Economic Analysis of the Short Sale Price Restrictions Under the Regulation SHO Pilot

Office of Economic Analysis
U.S. Securities and Exchange Commission

This Draft: September 14, 2006

This is a report of the staff of the Office of Economic Analysis. The Commission has expressed no view regarding the analysis, findings or conclusions herein.

Table of Contents

Economic Analysis of the Short Sale Price Restrictions under the Regulation SHO Pilot

A Study by the Staff of the Office of Economic Analysis[1]

I Introduction

A. Background

Short selling in exchange-listed stocks ("Listed Stocks") in the U.S. has been subject to a "tick test" since 1938. Rule 10a-1 under the Securities Exchange Act of 1934 allows short sales to occur only at an uptick or a zero uptick (also known as a "zero-plus tick") for Listed Stocks. That is, short sales in Listed Stocks may be effected above the last trade price or at the last trade price if the last trade price is higher than the most recent trade at a different price.[2] Prior to August 1, 2006, Nasdaq was not operating as an exchange and, therefore, its stocks were not Listed for the purposes of Rule 10a-1. However, in 1994, the National Association of Securities Dealers ("NASD") introduced a "bid test" for Nasdaq National Market Stocks ("Nasdaq NM Stocks"), which applies to trading on Nasdaq and trading reported to the NASD. This rule, the former NASD Rule 3350, specifies that whenever the bid is a downtick from the previous bid, traders other than market makers may sell short only at prices one penny above the bid.[3] Within this report, the tick test and bid test will be described more generally as "price restrictions."

---

[1] For further information, questions, or comments, please contact Amy Edwards (edwardsa@sec.gov), Stewart Mayhew (mayhews@sec.gov), Tim McCormick (mccormickt@sec.gov), or Allan Zebedee.

[2] Paragraph (a) of Rule 10a-1 governs short sales of any security registered on, or admitted to unlisted trading privileges on, a national securities exchange if such transactions are made pursuant to an effective transaction reporting plan as defined in Rule 600 of Regulation NMS. Unless a specific exemption applies, short sales are prohibited at a price that is either (1) below the last reported price of a transaction reported pursuant to an effective transaction reporting plan (known as a "minus tick"); or (2) at the last reported price if that price is lower than the last reported different price (known as a "zero-minus tick").

[3] When Nasdaq began operating as a national securities exchange, NASD Rule 3350 was replaced by Nasdaq Rule 3350 for Nasdaq NM stocks traded on Nasdaq, and NASD Rule 5100 for Nasdaq NM stocks traded over-the-counter and reported to a NASD facility. In connection with Nasdaq commencing operations as a national securities exchange the Nasdaq National Market was renamed to the Nasdaq Global Market and Nasdaq NM stocks were renamed Nasdaq Global Market stocks. See NASD Rule 4200(a)(6) (providing that the Nasdaq Global Market is the successor to the Nasdaq National Market); see also Securities Exchange Act Release No. 54071 (June 29, 2006),

In July 2004, the Securities and Exchange Commission (the "Commission" or the "SEC"), adopted Regulation SHO, which contains Rule 202T, allowing the Commission to establish, by separate order, a pilot program to examine the efficacy of price restrictions.[4] At the same time, the Commission issued an order ("Pilot Order") establishing a pilot program ("Pilot") exempting a third of the stocks in the Russell 3000 Index ("Russell 3000") from all price restrictions.[5] The pilot stocks constitute a sample of Russell 3000 stocks that is stratified across average daily trading volume levels within each of three groups, corresponding to New York Stock Exchange ("NYSE,") Nasdaq, and American Stock Exchange ("AMEX") issues.[6] The Pilot went into effect on May 2, 2005, and was scheduled to end on April 28, 2006,[7] but has been extended to August 6, 2007 to allow the Commission to consider potential rulemaking after evaluating the results of the Pilot.[8]

The Pilot was designed to enable the Commission and the broader community to evaluate whether the price restrictions have a substantive impact on market quality, and more generally to achieve a deeper understanding of how price restrictions affect the trading process. In its Pilot Order, the Commission provided further explanation for the Pilot:[9]

> The Pilot will enable us to obtain empirical data to help assess whether short sale regulation should be removed, in part or in whole, for actively-traded securities, or if retained, should be applied to additional securities. The Pilot will allow us to study trading behavior in the absence of a short sale price test on the stocks selected by comparing the trading behavior of the control group stocks to that of

71 FR 38922 (July 10, 2006) (File No. SR-NASD-2006-068). For purposes of this study, we refer to Nasdaq NM stocks as Nasdaq NM or Nasdaq Stocks and not Nasdaq Global Market stocks. Prior to Nasdaq commencing operations as an exchange, Nasdaq securities traded on exchanges on an unlisted trading privileges basis were not subject to any price restriction.

[4] See the adopting release, SEC Release No. 34-50103, July 28, 2004.

[5] See the first Pilot Order, SEC Release No. 34-50104, July 28, 2004.

[6] Stocks were selected for this sample by sorting the 2004 Russell 3000 first by listing market and then by average daily dollar volume from June 2003 through May 2004, and then within each listing market, selecting every third company starting with the second.

[7] SEC Release No. 34-50747, November 29, 2004.

[8] SEC Release No. 34-53684, April 20, 2006.

[9] SEC Release No. 34-50104, July 28, 2004.

> the Pilot stocks through empirical analysis. We will examine, among other things, the impact of price tests on market quality (including volatility and liquidity), whether any price changes are caused by short selling, costs imposed by a price test, and the use of alternative means to establish short positions.

To the extent that price restrictions have discernable effects, these should appear as differences between the pilot stocks, which the Commission selected to be a representative subsample of the Russell 3000 index, and the rest of the Russell 3000, which serve as control stocks. The results observed from the Pilot will help inform any subsequent rulemaking that the Commission may consider at the conclusion of the Pilot.

B. Overview

The goal of this study is to examine whether eliminating price restrictions has had any impact on market quality, broadly defined. We compute and compare various market statistics for pilot and control stocks both before and during the Pilot. The pilot stocks and control stocks are statistically similar prior to the Pilot. The analysis is conducted separately for both Listed Stocks and for Nasdaq NM Stocks to help distinguish the tick test from the bid test.

We designed this study to evaluate the various policy alternatives outlined in the first Pilot Order.[10] For example, the results of the Pilot might suggest eliminating all price restrictions, extending a uniform test to all securities, or removing price restrictions for a subset of stocks. Any of these alternatives would potentially affect not only the stocks in the Russell 3000, but others that have a lower market capitalization and perhaps are less actively traded than those in the pilot study. Price restrictions may have different effects for larger and smaller market capitalization stocks, or for more actively traded and less actively traded stocks. Accordingly, as part of our comparison of pilot and control stocks, we partition the sample into

[10] See SEC Release No. 34-50104, July 28, 2004.

groups based on market capitalization and turnover (trading volume divided by shares outstanding). The results for the smallest and least actively traded stocks within the Russell 3000 would be the most informative about the likely impact of price restrictions for those stocks that are not in the Russell 3000. Moreover, comparing large and small stocks (or high and low volume stocks) within the Russell 3000 should reveal whether any effects of the price restrictions are related to size or volume.

This study investigates various hypotheses relating to the potential effects of price restrictions. First, if price restrictions represent an economically meaningful constraint on short selling, they may induce some traders to avoid short selling or to reduce the size of their short positions. Thus, we test whether the level of short trading volume and short interest are significantly different for pilot and control stocks.[11] Both for Listed Stocks and Nasdaq NM Stocks, we find that price restrictions reduce the volume of executed short sales relative to total volume, indicating that price restrictions indeed act as a constraint to short selling. However, in neither market do we find significant differences in short interest across pilot and control stocks.

To the extent that price restrictions are applied in some markets and not in others trading the same stocks, traders who find the restrictions binding might avoid the constraint by choosing a venue where the constraint is not applied. Specifically, because not all markets that trade Nasdaq NM Stocks apply the Nasdaq Bid Test, short sellers can route their orders to avoid the rule., Removing the rule eliminates the need to avoid it and therefore might affect where short sales in Nasdaq NM Stocks are executed. Our results indicate that Nasdaq's share of short selling volume is negatively impacted by price restrictions, suggesting that some short sellers are routing orders to avoid price restrictions.

[11] Short interest is the total number of shares of a security that have been sold short and have not yet been repurchased.

Additionally, traders can avoid price restrictions by synthetically shorting in the option market rather than shorting the stock.[12] To measure the extent to which price restrictions drive short sellers to the option market, we compare option market trading activity for pilot and control stocks. We find no evidence that short sale price restrictions in equities have an impact on option trading or open interest.[13]

Regardless of whether price restrictions have any substantive impact on overall market liquidity or inhibit manipulation, they affect the ability of short sellers to demand liquidity by getting prompt execution of market orders. For purely mechanical reasons, we would expect price restrictions to affect the number of trades occurring on downticks vs upticks, and the percentage of time the market is in an upbid or downbid state. For Listed Stocks, we find that the application of the tick test results in significantly fewer than 50% of transactions occurring on downticks or zero downticks, while trading is more balanced when the tick test does not apply. For Nasdaq NM Stocks, we find that the percentage of time the market is in a downbid state declines when the bid test is removed, suggesting that downbids occur more regularly when the bid test applies.

To the extent that price restrictions inhibit the free movement of stock prices, they might make markets less liquid. On the other hand, because short sellers can rarely execute against a bid quotation, price restrictions force short sellers to act more like liquidity suppliers than liquidity demanders. Therefore, removing them might decrease the perceived supply of liquidity. To test whether price restrictions have a more general impact on liquidity or volatility, we compare quoted and effective spreads, intraday volatility, and the daily price range across

---

[12] A synthetic short position can be achieved by buying a put option and writing a corresponding call option in the same security. The term synthetic refers the fact that you can replicate the payoffs of an equity short sale without actually short selling the equity itself.

[13] Open interest is the total number of options contracts that have not yet been closed or fulfilled by delivery.

pilot and control stocks. We find that quoted depths are augmented by price restrictions but realized liquidity is unaffected. Further, we find some evidence that price restrictions dampen short term within-day return volatility, but when measured on average, they seem to have no effect on daily return volatility.

Finance theory predicts that under certain conditions, constraints on short selling may cause securities to be misvalued by the market, particularly when investors have highly divergent opinions about the stock.[14] A simple argument is that short sale constraints make it more costly for those investors who have a negative opinion of a stock to trade on their beliefs, and thus, their views may be reflected less in the stock price than those who have a positive view. Under more general assumptions, theoretic models predict that short sale constraints can cause stocks to be either overvalued or undervalued.[15] To test whether price restrictions constitute an economically consequential short sale constraint that influences equilibrium stock prices, we investigate whether the prices of pilot stocks react in response to the removal of the rule. We find that for Listed Stocks, control stocks outperform pilot stocks on average by about 24 basis points on the first day of the Pilot, suggesting that the tick test may cause stocks to be slightly overvalued. For Nasdaq NM Stocks, no significant return differential was observed surrounding the initiation of the pilot. We also examine stock returns for a six-month period following the initiation of the pilot program, to ascertain whether the elimination of price restrictions has had any discernible effect on stock prices over a longer horizon. We find that pilot stocks and control stocks have similar returns over this horizon, but some tests show weak evidence consistent with the hypothesis that price restrictions facilitate over-pricing. In the absence of price restrictions, prices do not rise as much as with price restrictions, leading to a lower equilibrium price.

