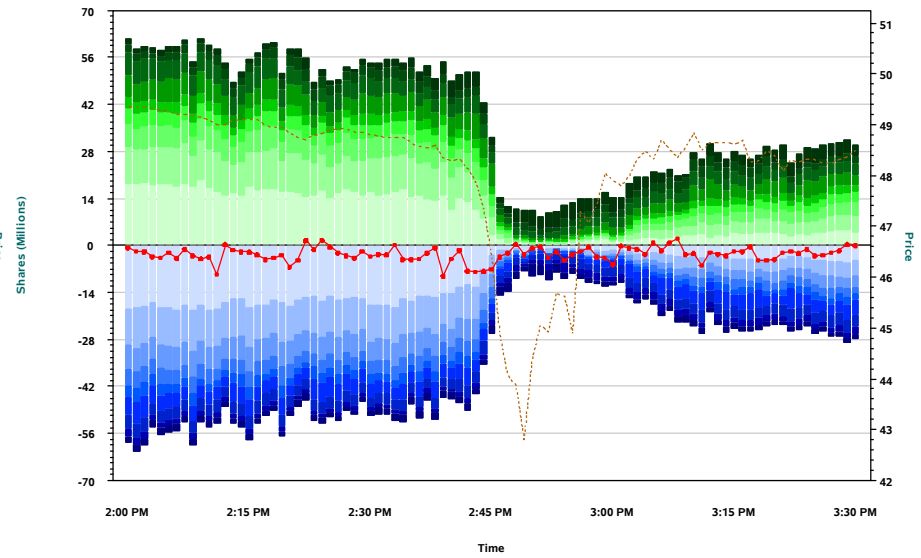## Full Market Depth and Net Aggressive Buy Volume

9:30am - 4:00pm

2:00pm - 3:30pm

2:30pm - 3:00pm

2:40pm - 2:55pm

Order Type:
- Mid+%0.1
- Mid+%0.2
- Mid+%0.3
- Mid+%0.4
- Mid+%0.5
- Mid+%1.0
- Mid+%2.0
- Mid+%3.0
- Mid+%5.0
- Mid+%5.0+
- Mid-%0.1
- Mid-%0.2
- Mid-%0.3
- Mid-%0.4
- Mid-%0.5
- Mid-%1.0
- Mid-%2.0
- Mid-%3.0
- Mid-%5.0
- Mid-%5.0+

Price: — — Minimum Executed Price   ●─●─● Net Aggressive Buy Volume

The order book depth reflects the total number of shares in unfilled limit orders, by ticker and minute. The data combines the information from NYSE Openbook, ArcaBook, NASDAQ ModelView, and BATS order book data.
Net Aggressive Buy Volume is defined as executed shares associated with aggressive buy orders minus executed shares associated with aggressive sell orders.
Aggressive buy orders are market buy orders and buy orders at or above the offer price. Aggressive sell orders are market sell orders and sell orders at or below the bid price.

Chart 3.A: ETF Top 100
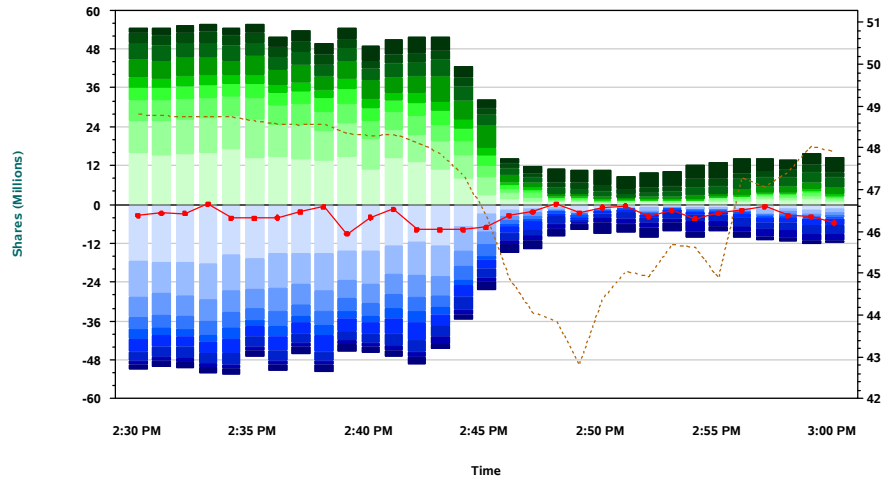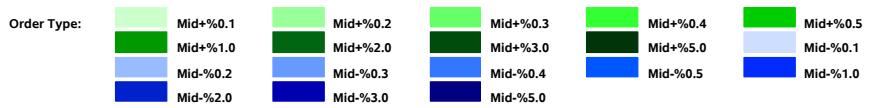## Market Depth (within 500 basis points) and Net Aggressive Buy Volume
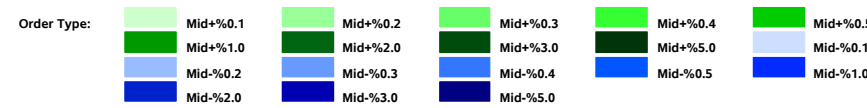

9:30am - 4:00pm

2:00pm - 3:30pm

2:30pm - 3:00pm

2:40pm - 2:55pm

Order Type:
Mid+%0.1, Mid+%0.2, Mid+%0.3, Mid+%0.4, Mid+%0.5
Mid+%1.0, Mid+%2.0, Mid+%3.0, Mid+%5.0, Mid-%0.1
Mid-%0.2, Mid-%0.3, Mid-%0.4, Mid-%0.5, Mid-%1.0
Mid-%2.0, Mid-%3.0, Mid-%5.0

Price: Minimum Executed Price   Net Aggressive Buy Volume

The order book depth reflects the total number of shares in unfilled limit orders, by ticker and minute. The data combines the information from NYSE Openbook, ArcaBook, NASDAQ ModelView, and BATS order book data.
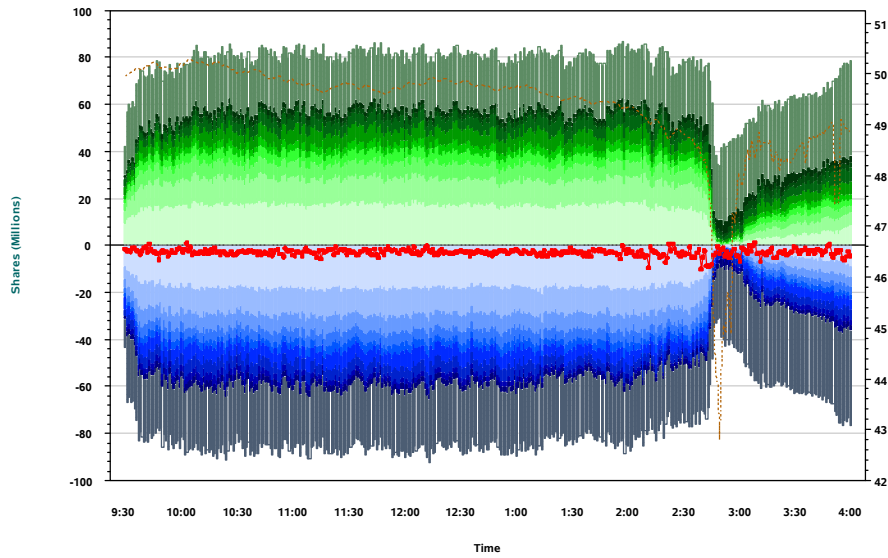Net Aggressive Buy Volume is defined as executed shares associated with aggressive buy orders minus executed shares associated with aggressive sell orders.
Aggressive buy orders are market buy orders and buy orders at or above the offer price. Aggressive sell orders are market sell orders and sell orders at or below the bid price.
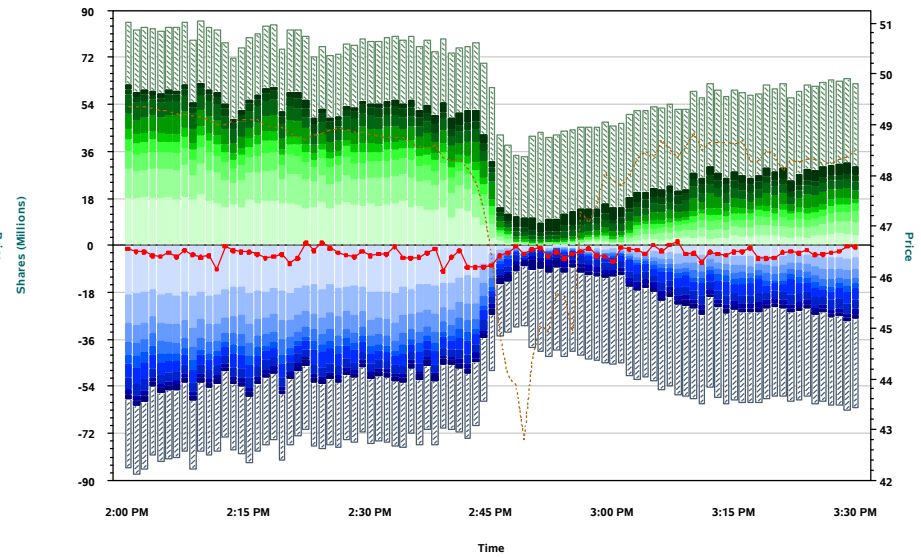
Chart 3.B: ETF Top 100
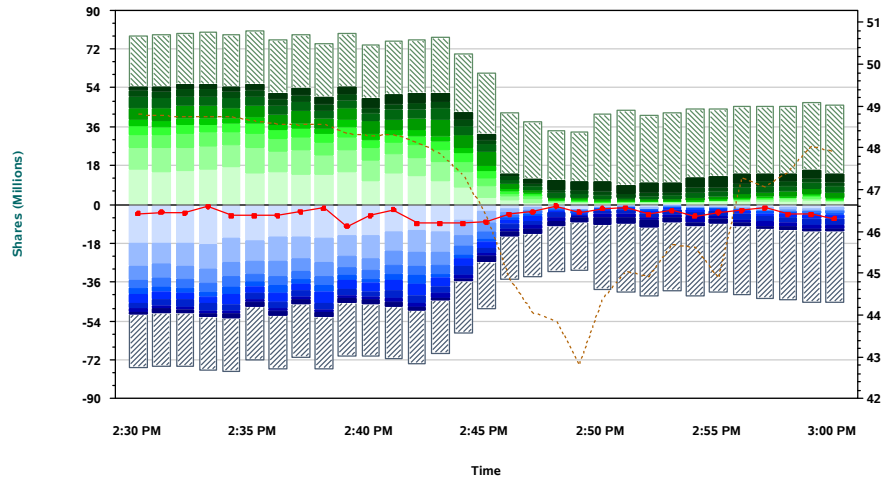## Full Market Depth and Net Aggressive Buy Volume
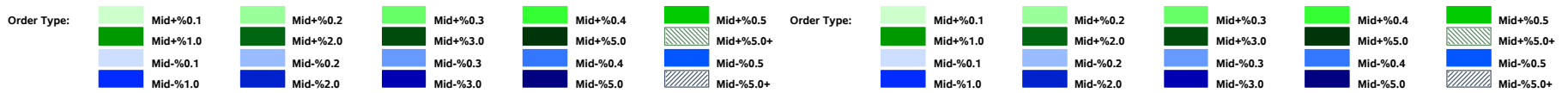

9:30am - 4:00pm

2:00pm - 3:30pm

2:30pm - 3:00pm

2:40pm - 2:55pm

Order Type:
Mid+%0.1 Mid+%0.2 Mid+%0.3 Mid+%0.4 Mid+%0.5
Mid+%1.0 Mid+%2.0 Mid+%3.0 Mid+%5.0 Mid+%5.0+
Mid-%0.1 Mid-%0.2 Mid-%0.3 Mid-%0.4 Mid-%0.5
Mid-%1.0 Mid-%2.0 Mid-%3.0 Mid-%5.0 Mid-%5.0+

Order Type:
Mid+%0.1 Mid+%0.2 Mid+%0.3 Mid+%0.4 Mid+%0.5
Mid+%1.0 Mid+%2.0 Mid+%3.0 Mid+%5.0 Mid+%5.0+
Mid-%0.1 Mid-%0.2 Mid-%0.3 Mid-%0.4 Mid-%0.5
Mid-%1.0 Mid-%2.0 Mid-%3.0 Mid-%5.0 Mid-%5.0+

Price: — — — Minimum Executed Price   ●●● Net Aggressive Buy Volume

Price: — — — Minimum Executed Price   ●●● Net Aggressive Buy Volume

The order book depth reflects the total number of shares in unfilled limit orders, by ticker and minute. The data combines the information from NYSE Openbook, ArcaBook, NASDAQ ModelView, and BATS order book data.
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Aggressive buy orders are market buy orders and buy orders at or above the offer price. Aggressive sell orders are market sell orders and sell orders at or below the bid price.

II.2.d. EQUITY-BASED HIGH FREQUENCY TRADERS

HFTs are proprietary trading firms that use high speed systems to monitor market data and submit large numbers of orders to the markets. HFTs utilize quantitative and algorithmic methodologies to maximize the speed of their market access and trading strategies.[39] Some HFTs are hybrids, acting as both proprietary traders and as market makers. In addition, some HFT strategies may take "delta-neutral" approaches to the market (ending each trading day in a flat position), while others are not delta-neutral and sometimes acquire net long and net short positions.

Of the HFTs we interviewed, we did not find uniformity in response to market conditions on May 6. Although some HFTs exited the market for reasons similar to other market participants, such as the triggering of their internal risk parameters due to rapid price moves and subsequent data-integrity concerns, other HFTs continued to trade actively. Among those HFTs that continued to trade, motivations varied, but were in part based on whether they thought their algorithms would be able to operate successfully (profitably) under the extreme market conditions observed that afternoon.

We examined the aggregate minute-by-minute dollar volume of trading by the 12 largest HFTs as reflected in audit trail data reported to FINRA[40] for securities listed on NYSE, NYSE Arca (which are primarily ETFs), and Nasdaq. This audit trail data includes trades reported by Nasdaq, reported to the Nasdaq TRF, and the ADF. It does not include trades executed on any other exchanges, including the NYSE, NYSE Arca, and BATS, or reported to any other exchange's trade reporting facility. Accordingly, the data encompasses less than half of the trading volume during the most volatile period on May 6. Moreover, HFTs generally are understood to be less active in the OTC market than in exchange markets. However, we believe that the data provides a useful means to evaluate the extent to which large HFTs participated, and withdrew from participation, in the combined Nasdaq and OTC markets on May 6. This data should not be used, however, to estimate total HFT participation across all markets.

Based on analysis of FINRA data, we found that 6 of the 12 HFTs scaled back their trading during some point after the broad indices hit their lows at about 2:45 p.m. Two HFTs largely stopped trading at about 2:47 p.m. and remained inactive through the rest of the day. Four other HFTs appear to have each significantly curtailed trading for a short period of time,

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[39] As noted in the Preliminary Report, other characteristics often attributed to proprietary firms engaged in high frequency trading are: (1) the use of high-speed and sophisticated computer programs for generating, routing, and executing orders; (2) use of co-location services and individual data feeds offered by exchanges and others to minimize network and other types of latencies; (3) very short time-frames for establishing and liquidating positions; (4) the submission of numerous orders that are cancelled shortly after submission; and (5) ending the trading day in as close to a flat position as possible (that is, not carrying significant, unhedged positions overnight). *See* Preliminary Report.

[40] These firms were identified by FINRA as either engaging in high frequency trading strategies (such as electronic market making or statistical arbitrage), or providing trading access to other HFT firms. The FINRA Equity Trade Journal data contains information on reported trades from Nasdaq, the Nasdaq Trade Reporting Facility (TRF), and the Alternative Display Facility (ADF). As noted in the text, the FINRA data contains only a subset of all trading activity. If a market participant identifier of these high frequency trading firms is on either side of the trade report, we count that trade as a HFT trade. During the period from 9:31 a.m. to 2:45 p.m., the 12 HFTs were involved in 46% of the trades in the FINRA Equity Trade Journal data.

ranging from as little as one minute (from 2:46 p.m. to 2:47 p.m.) to as long as 21 minutes (from 2:57 p.m. to 3:18 p.m.).

Figures 2.1, 2.2, and 2.3 show that aggregate trading activity of these 12 HFTs picked up just after 2:30 p.m. and increased significantly during the period in which the broad indices were rapidly declining from 2:43 p.m. through 2:46 p.m. Table II.1 shows that HFT trading activity during those three minutes increased by over 250% for NYSE Arca-listed securities, which we note are predominately ETFs.

Table II.1 HFT Trading Activity Per Minute of 12 HFTs (FINRA Data Set)

Market	2:43 to 2:46 p.m. ($ Mil.)	2:00 to 3:00 p.m., ex 2:43 to 2:46 p.m. ($ Mil.)	Percent Change
NYSE	368.8	168.0	117%
NYSE Arca	1,011.7	285.6	254%
Nasdaq	310.9	134.7	131%

These figures also show that as the broad markets recovered after 2:46 p.m., HFT activity in Nasdaq-listed stocks returned to prior (pre-2:43 p.m.) levels, activity in NYSE-listed stocks declined slightly, but activity in NYSE Arca-listed securities fell more dramatically. Since over two-thirds of the securities with broken trades were ETFs listed on NYSE Arca, we compared HFT trading activity in all securities with broken trades against those without broken trades.

As shown in Figures 2.4, 2.5, and 2.6, for securities listed at NYSE, NYSE Arca, and Nasdaq, participation rates of the 12 HFTs with and without broken trades were approximately equal from about 2:00 p.m. through 2:40 p.m. More notable, average participation rates for securities listed on NYSE Arca are higher than for NYSE or Nasdaq securities. The figures also show that at about 2:50 p.m., participation rates for securities with broken trades and those without broken trades diverge for securities listed on each of the three exchanges, but most noticeably in NYSE Arca-listed securities (particularly when compared to the previously high rate of participation in NYSE Arca-listed securities).

The data suggests that for at least the period from 2:00 p.m. through 2:40 p.m. on May 6, HFTs were relatively more active in ETFs (listed primarily NYSE Arca) than corporate stocks (listed primarily on NYSE and Nasdaq). Furthermore, their reduced participation in NYSE Arca-securities with broken trades reveals that they too were part of the general withdrawal of liquidity seen in those products.

Lastly, we examined the FINRA data set for HFT buying and selling activity to see if HFTs traded more heavily on one side or the other during the rapid decline of the broad market indices. In general, the FINRA data set indicates that HFTs were primarily sellers of securities on May 6. As an example, Figure 2.7 plots buys versus sells over the course of the day for all three types of listed securities. Prior to 2:00 p.m., HFT sells accounted for about 52.4% of their total activity in these stocks. Between 2:00 p.m. and 2:45 p.m., HFTs increased selling to 53.5% of their activity, and from 2:46 p.m. to 4 p.m., HFT selling activity dropped back to 52.0% of their activity. As discussed in Section 1 above, a portion of this selling of securities could be attributable to cross-market strategies in which one or more of the HFTs were contemporaneously buying a futures product and selling ETFs or stocks. In addition, one or more HFTs may have engaged in cross-product strategies of buying ETFs and contemporaneously selling stocks (or vice versa).

To assess HFT trading during the market decline in a more comprehensive fashion, we also examined a data set obtained from the largest public quoting markets on May 6 – each of the equities exchanges and Direct Edge (EDGA and EDGX). This data included total dollar volume on those markets across all securities by 15-minute increments, and was further categorized according to liquidity-taking and liquidity-providing buys and sells. Specific participant data was also provided for each executing broker-dealer that was among the top 20

aggressive sellers on each market during the rapid price decline on May 6. From this list of aggressive sellers, we aggregated data for 17 executing broker-dealers that appear to be primarily associated with HFT firms in order to compare trading patterns of these firms with the rest of the market. The group should not be used to extrapolate the overall percentage of trading volume of HFTs because it does not include, for example, the proprietary trading desks of multi-service broker-dealers that may engage in HFT strategies. Moreover, this data set does not include trading in the OTC market (except for Direct Edge).

For the 6-business-day period of May 3 through May 10, these 17 HFT firms averaged 43.8% of total dollar volume on the public quoting markets. Their trading was divided between 51.5% liquidity-taking buys and sells (aggressive trading – generally taking bids and lifting offers) and 48.5% liquidity-providing buys and sells (passive trading – generally posting bids and offers). Figure 2.8 plots the net aggressive dollar volume (total aggressive buys minus total aggressive sells – a positive figure means that the HFT firms were aggressively buying more than they were aggressively selling, and a negative number means that the HFT firms were aggressively selling more than they were aggressively buying), along with the dollar trading volume of the 17 HFT firms as a percentage of the total dollar trading volume on the public quoting markets. In addition, Table II.2 below sets forth the volume of their trading in each of four categories (aggressive selling, aggressive buying, passive selling, and passive buying) during 15 minute periods over the course of May 6, along with the percentage of the public quoting markets in each of those categories.

As a percentage of total market dollar volume, the activity for these 17 HFT firms increased in the period from 2:00 p.m. through 2:45 p.m. to a high of 50.3%, before sharply falling to 36.6% in the period from 2:46 through 3:00 p.m. This pattern is consistent with some HFT firms reducing or pausing trading during that time. Notably, the 17 HFT firms escalated their aggressive selling more significantly (reaching a total of $9.3 billion) than any other category of trading during the rapid price decline in the period ending 2:45 p.m. As noted above, a portion of this aggressive selling could be attributable to cross-market strategies in which the firms were contemporaneously buying futures products. In general, however, it appears that the 17 HFT firms traded with the price trend on May 6 and, on both an absolute and net basis, removed significant buy liquidity from the public quoting markets during the downturn.