---

[14] See, for example, Lintner (1969), Miller (1977), and Scheinkman and Xiong (2003).
[15] See Gallmeyer and Hollifield (2006).

One view of price restrictions is that they help prevent "bear raids," or that they make it more difficult for would-be manipulators to drive prices down below their true values. On the other hand, price restrictions might also make it more difficult for short sellers to move prices back toward their true value in response to upward manipulations. Because price restrictions are inherently short-term constraints, any substantive impact on the susceptibility of securities to manipulation is most likely to be manifest at short horizons. For this reason, we focus our investigation on price patterns that might indicate manipulative behavior at a daily or intraday frequency. To explore these issues, we proceed along three avenues of investigation.

First, to the extent that price restrictions create an environment less conducive to price patterns that might indicate downward manipulation and more conducive to price patterns that might indicate upward manipulations, we might expect to observe more extreme negative returns, and fewer extreme positive returns, for pilot stocks than for control stocks. To investigate this, we use our control-sample methodology to test whether the skewness of the returns distribution of short-horizon returns differs across pilot and control stocks.[16] Our results indicate no statistically significant impact of the pilot program on return skewness, measured at five-minute, thirty-minute, or one-day return intervals.

Second, we identify positive and negative price "spikes," or instances when extreme price moves are reversed shortly afterwards, and examine whether the frequency of positive and negative spikes differs across pilot and control stocks. We find that at a short (five-minute) horizon, pilot stocks tend to experience more price reversals than control stocks, but that this result is the same for negative and positive price reversals. At a thirty-minute horizon, we find no evidence that there are more price reversals for pilot stocks than control stocks.

[16] Bris, Goetzmann, and Zhu (2004), in a study of the effects of short sale regulations around the world, find evidence suggesting that short selling constraints can affect the skewness of the returns distribution.

Third, we use a time-series regression methodology to measure the extent to which positive and negative price changes are likely to be subsequently reversed. If price rules play an important role in preventing short sellers from temporarily driving prices down below their fair value, we would expect to see a larger portion of negative returns subsequently reversed for the pilot stocks than the control stocks. For Listed Stocks, we find that a larger portion of both negative and positive returns are subsequently reversed for pilot stocks than control stocks at a short (five-minute) horizon. The symmetry of these results is consistent with the increase in volatility discussed above rather than any marked increase in the potential for downward price pressure. On the other hand, a marked increase in the potential for downward price pressure relative to upward price pressure should lead to an asymmetry in positive and negative return reversal results. We do not find this asymmetry. At a thirty-minute horizon, we find no statistically significant difference in the magnitude of return reversals for Listed pilot and control stocks. For Nasdaq NM Stocks, we find no statistically significant difference in the magnitude of return reversals for pilot and control stocks for either five-minute or thirty-minute intervals.

One important element of the Pilot is the ability to examine whether the tick test affects stocks of varying sizes and volume differently. For example, does the tick test affect larger stocks in the same manner as smaller stocks and would the tick test be more effective for large or small stocks? To examine these questions, we divide the stocks into size, measured as market capitalization, and volume, measured as trading volume divided by shares outstanding (turnover), groups and run each of our tests again for each group. For most of our tests, we find that the tick and bid tests affect stocks the same no matter how large or small or how active are the stocks. In particular, we find that the tick and bid tests result in a lower percentage of short sale volume for most size and activity levels. We also find that the tick and bid tests result in lower bid and ask depth for most size and activity levels. Thus, the bid and tick tests do not affect liquidity in a way related to the size or activity level of a stock. Finally, the tick and bid tests do not affect returns at or following the start of the Pilot whether the stocks are large or small. On the other hand, the size and activity levels appear to matter for the effect of price restrictions on volatility and for routing decisions. The bid test affects routing decisions more in smaller stocks. Likewise, the bid and tick tests dampen permanent price volatility in small stocks while amplifying it in large stocks.

The remainder of this report is organized as follows. In section II, we recount the history of price restrictions, including Regulation SHO. Section III contains an overview of the academic literature relating to the tick test and the bid test. The data and construction of the samples are described in section IV. Section V explains the empirical methods used in the analyses. In section VI, we present our main analysis of the effect of removing price restrictions for pilot and control stocks over the first 6 months of the Pilot Period. More specifically, in section VI-A, we present our analyses of how eliminating price restrictions has affected the overall level of short volume and short interest, option market volume and open interest, and the frequency and duration of upticks or upbids within the day. In section VI-B, we present our analysis of how the removal of price restrictions has affected market quality, including measures of spreads and intraday volatility. In section VI-C, we report our results on whether lifting price restrictions has affected underlying stock prices or returns, the skewness of returns distributions, the incidence of positive and negative spikes, and the tendency of positive and negative shocks to subsequently reverse. In section VII, we investigate whether price restrictions affect all stocks similarly or whether certain types of stocks, such as small stocks, are more affected by the rules. Section VIII summarizes and concludes the report.

II History of Price Restrictions

This section briefly summarizes the historical background of the price restriction rules.[17] After the market crash of 1929, a popular view emerged that short sellers exacerbated the crash.[18] Public concerns about short selling became particularly acute in the aftermath of the international currency crisis of September 21-22, 1931, prompting Senator Arthur Capper of Kansas to introduce several bills aimed at restricting and taxing short selling. It was in this environment, on October 6, 1931, that the NYSE required that all sell orders must be marked long or short.[19] According to Meeker (1932, p. 147), this effectively acted as a rule against shorting on a downtick, as such trades were viewed as violations of the Exchange's rule against "demoralizing" trades.[20]

Shortly after its creation in 1934, the Commission recommended sixteen rules that all national securities exchanges should adopt. Among them was a recommendation for an explicit rule against shorting on a downtick:

> No member shall use any facility of time exchange to effect on the exchange a short sale of any security in the unit of trading at a price below the last sale price of such security on the exchange.[21]

Exceptions were specified for odd-lot trading and to allow regional exchanges to bring their prices in line with the primary exchange. Sixteen exchanges adopted this rule in 1935.[22]

---

[17] See also Meeker (1932), SEC, Report of the Special Study of the Securities Markets, reprinted in H.R. Doc. No. 95, 88th Cong., 1st Sess. (1963 "Special Study"), Macey, Mitchell, and Netter (1989), SEC Release No. 34-42037, October 20, 1999.
[18] See Frederick (1932).
[19] New York Stock Exchange, Notice Concerning Distinction Between Long and Short Account Selling Orders, October 5, 1931, reprinted in Appendix A of Meeker (1932).
[20] Constitution of the New York Stock Exchange (August 11, 1927) Article XVII, Section 4.
[21] SEC, *First Annual Report of the Securities and Exchange Commission* (1935), available from the Securities and Exchange Commission Historical Society.
[22] SEC, Report of the Special Study of the Securities Markets, reprinted in H.R. Doc. No. 95, 88th Cong., 1st Sess. (1963), p. 251.

Following sharp price drops in the fall of 1937, the Commission performed a study of the transactions of 20 securities on the NYSE for the periods September 7-13 and October 18-23 of that year[23] and found that short sales constituted a significant portion of the transactions in the declining market. The Commission adopted new short-selling rules, including a rule to formally define what is meant by a short sale and Rule 10a-1, the tick test.[24] This version of the tick test prohibited short sales "at or below the price at which the last sale, regular way, was effected on such exchange." The rule was adopted on January 24, 1938 and went into effect February 8, 1938.

The tick test was amended March 10, 1939 to allow for short selling at a zero uptick, or in other words at the last trade price, "provided that the last sale price was higher than the last different price which preceded it."[25] Certain exemption letters have been granted over the years, such as the exemption for diversified exchange traded funds.[26] However, the basic structure of this rule has remained essentially unchanged since 1939.

The Commission's Special Study (1963) identified three objectives of the tick test, which have been consistently used by the Commission as a framework for discussing the effectiveness of the regulation. These objectives are that the rule should:

(1) Allow relatively unrestricted short sales in an advancing market;
(2) Prevent short selling at successively lower prices, thus eliminating short selling as a tool for driving the market down; and
(3) Prevent short sellers from accelerating a declining market by exhausting all remaining bids at one price level, causing successively lower prices to be established by long sellers.

---

[23] SEC Release No. 1548, January 24, 1938, 3 FR 213 (January 26, 1938).
[24] Rule 3b-3 under the Exchange Act sets forth the definition of "short sale" and identifies the specific instances for determining a long position. 17 CFR 240. 3b-3.
[25] See the *Fifth Annual Report of the Securities and Exchange Commission*, Fiscal Year Ended June 30, 1939, United States Government Printing Office, Washington, available at http://www.sechistorical.org/collection/papers/1930/1939_SEC_AR.pdf
[26] See, *e.g.*, Letter re: SPDRs (January 27, 1993); Letter re: MidCap SPDRs (April 21. 1995); Letter re: Select Sector SPDRs (December 14, 1998); Letter re: Units of the Nasdaq-100 Trust (March 3, 1999); Letter re: ETFs (August 17, 2001) (class letter).

In 1976, the Commission proposed three alternative temporary rules that would have suspended the tick test for some or all registered securities.[27] In response to the proposal, several market participants, including the NYSE, opposed the proposal, and expressed concerns that abolishing the tick test might lead to increased volatility or decreased liquidity. The Commission withdrew the proposals in 1980.[28]

A House Report submitted by the Committee on Government Operations dated December 6, 1991 discusses several aspects of short selling, including the tick test.[29] The report suggests that short selling has negative price effects that "can have important and lasting consequences" and asserts that the tick test is "effective in stabilizing the market for exchange-listed stocks for the benefit of issuers and investors," although no evidence is cited in support of this view. The report also recommends that the tick test should be extended to the Nasdaq market.

On September 6, 1994, the Commission approved NASD Rule 3350 (the "bid test") as a temporary rule.[30] This created a bid test for trades executed by NASD members or their customers, but with exemptions for both equity and option market makers. Specifically, this rule prohibited short sales at or below (or less than one penny above) the best bid price whenever the prevailing inside bid price is lower than the previous inside bid. The bid test might appear less restrictive than the tick test, because it allows for unrestricted short selling at any price when the bid price is higher than the previous bid, and because of the market maker exemptions. Since its

---

[27] See SEC Release No. 13091, December 21, 1976.
[28] See SEC Release No. 34-42037, October 20, 1999.
[29] Short-Selling Activity in the Stock Market: Market Effects and the Need for Regulation (Part 1) (House Report), H.R. Rep. No. 102-414 (1991), *reprinted in* CCH Federal Securities Law Reports Number 1483 Part II (1992).
[30] See SEC Release No. 34-34277, July 6, 1994.

initial approval, the bid test has been re-approved annually as a temporary rule.[31] The bid test was in effect when Regulation SHO became effective in January 2005. When Nasdaq began operating as an exchange in August 2006, NASD Rule 3350 was replaced by Nasdaq Rule 3350 and NASD Rule 5100.[32]

The Commission re-opened the discussion on Rule 10a-1 in a concept release dated October 20, 1999.[33] In this release, the Commission requested comment on numerous issues surrounding the tick test, including:

- whether the tick test should be suspended when the daily stock return is above a threshold level;
- whether actively traded securities should be exempted from the tick test;
- whether the restrictions should apply only around certain market events such as at the open and close, around mergers and acquisitions, or at option expirations;
- whether hedging transactions be exempt from the tick test;
- whether the tick test should be revised in response to expanded after-hours trading or decimalization;
- whether the tick test should be extended to non-exchange-listed stocks; and,
- whether the tick test should be eliminated.

In October 2003, the Commission proposed a rule that would create a uniform bid test that would apply to both Listed and Nasdaq NM Stocks, with various exemptions.[34] In addition, the Commission proposed a pilot program that would suspend the tick test for actively-traded securities for two years.[35] As stated in the proposing release, "[t]he temporary suspension would allow the Commission to study the effects of relatively unrestricted short selling on market volatility, price efficiency, and liquidity."[36]

---

[31] Most recently, see SEC Release No. 34-53093, January 10, 2006.
[32] Nasdaq NM stocks are currently trading under an exemption from Rule 10a-1 in order to maintain the status quo until the conclusion of the Pilot or any further rulemaking by the Commission.
[33] See SEC Release No. 34-42037, October 20, 1999.
[34] See SEC Release No. 34-48709, October 28, 2003.
[35] See SEC Release No. 34-48709, October 28, 2003.
[36] See SEC Release No. 34-48709, October 28, 2003.

With the adoption of Regulation SHO in July 2004, the Commission decided to defer consideration of the uniform bid test and the proposed exemptions (proposed Rule 201), in order to first observe the results of the pilot program.[37] In connection with the establishment of a Pilot, the parameters governing a Pilot were expanded to include a broader spectrum of securities than envisioned in the proposing release, and the length of the Pilot was shortened to one year. As stated in the adopting release,

> the purpose of the Pilot is to assist the Commission in considering alternatives, such as: (1) eliminating a Commission-mandated price test for an appropriate group of securities, which may be all securities; (2) adopting a uniform bid test, and any exceptions, with the possibility of extending a uniform bid test to securities for which there is currently no price test; or (3) leaving in place the current price restrictions.

The details of the program, including the list of securities included in the Pilot, were specified in the Commission's Pilot Order of July 28, 2004.[38] The Pilot was originally scheduled to begin on January 3, 2005 and last for one year. However, because the industry needed more time to prepare their systems, the start date was postponed until May 2, 2005, and later, the terminal date of the Pilot was extended until August 6, 2007 to maintain the status quo for pilot stocks until the Commission evaluates the results of the study and considers potential rulemaking on price restrictions.[39] The Pilot Order suspends Rule 10a-1 and the bid test for approximately a third of the Russell 3000 stocks. The methodology for selecting the pilot stocks is detailed in the Pilot Order, and is summarized in section IV, below.

III Previous Evidence

The previous evidence on price restrictions gives us insight into how price restrictions work. In particular, it examines the effectiveness of the rules and the effect that the rules have on

[37] SEC Release No. 34-50103, July 28, 2004.
[38] SEC Release No. 34-50104, July 28, 2004.
[39] SEC Release No. 34-53684, April 20, 2006.

market quality. We are unaware of a previous study that compares the tick test to the bid test. Several concurrent studies also examine the effect of the Pilot on the tick and bid tests (Alexander and Peterson (2006), Diether, Lee, and Werner (2006), and Wu (2006)). These studies are summarized on Appendix A.

A. Effectiveness of the Rule

1. Shorting in a Declining Market

Several studies examine whether the rules appear to keep short sales from executing in declining markets. When Rule 10a-1 was adopted in 1938, it was motivated in part by a Commission study of short selling, based on two weeks of data in 1937. This study found that when a downtick rule applied, a substantial amount of short selling occurred during periods when the market was declining.[40] Two subsequent studies produced by staff at the Commission found that the tick test allows short selling in declining markets.[41] The Commission's 1963 Special Study concluded that Rule 10a-1 was not effective at achieving its objectives, stating that

> [p]resent rules appear inadequate to relieve the added pressure that short selling may create during a severe decline in the general market or a declining price trend in a particular security. Despite the rules, a relatively large volume of short selling occurred in particular stocks, including "market leaders" and "trading favorites," during the period of decline preceding the market break of May 28, 1962, and at critical junctures on that day, and many additional opportunities existed when short selling could have occurred.[42]

In a more recent study, Ferri, Christophe, and Angel (2004) examine short selling in a matched sample of Nasdaq National Market stocks, which were subject to the bid test, and Nasdaq SmallCap stocks, which were not, during a period of high volatility and rapidly declining

[40] The NYSE had a downtick rule prior to the Commission's tick test. A downtick rule is a weaker form of the tick test because it allows trading at the most recent price even if that price was a downtick.

[41] The Securities and Exchange Commission (1963), in the Special Study, examined the trading activity leading up to and during the market break of May 28, 1962. In a working paper by SEC staff, Marcotte and Martin (1977) study the tick test for the period from September 20 through October 15, 1976, during which time the Dow Jones Industrial Average fell by 8.12%. The results are summarized in Pollack (1986).

[42] 88th Congress, HR Doc No 88-95 (1st session, 1963), pp. 293-294.

stock prices (September 2000-August 2001). In their sample of 2,275 observations, they find no significant differences in the overall level of short selling, or the frequency of days with abnormally negative returns and abnormally high short selling.

Overall, the research above shows that short sales are executed in declining markets despite the application of the tick or bid tests. However, this does not mean that short sales are unaffected by the tick and bid tests. We discuss this further in the next section.

2. Short Sale Execution Quality

Another area of research examines whether these rules harm the execution quality of short sales by reducing the prices received by short sellers, by delaying the execution of short sales, or by reducing the fill rates.

Martin and Marquette (1977) conduct a simulation calibrated to the Dow 30 stocks, to estimate the degree to which the rule would have affected execution prices for market short sale orders submitted during this period of market decline. The simulation results indicate that even during this period of rapid price declines, randomly arriving short market orders would have executed at higher prices as a result of the uptick rule. Therefore, short sellers appear better off because of the tick test.

Albert, Smaby, and Robison (1997) examine the negative abnormal returns to stocks following large increases in reported short interest, as an estimate of the profitability of short selling. They find that short selling was more profitable for their Listed sample than their Nasdaq sample during a period (1987-1991) when only Listed Stocks were subject to a price restriction. Their findings imply that the uptick rule does not have a significant impact on the bottom line for short sellers.

While studying order data from the NYSE, Angel (1997) and Alexander and Peterson (1999) find that the tick test prevents short sales from demanding liquidity more than 90% of the time. As expected, the degree to which the tick test is binding depends on whether the market is rising or falling. Likewise, McCormick and Reilly (1996) find that the Nasdaq bid test prevents short sellers from demanding liquidity roughly 35% of the time. This proportion was found to be an increasing function of trading volume and, not surprisingly, a decreasing function of the day's stock return.

Both Angel (1997) and Alexander and Peterson (1999) conclude that Rule 10a-1 significantly impedes order execution quality for short sales, even in rising markets. For those cases where the stock price increased, short sellers can trade at the bid less than fifteen percent of the time. According to Alexander and Peterson (1999), the tick test appears to contradict the Commission's first stated objective for short selling regulation, to "allow relatively unrestricted short selling in an advancing market."

In addition, Alexander and Peterson (1999) also found that short sale orders have significantly lower execution rates and significantly longer times to execution than regular sales. Alexander and Peterson (2002) study how the tick test was affected by the reduction of the tick size from 1/8 to 1/16 in June 1997. As predicted, their evidence suggests that short sales were executed faster and at better prices after the reduction in tick size, confirming that the tick test is less binding when the tick size is smaller.

In summary, previous research shows that short sellers can receive better prices as a result of the tick test and that the tick test does not impede profit opportunities. However, the tick test and bid test restrict the ability of short sellers to demand liquidity even in rising markets.

DRAFT

This results in execution delays and lower fill rates. Tick size changes have lowered these costs, but short sellers are still precluded from demanding liquidity much of the time.

3. Manipulation

Many of the studies that examine the ability to short in a declining market do not address the question of whether short selling in a declining market increases the potential for manipulating a stock price below its fair value, or conversely, whether short selling helps prices adjust more quickly to their efficient values. Nor do the studies address the question of whether a tick test or bid test would have been effective at reducing the amount of short selling during declining markets. A few early studies of short selling in the 1930s concluded that there was no evidence that short sales had any material effect on the magnitude of price swings.[43]

Ferri, Christophe, and Angel (2004) come a little closer to questioning whether the bid test inhibits trading that may be indicative of manipulation. On days when stock prices are declining, the degree of short selling is positively related to returns for Nasdaq SmallCap stocks, which are not subject to the bid test, but not for matching Nasdaq NM stocks, which are subject to the bid test. This result is the reverse of what one would expect to see if the bid test helps prevent short sellers from pushing down prices. The authors conclude that "a bid test is unnecessary for investor protection."

B. Effect on Market Quality

Because the tick and bid tests appear to have some impact on the execution of short sales, even though short sales can still execute in declining markets, we might expect the tick and bid test to affect market quality. In a recent working paper, Jones (2003) re-examines the period surrounding the initiation of the tick test in the 1930s. He finds a significant reduction in bid ask

[43] See Twentieth Century Fund (1935), Macaulay and Durand (1951).

spreads and positive abnormal stock returns surrounding the initiation of the downtick rule on October 6, 1931, with no significant changes in trading volume, volatility, or the price impact of trades. He also finds similar results surrounding the initiation of Rule 10a-1 1938. He concludes that

> [b]ecause the uptick rule no longer constrains shorting as much as it once did, any liquidity effects are likely to be much more modest than the ones identified in the 1930's. However, it would not be surprising if repeal of the uptick rule were to lead to some reduction in individual stock liquidity, particularly in less liquid stocks.[44]

In research sponsored by NASD, McCormick and Reilly (1996) find that the introduction of the bid test did not have a substantive impact on market quality, as measured by volatility and bid ask spreads. A more comprehensive follow-up study by McCormick and Zeigler (1997), which was also sponsored by the NASD, supports the original finding that the implementation of the bid test had little or no impact on market quality. They find that quoted and effective spreads were narrower in 1997 than in 1994, but they attribute the changes to a gradual improvement in market quality over time, and not to the implementation of the bid test. They find no significant change in quoted spreads as a result of the bid test. While they do find a statistically significant decline in effective spreads, this is a natural consequence of a rule that forces short sellers to act as liquidity suppliers rather than liquidity demanders. Because the improvement in effective spreads is coming at the cost of delayed executions, it does not necessarily signify an improvement in market quality.