Dollar Volume of 12 High Frequency Traders
NYSE Listed
(FINRA Data Set)

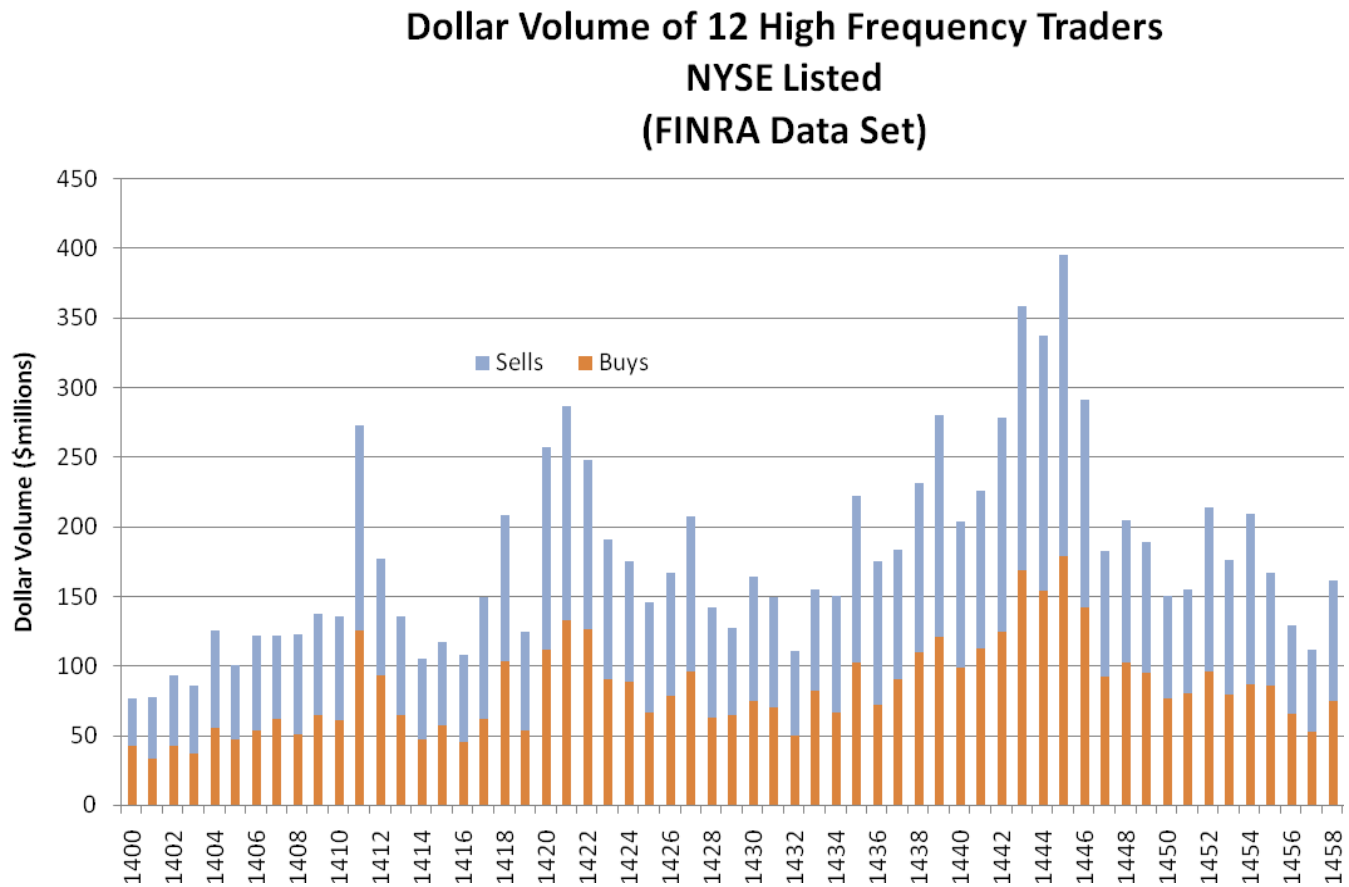Dollar Volume of 12 High Frequency Traders
NYSE Arca Listed
(FINRA Data Set)

Figure 2.3: Dollar Volume of High Frequency Traders for Nasdaq-Listed Securities

Dollar Volume of 12 High Frequency Traders
NASDAQ Listed
(FINRA Data Set)

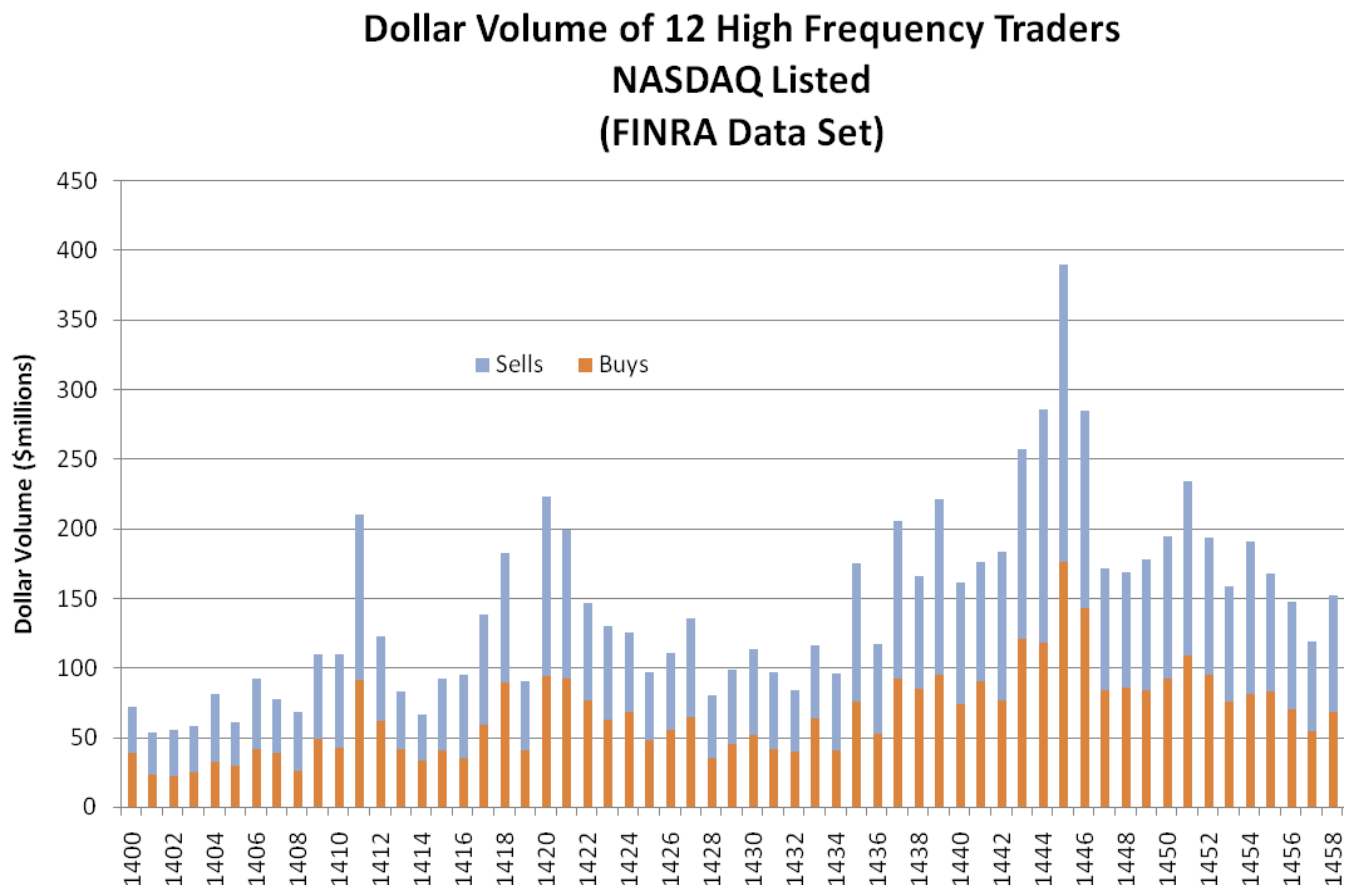**May 6, 2010 Market Event Findings**

Trade Participation Rate of 12 HFTs
NYSE Listed With & Without Broken Trades
(FINRA Data Set)

Figure 2.5: HFT Participation Rates for NYSE Arca-Listed Securities

Trade Participation Rate of 12 HFTs
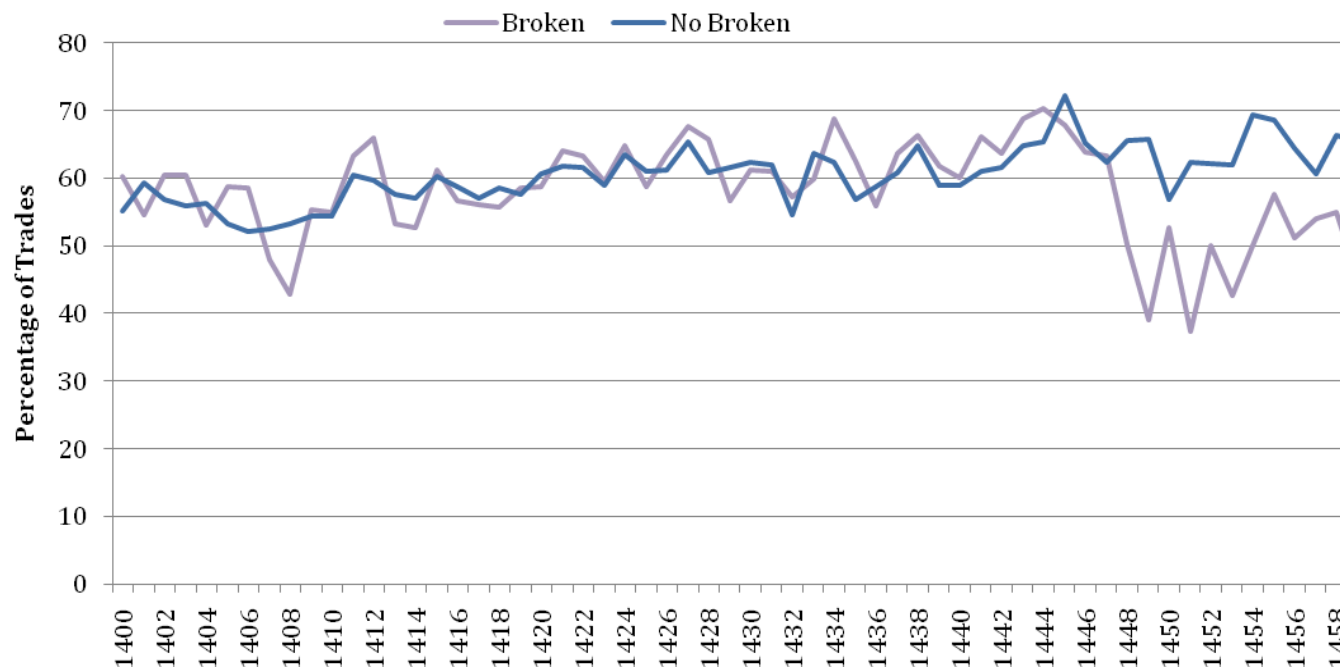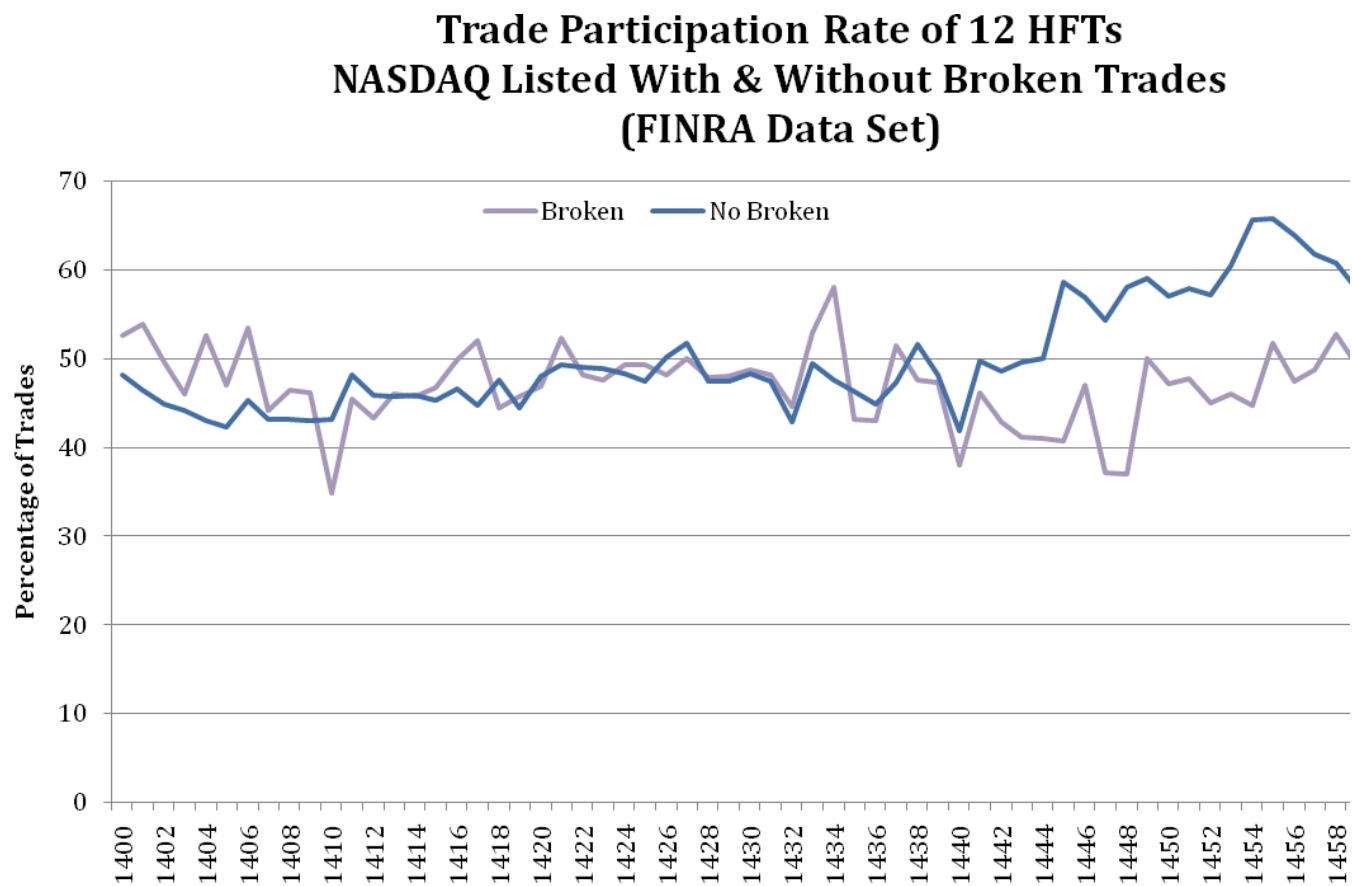NYSE Arca Listed With & Without Broken Trades
(FINRA Data Set)

　　　　　　　　　　　　　　May 6, 2010 Market Event Findings

Trade Participation Rate of 12 HFTs
NASDAQ Listed With & Without Broken Trades
(FINRA Data Set)

Figure 2.7: HFT Buying and Selling Ratios for Securities Listed on Nasdaq, NYSE Arca, and NYSE

HFT %Sell Dollar Volume
NASDAQ, NYSE Arca, and NYSE Listed
(FINRA Data Set)
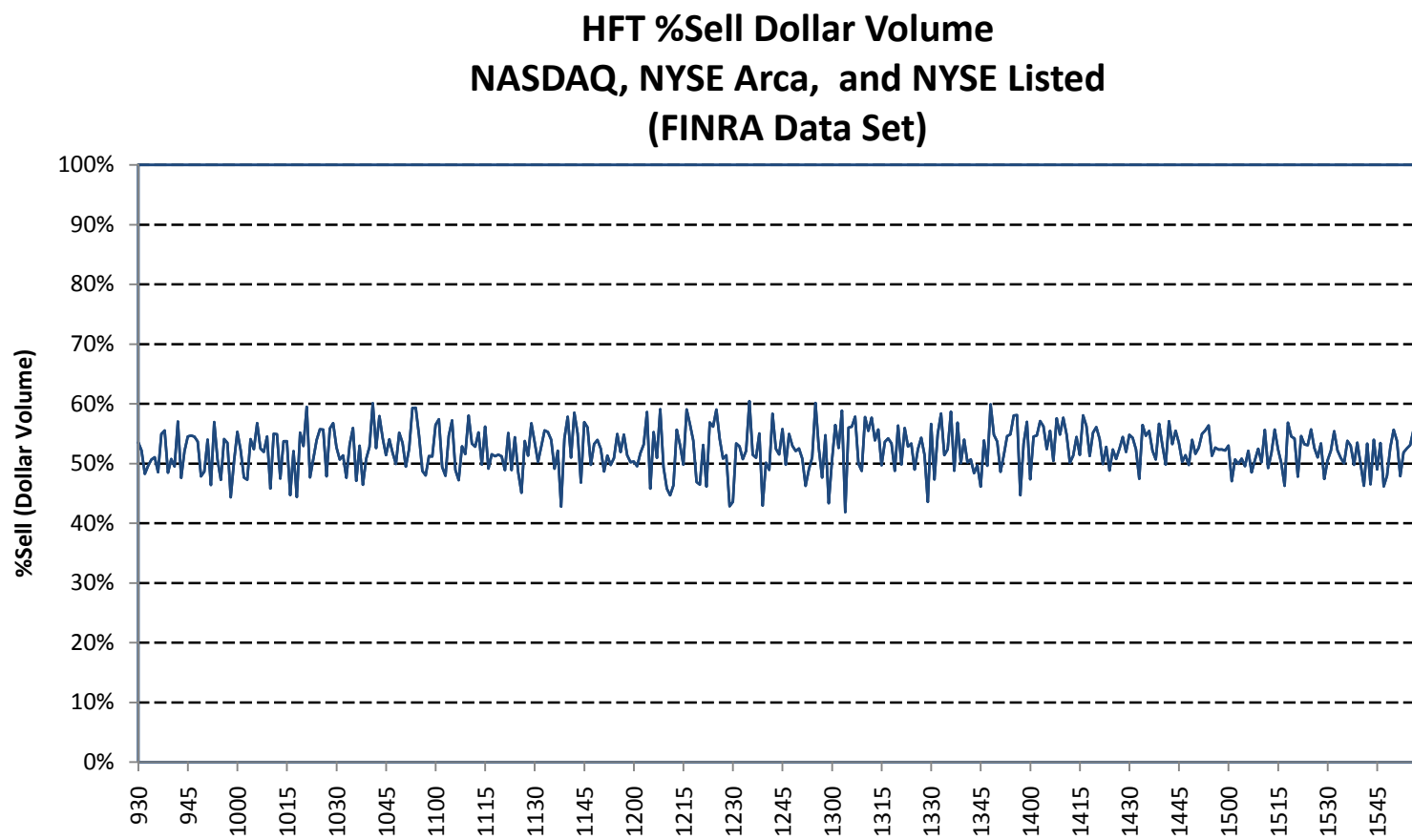
Figure 2.8: Aggressive Order Imbalance and Volume of 17 HFT Firms in Public Quoting Markets

Aggressive Order Imbalance and Volume of 17 HFT Firms
May 3 - May 10
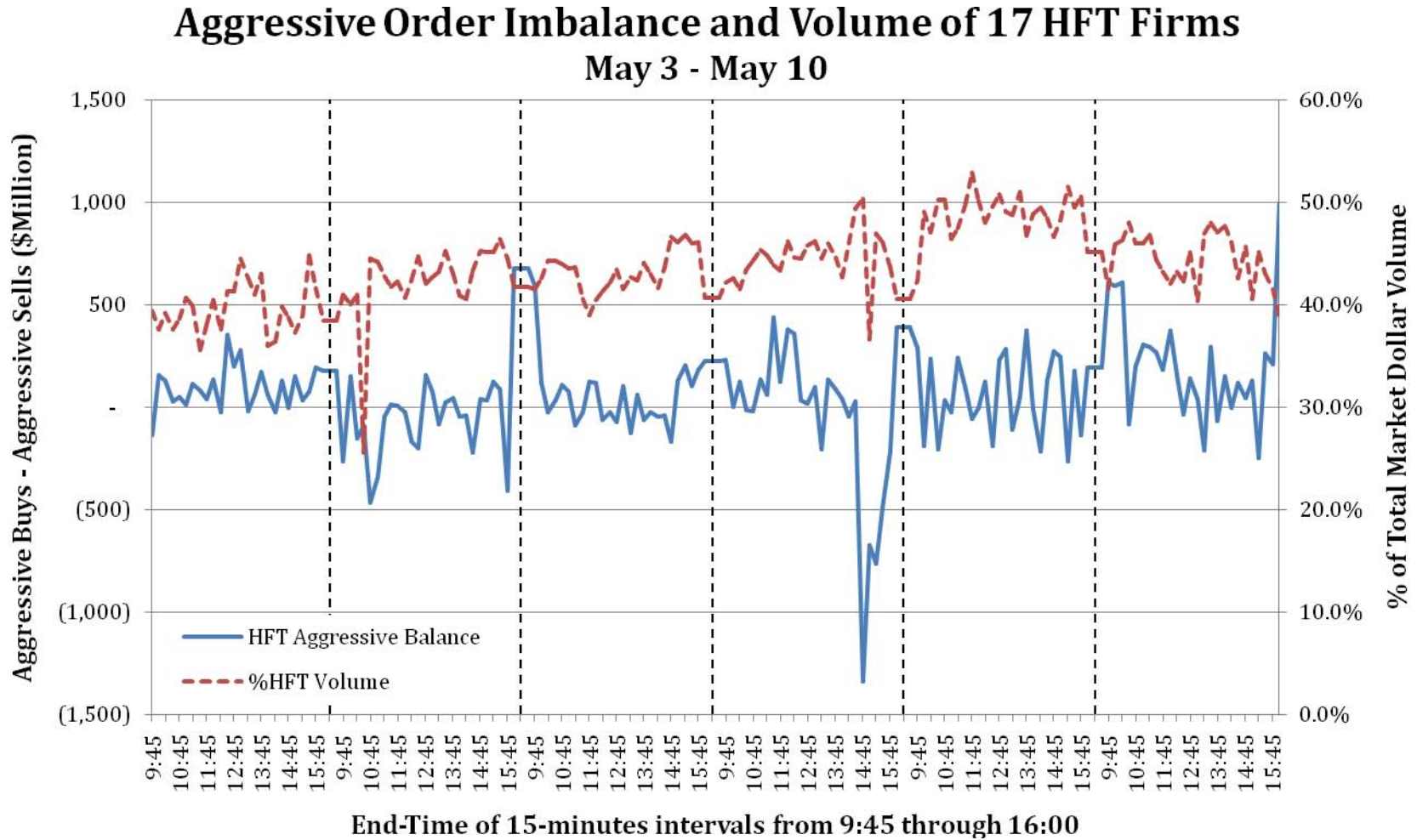
May 6, 2010 Market Event Findings

Table II.2: Dollar Volume of 17 High Frequency Trading Firms in Public Quoting Markets on May 6

| | HFT ($ Millions) | | | | | | | % of Total Market | | | | |
| | Aggressive | | | Passive | | | | Aggressive | | Passive | | |
	Sell	Buy	Net	Sell	Buy	Net	Long/Short	Sell	Buy	Sell	Buy	Total
9:45 AM	2,674	2,904	230	3,044	2,723	-322	-92	39.2%	37.8%	40.5%	40.9%	42.2%
10:00 AM	2,449	2,447	-2	2,278	2,331	53	51	38.8%	41.3%	39.5%	37.8%	42.6%
10:15 AM	2,046	2,170	123	2,000	1,918	-82	42	39.8%	40.2%	37.9%	38.2%	41.5%
10:30 AM	2,141	2,128	-13	1,879	1,828	-51	-64	41.0%	44.1%	40.0%	36.0%	43.4%
10:45 AM	2,085	2,063	-22	1,789	1,790	1	-21	41.9%	45.1%	40.2%	36.9%	44.3%
11:00 AM	2,654	2,785	131	2,432	2,424	-9	122	40.4%	47.0%	42.1%	37.7%	45.3%
11:15 AM	2,667	2,728	61	2,443	2,396	-47	15	39.4%	47.1%	43.2%	36.2%	44.8%
11:30 AM	2,224	2,659	435	2,669	2,214	-454	-19	38.9%	40.8%	41.8%	39.6%	43.9%
11:45 AM	1,683	1,805	122	1,631	1,612	-19	103	38.0%	44.4%	41.2%	37.3%	43.3%
12:00 PM	2,316	2,695	379	2,549	2,274	-275	104	40.3%	45.5%	44.1%	40.6%	46.2%
12:15 PM	1,790	2,145	355	2,010	1,792	-218	137	41.2%	41.7%	40.0%	42.4%	44.6%
12:30 PM	1,390	1,422	32	1,276	1,230	-46	-14	41.0%	45.4%	42.0%	37.3%	44.5%
12:45 PM	1,324	1,339	15	1,115	1,136	20	35	43.2%	47.4%	40.8%	38.2%	45.8%
1:00 PM	1,624	1,720	96	1,560	1,437	-123	-27	42.8%	47.1%	44.0%	38.9%	46.2%
1:15 PM	1,642	1,434	-208	1,233	1,318	85	-123	42.9%	45.8%	40.6%	35.5%	44.4%
1:30 PM	2,294	2,425	131	2,269	2,139	-130	1	39.9%	46.6%	44.8%	38.1%	46.0%
1:45 PM	1,834	1,919	85	1,811	1,688	-123	-38	39.0%	45.5%	44.2%	36.8%	44.6%
2:00 PM	1,834	1,871	37	1,879	1,651	-228	-191	38.2%	41.8%	43.3%	35.4%	42.6%
2:15 PM	4,002	3,955	-47	3,739	3,517	-221	-268	41.2%	47.6%	46.4%	37.1%	46.0%
2:30 PM	5,786	5,814	28	5,571	5,294	-277	-249	44.6%	49.0%	48.2%	41.8%	49.3%
2:45 PM	9,302	7,959	-1,343	7,528	7,714	185	-1,158	47.1%	51.8%	50.2%	39.9%	50.3%
3:00 PM	5,748	5,071	-677	5,575	5,480	-95	-772	34.0%	32.9%	37.8%	33.5%	36.6%
3:15 PM	5,820	5,054	-765	5,515	5,428	-86	-852	46.3%	42.2%	47.3%	44.3%	47.0%
3:30 PM	5,220	4,732	-488	4,823	4,984	160	-328	43.2%	45.0%	47.0%	42.2%	46.0%
3:45 PM	4,763	4,547	-216	4,677	4,324	-353	-568	42.6%	41.0%	43.4%	39.8%	43.7%
4:00 PM	6,173	6,561	388	7,658	7,194	-465	-76	33.3%	37.8%	45.7%	40.1%	40.6%

II.2.e. INTERNALIZERS

Internalizers, composed of both OTC market makers and block positioners, handle orders of their own customers or customers of other broker-dealers. Those acting as OTC market makers appear to handle a very large percentage of marketable (immediately executable) order flow of individual investors. Internalizers tend to use their own capital to trade opposite of retail customers. Normally, they match or provide price improvement compared to the NBBO that customers would receive if their order were sent directly to an exchange. If an internalizer is unwilling to match or improve the NBBO for a particular order, it will route the order to other trading centers. In doing so, it will generally prefer trading centers that do not charge an access fee, including dark pools[41] and even other internalizers, but if the order is not filled within a short time it will be routed directly to an exchange displaying the best available price.[42]

Internalizer behavior varied on May 6. For example, block positioners – with primarily institutional customers – presented a very different view than OTC market makers. Block positioners indicated that they were indirectly affected by the extreme volatility of May 6, since many of their clients backed away from the market in order to give themselves time to digest and make sense of events. On the other hand, OTC market makers indicated that their behavior was directly affected by market events and that they paused or halted internalization for some period of time.