Au-Yeung and Gannon (2003) estimate the joint dynamics of index and index futures returns in Hong Kong, surrounding the elimination of Hong Kong's uptick rule on March 25, 1996. Using a multivariate GARCH framework, they find evidence that Hong Kong's uptick

[44] This study was funded by the New York Stock Exchange.

rule was impeding price discovery on the index relative to the futures contract, and that conditional volatility for the index declined with the elimination of the uptick rule.

Overall, this evidence seems to indicate that tick tests can lead to narrower bid ask spreads, but impedes price discovery, while the bid test should not have any discernable effect on market quality. The construction of the Pilot study improves upon the design of these previous studies and allows us to study these issues in a more controlled environment.

IV Construction of the Samples

A. Selection of Pilot and Control Stocks

The stocks in the pilot sample are those specified in the Pilot Order.[45] Stocks were selected for this sample by sorting the 2004 Russell 3000 first by listing market and then by average daily dollar volume from June 2003 through May 2004, and then within each listing market, selecting every third company starting with the second. Because the selection process relied on average daily dollar volume, companies that had their initial public offering in May or June of 2004, just prior to the Russell reconstitution, were not included. The 32 stocks that are not listed on the NYSE, Amex, or Nasdaq NM were also excluded prior to sorting and selecting the pilot stocks.

While no companies have moved in and out of the Pilot, the pilot stocks might experience ticker symbol changes, listing changes, and mergers. We collected the necessary change information from NYSE, Amex, and Nasdaq, who keep track of and disseminate these changes. In the case of mergers between pilot and control stocks, the status of the resulting company is the same as the status of the company with the larger market capitalization of equity on the day prior to the first merger announcement. The pilot stocks that did not survive to the start of the Pilot on

[45] SEC Release No. 34-50104, July 28, 2004.

May 2, 2005 are not included in the analysis. Pilot stocks with listing changes during the Pilot are included in our analysis up until the date of the listing change even though they are still in the Pilot..

The stocks in the control sample come from the remainder of the 2004 Russell 3000 not included in the Pilot. We do not include the stocks with initial public offerings after May 2004 because these stocks were not eligible to be selected for the Pilot. Like the pilot sample, the control sample stocks can experience corporate events that make tracking them difficult. We keep track of ticker symbol changes, listing changes, and mergers using the daily symbol directories from the Nasdaq Trader web site and using Bloomberg. As with the pilot sample, we include only the control stocks that survive until May 2, 2005 and include stocks that are subsequently delisted up until the delisting date.

Table 1 reports the sample sizes and breaks down the sample in various dimensions. As the table indicates, our sample contains 504 listed pilot stocks and 973 listed control stocks that are subject to Rule 10a-1 and 439 Nasdaq pilot stocks and 917 Nasdaq control stocks that are subject to NASD Rule 3350. Table 1 also indicates that roughly 70% of Listed Stocks and 63% of Nasdaq NM Stocks have listed options. Because listing affects the short sale rules applied to trading, we report results for each of these sub-samples but not for the full sample. If an issuer switches its listing from Nasdaq to Amex or NYSE or vice versa after May 2, we keep that stock in the sample up until the day of the listing change. If an issuer changed its listing prior to May 2, it will be grouped according to its new listing and we include pre-period data only from that same listing.[46] Listings changes between Amex and NYSE do not affect our sample because the change does not affect the short sale rule applied.

[46] We exclude one stock that changed its listing on the first day of the pilot, Renasant Corporation RNST, formerly Peoples Holding Company, PHC.

Similarly, we keep stocks in our sample up until their last listed day even if they are acquired or otherwise move to markets that do not apply the same rule (i.e., move to the Nasdaq Capital Market, OTCBB, or the Pink Sheets) after May 2, 2005. We keep these stocks to avoid a survivorship bias, which is a bias associated with finding higher average returns than actually exist. We believe an analysis of the pilot would be particularly sensitive to survivorship bias and we therefore, make every effort to reduce it. Further, if an issuer moves its listing from Nasdaq to an exchange or from an exchange to Nasdaq, we keep the stock in the sample up until the list/delist date. We do this so that our analysis does not confuse the effects of the tick test with those of the bid test. Because we retain stocks in our sample until the stocks delist, our sample size on our last sample day (October 31, 2005) is smaller than our sample size on the first pilot day (May 2, 2005). In fact, we have about 88 fewer stocks in our sample on October 31 than we do on May 2. Despite the drop in sample size, the pilot stocks comprise about 1/3 of the sample stocks for both Listed and Nasdaq NM Stocks on October 31 as well as May 2.

B. Data and Sample Statistics

We examine these pilot and control stocks over a 210 day period in 2005. We examine the 82 day period from January 29 to April 29 as the Pre-Pilot Period during which the pilot and control stocks are subject to the same rules. The Pre-Pilot Period allows us to test whether the pilot and control stocks appear similar when they are subject to the same rule and it gives us a reference point to examine how the sample stocks change when the price restriction rules are removed. In the results section, this period is compared to the 128 day period from May 2, the first day of the pilot, to October 31, 2005.

Before comparing the Pre-Pilot Period to the Pilot Period, we first examine whether the pilot and control samples appear comparable over the Pre-Pilot Period. Table 2 gives this comparison separately for Listed and Nasdaq NM Stocks. The statistics are daily levels averaged over the Pre-Pilot Period. We use trade and quote data obtained from the Securities Industry Automation Corporation (SIAC) to estimate stock volume, price, spread, depth, and intraday returns, data from the Center for Research in Securities Prices (CRSP) to estimate market capitalization and daily returns, data from the Option Price Reporting Authority (OPRA) to estimate option volume and open interest, and the SRO Pilot data to estimate short selling levels.[47] Short interest, reported monthly, comes from the NYSE, Amex, and Nasdaq. Most of the measures in Table 2 are qualitatively similar for pilot and control stocks, according to a statistical t-test run at the 95% and 99% confidence levels (also stated as 5% and 1% significance levels). This evidence suggests that the two groups are a good match and supports the validity of further comparison of pilot and control stocks.

The statistics of Table 2 are divided into groups. The first group of statistics measures general stock characteristics such as volume, price, market capitalization, and short interest. The first three rows of Table 2 show that the pilot stocks have similar average volume to the control stocks whether volume is measured by the number of trades per day, the average daily share volume, or turnover. The average volume-weighted average price (VWAP) and average market capitalization diverge slightly. For both Listed and Nasdaq NM Stocks, the VWAP is higher for pilot stocks but the market capitalization is lower. Neither difference is statistically significant.

[47] The SRO Pilot data refers to the short selling records available from each of nine markets: American Stock Exchange, Archapelago Exchange (now a part of NYSE Group), Boston Stock Exchange, Chicago Stock Exchange, NASD, NASDAQ Stock Market (now NASDAQ Stock Exchange), New York Stock Exchange (now a part of NYSE Group), National Stock Exchange, and the Philadelphia Stock Exchange. This analysis aggregates the short selling data without regard to whether there exists a SIAC report for the short sale transaction.

The next group of statistics measures the level and nature of short selling. These statistics measure short interest, the short selling volume and location, and option volume and open interest. In Listed Stocks, short selling comprises about 24% of share volume and 27% of trades. The level jumps to 36% of share volume and 37% of trades in Nasdaq NM Stocks. Still, the level of short selling in pilot stocks is similar to that of control stocks prior to the start of the pilot. Because the bid test does not apply to all markets, we examine the share of short sales executed on Nasdaq to measure whether investors appear to be routing short sales away from Nasdaq. While we estimate this statistic for Listed Stocks as well, we focus on the Nasdaq NM Stocks for results. Rows ten to fifteen of Table 2 show that prior to the pilot, the pilot and control stocks have similar average option volume and open interest, statistically indistinguishable from each other.

The next set of statistics measures mechanical aspects of trading and quoting, in particular, the percentage of trades occurring on a downtick or zero downtick and the percentage of the day during which the last change in the bid was downward. These measures were selected because they both determine when a short sale can be executed and are influenced by the application of the price restrictions. Prior to the pilot, about 46% of trades in Listed Stocks occur on downticks or zero downticks, while slightly over 50% of trades in Nasdaq NM Stocks do. These percentages are similar for the pilot and control stocks. Likewise, the percentage of the day during which the most recent change in the bid was downward is similar for pilot and control stocks. For Listed Stocks, the most recent change in the bid was downward for about 39% of the day. This is indicative of the nature of a limit order book market to have short-lived liquidity imbalances followed by long periods of liquidity building. In other words, a large order quickly executes, removing several price levels in the limit order book, followed by a slow replenishing of the limit order book. In the Nasdaq market, which operates more like a dealer market than the listed market, stocks spend more time in a downbid situation, about 47% of the time.

Liquidity is the next important group of statistics. We measure displayed liquidity using quoted and effective spreads measured in absolute terms and also relative to prices, and using aggregated quoted ask and bid depth at the National Best Bid and Offer (NBBO). We measure realized liquidity using the NBBO for both Listed and Nasdaq NM Stocks. Like the earlier measures, the liquidity measures show that the pilot and control stocks are statistically similar for all measures. While the magnitude of some of the measures, particularly the quoted ask depth and quoted bid depth, appears higher for control stocks than for pilot stocks, the measures are actually statistically similar.

The final group of statistics gives the distribution of returns and prices over various periods. Table 2 gives average returns, average absolute returns, the skewness of the returns, and the variance of the returns over 5 minute, 30 minute, and 1 day periods. It also shows the daily price range and three variance ratios. The variance ratios measure the transitory volatility by comparing the variance of returns measured over short and long horizons. Overall, the pilot and control samples are statistically similar in the means, skewness, and transitory and total volatility. It is interesting to note that the returns for all samples and all horizons are positively skewed. This positive skewness has been documented in previous work and is correlated with short selling restrictions.

V Methods

A. Comparing Pilot and Control Stocks

We derive the results in this report using several empirical approaches. The first approach compares the pilot sample to the control sample both before and after the start of the pilot. The approach allows us to apply a standard t-test to the difference of the differences. As long as the pilot and control samples are generally well constructed, this approach will control for changes in market conditions that are unrelated to the pilot. However, this approach may not fully control for differences within the samples. Further, it is cumbersome when examining the differential effect of the pilot on sub-samples. Therefore, we will also employ a regression approach.

The regression approach includes multiple test variables at the same time and also controls for unforeseen differences between the pilot and control samples. Because the number of stocks changes over the sample period, we employ daily cross-sectional regressions for each sample day after the start of the pilot and then we average the coefficients. We employ variations on the following regression:

$$\text{Market Quality}_i = \alpha + \beta_1 \text{Pilot}_i + \beta_2 \text{Pre Pilot Market Quality}_i \tag{1}$$

where Market Quality is one of several dependent variables (e.g., effective spread) measured for each stock on one trading day, Pilot is equal to one for pilot stocks and zero for other stocks, and Pre-Pilot Market Quality is the average daily level of the dependent variable measured over the Pre-Pilot Period. If the dependent variable is generally larger for pilot stocks than control stocks, then β_1 will greater than zero. If this relation is persistent across time, then the average β_1 will be greater than zero. The Pre-Pilot Market Quality variable helps ensure that the coefficients on the indicator variables measure the effect of removing price restrictions. It also helps to control for any unforeseen differences between the pilot and control stocks.

We run all tests separately for stocks listed on an exchange and stocks listed on Nasdaq NM because the rule applied to trading of Nasdaq NM Stocks is different than the rule applied to the trading of stocks listed on exchanges.[48] This allows us to satisfy one purpose of the Pilot, which is to clearly distinguish the effect of each type of rule.

B. Behavior of Stock Prices Surrounding the Pilot Initiation

In order to evaluate whether the tick test or the bid test affects the level of stock prices, we examine average daily returns and average cumulative returns for pilot and control stocks over a 21-day period surrounding the beginning of the pilot. If pilot stocks are over-valued because of the price restrictions these returns should be significantly negative for pilot stocks relative to the control stocks on or around the first day of the pilot. Cumulative returns are normalized to zero on April 29, the trading day prior to the start of the pilot.

We believe it likely that any valuation effects of the pilot that are not already impounded into the price before the start of the pilot would most likely be observed immediately upon the initiation of the pilot, and reflected in the returns on the first day. However, we also consider the possibility that the effects of the pilot might be manifest over a longer time period. Therefore, we also examine returns over a six month time horizon. To avoid a survivor bias, we compound returns to the six month horizon if a stock falls out of the sample prior to October 31, 2005. In addition, to control for the systematic risk of a stock, we estimate an alpha for each stock. We estimate these alphas in-sample using the market model:

[48] It is worth noting that neither the bid test nor tick test applies to the trading of Nasdaq NM stocks on exchanges.

$$R_t = \alpha + \beta R_{Mt}$$

where R_t is the return on the stock in day t, and R_{Mt} is the equally-weighted market index return from CRSP for that day. We also estimate the tendency of the alphas to be significantly positive or negative. Pilot stocks might be more likely to have negative alphas than control stocks if either price restrictions corrected over-pricing over long horizons or if price restrictions prevent constant short selling pressure from pushing prices below their equilibrium level. Pilot stocks might be less likely to have positive alphas if price restrictions facilitate over-pricing.

C. Measuring Large Price Reversals

As part of our analysis of whether price restrictions inhibit price patterns that may be indicative of short-term price manipulation, we wish to examine the frequency of large short-term price movements that are immediately reversed. Although such price reversals, or "spikes," are bound to occur with some frequency due to the natural variation of prices, they may also be a sign of price manipulation. If the price patterns indicative of manipulation are more prevalent on the short side than on the long side, we would expect to see more negative price spikes than positive ones. And if price restrictions are effective at reducing the potential for price manipulation, we might expect to see significantly more price spikes for pilot stocks than control stocks.

To investigate this, we define the following measures of short-term price reversals:

$$\begin{aligned} &Negative: \min(-R_{t-1}, R_t^L)/\sigma_i \\ &Positive: \min(-R_t^L, R_{t-1})/\sigma_i \end{aligned}$$

In these formulas, σ_i represents the holding period (non-annualized) standard deviation of returns on stock *i,* measured using data in the Pre-Pilot Period, R_t is the simple one-period return on stock *i* at time *t*, and R_t^L is the one-period return measured as a percentage of the lagged stock price:

$$R_t = \frac{P_t - P_{t-1}}{P_{t-1}} \qquad R_t^L = \frac{P_t - P_{t-1}}{P_{t-2}},$$

where P_t represents the price of stock *i* at time *t*. We estimate these metrics using 5-minute and 30-minute horizons. The return as a percentage of the lagged price is used in the measure so that the adjacent returns will be compared on the same basis.[49]

We normalize the reversal measure by the standard deviation of returns on the same stock, computed using the same return interval over which the reversals are measured, in order to ensure that the measure will capture reversals that are large in magnitude compared to the typical movement on the stock. The standard deviation is computed using only pre-pilot returns data, so that the measure will not be affected by any changes in volatility that may be related to the pilot.

By definition, a "negative reversal" only occurs in periods when there is a negative return followed by a positive return—otherwise, the negative reversal measure is equal to zero. If a stock experienced a negative return of 3 standard deviations that was fully reversed in the next period, our negative reversal measure would be 3. If a return is only partially reversed, only the portion that is reversed is counted in the measure.

We do not test whether this measure changes across Pre-Pilot and Pilot Periods because the Pre-Pilot Period is already used to normalize the measure. Rather, we focus on differences between the control and pilot samples during the Pilot Period. In order to test whether the frequency of extreme reversals differs across the two samples, we use a nonparametric bootstrapping methodology that does not require any assumptions about the probability

[49] For example, if a stock price increases from 40 to 50 and then returns back to 40, this corresponds to a 25% return followed by a -20% return. In our measure, we would compute the negative return as a percentage of the original price, which would make it a -25% return.

distribution of returns or return reversals. Essentially, this method estimates the likelihood of observing a particular number of reversals under the null hypothesis that the distribution of reversals in the pilot sample is the same as the distribution in the control sample. This is implemented as follows. For a given "threshold" level of the reversals measure, we count the number of reversals in the pilot sample that exceed that threshold. We then select from the control sample (with replacement) a random sample of reversals equal in size to the pilot sample. Within this randomized sample, we count the number of reversals exceeding the threshold, and observe whether the number is higher or lower than the number observed in the pilot sample. We repeat the process 1,000 times and observe the frequency with which the number of reversals in the randomized control sample equals or exceeds the number in the pilot sample. We report the significance based on a two-tailed test—for example, the number of reversals in the pilot sample would be deemed significant at the five percent level if the a number that high occurs 2.5% of the time or less in randomized control samples.

D. Autoregression Methodology for Measuring Reversals

As an alternative approach to measuring the impact of the pilot on price reversals, we employ a new methodology. Similar in spirit to autoregression, this methodology involves measuring the extent to which positive and negative price movements reverse in subsequent periods. Specifically, we use intraday returns to estimate a model of the form:

$$R_t = \sum_{n=1}^{5} \alpha_n R_{t-n}^{-} + \sum_{n=1}^{5} \beta_n R_{t-n}^{+} \ .$$

In this equation, R_t represents the stock return in period t, and the regressors are the positive and negative components of lagged returns:

$$R_t^{-} = \min(0, R_t) \qquad\qquad R_t^{+} = \max(0, R_t)\ .$$

The estimated α and β coefficients measure the extent to which positive and negative returns tend to reverse or continue in subsequent periods. In a world where stock prices follow a random walk, the true coefficients would be equal to zero. Unlike an ordinary autoregression, this specification permits the degree of momentum or reversals to differ for positive and negative shocks. In either case, positive coefficients would indicate that returns exhibit short-term momentum, while a negative coefficient would indicate short-term reversals. For example, if the coefficients α_1 and α_2 were estimated to be -0.05 and -0.01, this would mean that a negative return of one percent would, on average, be followed by a positive return of five basis points in the next period, and a positive return of one basis point in the period after that. If the coefficients β_1 and β_2 were estimated to be -0.04 and -0.02, this would indicate that a positive return of one percent would on average be followed by negative returns of four and then two basis points in the next two periods. We are interested in comparing these coefficients for pilot and control stocks. If price restrictions help prevent short-term negative stock price manipulations, we would expect to see the α coefficients higher for pilot stocks than for control stocks.

E. Small and Low-Volume Stocks

One policy alternative outlined in the first Pilot Order was to extend a uniform test to all securities, including securities with a lower market capitalization or less actively traded than those included in the Pilot. While our analysis cannot directly investigate the effects of price restrictions for stocks beyond the range covered by the pilot sample, it can provide relevant evidence by investigating whether the impact of the Pilot has been substantially different for the smaller stocks than for the larger stocks in the Pilot, or whether the impact has differed for actively traded and less actively traded issues. To examine these questions, we run a series of regression-based tests of the following form:

$$\text{Market Quality}_i = \alpha + \sum_{k=1}^{9} \beta_k \text{Pilot}_i \times \text{Decile}_{ki} + \beta_{10}\text{Pilot}_i + \beta_{11}\text{Pre Market Quality}_i$$

where "Market Quality" represents a characteristic of interest such as spreads, depth, or volatility. The "Decile" variables are indicator variables corresponding to each of the nine lowest deciles, for two different decile partitions. The first partition ranks stocks by market capitalization on April 28, 2005. The second partition ranks stocks by annualized turnover in the Pre-Pilot Period as measured by its average daily share volume divided by its shares outstanding as of April 28, 2005 and multiplied by 250. In each case, the decile indicators take on a value of one if the stock falls within the designated decile, and zero otherwise. These partitions allow us to test whether the price restrictions have a larger impact on certain categories of stocks. In particular, we examine each $\beta_{10} + \beta_k$ to measure whether the pilot has a significant effect on stocks in decile *k*.

VI Results and Analysis

A. The Nature of Short Selling

1. Short Selling Activity

Price restrictions may impose costs on short sellers in the form of lower fill rates and delays on execution. If these costs are economically significant, then we would expect the removal of the price restrictions to result in increased short selling. We would expect short selling to increase more for pilot stocks than control stocks if the price restrictions are costly, or be the same for the pilot and control stocks if price restrictions are not costly.

Table 3 shows how removing the price restrictions affects the level of short selling, based on three different measures, including (i) the number of shares sold short on a given day divided by the total share volume, (ii) the number of trades involving short sales, and (iii) short interest. Panel A shows the Pre-Pilot Period to Pilot Period comparison while Panel B reports the average coefficients from regression analysis. In the Listed market, short volume increases significantly from 24.4% to 26.3% of total volume in the pilot sample, while the change is not statistically significant for the control sample. A comparison of these two changes reveals that short selling volume increases by about 2% of total volume as a result of removing the tick test, suggesting that the tick test imposes economic costs on short sellers. The same conclusion can be drawn from the statistics on short selling as a percentage of trades.

Similarly, both volume and trade measures for Nasdaq NM Stocks suggest that the application of the bid test reduces short selling. The regression analysis in Panel B confirms these conclusions and also shows that the effect of the tick test is stronger than the effect of the bid test.

Although our results indicate that price restrictions appear to constrain the volume and frequency of short sales, these effects are not reflected in short interest. As indicated in Table 3, both pilot and control stocks exhibited significant increases in short interest around the time of the Pilot Period. However, none of the tests indicate any significant difference between pilot and control stocks. Both the univariate results in Panel A and the regression-based results in Panel B lead to the same conclusion: price restrictions appear to have no effect on short interest for Listed Stocks or for Nasdaq NM Stocks. The same result is observed whether short interest is measured in percentage of shares outstanding or in “days to cover.”