For instance, some OTC internalizers reduced their internalization on sell-orders but continued to internalize buy-orders, as their position limit parameters were triggered. Other internalizers halted their internalization altogether. Among the rationales for lower rates of internalization were: very heavy sell pressure due to retail market and stop-loss orders, an unwillingness to further buy against those sells, data integrity questions due to rapid prices moves (and in some cases data latencies), and intra-day changes in P&L that triggered predefined limits. In some instances, when internalizers attempted to route some of their order flow to a dark pool or other internalizer, orders were rebuffed. Partly, this was due to internal systems issues at some entities, and partly this was because each internalizer was experiencing the same events and making the same decisions to reduce or halt internalization. Data on total volume by exchange clearly shows where internalizers and (though not extensively interviewed) dark pools stopped providing liquidity for incoming orders. Internalizers instead routed orders to the exchanges, putting further pressure on the liquidity that remained in those venues.

Trading volume across all markets reflects this withdrawal of liquidity. OTC trades are reported to a FINRA facility: the ADF or a TRF. The primary sources of ADF/TRF trades are OTC market makers and other internalizers, dark pools (alterative trading systems) that do not display quotations in the consolidated quotation data), and ECNs. On May 6, the ECNs

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[41]   Dark pools are alternative trading systems that do not provide their best-priced orders for inclusion in the consolidated quotation data. In general, dark pools offer trading services to institutional investors and others that seek to execute large trading interest in a manner that will minimize the movement of prices against their trading interest and thereby reduce trading costs.

[42]   An OTC market maker will rarely route an actual customer order. Instead it will route a corresponding principal order and when it is executed, the market maker will execute the customer order on a riskless principal basis.

with the most volume were EDGA and EDGX, operated by Direct Edge, and now operated as national securities exchanges. As shown in Figures 2.9 and 2.10, ADF/TRF trades as a percentage of overall trading volume declined rapidly after the price decline began at approximately 2:30 p.m. The first chart sets forth the total volume of ADF/TRF trades. The second chart focuses on the period from 2:00 p.m. to 2:30 p.m., and removes the volume of ADF/TRF trades attributable to EDGA and EDGX.[43]

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[43] EDGA and EDGX usually account for about 10% of consolidated volume. The other ECNs that report to a TRF account for a very small percentage of total volume.

Figure 2.9: *Volume across each large market venue*

Percent Shares Traded by Market Center
One-Minute Intervals

Legend: ADF/TRF, NASDAQ, NYSE, ARCA, BATS

May 6, 2010 Market Event Findings
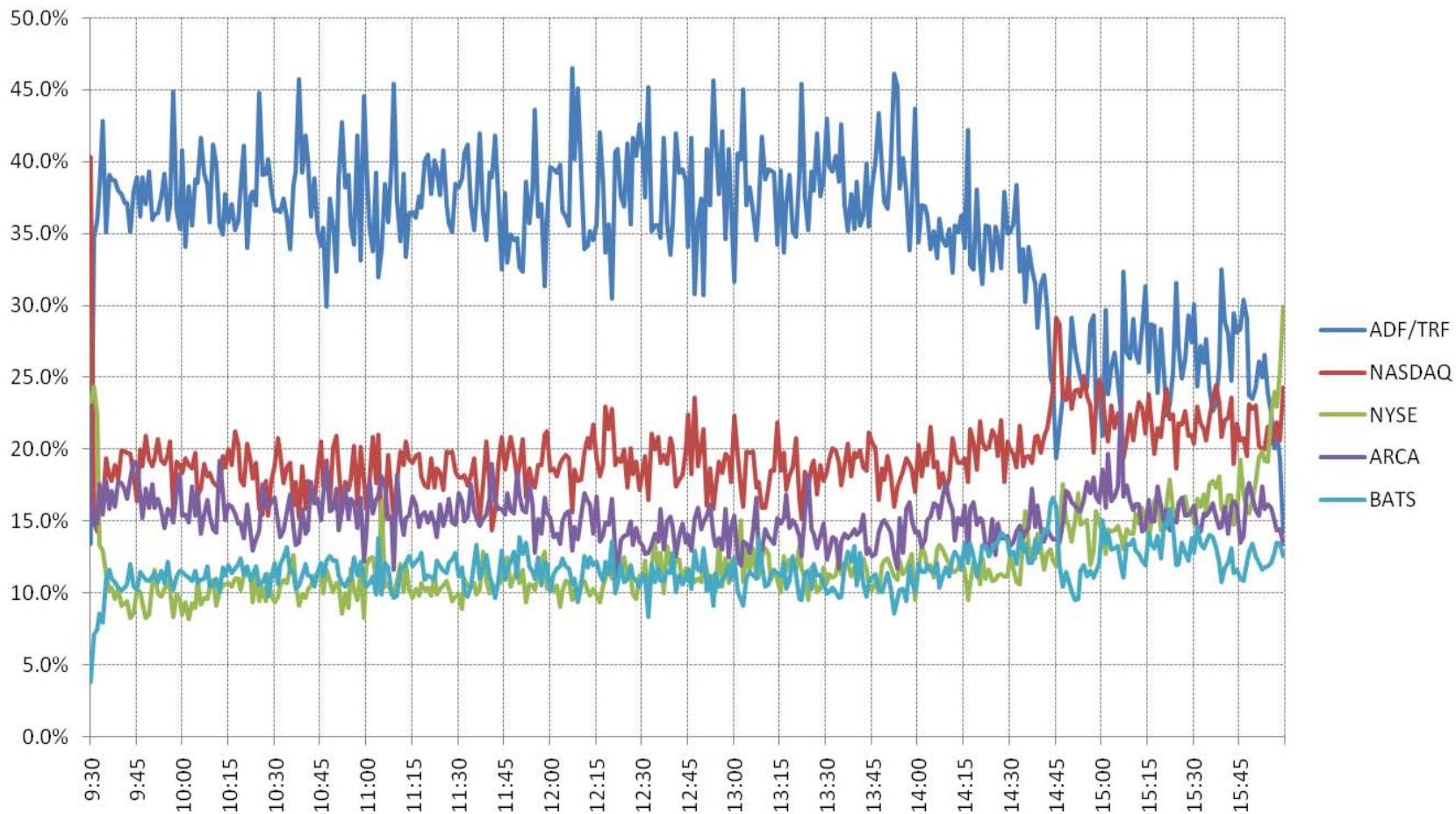
Figure 2.10: *Volume across each large market venue adjusted for Direct Edge*

Percent Shares Traded by Market Center, Adjusted for Direct Edge
One-Minute Intervals, 14:00 - 15:00

Legend: ADF/TRF 2, NASDAQ, NYSE, ARCA, BATS, Direct Edge
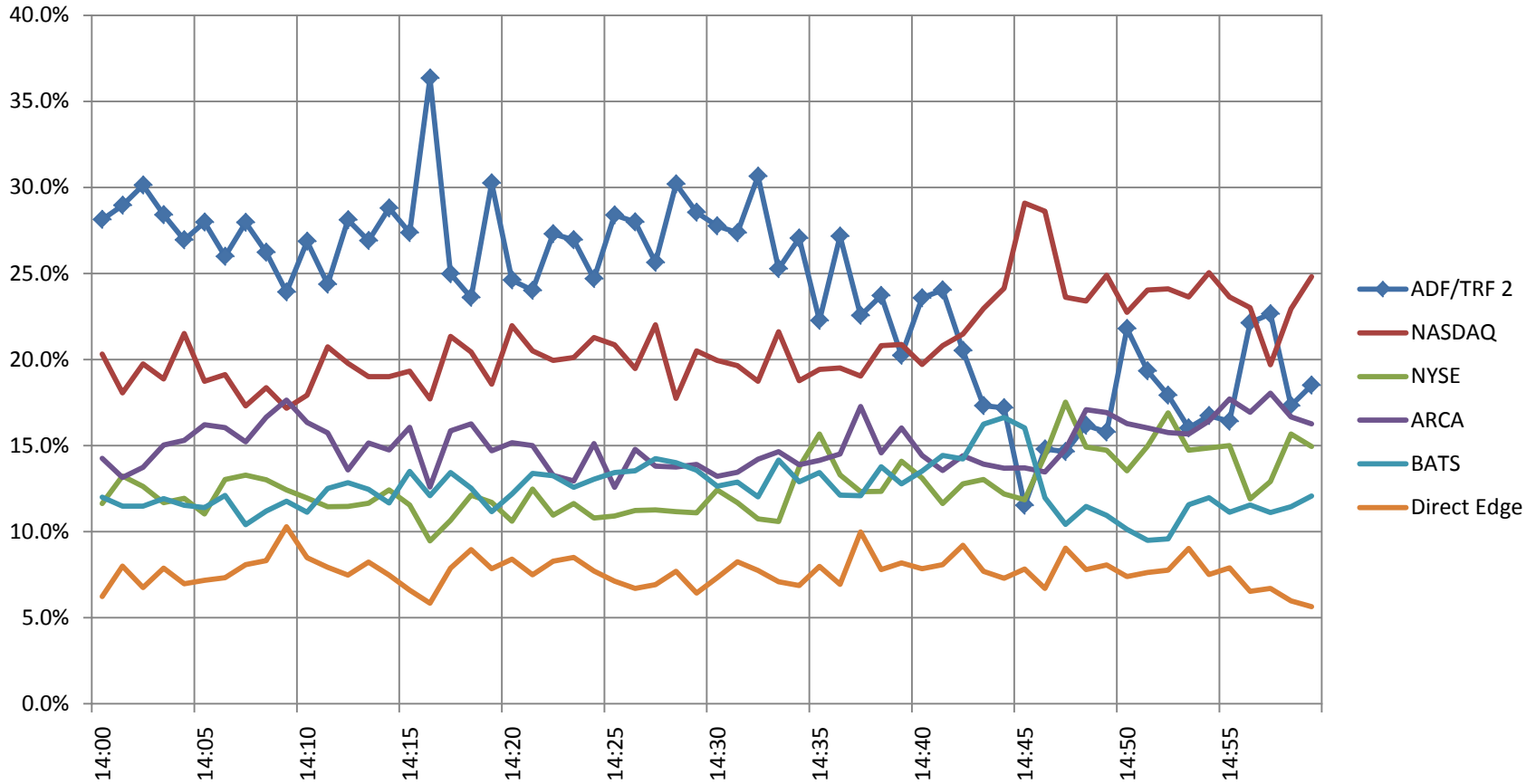
As can be seen in Figure 2.10, ADF/TRF volume percentages (excluding EDGA and EDGX) declined from 25-30% prior to the market disruption on May 6 to approximately 11% at approximately 2:45 p.m. This is consistent with a general reduction of internalization by OTC market makers and an increase in the number of transactions that were executed in the public markets as riskless principal. As discussed at the end of this section, orders that were part of this surge account for about half of the trades that were executed at the most depressed and extreme prices.

II.2.f.   OPTIONS MARKET MAKERS

Liquidity on options exchanges is derived from orders to buy or sell particular options series and quotations submitted by members of an exchange that are registered as options market makers ("OMMs"). Generally, however, the market for listed options depends upon the liquidity supplied by professional liquidity providers, such as market makers, to a greater extent than in the market for NMS stocks. This is due in part to the greater dispersion of trading interest across the thousands of series of listed options.[44]

The options exchanges allow a member, on a voluntary basis, to register as an OMM. All of the options exchanges, except BATS and NOM, require that at least one market maker be registered in a class in order for trading to occur in that class. As a practical matter, because equity options are multiply-traded across the options exchanges, a particular options class generally would not trade without a market maker on at least one exchange. Pursuant to the options exchanges' rules, the transactions of an OMM in its market making capacity generally must constitute a course of dealings reasonably calculated to contribute to the maintenance of a fair and orderly market, including maintaining two-sided quotations.[45]

We spoke with several of the options exchanges and OMMs regarding how the options markets and its participants functioned on May 6. In general, the options markets and participants reported that trading in options did not experience similar disruptions as in the underlying securities markets. However, because OMMs' behavior is heavily influenced by underlying market conditions, some OMMs widened their quotes or exited the options market on May 6.

OMMs reported that they make markets in options by calculating the value of the underlying security or basket of securities and then quoting slightly above and below this price, profiting from the bid-ask spread. Due to the derivative nature of options, OMMs adjust their quotes in response to price changes in the underlying security, typically via proprietary "auto-quote" systems that generate a theoretical price.

On May 6, while OMMs reported that they generally did not have problems receiving data from proprietary data feeds from the individual stock exchanges, OMMs considered the incoming data unreliable due to extreme volatility in underlying securities. Thus, in order to

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[44]   For a more in depth discussion of the options markets and OMM obligations, *see* Preliminary Report, at Appendix A-18.

[45]   Exchange rules dictate that OMMs provide continuous two-sided quotations throughout the trading day in thousands of individual series. Although BATS and NOM permit trading in an options class without a registered market maker, if a market maker is registered in a class, that market maker is subject to continuous quoting obligations as prescribed by the exchange. *See id.*

mitigate risk, OMMs began to widen their quotes, decreased their quotation size or temporarily withdrew from the market consistent with their quoting obligations. Some OMMs' systems automatically took their quotes $5 wide once they determined that the information they were receiving from the underlying exchanges was unreliable, while some other OMM's systems were programmed to go wide in a more graduated fashion upon certain triggers, while others did not widen to the $5 maximum.[46]

OMMs that widen their quotes do so with the expectation that their quotes will not be executed against. However, on May 6, at least one OMM reported that despite going wide, its quotations continued to be executed against.

Generally, there were no significant liquidity shortages reported in the options markets and very few trades were broken or adjusted. In addition, several relatively insignificant systems issues were noted. For instance, NYSE Arca experienced a system outage related to outbound order routing which resulted in the other options exchanges declaring self-help against that exchange. Some OMMs reported having problems with their internal quoting systems that required them to pull out of the market temporarily; however, they described these problems as existing "bugs" in their systems that came to light on May 6, but were not caused by the market activities that day. These OMMs reported that they were able to fix their systems and re-enter the market in a timely manner.

II.3.   ANALYSIS OF BROKEN TRADES
II.3.a. STUB QUOTES

As part of our interview process, we asked market participants about their use and interaction with stub quotes. Pursuant to exchange rules, registered market makers are required to engage in a course of dealing for their own account to assist in the maintenance, insofar as reasonably practicable, of fair and orderly markets. On equities markets, these exchange rules generally require a market maker to maintain a continuous two-sided quotation in the security or securities for which the member is registered as a market maker. However, such rules do not generally dictate the prices at which a market maker must quote.[47] When a market maker's liquidity has been exhausted, or if it is unwilling to provide liquidity, it may on some markets submit what is called a stub quote – an offer to buy or sell a given stock at a price so far away from the prevailing market that it is not intended to be executed, such as an order to buy at a penny or less or sell at $100,000 – to comply with its obligation to maintain a continuous two-sided quotation.[48]

Some equities exchanges provide for the automatic generation of stub quotes, and a subset require their market makers to use such a mechanism to ensure compliance with continuous two-sided quoting rules. Some allow for flexibility in specifying how auto-generated quotes

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[46]   Most of the options exchanges have rules that impose a maximum bid/ask spread of $5, although NOM and BATS do not have maximum limits. Unlike the underlying markets, the options markets generally do not allow for the publishing of stub quotes.

[47]   *See* Preliminary Report at Appendix A-9 to A-10 for a historical discussion of stub quotes. In addition, the Exchange Act does not require a national securities exchange to have market makers. *See*, *e.g.* Securities Exchange Act Release Nos. 61698 (March 12, 2010), 75 FR 13151 (March 18, 2010) (order granting the exchange registration of EDGX and EDGA)

[48]   *See*, *e.g.* Nasdaq Rule 4613; NYSE Arca Equities Rules 7.23 and 7.31(k); and BATS Rule 11.8.

cascade upwards or downwards as market prices move, though floors of 1 penny or 1/100th of a penny on the bid-side, and a ceiling of $99,999.99 on the ask-side are common. One reason that auto-generated quotes are implemented is to ensure market makers can "technically" meet their continuous two-sided quoting obligations even if they have temporarily disconnected from the exchange. A cancelled ("broken") trade priced at $0.01 may have been the result of an exchange-generated stub quote or an active market maker quoting at that same level. However, quotes of 15 cents or 22 cents for example, are most likely not exchange-generated, but instead represent stub-like quotes posted by a market maker. A market maker actively quoting at the "higher" price of 15 cents will have many more broken trades than a market maker who disconnected from trading and relied on exchange-generated stub quotes of one penny.

Some equities market makers told us that in the normal course of business they do not generally use stub quotes, but acknowledged that their systems, or their exchanges' systems used on their behalf, would have quoted at stub levels after their active quotes were exhausted in any particular security, or in all securities if they completely halted trading. In turn, some market participants responsible for routing orders reported that because they believed they had a firm obligation to fulfill customer market orders at the NBBO, they sent orders to be filled even though prices were at stub quote levels. Others reported that they assumed executions at stub quote prices would likely be broken, and sent orders seeking to hit stub quotes to prevent the piling up of orders in their internal systems. Additionally, some firms reported that their algorithmic trading systems attempted to execute against declining prices all the way down to stub quotes – either because such trading was consistent with the parameters for that system, or because the system did not necessarily recognize that it was hitting stub quotes (just that it was hitting the NBBO). These reported practices are consistent with the findings discussed below with respect to the types of orders involved in the broken trades that day.

II.3.b. BROKEN TRADES

As discussed in the Preliminary Report, the vast majority of the almost 2 billion shares traded on May 6 between 2:40 p.m. and 3:00 p.m. were at prices within 10% of their 2:40 p.m. value.[49] For most of the trades executed at a loss on May 6, their declines were consistent with the general declines in the broad market indices. We note that many of the securities that suffered rapid price moves found their prices reverting to their former levels nearly as quickly. This suggests that immediately-available liquidity was not able to fully absorb the considerable demand to sell (and in some cases buy) shares, and that prices recovered as soon as this pressure was reduced and the imbalance alleviated (*see* S&P 500 order book charts 1.A and 1.B at the beginning of this section).

Above, we discussed the behavior of market participants and the reasons for the general withdrawal of liquidity. As shown, spreads in securities rapidly widened as market makers and other providers of liquidity pulled back. Some market makers completely stopped quoting for all securities and, if required, relied on exchange-generated bids of one penny or less to fulfill their market making obligations – "stub quotes," as previously described. In some cases, stub quotes were continuously refreshed pursuant to functionality offered by the host exchange, whereas in other cases they were only refreshed up to a certain size after which point

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[49]   *See* Preliminary Report, at Tables 1 and 2.

automatic quoting stopped. Other equities market makers generated their own unrealistically-low stub-like bids for securities that were at or near the same level as exchange-generated stub quotes. In all cases, the market maker providing the stub quote generally did so with the assumption that its quotes would not be hit by incoming orders.

Executions against stub quotes represented a significant proportion of broken trades on May 6. Though the type of volatility experienced that day is very unusual, even more extraordinary was the fact that over 20,000 trades representing 5.5 million shares were executed at prices more than 60% away from their 2:40 p.m. value. These trades were subsequently broken by the exchanges and FINRA under their clearly erroneous rules because they were executed at clearly unrealistic prices under severe market conditions.[50] Almost two-thirds of shares in cancelled trades were executed at prices of less than $1.00, and about 5% were executed at prices above $100.

On May 6, both market orders and limit orders traded against stub quotes. A market order submitted to an exchange immediately seeks the best available liquidity, regardless of price. If the only liquidity available is a stub quote, the market order will execute against that price. Similarly, if a limit order is submitted with a limit price that represents the then-current NBBO and the NBBO at that time is a stub quote due to a lack of other available liquidity, it too would receive a stub quote execution. And since stub quotes are often generated in an automated fashion, as soon as one is lifted another is quickly posted and available to receive the next market or limit order. Analysis of the order routing by internalizers, discussed below, reflects such activity.

As noted previously, many internalizers of retail order flow stopped executing as principal for their customers that afternoon, and instead sent orders to the exchanges, putting further pressure on the liquidity that remained in those venues. Many trades that originated from retail customers as stop-loss orders or market orders were converted to limit orders by internalizers prior to routing to the exchanges for execution. If that limit order could not be filled because the market continued to fall, then the internalizer set a new lower limit price and resubmitted the order, following the price down and eventually reaching unrealistically-low bids. Since internalizers were trading as riskless principal, many of these orders were marked as

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[50] On September 10, 2010, the SEC approved new rules submitted by the national exchanges and FINRA that clarify the process for breaking erroneous trades. *See* Securities Exchange Act Release Nos. 62330 (June 21, 2010), 75 FR 36725 (June 28, 2010); 62331 (June 21, 2010), 75 FR 36746 (June 28, 2010); 62332 (June 21, 2010), 75 FR 36749 (June 28, 2010); 62333 (June 21, 2010), 75 FR 36759 (June 28, 2010); 62334 (June 21, 2010), 75 FR 36732 (June 28, 2010); 62336 (June 21, 2010), 75 FR 36743 (June 28, 2010); 62337 (June 21, 2010), 75 FR 36739 (June 28, 2010); 62338 (June 21, 2010), 75 FR 36762 (June 28, 2010); 62339 (June 21, 2010), 75 FR 36765 (June 28, 2010); 62340 (June 21, 2010), 75 FR 36768 (June 28, 2010); and 62342 (June 21, 2010), 75 FR 36752 (June 28, 2010); 62335 (June 21, 2010), 75 FR 37494 (June 29, 2010); and 62341 (June 21, 2010), 75 FR 36756 (June 28, 2010). The comment period for each of these proposals has been extended to September 10, 2010. *See* Securities Exchange Act Release Nos. 62797 (Aug. 30, 2010) and 62798 (Aug. 30, 2010).

short even though the ultimate retail seller was not necessarily short.[51] This partly helps explain the data in Table 7 of the Preliminary Report in which we had found that 70-90% of all trades executed at less than five cents were marked short.

Detailed analysis of trade and order data revealed that one large internalizer (as a seller) and one large market maker (as a buyer) were party to over 50% of the share volume of broken trades, and for more than half of this volume they were counterparties to each other (i.e., 25% of the broken trade share volume was between this particular seller and buyer). Furthermore, in total, data show that internalizers were the sellers for almost half of all broken trade share volume. Given that internalizers generally process and route retail trading interest, this suggests that at least half of all broken trade share volume was due to retail customer sell orders.

The data also provides important information regarding the extent to which declarations of self-help against NYSE Arca by Nasdaq and BATS may have exacerbated the issues on May 6. For example, the large market maker mentioned above specialized in ETFs and was registered as a market maker in ETFs on NYSE Arca. The internalizer had directly routed approximately 2,400 sell orders to NYSE Arca for about 1.7 million shares that resulted in broken trades. This same internalizer had also routed approximately 2,900 sell orders for a total of about 400,000 shares to BATS and Nasdaq that resulted in broken trades. If this example is typical of the price patterns at that time, and given that the internalizer would have routed to the exchange with the best available price, it seems that the general withdrawal of liquidity that led to broken trades was at least as prevalent on NYSE Arca as it was on Nasdaq and BATS. This suggests that if Nasdaq or BATS had re-routed orders to NYSE Arca, then these orders would have also been executed at unrealistically-low prices on NYSE Arca and subsequently broken. From this example it does not seem that self-help led to orders "routing around" liquidity at NYSE Arca, but rather that liquidity had been withdrawn across all exchanges, including NYSE Arca.[52]

The fact that a single market maker on NYSE Arca represented so many broken trades suggests that this market maker was one of the last providers of liquidity for those securities in that market. Other market makers had either stopped quoting or were quoting at even lower prices, demonstrating the extent to which liquidity had virtually evaporated.

An analysis of order types reveals that almost 90% of all broken trades were sold with a limit price. Given the assumption that a large number of sell orders were due to retail customers, we would have expected a higher percentage of market orders. However, as previously discussed, internalizers often convert market orders to other order types (such as marketable limit orders

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[51] Reg. SHO imposes uniform order marking requirements for sales of all equity securities. Pursuant to Reg. SHO, an order can be marked "long" when the seller owns the security being sold and the security either is in the physical possession or control of the broker-dealer, or it is reasonably expected that the security will be in the physical possession or control of the broker or dealer no later than settlement. If a person does not own the security being sold, or owns the security sold but does not reasonably believe that the security will be in the possession or control of the broker-dealer prior to settlement, the sale must be marked "short." In the case of an internalizing broker-dealer that is facilitating a customer sell order where the customer is net long and the broker-dealer is net short, but is effecting the sale as principal or riskless principal, the broker-dealer must mark the principal leg of the transaction as short.

[52] *See* Section 3 for further details on the timing and potential effects of self-help declarations.

at the current NBBO) when they route customer orders to the exchanges for execution. On the buy-side we find that market orders were used in less than 1% of all broken trades.

In summary, our analysis of trades broken on May 6 reveals they were concentrated primarily among a few market participants. A significant number of those trades were driven by sell orders from retail customers sent to internalizers for immediate execution at then-current market prices. Internalizers, in turn, routed these orders to the public exchanges for execution at the NBBO. However, for those securities in which market makers had withdrawn their liquidity, there was insufficient buy interest, and many trades were executed at very low (and sometimes very high) prices, including stub quotes.

III. POTENTIAL IMPACT OF ADDITIONAL FACTORS

In this section we explore the potential impacts of three additional factors on the events of May 6: the use of LRPs by the NYSE, in which trading is effectively banded on the NYSE in NYSE-listed stocks exhibiting rapid price moves; declarations of self-help by Nasdaq against NYSE Arca under which Nasdaq temporarily stopped routing orders to NYSE Arca; and delays in NYSE quote and trade data disseminated over the CQS and CTS data feeds.

III.1. NYSE LIQUIDITY REPLENISHMENT POINTS

NYSE utilizes a hybrid floor/electronic trading model, unlike most other markets today which are fully electronic. Within this model NYSE has implemented price-bands known as "liquidity replenishment points." LRPs are intended to act as a "speed bump" and to dampen volatility in a given stock by temporarily converting from an automated market to a manual auction market when a price movement of sufficient size is reached. In such a case, trading on NYSE in that stock will "go slow" and automatic executions will cease for a time period ranging from a fraction of a second to a minute or two to allow the Designated Market Maker ("DMM") to solicit and/or contribute additional liquidity before returning to an automated market. LRP limits vary according to each security's share price and average daily volume within specified ranges, generally falling between 1% and 5% of share price.[53] It is worth noting that hitting a LRP does *not* cause trading in the security to completely halt or pause, but only to go slow on the opposite side of the market that hit the LRP (or both sides if the quote has locked or crossed the market), thereby preventing the automatic execution of trades at prices beyond the LRP limit.

A LRP may be triggered even when there is additional interest on NYSE's order book beyond the LRP price point. In these cases NYSE will suspend automated quotations in the security, and will identify its quote on the consolidated tape with a "non-firm" indicator. This is referred to as a "slow market" or "going slow" in the security. Other markets are permitted to bypass NYSE's quote when it is identified as "non-firm."

Most LRPs either resolve themselves within a second, when additional buy or sell interest brings prices back within the LRP limits, or are resolved just as quickly by a DMM's algorithm that automatically sets a new resumption price according to buy and sell interest. Once the LRP is resolved the quotes are no longer labeled as "slow" and automated executions resume. In some cases a DMM's algorithm will be used to determine the resumption price at which automated quoting and executions can continue. In other cases, when additional liquidity is needed beyond what the DMM's algorithm is programmed to supply, the resumption price is determined manually by the DMM in a process that can take from a few seconds to a minute or more.

Upon resumption of automatic executions, a new LRP is calculated for the security. On days of extraordinary market volatility, stocks with significant and/or continual declines may cause NYSE trading to remain in the "slow" mode for extended periods or to intermittently return

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[53] LRPs are triggered much more frequently than the recently approved inter-market volatility trading pauses in individual stocks, which are triggered by a price movement of 10% or more over a five-minute period. *See* Securities Exchange Act Release No. 34-62252 (June 10, 2010), 75 FR 34186 (June 16, 2010).

to automated execution status before quickly again hitting an LRP and thereby "going slow" again. However, even in cases of prolonged or recurring LRPs in a particular security, customer interest in the security is not "trapped" by the LRP(s) or the slow market state. Customers may cancel their interest at any time prior to execution, regardless of the state of the market.

As discussed in the Preliminary Report,[54] many securities triggered LRPs multiple times on the afternoon of May 6, and though 75% of all events were resolved in less than 1 second, others lasted many seconds, or were in an extended period of multiple sub-second LRPs. Between 2:30 p.m. and 3:00 p.m., more than 1000 securities triggered LRP events lasting more than 1 second, compared to a "normal" day average of only 20-30 such events.[55]

According to the market participants we interviewed, their systems are programmed to automatically adjust for slow quotes on NYSE and will route orders to other exchanges as needed. And, as mentioned, participants have the option of automatically cancelling existing orders on NYSE if so desired. Participants did not report they had difficulty routing or felt their orders were "trapped" as a result of LRP events.

However, a number of market participants told us that the fact so many LRPs were being triggered further underscored the severity of market conditions as they were unfolding, and that this additional "evidence" played into their decisions to reduce liquidity, pause trading, or withdraw from the markets.

Though market participants told us they were able to route their orders as needed, it is nevertheless possible that residual liquidity could have been trapped on NYSE during the LRP events, and that this liquidity could have absorbed some of the sell pressure of securities with the most severe price dislocations. In this regard, we note that over 80% of the 326 securities having broken trades were not listed on NYSE and therefore not subject to the LRP events.[56] For those listed on NYSE we found 42 of the 56 stocks for which broken trades occurred on other exchanges were, in aggregate, subject to 180 LRPs lasting 10 seconds or longer.[57]

With this sample, we addressed two questions: first, is there evidence that a substantial percentage of trades executed elsewhere might have been otherwise executed against liquidity that appeared on NYSE during the LRP; and second, during the LRP and when other exchanges were permitted to route around the NYSE, is there evidence of liquidity flowing into NYSE. That is, does NYSE appear to be drawing away and "trapping" additional liquidity from other exchanges during the LRP?

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[54] *See* Preliminary Report, Figure 9 and accompanying text.

[55] We note that spikes in the number of LRPs have also occurred in the past during periods of "ordinary" high market volatility in September-October 2008 and October-December 2009.

[56] *See* Preliminary Report, Table 4.

[57] There were no broken trades on NYSE because executions were not permitted outside the LRP bands.

As an indicator of "trapped" liquidity, we compared the estimated "available" bid depth during the LRP for each stock to the number of executions on other exchanges.[58] Based on our sample, it does not appear that a substantial number of executions might have benefited from access to NYSE liquidity. For over half of the LRPs, there was no possibility of "trapped" liquidity because either no executions were reported on other exchanges during the LRP event (36 cases) or available bid depth at NYSE itself was zero (61 cases).

For 83 LRPs in 29 stocks, executions occurred on other exchanges at the same time there was available liquidity on NYSE. Figure 3.1 presents each of these events on a grid comparing the number of shares executed by other exchanges on the vertical axis (from 100 to 1 million shares) with the number of shares of available liquidity on NYSE during the LRP on the horizontal axis (from 100 to 100,000 shares). The dotted red line indicates the threshold above which there were significantly more shares executed at other exchanges than there was liquidity at NYSE, and below which there was more liquidity available on NYSE than there were shares executed at other exchanges. It is important to note that the data includes all of the shares executed on other exchanges, and is not limited to executions that resulted in broken trades. In this respect our impact estimate is quite conservative, and even so, we see that there were only 19 LRP events affecting 12 stocks in which available liquidity on NYSE within 500 basis points of the NBBO may have been able to absorb the sell pressure.

The data also do not suggest that significant liquidity was being attracted to the NYSE during the LRP. We measured the total number of bid shares gained (lost) from the second prior to the LRP to the second after the conclusion of the LRP. Only one third of the LRPs (59 cases) were associated with any increase in bid depth within 500 basis points of the NBBO during the LRP. For the entire sample, the average increase in available liquidity was only 133 shares. Further exploration of the data did not evidence a pattern that suggests an increase in bid depth is associated with the length of the LRP, which would be expected if unexecutable bids were being drawn into NYSE during the LRP.

Taken as a whole:
- the actions of market participants, including their ability to route around "slow" quotes and cancel orders if desired;
- the fact that the majority of securities with broken trades were not subject to LRPs; and
- that for those stocks subject to lengthy LRPs, only 12 may have had sufficient liquidity on NYSE to absorb some of the sell pressure that was executed on other exchanges;

we conclude that NYSE LRPs did not cause or create the broad-based liquidity crisis on May 6.

Nonetheless, as stated above, market participants reported that the increasing number of LRPs being triggered on NYSE underscored the severity of market conditions as they were

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[58] We estimated the available bid depth during the LRP by reference to the minimum of the bid depth resting on NYSE within 500 basis points from the mid-quote of the NBBO in the second prior to the LRP and a similar bid depth in the second after the conclusion of the LRP. We chose the minimum to account for orders being cancelled or executed during the LRP, in which case these quotes were not trapped.

unfolding, and that this additional "evidence" played into their decisions to reduce liquidity, pause trading, or withdraw from the markets.

Figure 3.1: Shares available on NYSE (within 500 basis points of the NBBO) compared to shares executed on other exchanges during LRPs lasting 10 seconds or longer

83 NYSE LRP Events for a subset of 29 Stocks that experienced Broken Trades on other Exchanges

64 Events (26 stocks)

19 Events (12 stocks)

NYSE liquidity insufficient
NYSE liquidity potentially trapped

Shares Executed on other Exchanges during LRP

Shares Available on NYSE during LRP

May 6, 2010 Market Event Findings
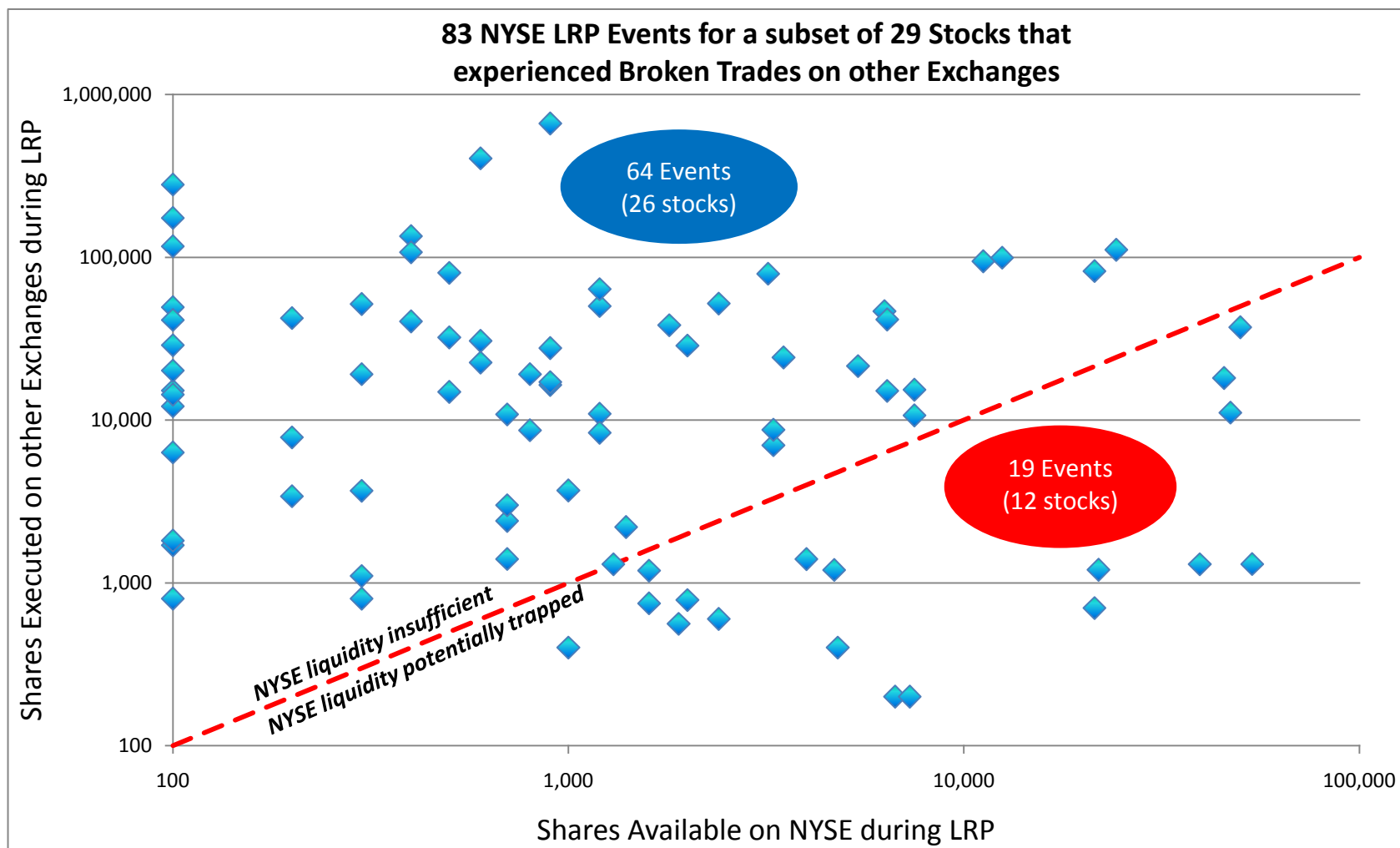
III.2. DECLARATIONS OF SELF-HELP AGAINST NYSE ARCA

We have examined whether the declarations of "self-help" against NYSE Arca by Nasdaq at 2:36:59 p.m. and by Nasdaq OMX BX at 2:38:40 p.m. ("Self-Help Declarations") affected the availability of liquidity on May 6 and thereby contributed to imbalances between liquidity supply and demand.[59] As discussed below, self-help is an exception to Rule 611 of Regulation NMS that permits (but does not require) a trading center to bypass the quotations of an exchange that is experiencing a systems problem. The exception is intended to assure that market participants are not required by rule to route orders to execute against quotations that are not immediately accessible. By declaring self-help against NYSE Arca, Nasdaq and Nasdaq OMX BX executed trades, and Nasdaq routed orders,[60] without regard to the protected quotations displayed by NYSE Arca. The discussion below first gives an overview of Rule 611 and the self-help exception and then evaluates the effect of the Self-Help Declarations on May 6.

III.2.a. OVERVIEW OF RULE 611 AND THE SELF-HELP EXCEPTION

In general, Rule 611(a) requires trading centers[61] to establish, maintain, and enforce written policies and procedures reasonably designed to prevent "trade-throughs"[62] – the execution of trades at prices inferior to "protected quotations."[63] To be protected, a quotation must, among other things, be immediately and automatically accessible and be an exchange's best (highest) bid or best (lowest) offer (also referred to as "top-of-book" quotations). An exchange's additional quotations at prices above or below its best-priced quotations ("depth-of-book" quotations) are not protected quotations.[64] As a result, market participants are entitled to make

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[59]   There were other declarations of self-help on May 6. Earlier in the day, several exchanges declared self-help against CBSX (the equity trading facility of the Chicago Board Options Exchange), but all of the declarations were revoked by 1:15 p.m. Subsequent to the Self-Help Declarations, National Stock Exchange ("NSX") declared self-help against the NYSE at 2:48:11 p.m. and against NYSE Arca at 2:51:11 p.m., BATS declared self-help against NYSE Arca at 2:49:17 p.m., and three broker-dealers declared self-help against NYSE Arca at 2:50:51 p.m. and after. We have not discussed these self-help declarations because they occurred before or after the general market disruption on May 6.

[60]   The equities trading facility of Nasdaq OMX BX does not route equities to other market centers. *See* Securities Exchange Act Release No. 59154 (December 23, 2008), 73 FR 80468 (December 31, 2008).

[61]   The term "trading center" is defined in Rule 600(b)(78) of Regulation NMS. It is broadly defined to include exchanges, alternative trading systems (including dark pools), exchange market makers, OTC market makers, and any other broker-dealers that execute trades internally.

[62]   The term "trade-through" is defined in Rule 600(b)(77) of Regulation NMS as "the purchase or sale of an NMS stock during regular trading hours, either as principal or agent, at a price that is lower than a protected bid or higher than a protected offer."

[63]   "Protected quotation" is defined in Rule 600(b)(58) as a protected bid or protected offer, and those terms are defined in Rule 600(b)(57) of Regulation NMS as, among other things, automated quotations (as defined in Rule 600(b)(3)) in NMS stocks that are displayed by a national securities exchange or a national securities association. On May 6, 2010, ten such entities were entitled to display protected quotations – BATS, CBSX, Chicago Stock Exchange, International Securities Exchange LLC, Nasdaq, Nasdaq OMX BX, NSX, NYSE, NYSE Amex, and NYSE Arca.

[64]   Prior to adopting Regulation NMS, the SEC requested comment on whether to require protection of certain depth-of-book quotations. A large majority of commenters did not support depth-of-book protection because they believed it would unduly restrict competition among markets and be significantly more costly to implement than top-of-book protection. *See* Securities Exchange Act Release No. 51808 (June 9, 2005), 70 FR 37496, 37529-37530 (June 29, 2005) ("Regulation NMS Adopting Release").

their own determination, based on best execution and other factors, of whether to route orders to execute against an exchange's depth-of-book quotations.

Rule 611(b) provides a number of exceptions from the general requirement to prevent trade-throughs of protected quotations, all of which must be implemented through policies and procedures that are reasonably designed to comply with the terms of the exception. One of the exceptions is commonly referred to as "self-help." Specifically, Rule 611(b)(1) provides an exception for a trade-through that "was effected when the trading center displaying the protected quotation that was traded through was experiencing a failure, material delay, or malfunction of its systems or equipment." The Regulation NMS Adopting Release interpreted this rule language to mean that "trading centers should be entitled to bypass another trading center's quotations if it repeatedly fails to respond within one second to incoming orders attempting to access its protected quotations," and noted that, as a result, "trading centers will have the necessary flexibility to respond to problems at another trading center as they occur throughout the trading day."[65] The Regulation NMS Adopting Release also discussed the policies and procedures that are reasonably required to comply with the self-help exception. Among other things, it indicated that the declarer of self-help must adopt objective parameters for use of the exception, must immediately notify the exchange that is the subject of the self-help declaration, and must assess whether the cause of a problem lies with its own systems rather than such exchange's systems.[66]

Two additional exceptions from Rule 611 are relevant to an evaluation of the effect of the Self-Help Declarations on May 6. Both exceptions are based on the use of intermarket sweep orders ("ISOs"). As defined in Rule 600(b)(30) of Regulation NMS, all ISOs must, among other things, specify a limit price indicating that additional ISOs, as necessary, have been routed to execute against all protected quotations with better prices than such limit price. As a result, all ISOs must be limit orders, and the router of the ISO must assume responsibility for any protected quotation with better prices than the limit price. Rule 611(c), in turn, requires that the trading center or broker-dealer responsible for the routing of an ISO take reasonable steps to assure that the ISO meets the requirements of Rule 611(b)(30). All ISOs must have a trading center or broker-dealer that is responsible for their routing.

Rule 611(b) provides two types of ISO exceptions. One type (set forth in Rule 611(b)(6)) allows a trading center to execute an order at a price if it simultaneously routes ISOs to execute against the full displayed size of any protected quotations with better prices than the execution price. Another type of ISO exception (set forth in Rule 611(b)(5)) allows order routers to control the execution of their limit orders by routing ISOs themselves and directly assuming responsibility for preventing trade-throughs. When a trading center receives an incoming order marked ISO, Rule 611(b)(5) provides an exception that allows the trading center to execute the ISO immediately without regard to better-priced protected quotation at other trading centers.

When an ISO exception is used in conjunction with the self-help exception, the trading center or broker-dealer responsible for routing an ISO is entitled to use the self-help exception to bypass the protected quotations of an exchange that is experiencing systems problems. Such

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[65]   *See* Regulation NMS Adopting Release, *supra* note 64, at 37521.

[66]   *See id.*, at 37521-37522.

trading center or broker-dealer must implement the self-help exception through the reasonable policies and procedures that were noted above.

In assessing the effect of the self-help exception on May 6 or any other day, it is important to recognize what use of the exception does <u>not</u> do. In particular, the declaration of self-help by a trading center or broker-dealer against an exchange does not automatically remove such exchange's quotations from the montage of protected quotations, nor does the declaration of self-help entitle any other market participant (beyond the declarer of self-help) to bypass such exchange's quotations when it executes trades itself or routes ISOs to other venues. In this regard, the limited scope of the self-help exception reflects the variable nature of systems problems that can affect the routing and execution of orders. In some instances, an exchange may be experiencing problems that affect all routers, but, in other instances, an exchange's problems may affect only a single order router or group of order routers (such as with an isolated connectivity problem). Use of the self-help exception is limited to those trading centers and broker-dealers that have a reasonable basis to believe that the orders they route to an exchange will be affected by that exchange's systems problem.

III.2.b. EVALUATION OF SELF-HELP DECLARATIONS ON MAY 6

Nasdaq declared self-help against NYSE Arca at 2:35:59 p.m., and Nasdaq OMX BX declared self-help against NYSE Arca at 2:38:40 p.m. The Nasdaq declaration was revoked at 3:01:09 p.m., and the Nasdaq OMX BX exception was revoked at 3:01:55 p.m. Data indicate that for a subset of securities NYSE Arca repeatedly did not respond to orders from these exchanges within one second. Consistent with Rule 611, Nasdaq and Nasdaq OMX BX notified NYSE Arca directly concerning their use of the self-help exception. They also publicly disclosed their Self-Help Declarations by, among other things, publishing them on their Internet website. As a result, many market participants were aware of the Self-Help Declarations soon after they were made.

As discussed above, the Self-Help Declarations entitled only Nasdaq and Nasdaq OMX BX to execute trades and route ISOs without regard to NYSE Arca quotations.[67] Our discussions with market participants indicate that many knew of the Self-Help Declarations, but, with one exception noted below, all market participants stated that they continued routing orders to NYSE Arca despite the Self-Help Declarations. In addition, no market participants indicated that they programmed their trading systems to include the declaration of self-help against one or more exchanges as a risk control that could affect their trading behavior, which is consistent with the fact that most participants route their trades directly.

The single exception was a market participant that did not declare self-help itself, but rather simply removed NYSE Arca from its routing table at approximately the same time that Nasdaq declared self-help. This market participant did not, however, execute any trades internally that traded through the NYSE Arca quotations, nor did it route any ISOs. Accordingly, the effect of this course of action was limited to orders that the market participant routed to Nasdaq and Nasdaq OMX BX (i.e., the only exchanges that bypassed NYSE Arca during the general market disruption on May 6).

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[67]   Although Nasdaq OMX BX does not route equities, its Self-Help Declaration still entitled it to trade-through NYSE Arca's quotation.

A potential concern about the effect of the Self-Help Declarations on May 6 is that they could have led to inaccessible liquidity at NYSE Arca when Nasdaq and Nasdaq OMX BX began bypassing the quotations of NYSE Arca. If a significant volume of liquidity demanding order flow bypassed NYSE Arca, it could have exacerbated the overall imbalance between the liquidity supply and demand during the general market disruption. For the Self-Help Declarations to have caused such a result, however, a significant volume of order flow would need to have been diverted away from NYSE Arca to Nasdaq and Nasdaq OMX BX (at which point, Nasdaq or Nasdaq OMX BX would either have executed the orders themselves or routed them away as ISOs to exchanges other than NYSE Arca).

To assess quantitatively the extent to which the Self-Help Declarations may have caused a bypassing of liquidity at NYSE Arca, we have examined two types of data: (i) the percentage of trading volume executed on NYSE Arca before and after the Self-Help Declarations; and (ii) the volume of liquidity demanding sell orders that were executed at NYSE Arca during the general price decline compared with the volume of liquidity demanding sell orders that Nasdaq routed away to other exchanges during the same time period.

First, NYSE Arca executed a comparable volume of trading before and after the Self-Help Declarations. From 2:00 p.m. through 2:36 p.m., NYSE Arca's percentage of total share volume across all NMS stocks was approximately 14.7%. From 2:37 p.m. till 3:00 p.m., NYSE Arca's percentage of total share volume was approximately 15.4%. The comparable volume of trading indicates that NYSE Arca liquidity continued to be accessible after the Self-Help Declarations.

Second, during the period of the general price decline in individual securities from 2:30 p.m. to 2:47 p.m., NYSE Arca executed approximately 162 million shares in liquidity taking sell and sell short orders across all NMS stocks. By comparison, Nasdaq routed away to other quoting markets approximately 22 million shares in liquidity taking sell and sell short orders across all NMS stocks, or only 13.6% of the volume of liquidity taking sell orders that were routed directly to and executed on NYSE Arca during that time frame.

Additionally, as discussed above in Section 2, the data with respect to broken trades on May 6, suggests that liquidity was not trapped on NYSE Arca.

In sum, we do not find that the Self-Help Declarations directly contributed to the severe imbalances between liquidity supply and demand on May 6. However, the Self-Help Declarations likely contributed more generally to concerns among many market participants about abnormal trading and data reliability. Nonetheless, nearly all market participants appear to have continued routing orders directly to NYSE Arca when it displayed the best priced quotations. This order flow caused NYSE Arca trading and prices to remain closely aligned with trading and prices at other markets.