The fact that we document statistically significant increases in short selling volume but not in short interest can be interpreted in various ways. One interpretation is that the increase in short volume is due primarily to increased short selling by parties that close out their short positions within the day—or, more generally, that the increase in short volume was accompanied by a decrease in the average horizon over which short positions are held. We should also note that the absence of a statistically significant result does not imply that no change occurred. Given that we observe short interest only monthly, it is possible that our statistical test did not have sufficient power to detect a change in short interest.

Because short sales in Nasdaq NM Stocks executed outside of the Nasdaq market are not subject to the bid test, short sellers can avoid the bid test by sending orders to markets other than Nasdaq. The removal of the bid test might result in an increase in short sales on Nasdaq in Nasdaq NM Stocks because the order routing decision might no longer be affected by the application of the bid test. The Nasdaq market share statistics in Panel A of Table 3 show that Nasdaq's market share in short sales increased 3.9% in pilot stocks and by 1.3% in non-pilot stocks. The difference of 2.6% is statistically significant, which is consistent with the non-uniform application of the bid test altering order routing decisions.

2. Option Activity

If price restrictions drive short sellers to trade options in lieu of stocks, then their removal should decrease option activity. Table 4 summarizes the changes in option trading for pilot and control stocks between the Pre-Pilot Period and Pilot Period. There are a total of 628 pilot and 1,263 control stocks that had listed options included in the analysis. Put and call option trading volume is aggregated over all classes and markets for each underlying stock on a daily basis.

Then, the put and call option trading volume is averaged across days for each stock for period before the pilot and for the period of the pilot. The change in put option trading volume is calculated as the average daily put (call) volume during the pilot minus the average daily put (call) volume before the pilot. Finally, the change is averaged across stocks to yield the results reported in Table 4. Averaging across stocks allows us to maintain the independence of the observations and perform a t-test comparing the mean of the pilot stocks to the mean of the control stocks. The results for open interest and signed option volume use the same methodology.

If the price restriction drives would-be stock short sellers to trade options to implement their investment strategies, then the lifting of the price restrictions on the pilot stocks would lead to a significant decline in option trading for pilot stocks relative to the control stocks. As indicated in table 4, between the Pre-Pilot Period and Pilot Period, we do observe a slight increase in average trading volume for calls and puts on Listed Stocks, a decrease in average trading volume of calls and puts on Nasdaq NM Stocks, and an increase the average open interest of all categories. Based on the paired *t* test, however, we find no statistically significant changes at the 5% confidence level. We also observe that open interest increased less on average for control stocks than for pilot stocks, but again, based on the two-sample *t* test, we find no statistically significant differences between the changes in the pilot and control samples.

As an additional measure, we examine signed option volume. This is computed by subtracting the change in the put volume from the change in the call volume. A positive signed option volume suggests either an increase in long side buyer speculation or a decrease in short side seller speculation. A negative signed option volume suggests either a decrease in long side buyer speculation or an increase in short side seller speculation. For example, if the change in the call volume is -10 and the change in the put volume is -5, then the signed option volume equals -5. On the other hand, if the change in the call volume is -5 and the change in the put volume is -10, then the signed option volume is 5. Again, we find no significant difference between pilot and control stocks.

Since short sellers may use short-term options in lieu of equity short sales, Table 4, Panel B shows the results for short-term options only.[50] The results are quantitatively similar to the results in Table 4, Panel A. Thus, the conclusions drawn from Table 4, Panel A hold for short-term options.

Overall, the options market results provide no statistical evidence supporting the hypothesis that the tick test drives would-be short sellers away from the equity markets and to the options markets to trade.[51] Option trading volume of pilot Nasdaq NM Stocks show a decline in option volume relative to control stocks of 15%, but this difference is not statistically significant.

3. Mechanical Effects

Price restrictions have the mechanical effect of forcing short sellers to be liquidity suppliers instead of liquidity demanders because short sales can rarely be executed against the bid price. Therefore, we expect the removal of price restrictions to be associated with changes in quoting and trading purely because of the mechanics of the rules. In particular, Table 2 shows that about 46% of trades occur on downticks when the tick test applies. We expect that the removal of the tick test will lead to more balanced trading around 50% downticks because short

[50] Long and short-term options are identified using the Options Clearing Corporation directory as of October 31, 2005.

[51] A regression model that controlled for changes in volatility in the pre- and post-periods provided results that were consistent with those in Table 4.

sales can now execute on downticks. This effect should be more obvious in Listed Stocks than Nasdaq NM Stocks where the trades occur on downticks half the time even with the bid test.

A second potential mechanical effect is the percentage of time during the day when the most recent bid change was downward. Table 2 shows that this figure is around 39% when the tick test applies and 47% when the bid test applies. Removing either price restriction could increase the percentage of the day with down bids because short sales can more easily hit the bid to force more downbids. Conversely, if the different price restrictions can explain some of the divergence in these figures, we expect the percentage of downbids in Listed Stocks and Nasdaq NM Stocks to converge.

Table 5 shows how the tick and bid tests affect trading and quoting mechanics. The downtick rows in Panel A show that the percentage of trades on downticks increases from 46% to almost 50% in pilot Listed Stocks. Conversely, the percentage of trades on downticks in control Listed Stocks goes down. On net, the percentage of trades on downticks is fairly balanced when the tick test does not apply and is skewed toward upticks when the tick test does apply. Nasdaq NM Stocks appear to have much more balanced trading even with the bid test so that removing the bid test results smaller increase in the number of downticks. Panel B confirms the result that the tick test has a much larger effect on trading mechanics than the bid test.

The downbid rows in Table 5 measure the percentage of the trading day during which the most recent bid change was downward. Pilot Listed Stocks experience a small increase in the prevalence of downbids but this increase is roughly similar to an increase experienced by control Listed Stocks. The results show a decline in the prevalence of downbids for pilot Nasdaq NM Stocks, suggesting that short selling under the bid test might shorten the duration of upbids, reflecting the restriction that short sales can only hit upbids.

B. Market Quality

1. Liquidity Measures

Because price restrictions alter how orders transact with each other, they have the potential to alter traditional measures of liquidity. In particular, the price restrictions will often keep a short sale from executing against the bid quote. Therefore, we expect the depth at the bid quote to be lower without price restrictions. If a short sale can not execute against the bid, it often adds depth to the ask quote, and hence, the depth of the ask might be lower without price restrictions. Alternatively, a restricted short sale might set a lower ask price and an unrestricted short sale might exhaust the depth at the bid resulting in a lower bid price. Either way, short sale price restrictions can result in a narrower quoted bid-ask spread.

While quoted spreads and depths measure the displayed supply of liquidity, the effective spread measures liquidity actually available to investors. Therefore, an examination of effective spreads is necessary to understand the effect of price restrictions on liquidity. Because price restrictions can affect the displayed liquidity, we might also expect them to affect the actual liquidity as well.

Table 6 shows results on the effect of price restrictions on liquidity. For the pilot sample, the ask depth decreases for Listed Stocks but increases for Nasdaq NM Stocks. The control sample experiences an increase in depth at the ask. Comparing the changes reveals that the ask depth of the pilot stocks decreased relative to the ask depth for the control stocks in both Listed and Nasdaq NM Stocks. This change is significant for Listed Stocks in both the univariate and regression-based tests, but is significant for Nasdaq NM Stocks only in the regression-based tests in Panel B. Panel B also shows that the ask depth is augmented about three round lots more when a tick test applies than when a bid test applies.

The bid depth results in Table 6 are slightly different than the ask depth results. The bid depth increases for all sub-samples, but the difference between the pilot and control samples is not significant in Panel A, while Panel B suggests that the bid depth of the pilot stocks does not increase as much as the bid depth of the control stocks. This effect is larger for Nasdaq NM Stocks than for Listed Stocks, therefore, the bid test seems to augment the bid depth more than the tick test does by about one round lot.

We examine two measures of quoted spread. The first, known as the "absolute spread," is simply the difference between the ask price and the bid price, measured in pennies. The second, called the "relative spread," is the absolute spread divided by the bid-ask midpoint, thus measuring the displayed cost to trade as a percentage of the stock's value. Panel A shows that the quoted spreads did not change much when the pilot started for either the pilot stocks or the control stocks. Only the relative quoted spread in control stocks saw an increase but that increase was not statistically different from the change in relative spreads experienced by the pilot stocks. The conclusions from Panel B give a more mixed picture. Quoted spreads decline about 0.3 cents more for pilot stocks, a result that is the same for Listed Stocks and Nasdaq NM Stocks. This result suggests that the tick and bid tests appear to reduce liquidity. However, the results on relative quoted spreads yield the opposite conclusion. While these results are statistically significant, the point estimates are fairly small. The quoted spreads decline by less than half a penny and the relative quoted spread increases by less than a basis point. Taken together, these results suggest that the tick and bid tests have a slight effect on quoted spreads, if any.

In addition to quoted spreads we also examine effective spreads, estimated for each trade by computing the absolute value of the difference between execution price and the current bid-ask quote midpoint. As we did for the quoted spread, we estimate both absolute and relative effective spreads. The effective spread results in Panel A of Table 6 look quite similar to the quoted spread results. Only one of the changes is statistically significant, a decline in the effective spread of pilot Nasdaq NM Stocks. This result alone would suggest that the application of the bid test decreases liquidity. However, this conclusion is weakened by the lack of statistical significance in the other sub-samples and the lack of a difference between the pilot and control stocks. The Panel B results suggest that the tick test has no impact on effective spreads, but the results on the bid test are mixed. The bid test appears to decrease effective spreads and increase relative effective spreads. Like the results on quoted spreads, the magnitudes of these changes are small.

Overall, the Regulation SHO Pilot shows us that the price restrictions appear to augment depth at both the ask price and the bid price, but price restrictions have little if any effect on realized liquidity. These results are fairly consistent whether the price restriction is structured as a tick test or as a bid test, although the tick test augments the ask depth more and the bid test augments the bid depth more.

2. Return Volatility

The next set of tests examine whether removing the price restrictions alters return volatility. Table 7 displays test results for several volatility measures and several return horizons to capture different aspects of volatility.

The daily price range measures the degree to which prices fluctuate within a day by comparing the high price to the low price in a day. The daily price range declines from the Pre-Pilot Period to the Pilot Period for each subsample. This decline is statistically significant for both Listed and Nasdaq control samples and for the Nasdaq pilot sample, but not for the Listed pilot sample. Panel A suggests that the decline was statistically similar for pilot and control stocks, while the Panel B regression suggests that the daily price range increased for pilot stocks relative to control stocks for both the Listed and Nasdaq samples. Taken together, the daily price range results are mixed on whether the tick and bid tests dampen volatility.