III.3. MARKET DATA ISSUES

Rule 603(b) of Regulation NMS requires equity exchanges and FINRA to act jointly to disseminate consolidated information, including an NBBO, on quotations for and transactions in NMS stocks. The consolidated information is disseminated through securities information processors that collect, process, and prepare for publication such information including the price, size, and symbol of quotations and executions. In addition, many exchanges offer proprietary data feeds directly to customers that include details of trades and orders on that

exchange only. These proprietary data feeds must be offered on terms that are fair and reasonable, and cannot be sent to customers any sooner than the data provided to the processors. However, because the proprietary data feeds are not consolidated, such data feeds may reach the end user faster than the consolidated feeds.

On the afternoon of May 6, NYSE set quote traffic records and experienced significant delays in its dissemination of certain execution and quotation information. At the time, NYSE was in the middle of upgrading its systems that publish information to the processors. NYSE explained that the sustained high volume of market data delayed the dissemination of quotation and execution information to the processors in 1,665 NYSE listed symbols (A – HEZ, KC – MGZ) (the "1665 Symbols") that were traded on NYSE servers that had not been upgraded.[68]

Between 2:44:45 p.m. and 2:46:29 p.m. on May 6, NYSE quotes in the 1665 Symbols had average delays to the CQS of over 10 seconds. Between 2:45 p.m. and 2:50 p.m., over 40 of the 1665 Symbols had an average delay to CQS of more than 20 seconds, and the average delay for all of the 1665 Symbols was just over 5 seconds. During the same five-minute period, however, NYSE disseminated quotation information for the 1665 Symbols through one of its proprietary data feeds with an average delay of just over 8 milliseconds, or 0.008 seconds.

NYSE also experienced delays disseminating transaction information to the consolidated feed and through at least one of its proprietary data feeds. Between 2:45 p.m. and 2:50 p.m., NYSE transactions in the 1665 Symbols had average delays to the CTS of over five seconds (with some delays lasting as long as 35 seconds) and average delays through one of its proprietary data products of over seven seconds. We are unaware of any other delays NYSE may have experienced on other proprietary data products.

SEC rules require that the exchanges and FINRA provide timely and accurate data to the CTS and CQS systems to inform all participants of the trading and quoting activities occurring in the market place. At the time of this report, there has been considerable attention in the public media regarding these data delays, and we agree that this is an important topic that should be addressed. However, it is equally important that we explore the extent to which these delays may have impacted trading on May 6.

The CTS and CQS systems represent a consolidated view of trading and top-of-book quoting[69] across all national exchanges and ECNs, and trading at internalizers and dark pools. As such, the relative timing of trades and quotes within these systems are subject to some aggregation delays, which generally are less than 10 milliseconds. As discussed in Section 2, many large market participants route orders directly to exchanges and subscribe to the proprietary feeds from each exchange in order to minimize aggregation delays and receive depth-of-book quotes. Accordingly, automated systems making trading decisions based on these feeds should not have been directly affected by delays in the CTS and CQS system. It is important to note that retail order flow is generally handled by internalizers who are also among those participants that use proprietary exchange feeds to make trading and routing decisions.

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[68]   NYSE informed us that it has since completed the upgrade to its systems.

[69]   The CQS provides only the best bid and best offer per exchange. Bids and offers deeper in each exchange's books are not disseminated through CQS.

However, firms that use proprietary feeds to make trading decisions may still have been impacted by delays on the CTS and CQS feeds. As discussed, concerns about data integrity contributed to pauses or halts in many automated trading systems, which in turn led to a reduction in general market liquidity. Most firms reported to us that the primary drivers of their integrity-based halts were *observed*, rapid changes in the E-Mini and *observed*, rapid changes in individual securities. But data-integrity checks based on the CTS and CQS feeds would have been directly affected by delays in the consolidated market data, and firms using those integrity-checks reported that this influenced, and to some extent supported, their decisions to pause or halt trading.

For firms employing trading strategies that are less time-sensitive, and whose automated systems rely solely on data from the CQS and CTS, data delays on these feeds could have directly triggered integrity-pauses. Some such firms reported that delays on the CQS and CTS were a more significant part, though not the sole reason, for their decision to curtail or halt trading on the afternoon of May 6. We note, however, that while these types of firms are not generally market makers or liquidity providers, they can be significant fundamental buyers and sellers.

A number of other hypotheses regarding the causes and implications of these data delays have been offered. One specific concern is that traders could take advantage of the timing delay between data reported to the consolidated feed and data reported on the proprietary feeds by buying securities at prices on one feed and selling securities at prices on the other. It generally is not possible to do this, however, since the consolidated feeds do not reflect a separate trading market from the exchanges. One cannot "buy" or "sell" at an exchange's prices as shown on the consolidated data feeds separately from the exchange's prices as shown on its proprietary data feed. All orders attempting to execute against an exchange quote in the consolidated data feed must be routed to that exchange where they will be matched in real-time based on then-available quotes at that exchange. These real-time exchange matching system prices may be different from the quotes in the consolidated data feeds if, as on May 6, the exchange is experiencing latencies in transmitting its data to the consolidated data processors. The exchange's prices in the consolidated data feeds are quite literally inaccurate – they do not in fact reflect prices that are currently available to anyone at the exchange.

One potential exception would be a dark pool that executes trades based on exchange prices, but uses the consolidated data feeds to reference those prices rather than subscribing to the exchanges' proprietary data feeds. In such a case, it could be possible for a trader to route an order to the dark pool hoping for an execution at a stale price and, if it received such an execution, to then route an order to an exchange to capture the differential between the current price and the stale price. We believe, however, that dark pools representing the great majority of dark pool volume subscribe to the proprietary data feeds so that the opportunity for this trading tactic is limited.

Moreover, if there are latencies in transmitting exchange data to the consolidated data processors, investors who make real-time decisions to buy or sell based on observed prices in the consolidated feeds (as do most individual investors) are likely to find that their orders are not filled in the manner expected, and these investors will be at a disadvantage compared to those making decisions based on proprietary feeds. This is one of the reasons data delays on the consolidated feed should be kept to an absolute minimum.

Some market participants and firms in the market data business have analyzed the CTS and CQS data delays of May 6, as well as the quoting patterns observed on a variety of other days. It has been hypothesized that these delays are due to a manipulative practice called "quote-stuffing" in which high volumes of quotes are purposely sent to exchanges in order to create data delays that would afford the firm sending these quotes a trading advantage.

Our investigation to date reveals that the largest and most erratic price moves observed on May 6 were caused by withdrawals of liquidity and the subsequent execution of trades at stub quotes. We have interviewed many of the participants who withdrew their liquidity, including those who were party to significant numbers of buys and sells that occurred at stub quote prices. As described throughout this report each market participant had many and varied reasons for its specific actions and decisions on May 6. For the subset of those liquidity providers who rely on CTS and CQS data for trading decisions or data-integrity checks, delays in those feeds would have influenced their actions. However, the evidence does not support the hypothesis that delays in the CTS and CQS feeds triggered or otherwise caused the extreme volatility in security prices observed that day.

Nevertheless, as discussed in the Executive Summary, the events of May 6 clearly demonstrate the importance of data in today's world of fully-automated trading strategies and systems. The SEC staff will therefore be working closely with the market centers to help ensure the integrity and reliability of their data processes, especially those that involve the publication of trades and quotes to the consolidated tape. In addition, the SEC staff will be working with the market centers in exploring their members' trading practices to identify any unintentional or potentially abusive or manipulative conduct that may cause such system delays that inhibit the ability of market participants to engage in a fair and orderly process of price discovery.

IV. ANALYSIS OF ORDER BOOKS

As stated in the Preliminary Report, "The temporary nature of the decline in prices in the broader market may be indicative of a failure in liquidity."[70]   Based on the limited data available at that time, we observed only that temporary price dislocations could have been associated with an unusually high demand for liquidity, or an unusually weak supply of liquidity, or some combination of these factors.

In this report we have extended our analyses to include the full order books of many thousands of securities and ETFs. To do so we obtained NYSE OpenBook Ultra and NYSE ArcaBook data, Nasdaq ModelView and similar data from BATS. These sources provided minute-by-minute "snapshots" of the order book, for all listed securities.[71]   These data allowed us to calculate the number of shares represented by buy and sell limit orders on these exchanges at a wide range of price points. We measured the price points in terms of the relative distance from the midpoint of the NBBO. These data provide a detailed picture of the available liquidity for each security, throughout the day.

In addition, we obtained order audit trail files from several sources, including NYSE, NYSE Amex, NYSE Arca, Nasdaq and BATS, each containing detailed data on orders received, modified, canceled, and executed. In total, this data contained 5.3 billion records.

IV.1. ANALYSIS OF CHANGES IN LIQUIDITY AND PRICE DECLINES

In addition to the analyses of specific order books presented in Sections I and II, order book and order audit trail data were used to look for a general relationship between price-changes and liquidity-changes for approximately 5,000 non-ETF securities.

To look at liquidity changes, we sorted each of the securities into quintiles based on the extent to which the buy-side order book for that security contracted on May 6. As a measure of the extent of the contraction, we used the minimum buy-side depth observed in any minute on that day, divided by its median depth on that day. In addition, because of possible systematic differences between securities with typically different sized order books we sorted these securities into quintiles based on the respective median of their buy-side depths within 500 basis points ("bp") of the mid-quote, as measured in one minute increments on May 6.

Crossing the quintiles based on the typical depth of the order book with quintiles based on the contraction of the order book creates 25 categories spanning 4,920 non-ETF securities. For the securities in each of these categories, Table IV.1 presents the average and the median intraday stock price drop, measured as the open to low, and the number of securities in the category.

The results in Table IV.1 show that, except for securities in the lowest 20% of typical buy-side depth (far left column), drops in price become increasingly more severe with ever-larger drops

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[70]   *See* Preliminary Report, at 22.

[71]   These exchanges, combined, reflect approximately 90% of the executions on exchanges on May 6. We note that BATS data is limited to five price points on either side of the mid-quote and as a result our analysis may understate the total available liquidity.

in liquidity. The most severe average price drop of 39.8% occurred in the 22 securities that had both the greatest intraday average of buy-side depth and the worst decline in that depth.

Table IV.1: *Average and median intra-day price declines for 4,920 corporate stocks as a function of buy-side liquidity lost on May 6.*

Lowest Remaining Liquidity	Typical Buy-Order Depth (thousands of standardized shares)						
	Less than 0.5	0.5 to 2.2	2.2 to 7.4	7.4 to 28.3	More than 28.3	**Total**	
More than 17%	-3.76%	-5.27%	-5.83%	-5.65%	-6.35%	-5.24%	mean
	-2.69%	*-4.45%*	*-5.20%*	*-5.79%*	*-6.50%*	*-4.89%*	*median*
	238	244	198	153	151	984	# obs
10–17%	-5.24%	-6.65%	-8.03%	-8.45%	-8.31%	-7.83%	mean
	-4.59%	*-5.72%*	*-7.14%*	*-7.95%*	*-8.15%*	*-7.41%*	*median*
	65	156	165	246	352	984	# obs
6–10%	-6.94%	-8.57%	-9.19%	-9.36%	-9.36%	-9.06%	mean
	-5.65%	*-7.08%*	*-8.16%*	*-8.55%*	*-9.02%*	*-8.45%*	*median*
	69	116	190	291	318	984	# obs
2–6%	-8.27%	-9.82%	-11.88%	-12.78%	-12.33%	-11.36%	mean
	-7.52%	*-8.21%*	*-9.88%*	*-9.71%*	*-9.58%*	*-9.21%*	*median*
	92	224	282	245	141	984	# obs
Less than 2%	-7.26%	**-11.64%**	**-15.97%**	**-23.20%**	**-39.78%**	-11.18%	mean
	-5.43%	*-8.36%*	*-12.35%*	*-12.97%*	*-26.31%*	*-7.51%*	*median*
	520	244	149	49	22	984	# obs

Notes: Typical buy order depth is measured as the median number of standardized shares bid within 500 basis points of the mid-quote on a minute-by-minute basis during May 6. Lowest remaining liquidity equals the minimum of these values divided by the median. Price declines are measured from the opening to the intra-day low. Results are bucketed by quintile. Shares are standardized across securities to a value of $50/share (bid price) at 9:30am.

IV.2. DETAILED ORDER BOOK DATA FOR SELECTED SECURITIES

Charts for seven selected securities[72] presenting a detailed look at minute-by-minute changes in order book depth, aggressive executed orders, and price changes, are discussed below. Data presented on each chart includes:

- ORDER DEPTH. The blue bars show the market depth for resting buy-side orders, and the green bars show the depth for resting sell-side orders. There is a separate bar for each minute during trading hours, and the height of the bars in the lightest shades show the number of shares available for purchase/sale within 10 basis points of the midpoint of the NBBO. As the shades get darker, the range of prices expands, initially by increments of 10 bp (to 20 bp, 30 bp, 40 bp, and 50 bp), and then by larger increments (to 100 bp, 200 bp, 300 bp, and finally to 500 bp). It is important to note that the range of prices reflected by darker colors is associated with non-linear price increments. For each security there are two sets of charts: the first presents liquidity limited to within 500 bp of the NBBO midpoint, and the second presents all available liquidity.[73]

- PRICES. The dotted yellow lines show the minimum executed price for each minute, obtained from the NYSE Trades and Quotes database ("TAQ").

- NET AGGRESSIVE BUY VOLUME. The charts also include a solid red line that shows the number of executed shares characterized as Net Aggressive Buy Volume. This is computed by summing the number of executed shares in any given minute resulting from buy market orders and buy limit orders priced at or above the national best offer, and subtracting the number of executed shares in that same minute resulting from sell market orders and sell limit orders priced at or below the national best bid.

The charts show a consistent pattern of liquidity rapidly shrinking at approximately 2:45 p.m. for each security. For some securities liquidity declines faster than others, and in some cases the extent of the decline is more dramatic than others, but the pattern is remarkably consistent across both corporate stocks and ETFs.

Accenture plc (ACN): Charts 4.A and 4.B

As described in the Preliminary Report, share prices of Accenture fell from nearly $40 to one cent and recovered all of their value within a matter of seconds. The bids for ACN rapidly declined in seven seconds from about $30 at 2:47:47 p.m. to $0.01 by 2:47:54 p.m. ACN had 112 broken trades, all of which occurred between 2:47:51 p.m. and 2:48:01 p.m.

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[72] These seven securities were chosen as typical examples representing patterns of liquidity observed in many individual stocks and ETFs on May 6. Some of these securities were previously discussed in the Preliminary Report. The data and discussions presented in the section are limited only to trading and liquidity on May 6, and no meaning should be construed about the companies themselves or their trading patterns on days other than May 6.

[73] It is important to note that limit orders that are more than 500 bp from the NBBO midquote include a very wide range of prices (including stub-quotes), and were probably viewed as unlikely to be executed. These orders may have been placed months prior to May 6.

Charts 4.A and 4.B show that, prior to 2:20 p.m., there were approximately 200,000 shares available as selling liquidity and 120,000 to 140,000 shares for purchase within 500 bp of the NBBO midpoint. Outside of this price range, there are an additional 400,000 to 600,000 shares associated with sell orders, and prior to 2:30 p.m., an additional 50,000 to 100,000 shares associated with buy orders. In aggregate, the number of sell orders accounted for up to, and in some cases, more than, twice the number of buy orders. Although there are some fluctuations, the book of limit orders remains fairly stable until around 2:20 p.m.

After 2:20 p.m., liquidity began to disappear, gradually getting smaller on both the buy side and the sell side. Until 2:40 p.m., the amount of sell liquidity within 500 bp continued to exceed the amount of buy liquidity within 500 bp by almost 100%, and outside of the 500 bp range, the disparity was even greater. Within the next few minutes, the amount of sell liquidity fell rapidly until by 2:43 p.m. there were only 50,000 shares available for either selling liquidity or buying liquidity. From 2:43 p.m. through 2:44 p.m., selling liquidity fell sharply, perhaps as orders were executed, and buying liquidity declined less, so that at 2:44 p.m., there were approximately 33,000 shares with orders to purchase within 500 bp of the NBBO midpoint, but only approximately 22,000 shares with orders to sell within 500 bp.

Over the period, the amount of buy-side liquidity actually increased, so that in the minute prior to the drop in the stock price, the amount of buy limit orders was approximately 45,000 shares, more than four times the number of sell limit orders. By the end of minute when the broken trades occurred (shown on the chart as 2:48 p.m., representing a snapshot of the order book at 2:48:00 p.m. exactly), we did not observe any shares available as either buy or sell limit orders within 5% of the NBBO. Outside of this price range, there are many sell orders, but no buy orders. Orders were executed against stub quotes during that minute. In the next minute, share prices recovered, and liquidity reappeared. However, the full depth of the order book does not return to pre-2:20 p.m. levels until just before the close of the markets at 4 p.m.

The charts also include information about order flow, specifically the net number of executed aggressive buy orders per minute. The data indicate that there were more aggressive sell orders than buy orders throughout the day, with a few exceptions. In addition, the net number of aggressive buy orders per minute indicates some potentially significant increases in selling pressure. These downward spikes do not approach the number of shares available for purchase within 500 bp of the mid-quote, however, until 2:43 p.m. and 2:46 p.m. Based on these data, it appears that the drop in price was associated with the decline in liquidity that was concurrent with an observed increase in selling pressure.

Proctor & Gamble Co. (PG), Charts 5.A and 5.B

Procter & Gamble is another company whose stock price decline was discussed in the Preliminary Report. PG declined from more than $60 to a low of $39.37 in approximately three and a half minutes (a 36.14% decline from the 2:40 p.m. price), then recovered above $60 in approximately one minute. We observed that the decline in PG did not begin until 2:44 p.m., well after the broader market indices, which began their precipitous drop at approximately 2:40 p.m.

Charts 5.A and 5.B indicate that PG had far more absolute market depth than ACN during the morning and early afternoon of May 6. The amount of shares in sell limit orders within 500 bp is nearly ten times the comparable number of shares for ACN. The difference is not as dramatic for buy limit orders, where the ratio is closer to four times the comparable number

for ACN. Throughout the day, the number of shares in the selling limit order book strongly exceeded the number of shares in the buying limit order book. The ratio appears to be steady, at approximately four-to-one, between the open and 2:39 p.m., either within the 500 bp range or outside of that range.

At 2:40 p.m., the amount of selling liquidity within the 500 bp range dropped from approximately 1,200,000 shares to approximately 500,000 shares, while the amount of buying liquidity was roughly unchanged at approximately 230,000 shares. Liquidity continued to disappear until 2:47 p.m., when PG hit its lowest price, and the amount of buy and sell liquidity within 500 bp was less than 50,000 shares on each side. It is noticeable that the amount of liquidity within 500 bp did not return to its earlier levels at any time after this drop. After 3 p.m. it remains fairly steady at approximately 250,000 shares of selling liquidity and 100,000 shares of buying liquidity. It is also apparent that the total liquidity, which includes the full range of quotes, did not decline on the sell side, but the total buying liquidity was dramatically reduced at 2:47 p.m.

The charts also indicate that the net aggressive selling executed orders exceeded the amount of available buy limit orders within 500 bp at 2:45 p.m. However, the balance shifted toward aggressive buy executions, so that by 2:47 p.m., the number of aggressive buys exceeded the number of aggressive sells.

3M Co. (MMM), Charts 6.A and 6.B

The Preliminary Report also discussed 3M, another large capitalization stock that declined substantially. We observed that the bid-ask spread for MMM stayed quite narrow, and volume remained significant, even as the price declined from about $82 at 2:44 p.m. to a low of approximately $68 at 2:46 p.m. Prior to reaching this low, the bid-ask spread over any given second dramatically widened and remained erratic before beginning a slow and choppy recovery.

In addition, we noted that MMM first declined from approximately $82.50 at 2:44 p.m. to approximately $71.00, then slowly began to recover. Though this 14% decline was substantial, at approximately 2:46 p.m., the price declined sharply for a second time and hit a daily low of $67.98, resulting in a total decline from its 2:40 p.m. price of 18.39%, second only to PG among DJIA stocks. The price then suddenly climbed within a few seconds to approximately $77.

As shown in Charts 6.A and 6.B, MMM is closer in magnitude of available liquidity to Accenture than PG, with selling liquidity within 500 bp ranging from 340,000 shares to 150,000 shares prior to 2:15 p.m. As with both PG and ACN, MMM had more selling liquidity during the morning hours than buying liquidity, with a ratio that was close to two-to-one for most of the day. Also, throughout most of the day, aggressive selling volume exceeded aggressive buying volume. There was a pronounced decline in selling liquidity of approximately 100,000 shares just before 2 p.m. Selling liquidity within 500 bp continued to decline, and buying liquidity also fell, between 2:00 p.m. and 2:45 p.m. Like both PG and ACN, the available liquidity in MMM was very low between 2:45 and 2:50 p.m. Also, like PG, there was no substantial decline in selling liquidity in the range beyond 500 bp, between 2:45 p.m. and 2:50 p.m., despite the large decline in buying liquidity in this wider price range.

The observed second dip in MMM prices, discussed in the Preliminary Report, appears to coincide with a small increase in net aggressive selling volume, and at the time of the second downward spike in prices, it is clear that there is still very little liquidity within 500 bp of the NBBO midpoint.

International Business Machines Corp (IBM), Charts 7.A and 7.B

In the Preliminary Report, we observed that IBM was a security with a much smaller price decline than the securities described above. In light of the observed differences in price patterns for executions, it is interesting to note many common features with regards to the patterns of liquidity availability and aggressive selling pressure. Charts 7.A and 7.B show that, similar to ACN, PG, and MMM, liquidity was much higher prior to 2:00 p.m., and it declined with increasing speed until it hit its low point at 2:47 p.m. The available liquidity at 2:47 p.m. was approximately 10,000 shares within 500 bp in selling liquidity and approximately 30,000 shares within 500 bp in buying liquidity, far less than the roughly 250,000 shares of comparable selling and buying liquidity available between 11:00 a.m. and 2:10 p.m.

A difference between IBM and ACN, PG, and MMM is that the net aggressive selling orders exceeded the number of shares available in the limit order book at 2:45 p.m., even though the overall price decline of IBM was modest by comparison to those other securities. This may indicate that incoming buy-orders were replenishing the order book at a pace that was fast enough to prevent a further erosion of prices. Even so, we note that buy-side market depth declined to a minimum of approximately 12% of its median value on May 6. Based on the data summarized in Table IV.1, IBM was therefore in the second lowest quintile of liquidity-contraction. This is consistent with the premise that relative market-depth declines are a reasonable indicator of the magnitude of corresponding price declines.

Apple Inc. (AAPL), Charts 8.A and 8.B

In contrast to the stocks discussed above, the depth of the buy order book for AAPL (within 500 bp of the mid-quote) exceeded the depth of its sell order book throughout most of the day until 2:39 p.m. However, just as for the other securities, the available liquidity dropped rapidly between 2:30 p.m. and 2:45 p.m., reaching a minimum where very few shares were available at 2:47 p.m., when its price rapidly declined.

Unlike ACN, PG, MMM, and IBM, AAPL showed spikes of executed aggressive buying orders throughout the day that exceeded the number of contemporaneous executed aggressive selling orders. In addition, the data shows three large spikes in net aggressive executed selling orders, at 2:35 p.m., 2:37 p.m., and 2:45 p.m. However, it does not appear that these spikes created significant imbalances between the buy-order book and the sell-order book. Rather, these imbalances were manifest starting at 2:48 p.m., when the price of AAPL was recovering. We also note that there were two broken trades in APPL occurring at approximately 3:29 p.m. when 895 shares were executed at high stub-quote prices of $100,000.

General Electric Co. (GE), Charts 9.A and 9.B

The data on liquidity and aggressive net executed orders for GE does not indicate a dramatically different pattern than what was observed for ACN, PG, MMM, IBM, and AAPL. First, GE had a substantially deeper book, compared to PG at approximately 1,800,000 to 2,500,000 shares of buying liquidity and 1,200,000 to 1,800,000 shares of selling liquidity. Second, like AAPL, within the 500 bp range, its buy liquidity exceeded its sell liquidity, but

outside of that range, GE had more sell liquidity than buy liquidity. Like each of the other securities, both buy and sell liquidity declined dramatically around 2:30 p.m. Compared to PG, GE had more liquidity available at 2:47 p.m. and 2:48 p.m., reaching a minimum of approximately 200,000 shares of selling liquidity and 250,000 shares of buying liquidity within the 500 bp range. It also had large spikes in aggressive net executed selling orders, similar to AAPL, PG and IBM.

iShares Russell 2000 Index (IWM), Charts 10.A and 10.B

As observed in the Preliminary Report, a disproportionate number of the stocks with substantial stock price declines and recoveries were ETFs. The patterns of liquidity and aggressive order imbalance for the iShares Russell 2000 Index in Charts 10.A and 10.B show many common elements, but also some differences when compared with the non-ETF securities.