To explore intraday volatility further, we examine our next two volatility measures, absolute returns and return variance, over three time horizons, 5 minutes, 30 minutes, and one day.[52] These measures would increase for pilot stocks over the shorter horizons if the tick and bid tests dampen transitory volatility. The measures would increase for the pilot stocks over the longer horizons if the tick and bid tests dampen permanent volatility. Economically, transitory volatility captures the efficiency of the trading mechanism while permanent volatility captures the effects on equilibrium prices. We separately analyze absolute returns and return variance because each measures volatility slightly differently. Return variance has a tendency to put more weight on larger price movements than absolute returns.

The average absolute returns are lower during the Pilot Period for the control sample across all three return horizons. The univariate results in Panel A show that the pilot stocks experienced a statistically similar decline in the absolute returns as the control stocks for the 30 minute and daily horizons. At the five-minute horizon, however, the pilot sample experienced an increase in absolute returns relative to the control stocks for both Listed and Nasdaq NM Stocks.

[52] The 5 and 30 minute absolute returns and variances are estimated without including the first half hour of the trading day, after hours trading, or pre-open trading.

The regression results in Panel B confirm this finding and shows that the effect is larger for Listed Stocks. Panel B also confirms the results for the daily horizon but indicates that absolute returns increased over the 30-minute horizon for pilot stocks relative to control stocks. While the 30-minute results are mixed, the absolute return results suggest that the tick and bid tests have no effect on the magnitude of daily returns while they seem to dampen the magnitude of five minute returns. Further, the tick test seems to dampen short-term returns more than the bid test.

The return variance results in Panels A and B are quite a bit weaker. Panel A shows that the changes to return variances experienced by pilot stocks are statistically similar to the changes in return variances experienced by control stocks for both Listed Stocks and Nasdaq NM Stocks, and this result holds for all three return horizons. Panel B confirms this result for the 30 minute and daily return horizons but finds that pilot Listed Stocks seem to experience an increase in return volatility over the 5 minute horizon relative to control Listed Stocks. In summary, the bid test seems to have no effect on return variance over any time horizon while the tick test might dampen return variance over the five minute horizon.

Because the results above suggest that price restrictions may dampen transitory volatility, we next focus on variance ratios that are specifically designed to capture transitory volatility by comparing the short horizon volatility to longer horizon volatility. If no transitory volatility exists, variance ratios are designed to equal one. We examine three different variance ratios. We compare five minute variance to thirty minute variance, five minute variance to daily variance, and thirty minute variance to daily variance. Panels A and B show that the variance ratio of five to thirty minute returns increased for pilot Listed Stocks relative to control Listed Stocks. Further, Panel B shows that the change for Listed Stocks differs significantly from that of Nasdaq NM Stocks. However, none of the other variance ratios changed significantly.

Because the variance ratios relative to the daily level did not show any changes, the results on transitory volatility are somewhat weak. However, the result for Listed Stocks over the five minute horizon to thirty minute horizon still helps solidify the conclusion that the tick test dampens transitory volatility over the five-minute horizon but seems to have no effect on permanent volatility.

C. Effect on Stock Prices

As outlined in section III above, numerous theoretical models suggest that short selling constraints can affect equilibrium stock prices. Some of these models predict that stocks are likely to be more overpriced when short selling constraints are more binding, and when investors disagree more about the stock's true value.

Our evidence above suggests that price restrictions do constrain short selling somewhat. Thus, we are interested in testing the hypothesis suggested by these theories, that removing price restrictions will lessen overpricing. This hypothesis is not likely to hold unless the price restrictions are significant relative to other short selling constraints and our sample stocks are overpriced prior to the start of the pilot. Therefore, rejecting the hypothesis might mean that price restrictions are minor relative to other short selling constraints or that our sample stocks were not overpriced.

Table 8 reports average daily returns and average cumulative returns for pilot and control stocks in the period surrounding the beginning of the pilot. If pilot stocks are over-valued because of the price restrictions, these returns should be significantly negative for pilot stocks relative to the control stocks. Cumulative returns are normalized to zero on April 29, the trading day prior to the start of the pilot. As indicated in Panel A of Table 8, we observe for Listed

Stocks a statistically significant difference between the average returns of control and pilot stocks on May 2, the first day of the pilot. The average control stock experienced a return that exceeded the average pilot stock by about twenty-four basis points. However, we do not observe significant differences in returns on other days after the start of the pilot, nor are the cumulative returns statistically distinguishable at horizons beyond the first day. For Nasdaq NM Stocks, we observe no differences in daily or cumulative returns at or after the start of the pilot that are statistically significant at the five percent confidence level.[53] Because the Listed difference does not persist and because of a lack of a difference in Nasdaq NM Stocks, neither the tick nor the bid test appear to cause stocks to be over-valued.

Figure 1 displays the returns for the pilot and control samples over the first six months of the pilot. The figure gives the raw returns as well as the market adjusted returns. Returns in general appear to be positive over this period but are close to zero when subtracting the market return. Further, the pilot sample appears to under-perform the control sample, especially for Listed Stocks. Table 9 confirms that the six month returns of the pilot stocks appears lower than that of the control stocks. However, this result is not statistically significant. Therefore, the six month returns for the pilot sample are statistically similar to the six month returns for the control sample.

Table 9 also shows that the average alphas are negative but very close to zero. This means that when controlling for risk, the returns of the sample stock are about the same as the returns of the market portfolio. Further, the univariate results of Panel A and the regression results of Panel B show that the alphas of the pilot sample are statistically similar to the alphas of

[53] On the Nasdaq NM side, we do observe a statistically significant difference on a single day several days prior to the start of the pilot (April 26). In Table 8, we tested for statistical significance on 21 separate days in two different markets, for a total of 42 different hypothesis tests. Under the hypothesis that the pilot has no effect, we would expect random errors to cause roughly two out of the 42 tests to show false positive significance at the five percent level.

the control sample. Therefore, the pilot stocks did not underperform the control stocks. This suggests that the removal of the price restrictions will not result in either a long horizon correction of over-pricing nor is it likely to lead to prices being driven below their equilibrium value.

Table 9 also shows the tendency of the alphas to be significantly positive or significantly negative. An alpha is deemed to be negative if the estimate is significantly negative at the 5% level in a two-tailed test. Similarly, an alpha is considered to be positive if the estimate is significantly positive at the 5% level in a two-tailed test. If the alphas are completely random, we would expect to find 2.5% of them positive and 2.5% of them negative. Table 9 shows that the frequency of positive alphas is less than 2.5% while the frequency of negative alphas is slightly higher.[54] The frequency of negative alphas is statistically similar for pilot stocks and control stocks, providing further evidence against prices being driven below their equilibrium level. Among Listed Stocks, the control stocks appear to be more likely to have positive alphas, potentially because price restrictions facilitate over-pricing. This finding however, is weakened by the observation that fewer than 2.5% of control stocks have significantly positive alphas.

D. Market Manipulation

Because the type of analysis conducted in this study cannot directly prove whether market participants are engaging in manipulative practices, it is inherently difficult to measure whether the Pilot has had any impact on the degree to which markets are susceptible to manipulation. Our approach is to identify certain data patterns that we would expect to be more

[54] We also estimated the alphas using the value-weighted index. About 2.5% or fewer alphas were significantly positive and about 2.5% or fewer were significantly negative.

prevalent in a world where prices are manipulated, and investigate to see if these price patterns are more common for pilot stocks than control stocks. Such a pattern does not necessarily mean that manipulation has occurred, but indicates that we might have cause for further analysis.

As argued above in section I-B, if price restrictions inhibit manipulation by short sellers and/or facilitate upward manipulation, we might expect to see more large, sudden price declines and more price increases in pilot stocks than control stocks. If so, this should be reflected in the form of decreased skewness in the short-term returns distribution.

Table 10 reports results of statistical tests based on 5-minute, 30-minute, and 1-day returns. For each returns horizon, we follow the same approach as before and test for changes in skewness between the Pre-Pilot Period and Pilot Period, separately for pilot and control stocks, and for Listed and Nadaq stocks, and then test whether the difference of differences is significantly different from zero.

As the table indicates, we find no significant changes between the Pre-Pilot Period and Pilot Period, with the single exception that there appears to have been a marginally significant decline in the skewness of Listed pilot stocks at the 30-minute return interval. However, neither in this nor any other case do we find any statistically significant differences between pilot and control stocks. Thus, we find no evidence that the pilot program has had any impact on returns skewness. The results reported in Table 10 are based on the skewness of returns computed using trade prices.[55]

Our second approach to testing whether eliminating price restrictions may lead to an increase in price patterns indicative of market manipulation involving short sales is to examine the relative frequency of large negative and positive price reversals, as explained in section V-C,

[55] We also performed the test using returns computed using quote midpoints (results not reported) and again found no significant differences between pilot and control stocks. Using this alternative measure, the point estimates indicate an even smaller difference than indicated in Table 9.

above. Our results are presented in Table 11. Panel A reports results for return reversals occurring over subsequent 5-minute intervals, and Panel B reports results based on 30-minute intervals.

In this table, the line corresponding to “Reversal Size > 2” reports the number of times (per 100,000 observations) that a stock price move of 2 standard deviations or more was reversed in the subsequent period. So, for example, the number 338.4 in the first column of Panel A indicates that for Listed, pilot stocks, the frequency of negative five-minute reversals greater than two standard deviations in magnitude is approximately 0.003384, or 338.4 out of 100,000. In this table, statistical significance is ascertained using a nonparametric bootstrapping procedure outlined in section V-C. This test, which is applied only to the pilot sample, indicates whether the observed frequency of reversals would constitute a rare event under the null hypothesis that the distribution of reversals is the same for control and pilot stocks. Results are reported for thresholds ranging from two to nine standard deviations.

Our results in Panel A indicate that the pilot stocks tend to experience significantly more 5-minute return reversals than the control stocks, at least for thresholds in the range of two to four standard deviations. This same result is observed for Listed Stocks and Nasdaq NM Stocks. If price restrictions deter price patterns consistent with downward manipulations but not upward manipulations, we might expect to see more negative price reversals in the pilot sample than the control sample, but no difference in positive reversals. In our sample, however, the effect of the pilot appears to be equally as strong, if not stronger, for positive reversals than for negative reversals.

The results based on the 30-minute horizon, reported in Panel B, tell a different story. At the 30-minute horizon, there is no longer any statistical evidence that pilot stocks have a higher frequency of reversals than control stocks.[56] If anything, the result is in the opposite direction—for Listed Stocks at the higher threshold levels, there appears to be some evidence that there are significantly fewer positive reversals for pilot stocks than control stocks.

As explained in Section V-D, above, our third approach to investigating whether removing price restrictions increases the prevalence of price patterns consistent with market manipulation is to use an autoregression model to estimate the extent to which positive and negative returns tend to be reversed in subsequent periods. The results of this analysis are presented in Table 12.