For most of the day there was very significant buy order and sell order market depth of approximately 1.8 million shares.   Starting at 2:44 p.m. there was a dramatic contraction both buy depth and sell depth, and by 2:50 p.m. liquidity within 500 bp from the mid-quote had all but vanished. However, price declines were modest throughout the time period.

Also of note is that quotes were highly concentrated within about 30 bp from the mid-quote, with relatively almost no market depth beyond 500 bp. As liquidity declined after 2:45 p.m., a greater fraction of total market depth only existed beyond 500 bp of the mid-quote.

Chart 4.A: Accenture plc. (ACN)
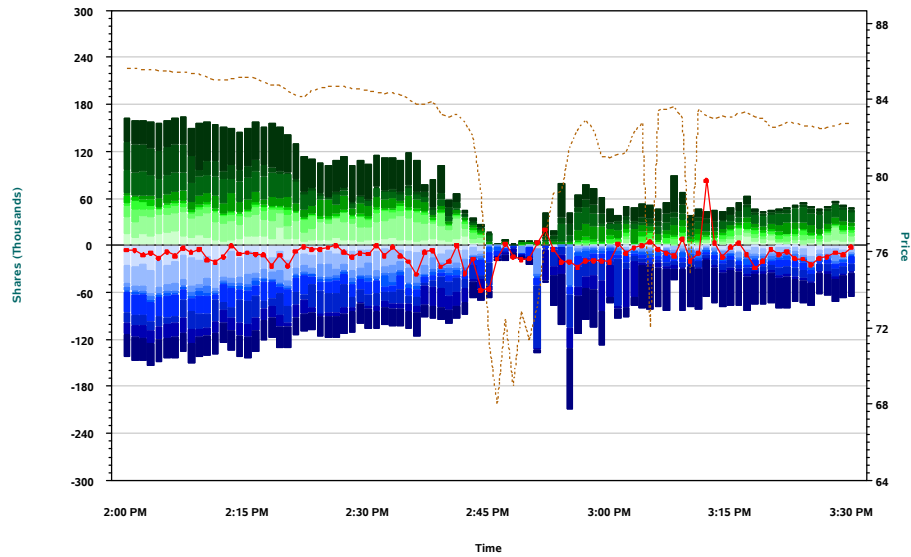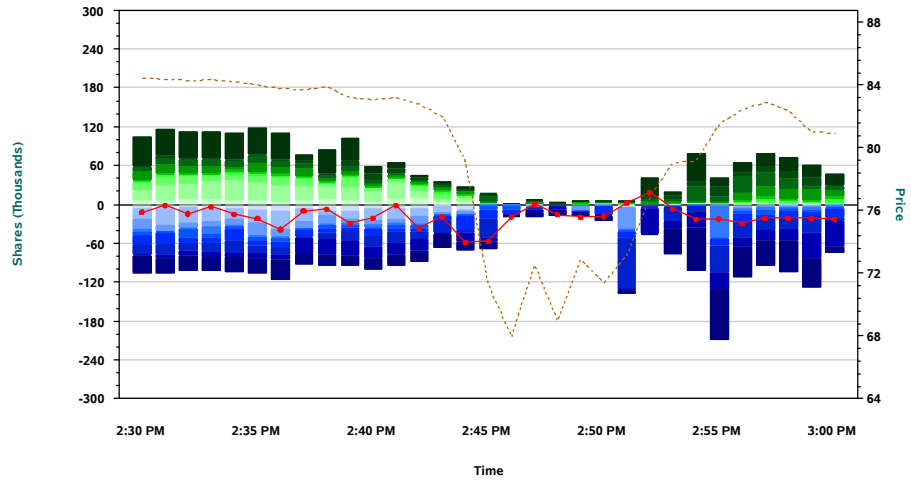## Market Depth (within 500 basis points) and Net Aggressive Buy Volume

9:30am - 4:00pm

2:00pm - 3:30pm

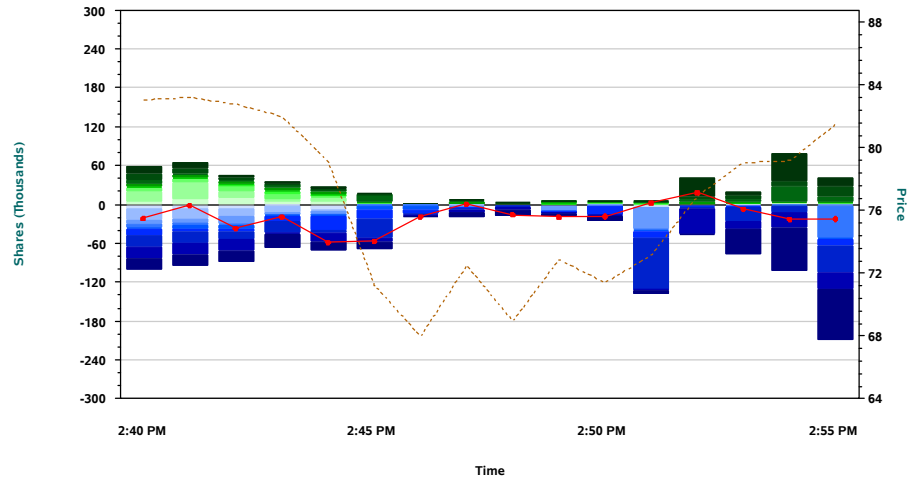

2:30pm - 3:00pm

2:40pm - 2:55pm

Order Type:
- Mid+%0.1
- Mid+%0.2
- Mid+%0.3
- Mid+%0.4
- Mid+%0.5
- Mid+%1.0
- Mid+%2.0
- Mid+%3.0
- Mid+%5.0
- Mid-%0.1
- Mid-%0.2
- Mid-%0.3
- Mid-%0.4
- Mid-%0.5
- Mid-%1.0
- Mid-%2.0
- Mid-%3.0
- Mid-%5.0

Price: Minimum Executed Price   Net Aggressive Buy Volume

The order book depth reflects the total number of shares in unfilled limit orders, by ticker and minute. The data combines the information from NYSE Openbook, ArcaBook, NASDAQ ModelView, and BATS order book data.
Net Aggressive Buy Volume is defined as executed shares associated with aggressive buy orders minus executed shares associated with aggressive sell orders.
Aggressive buy orders are market buy orders and buy orders at or above the offer price. Aggressive sell orders are market sell orders and sell orders at or below the bid price.
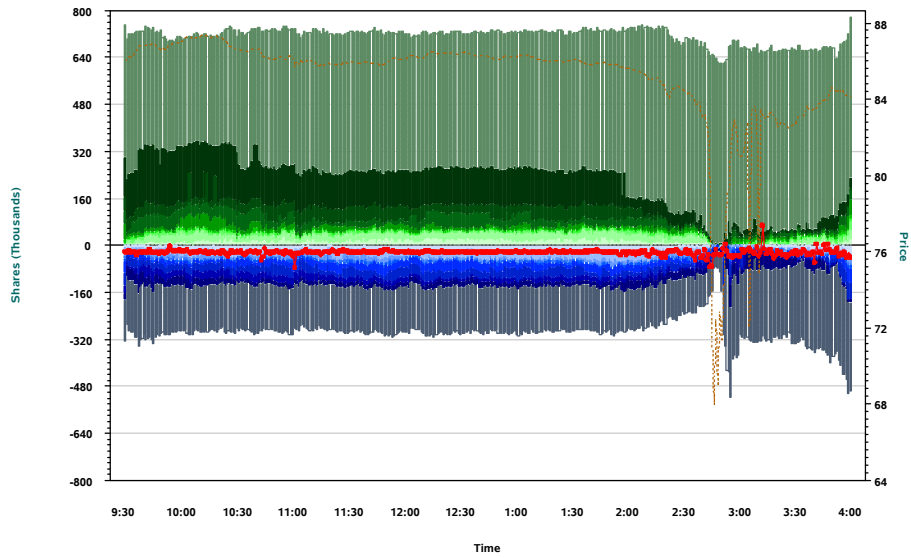The traded price fell 99.98% from $41.52 at 2:30PM to $0.01 at 2:47PM (based on TAQ data).
There were 112 broken trades with 10,790 shares from 2:36pm to 3:02pm. There were 112 broken trades with 10,790 shares throughout the day.
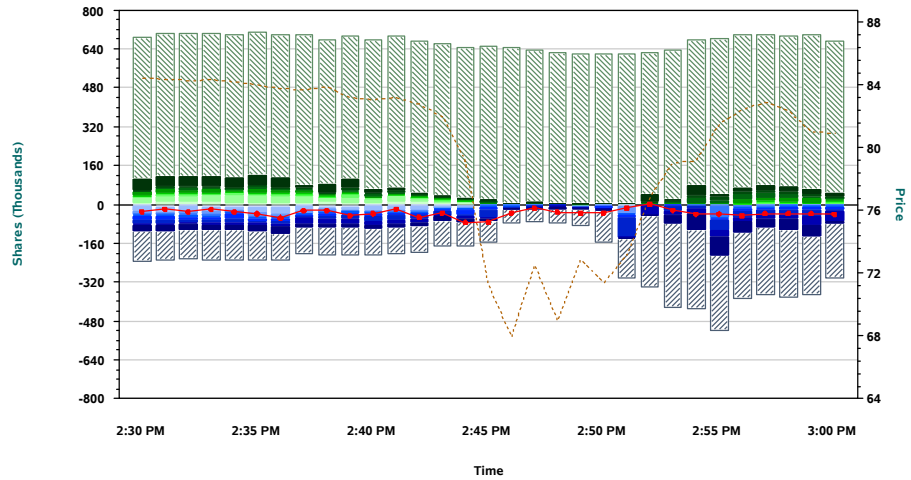
9:30am - 4:00pm

2:00pm - 3:30pm

2:30pm - 3:00pm

2:40pm - 2:55pm

Order Type:

Mid+%0.1	Mid+%0.2	Mid+%0.3	Mid+%0.4	Mid+%0.5
Mid+%1.0	Mid+%2.0	Mid+%3.0	Mid+%5.0	Mid+%5.0+
Mid-%0.1	Mid-%0.2	Mid-%0.3	Mid-%0.4	Mid-%0.5
Mid-%1.0	Mid-%2.0	Mid-%3.0	Mid-%5.0	Mid-%5.0+

Order Type:

Mid+%0.1	Mid+%0.2	Mid+%0.3	Mid+%0.4	Mid+%0.5
Mid+%1.0	Mid+%2.0	Mid+%3.0	Mid+%5.0	Mid+%5.0+
Mid-%0.1	Mid-%0.2	Mid-%0.3	Mid-%0.4	Mid-%0.5
Mid-%1.0	Mid-%2.0	Mid-%3.0	Mid-%5.0	Mid-%5.0+

Price: — — Minimum Executed Price   ●●● Net Aggressive Buy Volume

Price: — — Minimum Executed Price   ●●● Net Aggressive Buy Volume

The order book depth reflects the total number of shares in unfilled limit orders, by ticker and minute. The data combines the information from NYSE Openbook, ArcaBook, NASDAQ ModelView, and BATS order book data.

Net Aggressive Buy Volume is defined as executed shares associated with aggressive buy orders minus executed shares associated with aggressive sell orders.

Aggressive buy orders are market buy orders and buy orders at or above the offer price. Aggressive sell orders are market sell orders and sell orders at or below the bid price.

The traded price fell 99.98% from $41.52 at 2:30PM to $0.01 at 2:47PM (based on TAQ data).

There were 112 broken trades with 10,790 shares from 2:36pm to 3:02pm. There were 112 broken trades with 10,790 shares throughout the day.

Chart 5.A: Procter & Gamble Company (The) (PG)
Market Depth (within 500 basis points) and Net Aggressive Buy Volume

9:30am - 4:00pm

2:00pm - 3:30pm

2:30pm - 3:00pm

2:40pm - 2:55pm

Order Type:
Mid+%0.1 | Mid+%0.2 | Mid+%0.3 | Mid+%0.4 | Mid+%0.5
Mid+%1.0 | Mid+%2.0 | Mid+%3.0 | Mid+%5.0 | Mid-%0.1
Mid-%0.2 | Mid-%0.3 | Mid-%0.4 | Mid-%0.5 | Mid-%1.0
Mid-%2.0 | Mid-%3.0 | Mid-%5.0

Price: — — Minimum Executed Price   ●●● Net Aggressive Buy Volume

The order book depth reflects the total number of shares in unfilled limit orders, by ticker and minute. The data combines the information from NYSE Openbook, ArcaBook, NASDAQ ModelView, and BATS order book data.
Net Aggressive Buy Volume is defined as executed shares associated with aggressive buy orders minus executed shares associated with aggressive sell orders.
Aggressive buy orders are market buy orders and buy orders at or above the offer price. Aggressive sell orders are market sell orders and sell orders at or below the bid price.
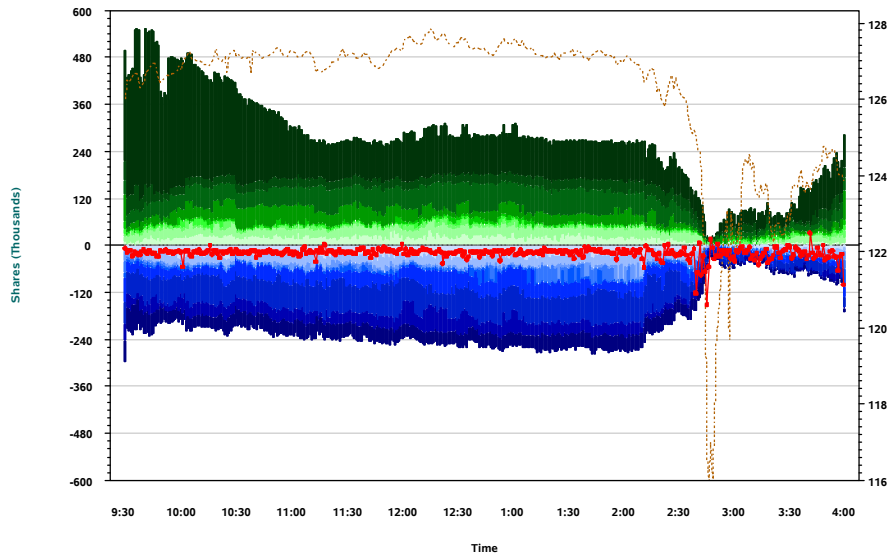The traded price fell 36.69% from $62.19 at 2:30PM to $39.37 at 2:47PM (based on TAQ data).
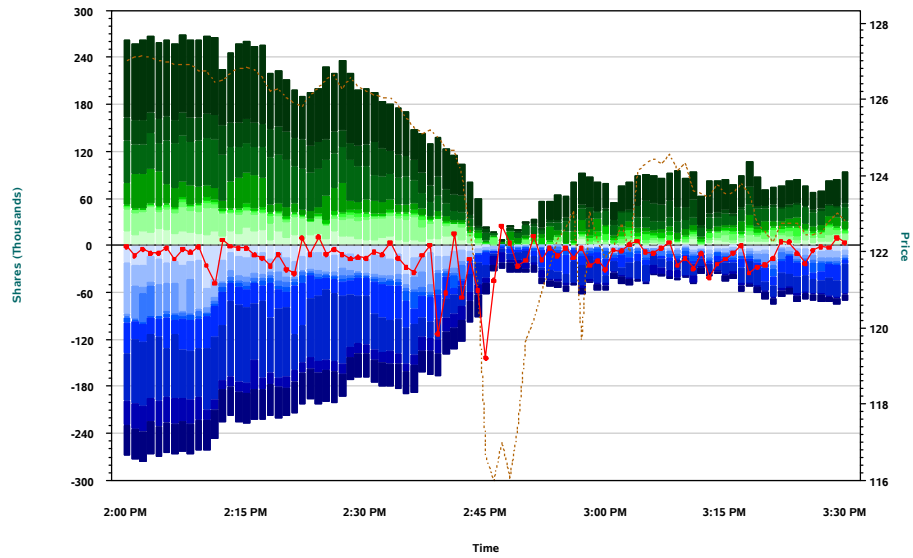There were no broken trades on May 6, 2010.

Chart 5.B: Procter & Gamble Company (The) (PG)
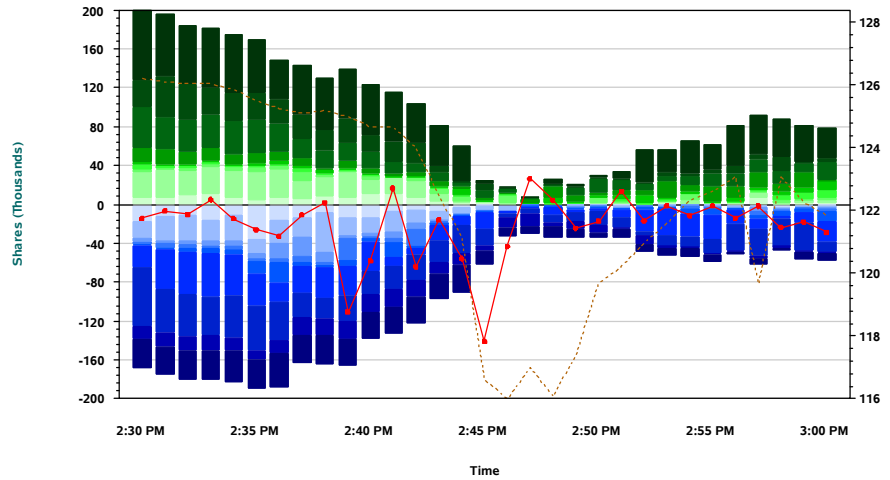## Full Market Depth and Net Aggressive Buy Volume

9:30am - 4:00pm

2:00pm - 3:30pm

2:30pm - 3:00pm

2:40pm - 2:55pm

Order Type:
Mid+%0.1 Mid+%0.2 Mid+%0.3 Mid+%0.4 Mid+%0.5
Mid+%1.0 Mid+%2.0 Mid+%3.0 Mid+%5.0 Mid+%5.0+
Mid-%0.1 Mid-%0.2 Mid-%0.3 Mid-%0.4 Mid-%0.5
Mid-%1.0 Mid-%2.0 Mid-%3.0 Mid-%5.0 Mid-%5.0+

Order Type:
Mid+%0.1 Mid+%0.2 Mid+%0.3 Mid+%0.4 Mid+%0.5
Mid+%1.0 Mid+%2.0 Mid+%3.0 Mid+%5.0 Mid+%5.0+
Mid-%0.1 Mid-%0.2 Mid-%0.3 Mid-%0.4 Mid-%0.5
Mid-%1.0 Mid-%2.0 Mid-%3.0 Mid-%5.0 Mid-%5.0+

Price: — — Minimum Executed Price   ●●● Net Aggressive Buy Volume

Price: — — Minimum Executed Price   ●●● Net Aggressive Buy Volume

The order book depth reflects the total number of shares in unfilled limit orders, by ticker and minute. The data combines the information from NYSE Openbook, ArcaBook, NASDAQ ModelView, and BATS order book data.
Net Aggressive Buy Volume is defined as executed shares associated with aggressive buy orders minus executed shares associated with aggressive sell orders.
Aggressive buy orders are market buy orders and buy orders at or above the offer price. Aggressive sell orders are market sell orders and sell orders at or below the bid price.
The traded price fell 36.69% from $62.19 at 2:30PM to $39.37 at 2:47PM (based on TAQ data).
There were no broken trades on May 6, 2010.

Chart 6.A: 3M Company (MMM)
Market Depth (within 500 basis points) and Net Aggressive Buy Volume
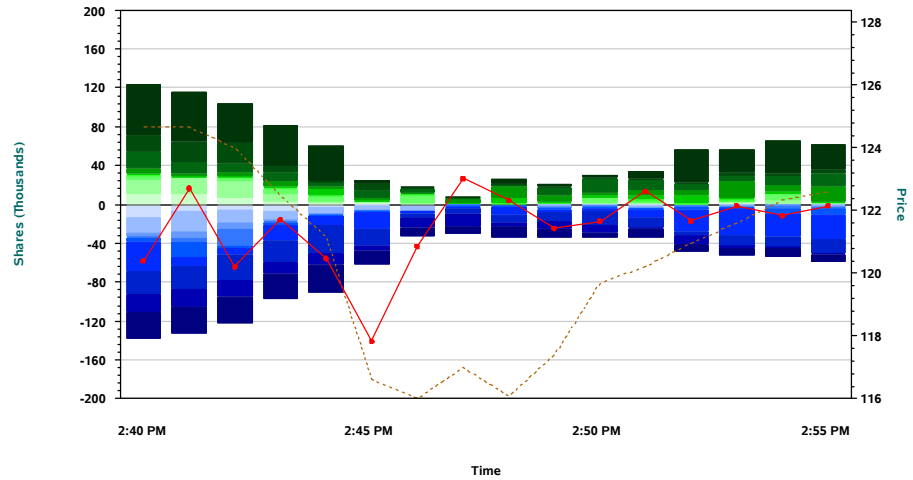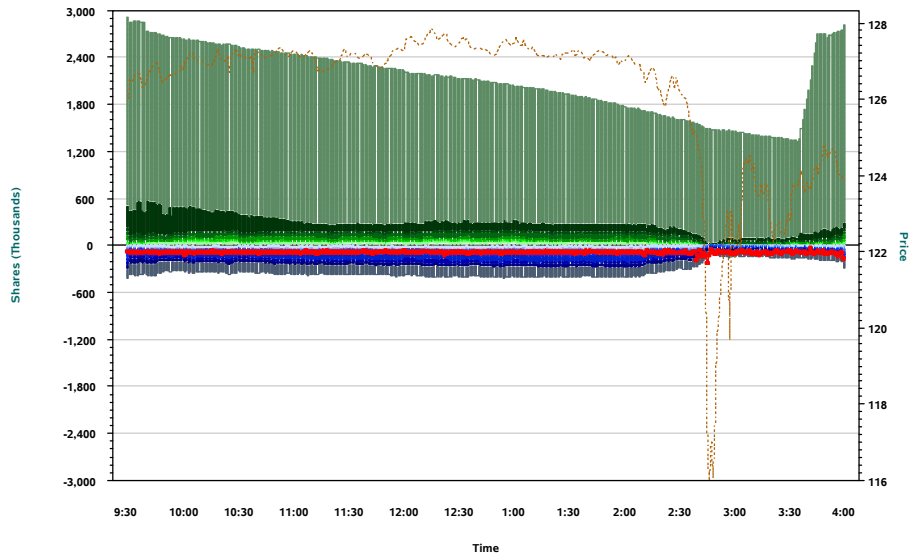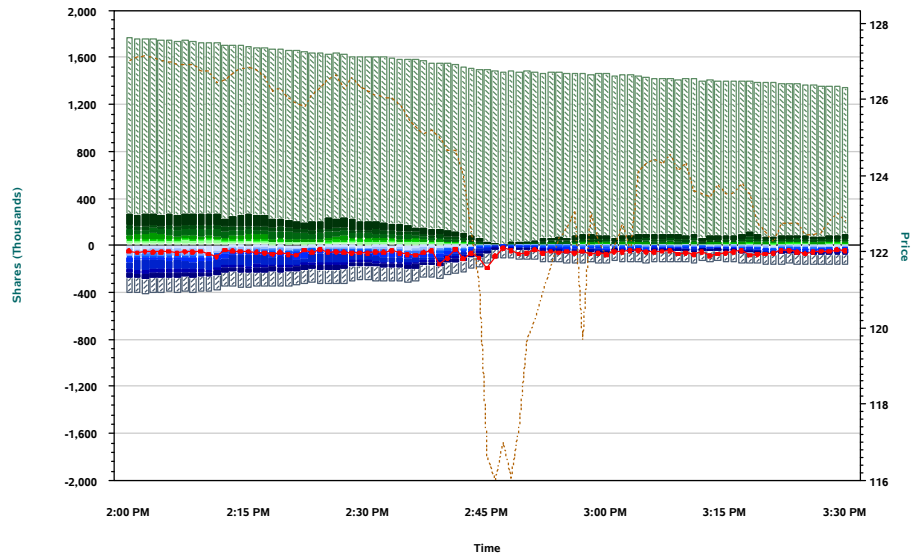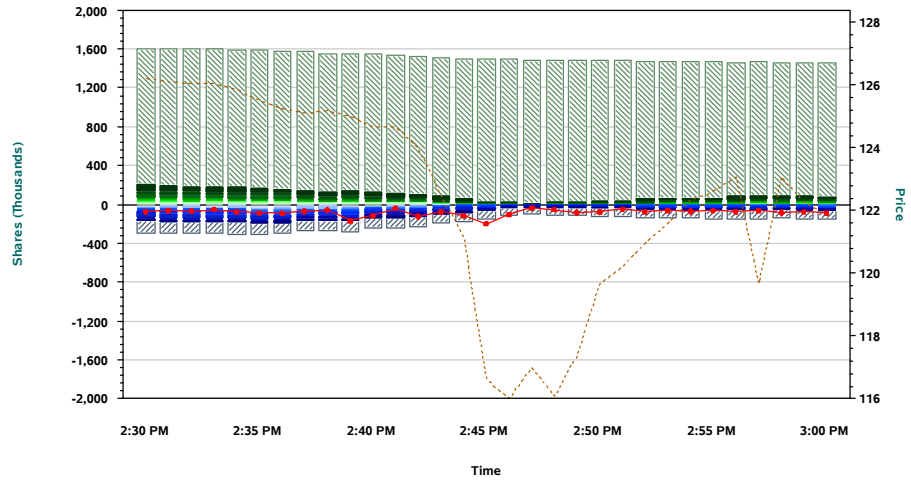
9:30am - 4:00pm

2:00pm - 3:30pm

2:30pm - 3:00pm

2:40pm - 2:55pm

Order Type:
- Mid+%0.1
- Mid+%0.2
- Mid+%0.3
- Mid+%0.4
- Mid+%0.5
- Mid+%1.0
- Mid+%2.0
- Mid+%3.0
- Mid+%5.0
- Mid-%0.1
- Mid-%0.2
- Mid-%0.3
- Mid-%0.4
- Mid-%0.5
- Mid-%1.0
- Mid-%2.0
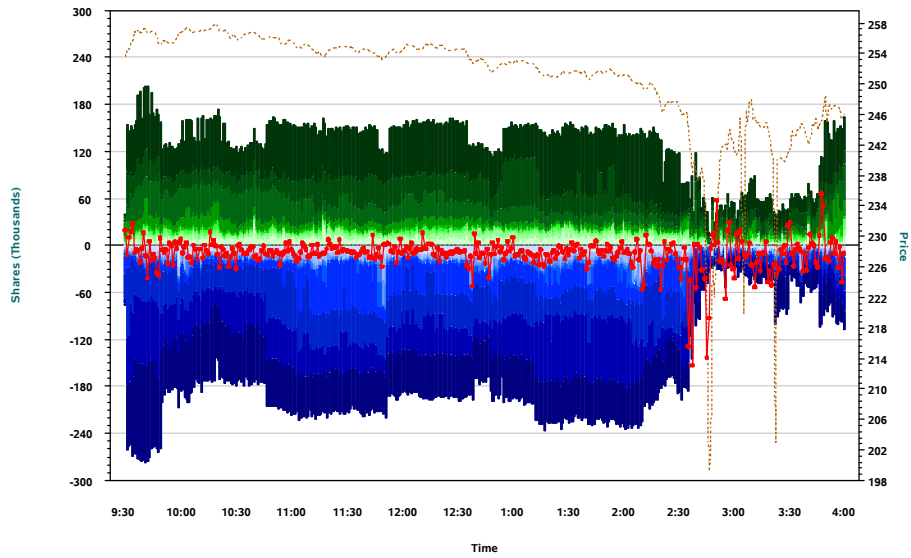- Mid-%3.0
- Mid-%5.0

Price: — — Minimum Executed Price   ●●● Net Aggressive Buy Volume

The order book depth reflects the total number of shares in unfilled limit orders, by ticker and minute. The data combines the information from NYSE Openbook, ArcaBook, NASDAQ ModelView, and BATS order book data.
Net Aggressive Buy Volume is defined as executed shares associated with aggressive buy orders minus executed shares associated with aggressive sell orders.
Aggressive buy orders are market buy orders and buy orders at or above the offer price. Aggressive sell orders are market sell orders and sell orders at or below the bid price.
The traded price fell 19.65% from $84.61 at 2:30PM to $67.98 at 2:46PM (based on TAQ data).
There were no broken trades on May 6, 2010.

Chart 6.B: 3M Company (MMM)
Full Market Depth and Net Aggressive Buy Volume

9:30am - 4:00pm

2:00pm - 3:30pm

2:30pm - 3:00pm

2:40pm - 2:55pm

Order Type: Mid+%0.1 Mid+%0.2 Mid+%0.3 Mid+%0.4 Mid+%0.5 Mid+%1.0 Mid+%2.0 Mid+%3.0 Mid+%5.0 Mid+%5.0+ Mid-%0.1 Mid-%0.2 Mid-%0.3 Mid-%0.4 Mid-%0.5 Mid-%1.0 Mid-%2.0 Mid-%3.0 Mid-%5.0 Mid-%5.0+

Price: — Minimum Executed Price   ●─●─● Net Aggressive Buy Volume

The order book depth reflects the total number of shares in unfilled limit orders, by ticker and minute. The data combines the information from NYSE Openbook, ArcaBook, NASDAQ ModelView, and BATS order book data.
Net Aggressive Buy Volume is defined as executed shares associated with aggressive buy orders minus executed shares associated with aggressive sell orders.
Aggressive buy orders are market buy orders and buy orders at or above the offer price. Aggressive sell orders are market sell orders and sell orders at or below the bid price.
The traded price fell 19.65% from $84.61 at 2:30PM to $67.98 at 2:46PM (based on TAQ data).
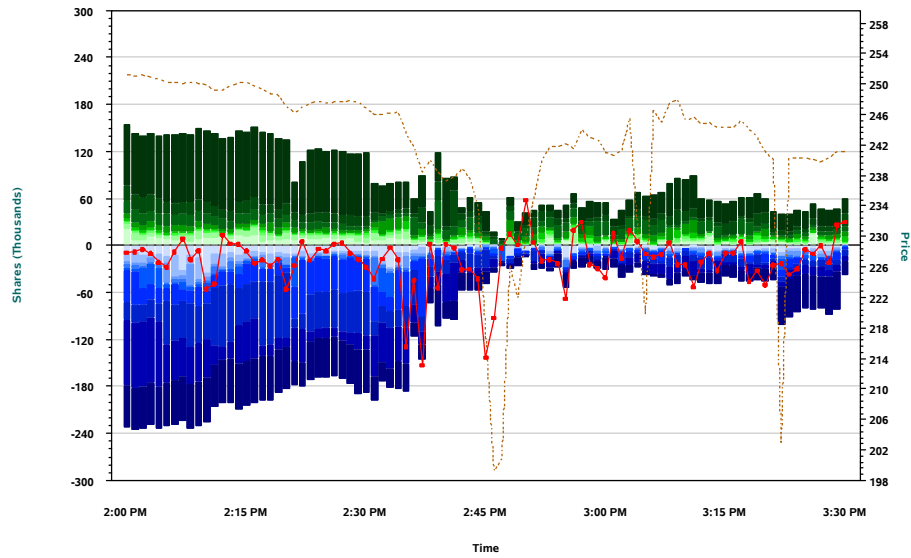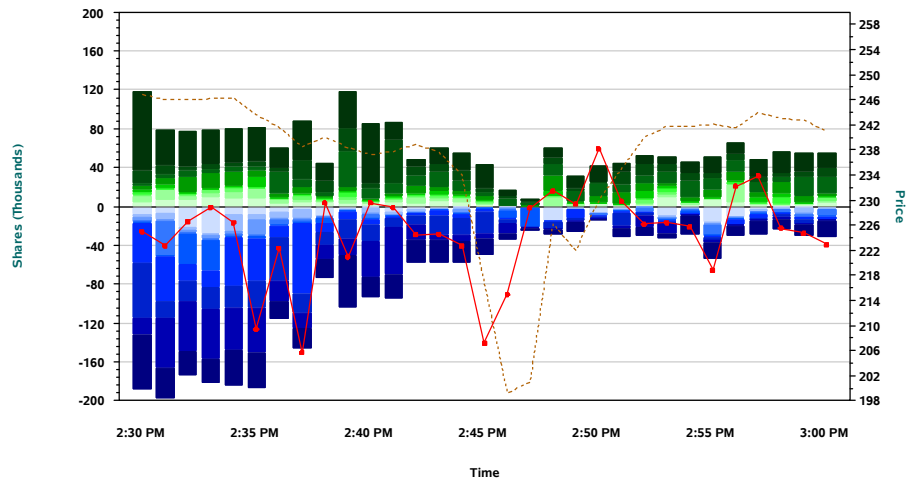There were no broken trades on May 6, 2010.

Chart 7.A: International Business Machines Corporation (IBM)
Market Depth (within 500 basis points) and Net Aggressive Buy Volume

9:30am - 4:00pm

2:00pm - 3:30pm

2:30pm - 3:00pm
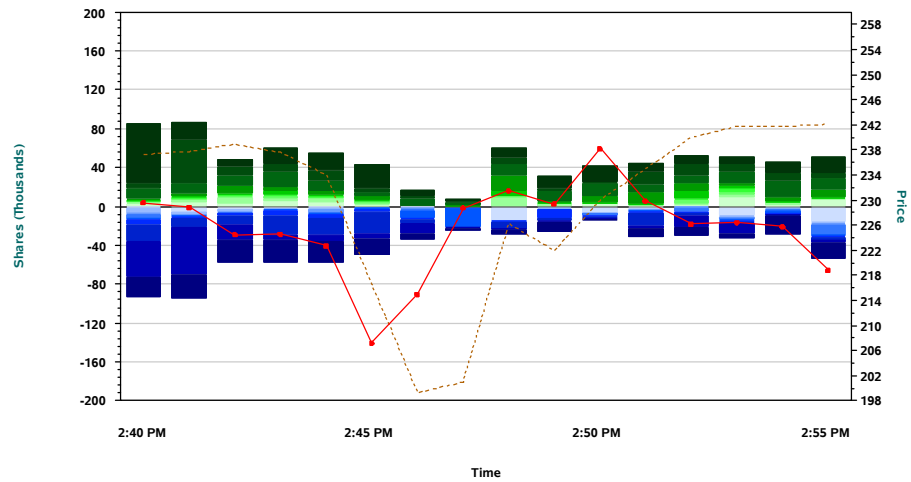

2:40pm - 2:55pm

Order Type:
- Mid+%0.1
- Mid+%0.2
- Mid+%0.3
- Mid+%0.4
- Mid+%0.5
- Mid+%1.0
- Mid+%2.0
- Mid+%3.0
- Mid+%5.0
- Mid-%0.1
- Mid-%0.2
- Mid-%0.3
- Mid-%0.4
- Mid-%0.5
- Mid-%1.0
- Mid-%2.0
- Mid-%3.0
- Mid-%5.0

Price: — — Minimum Executed Price ●●● Net Aggressive Buy Volume

The order book depth reflects the total number of shares in unfilled limit orders, by ticker and minute. The data combines the information from NYSE Openbook, ArcaBook, NASDAQ ModelView, and BATS order book data.
Net Aggressive Buy Volume is defined as executed shares associated with aggressive buy orders minus executed shares associated with aggressive sell orders.
Aggressive buy orders are market buy orders and buy orders at or above the offer price. Aggressive sell orders are market sell orders and sell orders at or below the bid price.
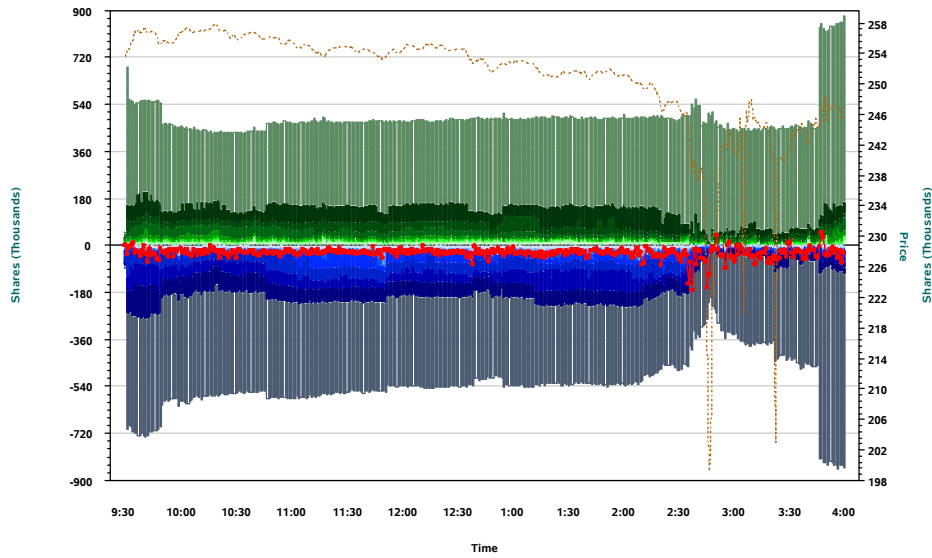The traded price fell 8.31% from $126.52 at 2:30PM to $116.00 at 2:46PM (based on TAQ data).
There were no broken trades on May 6, 2010.

Chart 7.B: International Business Machines Corporation (IBM)
Full Market Depth and Net Aggressive Buy Volume

9:30am - 4:00pm

2:00pm - 3:30pm

2:30pm - 3:00pm

2:40pm - 2:55pm

Order Type:	Mid+%0.1	Mid+%0.2	Mid+%0.3	Mid+%0.4	Mid+%0.5
	Mid+%1.0	Mid+%2.0	Mid+%3.0	Mid+%5.0	Mid+%5.0+
	Mid-%0.1	Mid-%0.2	Mid-%0.3	Mid-%0.4	Mid-%0.5
	Mid-%1.0	Mid-%2.0	Mid-%3.0	Mid-%5.0	Mid-%5.0+

Price: — — Minimum Executed Price ●●● Net Aggressive Buy Volume

The order book depth reflects the total number of shares in unfilled limit orders, by ticker and minute. The data combines the information from NYSE Openbook, ArcaBook, NASDAQ ModelView, and BATS order book data.

Net Aggressive Buy Volume is defined as executed shares associated with aggressive buy orders minus executed shares associated with aggressive sell orders.

Aggressive buy orders are market buy orders and buy orders at or above the offer price. Aggressive sell orders are market sell orders and sell orders at or below the bid price.

The traded price fell 8.31% from $126.52 at 2:30PM to $116.00 at 2:46PM (based on TAQ data).

There were no broken trades on May 6, 2010.

Chart 8.A: Apple Inc. (AAPL)
Market Depth (within 500 basis points) and Net Aggressive Buy Volume

The order book depth reflects the total number of shares in unfilled limit orders, by ticker and minute. The data combines the information from NYSE Openbook, ArcaBook, NASDAQ ModelView, and BATS order book data.

Net Aggressive Buy Volume is defined as executed shares associated with aggressive buy orders minus executed shares associated with aggressive sell orders.

Aggressive buy orders are market buy orders and buy orders at or above the offer price. Aggressive sell orders are market sell orders and sell orders at or below the bid price.
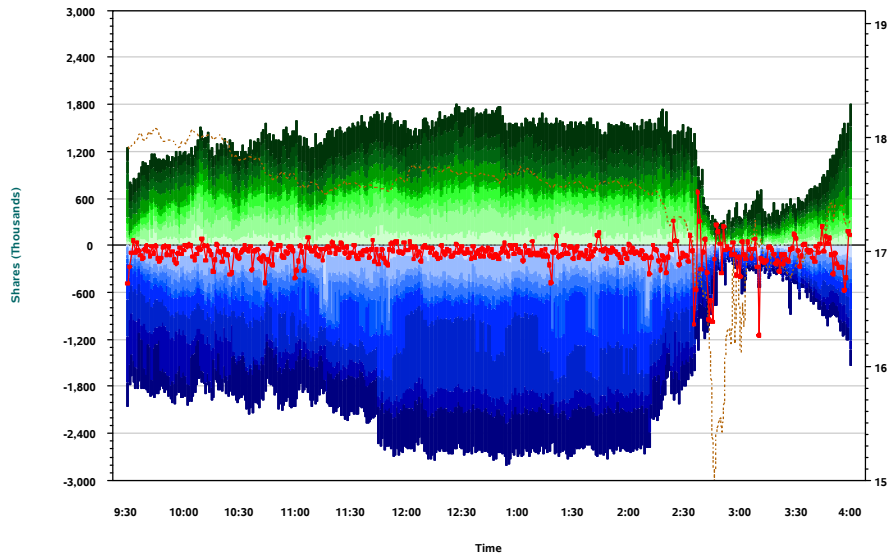
The traded price fell 19.55% from $247.65 at 2:30PM to $199.25 at 2:46PM (based on TAQ data).

There were no broken trades between 2:36pm to 3:02pm. There were 2 broken trades with 895 shares throughout the day.
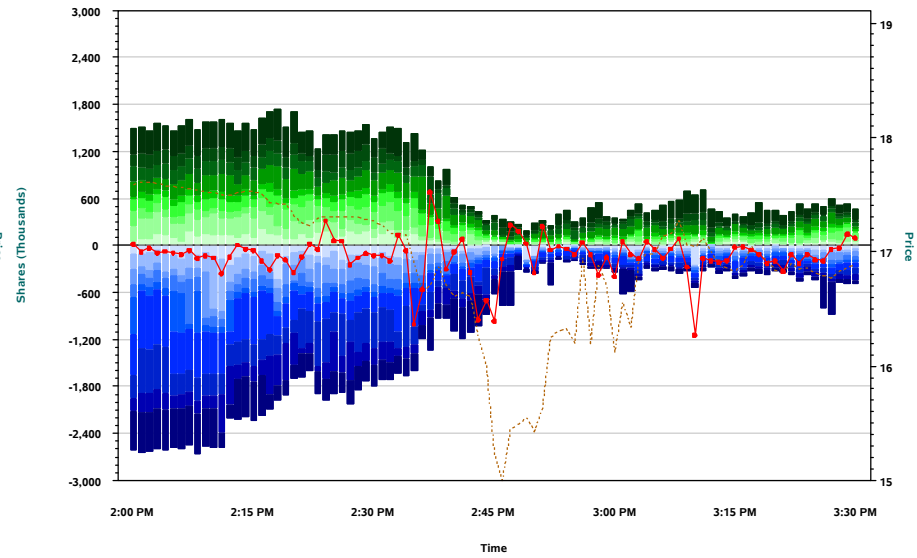
Chart 8.B: Apple Inc. (AAPL)
Full Market Depth and Net Aggressive Buy Volume

9:30am - 4:00pm

2:00pm - 3:30pm

2:30pm - 3:00pm

2:40pm - 2:55pm

Order Type:
- Mid+%0.1 — Mid+%0.2 — Mid+%0.3 — Mid+%0.4 — Mid+%0.5
- Mid+%1.0 — Mid+%2.0 — Mid+%3.0 — Mid+%5.0 — Mid+%5.0+
- Mid-%0.1 — Mid-%0.2 — Mid-%0.3 — Mid-%0.4 — Mid-%0.5
- Mid-%1.0 — Mid-%2.0 — Mid-%3.0 — Mid-%5.0 — Mid-%5.0+

Price: — — — Minimum Executed Price   ●─●─● Net Aggressive Buy Volume

The order book depth reflects the total number of shares in unfilled limit orders, by ticker and minute. The data combines the information from NYSE Openbook, ArcaBook, NASDAQ ModelView, and BATS order book data.
Net Aggressive Buy Volume is defined as executed shares associated with aggressive buy orders minus executed shares associated aggressive sell orders.
Aggressive buy orders are market buy orders and buy orders at or above the offer price. Aggressive sell orders are market sell orders and sell orders at or below the bid price.
The traded price fell 19.55% from $247.65 at 2:30PM to $199.25 at 2:46PM (based on TAQ data).
There were no broken trades between 2:36pm to 3:02pm. There were 2 broken trades with 895 shares throughout the day.

Chart 9.A: General Electric Company (GE)
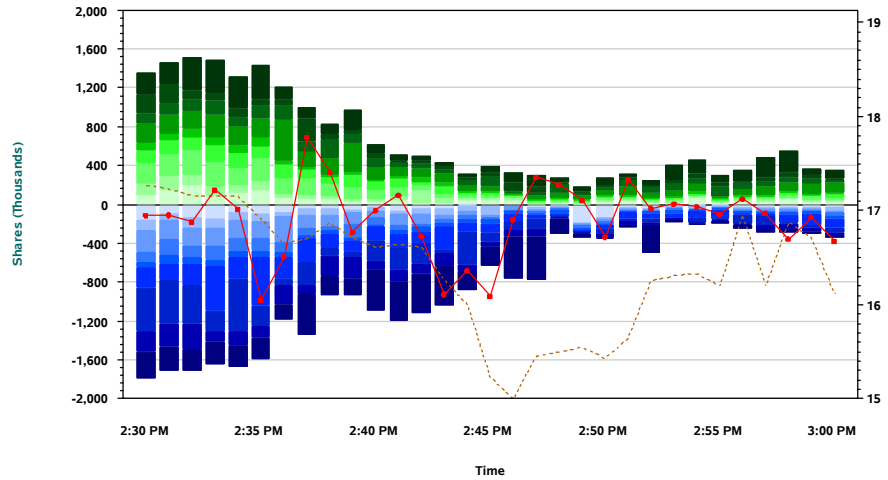## Market Depth (within 500 basis points) and Net Aggressive Buy Volume
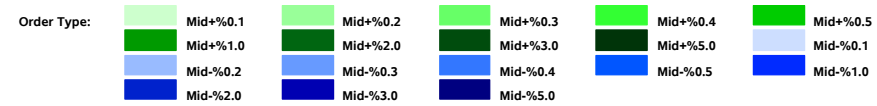
9:30am - 4:00pm

2:00pm - 3:30pm
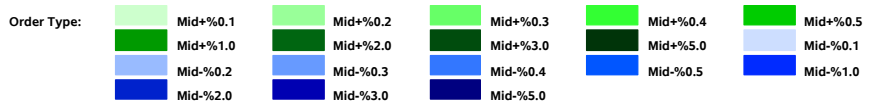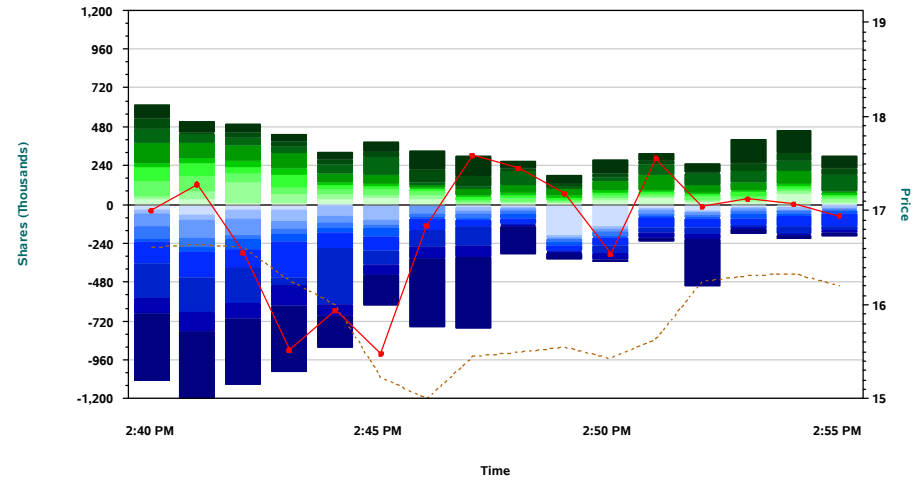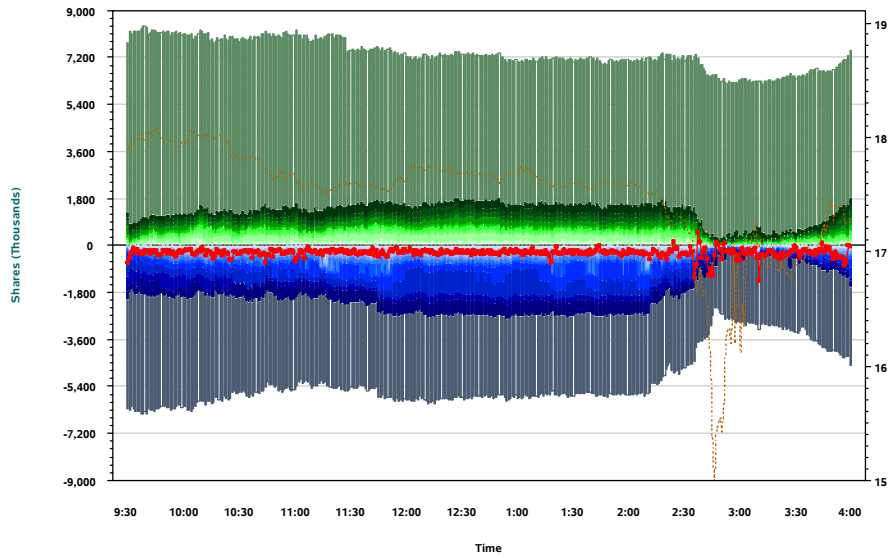
2:30pm - 3:00pm

2:40pm - 2:55pm

Order Type:	Mid+%0.1	Mid+%0.2	Mid+%0.3	Mid+%0.4	Mid+%0.5
	Mid+%1.0	Mid+%2.0	Mid+%3.0	Mid+%5.0	Mid-%0.1
	Mid-%0.2	Mid-%0.3	Mid-%0.4	Mid-%0.5	Mid-%1.0
	Mid-%2.0	Mid-%3.0	Mid-%5.0		

Order Type:	Mid+%0.1	Mid+%0.2	Mid+%0.3	Mid+%0.4	Mid+%0.5
	Mid+%1.0	Mid+%2.0	Mid+%3.0	Mid+%5.0	Mid-%0.1
	Mid-%0.2	Mid-%0.3	Mid-%0.4	Mid-%0.5	Mid-%1.0
	Mid-%2.0	Mid-%3.0	Mid-%5.0		

Price: — — Minimum Executed Price   ●●● Net Aggressive Buy Volume

Price: — — Minimum Executed Price   ●●● Net Aggressive Buy Volume

The order book depth reflects the total number of shares in unfilled limit orders, by ticker and minute. The data combines the information from NYSE Openbook, ArcaBook, NASDAQ ModelView, and BATS order book data.
Net Aggressive Buy Volume is defined as executed shares associated with aggressive buy orders minus executed shares associated with aggressive sell orders.
Aggressive buy orders are market buy orders and buy orders at or above the offer price. Aggressive sell orders are market sell orders and sell orders at or below the bid price.
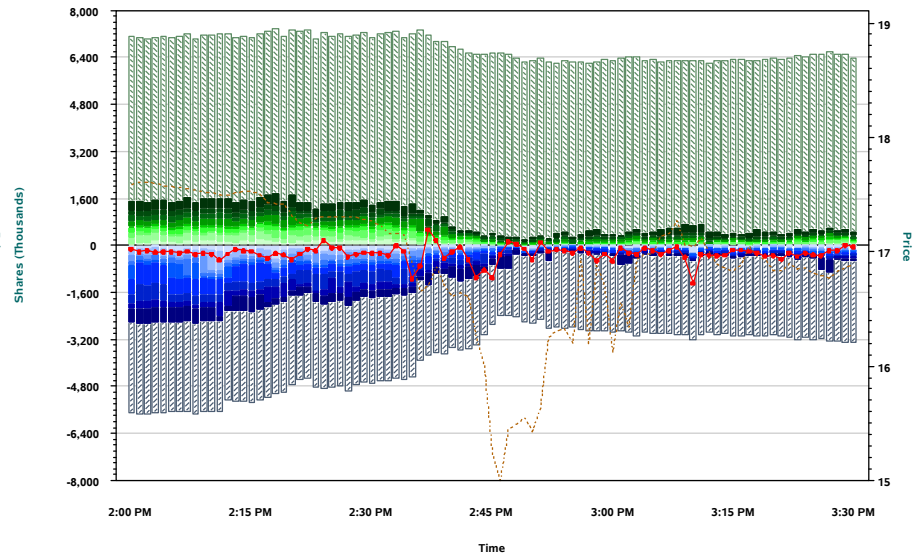The traded price fell 13.29% from $17.30 at 2:30PM to $15.00 at 2:46PM (based on TAQ data).
There were no broken trades on May 6, 2010.

Chart 9.B: General Electric Company (GE)
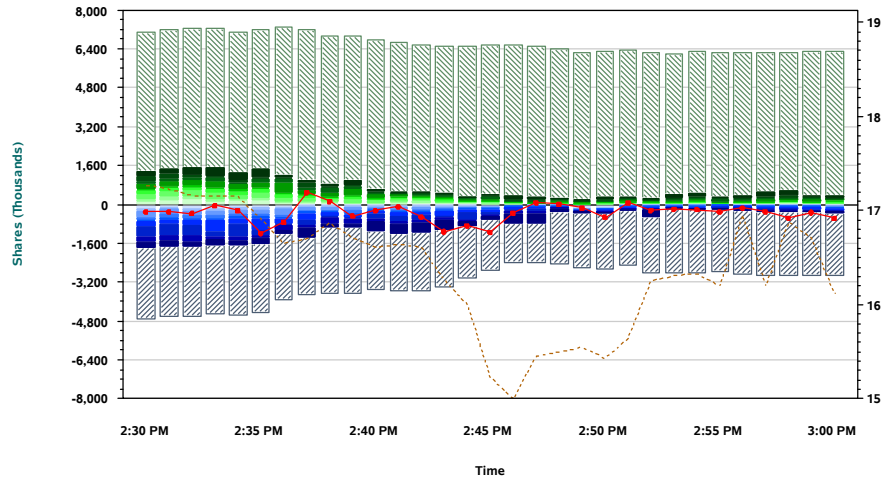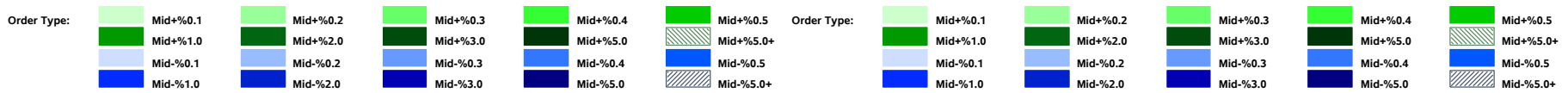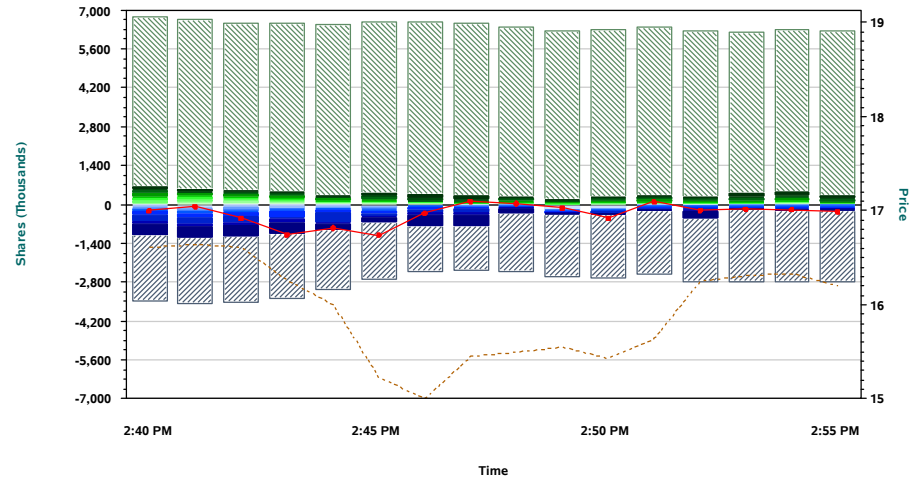## Full Market Depth and Net Aggressive Buy Volume

9:30am - 4:00pm

2:00pm - 3:30pm

2:30pm - 3:00pm

2:40pm - 2:55pm

Order Type:
Mid+%0.1 Mid+%0.2 Mid+%0.3 Mid+%0.4 Mid+%0.5
Mid+%1.0 Mid+%2.0 Mid+%3.0 Mid+%5.0 Mid+%5.0+
Mid-%0.1 Mid-%0.2 Mid-%0.3 Mid-%0.4 Mid-%0.5
Mid-%1.0 Mid-%2.0 Mid-%3.0 Mid-%5.0 Mid-%5.0+

Price: — — Minimum Executed Price   ●—●—● Net Aggressive Buy Volume

The order book depth reflects the total number of shares in unfilled limit orders, by ticker and minute. The data combines the information from NYSE Openbook, ArcaBook, NASDAQ ModelView, and BATS order book data.
Net Aggressive Buy Volume is defined as executed shares associated with aggressive buy orders minus executed shares associated with aggressive sell orders.
Aggressive buy orders are market buy orders and buy orders at or above the offer price. Aggressive sell orders are market sell orders and sell orders at or below the bid price.
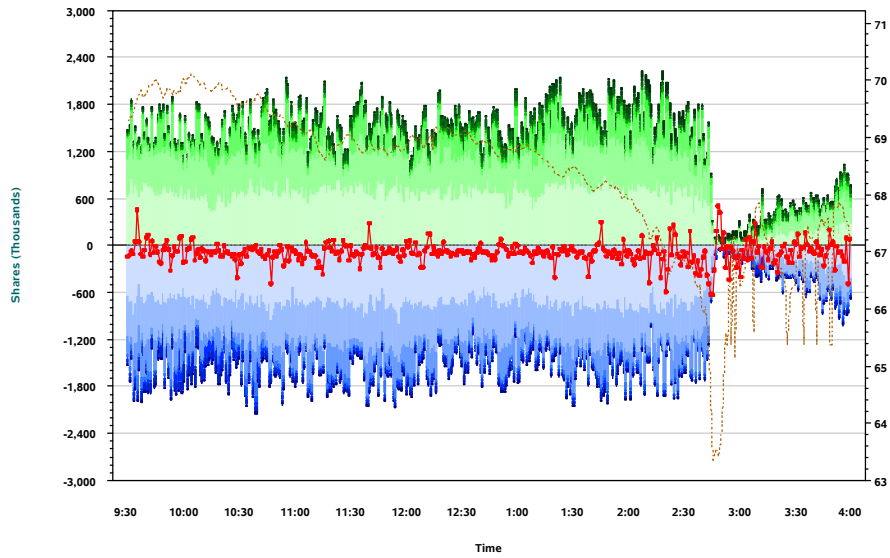The traded price fell 13.29% from $17.30 at 2:30PM to $15.00 at 2:46PM (based on TAQ data).
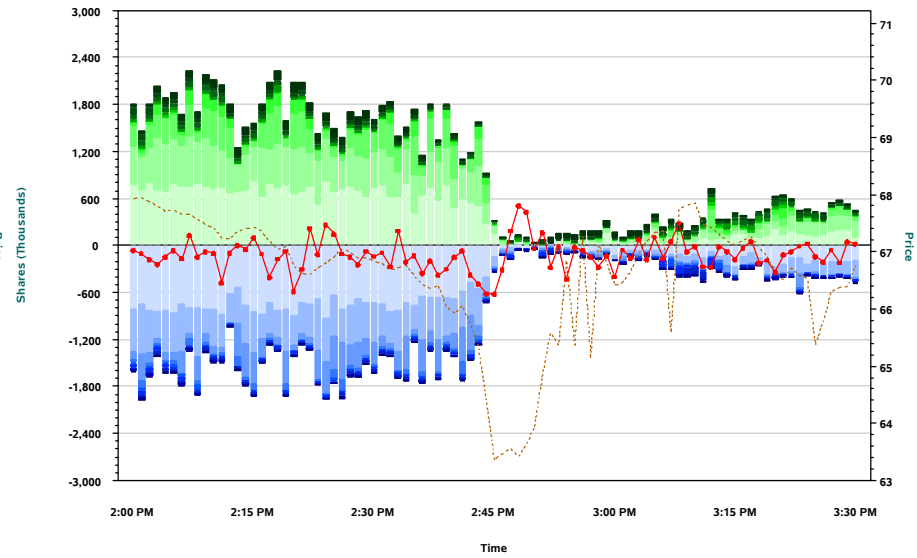There were no broken trades on May 6, 2010.

Chart 10.A: Russell 2000 Index (Barclays) (IWM)
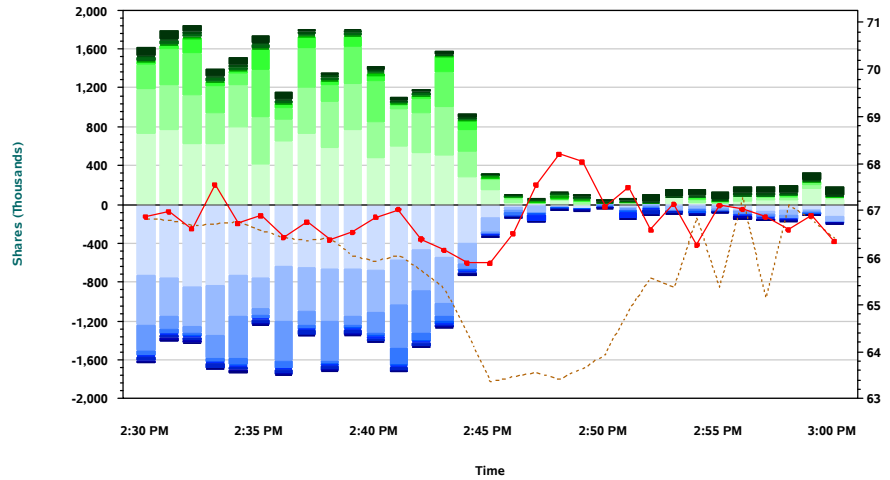## Market Depth (within 500 basis points) and Net Aggressive Buy Volume
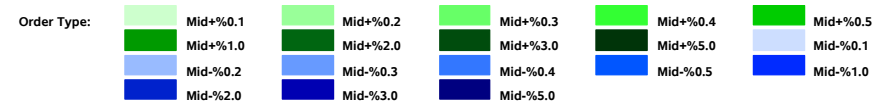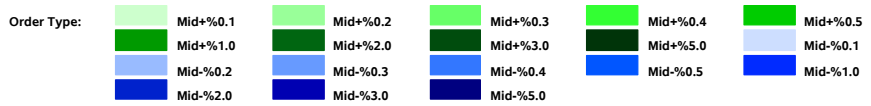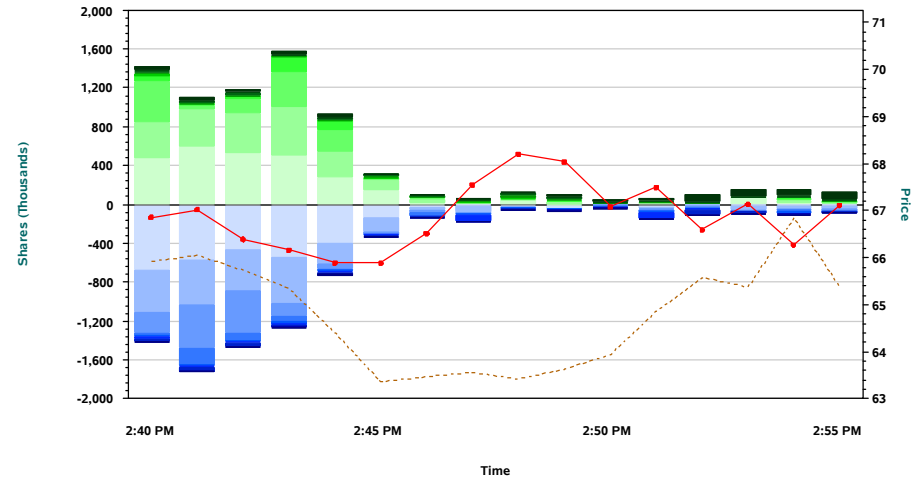
9:30am - 4:00pm

2:00pm - 3:30pm

2:30pm - 3:00pm

2:40pm - 2:55pm

Order Type:
Mid+%0.1   Mid+%0.2   Mid+%0.3   Mid+%0.4   Mid+%0.5
Mid+%1.0   Mid+%2.0   Mid+%3.0   Mid+%5.0   Mid-%0.1
Mid-%0.2   Mid-%0.3   Mid-%0.4   Mid-%0.5   Mid-%1.0
Mid-%2.0   Mid-%3.0   Mid-%5.0

Price: — — — Minimum Executed Price   ●—●—● Net Aggressive Buy Volume

Order Type:
Mid+%0.1   Mid+%0.2   Mid+%0.3   Mid+%0.4   Mid+%0.5
Mid+%1.0   Mid+%2.0   Mid+%3.0   Mid+%5.0   Mid-%0.1
Mid-%0.2   Mid-%0.3   Mid-%0.4   Mid-%0.5   Mid-%1.0
Mid-%2.0   Mid-%3.0   Mid-%5.0

Price: — — — Minimum Executed Price   ●—●—● Net Aggressive Buy Volume

The order book depth reflects the total number of shares in unfilled limit orders, by ticker and minute. The data combines the information from NYSE Openbook, ArcaBook, NASDAQ ModelView, and BATS order book data.
Net Aggressive Buy Volume is defined as executed shares associated with aggressive buy orders minus executed shares associated with aggressive sell orders.
Aggressive buy orders are market buy orders and buy orders at or above the offer price. Aggressive sell orders are market sell orders and sell orders at or below the bid price.
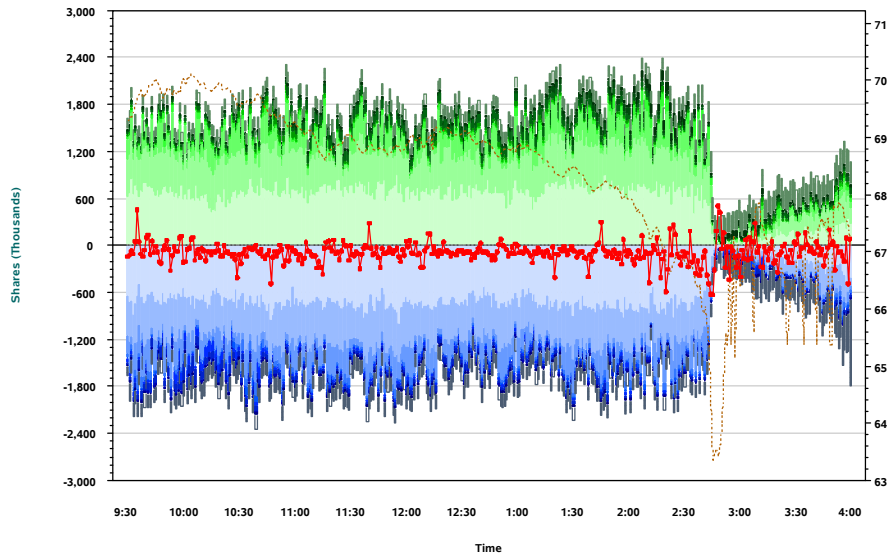The traded price fell 5.36% from $66.95 at 2:30PM to $63.36 at 2:45PM (based on TAQ data).
There were no broken trades between 2:36pm to 3:02pm. There were 5 broken trades with 1,300 shares throughout the day.
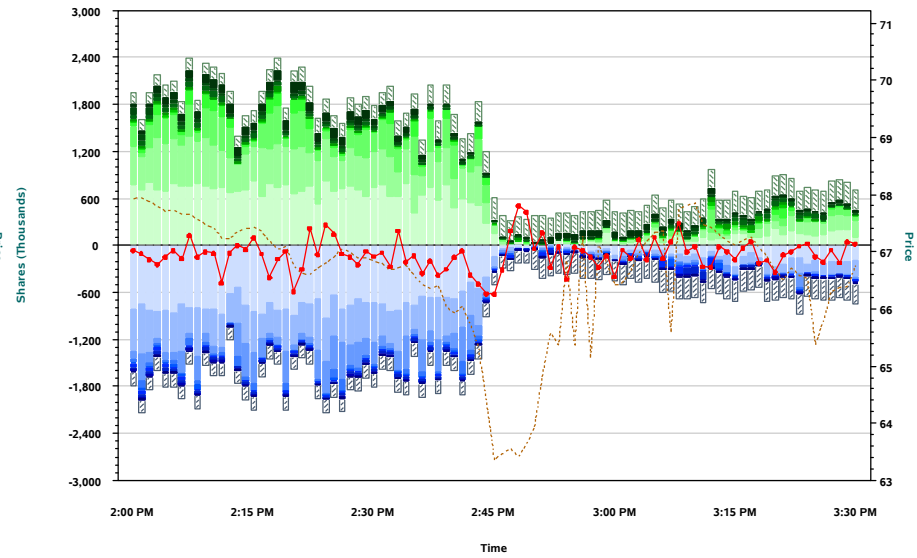
Chart 10.B: Russell 2000 Index (Barclays) (IWM)
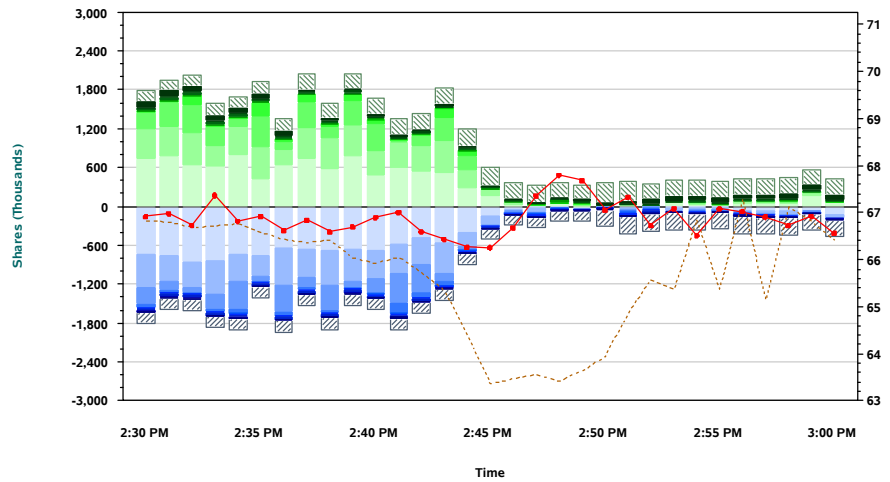## Full Market Depth and Net Aggressive Buy Volume
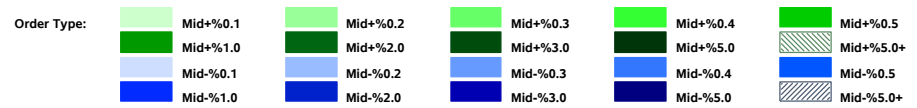

9:30am - 4:00pm

2:00pm - 3:30pm

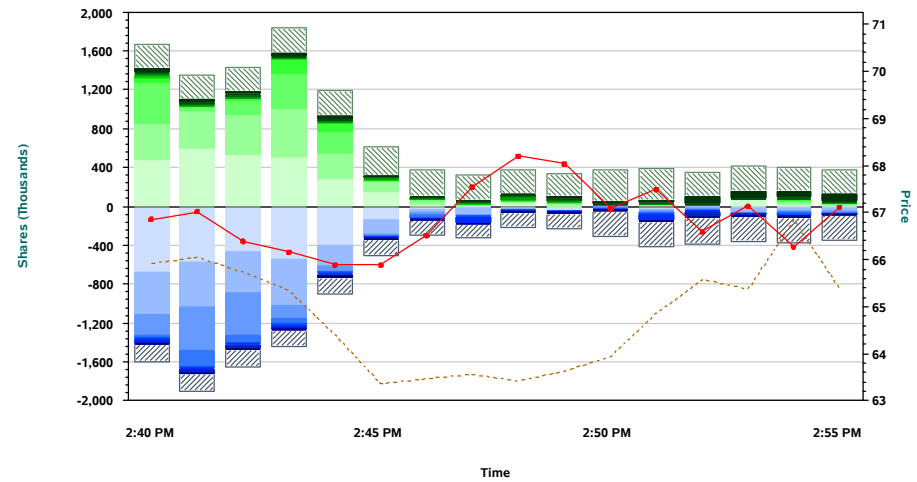*2:30pm - 3:00pm*

2:40pm - 2:55pm

Order Type:

Mid+%0.1	Mid+%0.2	Mid+%0.3	Mid+%0.4	Mid+%0.5
Mid+%1.0	Mid+%2.0	Mid+%3.0	Mid+%5.0	Mid+%5.0+
Mid-%0.1	Mid-%0.2	Mid-%0.3	Mid-%0.4	Mid-%0.5
Mid-%1.0	Mid-%2.0	Mid-%3.0	Mid-%5.0	Mid-%5.0+

Order Type:

Mid+%0.1	Mid+%0.2	Mid+%0.3	Mid+%0.4	Mid+%0.5
Mid+%1.0	Mid+%2.0	Mid+%3.0	Mid+%5.0	Mid+%5.0+
Mid-%0.1	Mid-%0.2	Mid-%0.3	Mid-%0.4	Mid-%0.5
Mid-%1.0	Mid-%2.0	Mid-%3.0	Mid-%5.0	Mid-%5.0+

Price: ─── Minimum Executed Price   ●─●─● Net Aggressive Buy Volume

Price: ─── Minimum Executed Price   ●─●─● Net Aggressive Buy Volume

The order book depth reflects the total number of shares in unfilled limit orders, by ticker and minute. The data combines the information from NYSE Openbook, ArcaBook, NASDAQ ModelView, and BATS order book data.
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Aggressive buy orders are market buy orders and buy orders at or above the offer price. Aggressive sell orders are market sell orders and sell orders at or below the bid price.
The traded price fell 5.36% from $66.95 at 2:30PM to $63.36 at 2:45PM (based on TAQ data).
There were no broken trades between 2:36pm to 3:02pm. There were 5 broken trades with 1,300 shares throughout the day.