Panel A shows how five minute returns are correlated with the returns of each of five previous five-minute periods. A positive number reflects returns in the same direction. A negative number reflects return reversals. Most of the coefficients in Table 12 are negative, reflecting a tendency for five-minute price changes to be reversed over subsequent periods. While many of the autocorrelations changed from the Pre-Pilot to Pilot Period, we focus on how the pilot sample compares to the control sample. Over one lag, removing price restrictions makes returns in Listed Stocks more negatively autocorrelated. This is true whether the previous returns were positive or negative. The effect continues for two lags (ten minutes), but only following positive returns. Price restrictions have no effect on five-minute return autocorrelation in Nasdaq NM Stocks.

---

[56] Panel B of Table 11 reports results for 32 different hypothesis tests (eight different thresholds, positive and negative reversals, Listed and Nadaq samples). Of these 32 tests, only one indicates statistical significance at the five percent level (negative reversals for Listed Stocks at the 3-standard deviation threshold). Even under the null hypothesis of no true effect, we would expect any individual test to show a "false positive" at the 5% significance level approximately 5% of the time. Thus, one significant test statistic out of 32 tests does not constitute a meaningful rejection of the null hypothesis.

Panel B shows the results for thirty minute returns. Measured relative to control stocks, the pilot stocks experience no statistically significant increase in return correlation for any of the thirty minute intervals examined.

In summary, returns in Listed Stocks are negatively serially correlated following both positive and negative returns over short horizons and removing price restrictions increases this negative correlation. The symmetry of these results is consistent with the volatility results above. We find no statistically significant impact for Nasdaq NM Stocks.

E. Small and Low-Volume Stocks

The analysis presented heretofore analyzes Listed Stocks and Nasdaq NM Stocks separately, but beyond this does not make any effort to ascertain whether the pilot may have a disproportionate or qualitatively different effect on smaller or less liquid stocks. In order to address these questions, we partition the sample into deciles according to market capitalization and turnover. As described above in section V-E, we partition the sample into deciles before separating them across markets, to ensure that Listed Stocks and Nasdaq NM Stocks in the same decile are comparable. The sample sizes resulting from these decile partitions are reported in Table 13. As the table indicates, the Listed Stocks are more concentrated in the higher deciles of market capitalization, while the opposite is true for Nasdaq NM Stocks. However, both Listed and Nasdaq NM Stocks have representation across all deciles of the two measures.

Tables 14 through 26 present our results analyzing how many of the results presented earlier vary as a function of size and liquidity. As explained in section V-E, above, these tables are based on a regression analysis where each model includes a pilot indicator and a pilot indicator interacted with indicator variables for deciles one through nine. In this model, the marginal effect of the pilot is captured through two channels, first through the pilot indicator variable, and secondly through the interacted indicator variable. To facilitate interpretation, the tables report the sum of the coefficients on the pilot dummy and the interacted terms. This way, the entries in the table show directly how the pilot sample differs from the control sample within each decile.

Table 14 shows how the tick and bid tests affect short selling volume for stocks in each size and turnover decile. Removing the rules increases short selling volume in almost every size and volume decile. Further, the tick test appears to hinder short selling slightly more in small stocks than in large stocks. The bid test, on the other hand, appears to hinder short selling slightly more in large stocks than in small stocks. The affect of the tick and bid tests appear unrelated to turnover level. According to the Nasdaq market share results in Table 15, the removal of the bid test on Nasdaq seems to increase Nasdaq's market share more for small stocks than for large stocks. Overall, the tick and bid tests do seem to have differing affects on short selling for stocks of varying sizes.

In results not reported in tables, only the tick test has a differential effect on the balance of trading in stocks of differing sizes while all other mechanical effects are similar across size and activity levels. The tick test has a bigger effect on the symmetry of trading in smaller stocks but a constant effect on the symmetry of stocks of varying activity levels.

Tables 16 and 17 show whether the augmentation of the bid and ask depth is similar for large and small stocks. These patterns are qualitatively similar in both tables. The tick test augments depth across almost all size and activity levels without clearly augmenting large or small stocks more. The bid test's influence on depth, however, varies widely across size and activity levels without a discernable pattern. Therefore, the depth augmentation from the tick and bid tests appears unrelated to the size or activity level of the stocks.

As stated above, the increase in the depth at the inside quote affects the displayed supply of liquidity but might not influence realized liquidity, as measured by effective spreads. Table 18 shows that the tick test has no effect on effective spreads for almost all size and activity levels. The bid test, however, seems to result in lower effective spreads for large or more active stocks and potentially higher spreads for small or less active stocks. When significant, however, the magnitudes are still only a few basis points.

The results above show that transitory volatility is dampened by the tick test with much weaker evidence on the bid test. Table 19 shows that the tick test primarily dampens the volatility of small stocks but seems to amplify the volatility of large stocks. The bid test shows a similar pattern but to a lesser degree. The results across turnover levels are not as striking. The tick test seems to dampen volatility for most activity levels and the bid test shows similar yet substantially weaker evidence.

Table 20 summarizes the evidence on how the tick and bid tests affect longer-term variance. While the tick test does not affect the daily return variance in stocks as a whole, it does seem to dampen daily return variance in small stocks and increase daily return variance in large stocks. The bid test shows a similar pattern but the effect is only significant for a few of the smaller size levels. The tick and bid tests have no effect on daily return variance for any activity level.

The results above show little evidence that the tick or bid tests affect price levels. However, there is a 24 basis point return difference between pilot and control Listed Stocks on the first day of the Pilot. Table 21 summarizes whether this return difference varies by size or activity level. The evidence shows that for most size and activity levels, the pilot and control stocks experienced a statistically similar return on the first day of the Pilot. The Listed pilot stocks had a lower return than the control stocks in the largest size group while the Nasdaq NM pilot stocks had a lower return than the control stocks in the highest turnover group. Hence, the prior results seem to be driven by the large Listed Stocks.

Table 22 compares the pilot stock six-month alphas to the control stock six-month alphas for the various size and activity groups. Like the May 2 results, the pilot alphas are statistically similar to the control alphas in every size and activity level. Therefore, the tick and bid tests do not promote or hinder pricing efficiency for any size or activity level.

Recall from Table 11 that negative and positive five-minute price reversals are more prevalent in the pilot sample than the control sample, especially for Listed Stocks. Repeating our analysis across deciles, we find the difference between pilot and control Listed Stocks is significantly more pronounced for stocks with the lowest market capitalization (results not presented). These findings are consistent with our other results indicating that smaller stocks tend to be more volatile when the tick test is removed. However, for the smallest Listed Stocks, we observe a greater number of positive than negative price spikes, suggesting that removing the tick test does not make smaller stocks unduly susceptible to negative price pressure.

VII Summary and Conclusions

The pilot program established by Regulation SHO exempted approximately one third of the Russell 3000 stocks from the "tick test" (Rule 10a-1) for Listed Stocks and the "bid test" (former NASD Rule 3350) for Nasdaq NM Stocks traded on Nasdaq or traded OTC and reported to an NASD facility. The pilot was designed to facilitate comparison between the pilot stocks and control stocks, thus creating an unprecedented opportunity to observe in a controlled environment the effects of removing the price restrictions.

This study has compared pilot and control stocks along numerous dimensions, in an effort to capture a broad range of possible effects. Our main empirical results are as follows:

- The pilot is associated with increased short selling volume in Listed and Nasdaq NM Stocks, but appears to have no impact on the level of short interest in either market. The increase in short selling is slightly higher for small Listed Stocks than for large Listed Stocks.

- The pilot is associated with an increase in Nasdaq's share of trading volume in Nasdaq NM Stocks, suggesting that market participants are routing trades to other venues in order to avoid the bid test. The market share increases more for smaller stocks. For the largest Nasdaq NM Stocks, such as those included in the Nasdaq 100, there is no significant difference in market share.

- We find no evidence that the pilot has had any impact on the level of trading activity in the options market, as we would have expected to see if market participants are using option markets to avoid the tick test or the bid test.

- For Listed Stocks, less than 46% of all trades are executed on down bids when the tick test applies, while the number is close to 50% for pilot stocks, suggesting that Rule 10a-1 constrains the execution price in four to five percent of trades. For Nasdaq NM Stocks, Rule 3350 does not explicitly prevent trading on downticks, but our results show that it effectively constrains trading on downticks for about one half of one percent of trades.

- The pilot is associated with a decrease in quote depth, especially on the ask side for Listed Stocks—our evidence confirms that Rule 10a-1 forces some short sellers who would otherwise be liquidity demanders to act as liquidity suppliers. The decrease in depth appears unassociated with size or turnover.

- Other than the effect on market depth, the pilot has had no clear effect on market liquidity—most of our tests indicate that liquidity was not significantly impacted by the pilot, but some tests indicate small increases or decreases in liquidity, depending on the measure.

- The pilot is associated with an increase in some measures of intraday volatility. These increases appear to be confined to the smaller stocks as larger stocks experienced a decline in volatility during the pilot.

- On average across all types of stocks, the pilot does not appear to have any significant effect on daily volatility—however, our results indicate the pilot is associated with lower volatility for stocks with higher market capitalization, and higher volatility for stocks with lower market capitalization.

- Based on the price reaction to the initiation of the pilot, we find limited evidence that the tick test distorts stock prices—on the day the pilot went into effect, Listed Stocks in the pilot sample underperformed Listed Stocks in the control sample by approximately 24 basis points. However, the pilot and control stocks had similar returns over the first six months of the pilot.

- We find no evidence of "bear raids" associated with the pilot. More specifically, we test for evidence of bear raids in three ways:

    - We test whether the pilot has affected the relative frequency of large negative vs. large positive stock returns, as reflected in the skewness of the returns distribution. There is no difference in skewness between control and pilot stocks
    - A bear raid may be associated with a large negative return that is very quickly reversed, or a "negative price spike." Although we do find a higher incidence of negative price spikes in the pilot sample at some horizons, the same thing is observed for positive price spikes.
    - We also measure directly the tendency for price movements to be reversed in subsequent periods. Again, we find that the pilot is associated with a slightly greater tendency for price changes to be reversed, but this effect is observed equally for positive and negative returns.

In summary, having examined the impact of the Regulation SHO Pilot on a wide array of market characteristics, we conclude that price restrictions constitute an economically relevant constraint on short selling. Our evidence suggests that removing price restrictions for the pilot stocks has had an effect on the mechanics of short selling, order routing decisions, displayed depth, and intraday volatility, but on balance has not had a deleterious impact on market quality or liquidity. In various dimensions, our evidence confirms that the tick test of Rule 10a-1 acts as a more binding constraint than the bid test of former NASD Rule 3350. On most dimensions, the effects of the pilot do not appear to be systematically related to market capitalization or trading volume, suggesting that our results give a reasonable picture of what we might expect to see if price restrictions were removed for all stocks, including smaller stocks and stocks less actively traded than those in the Russell 3000. However, some results, particularly those involving volatility, suggest that the effect of the tick test and the bid test may be systematically related to market capitalization.

We conclude with a few caveats. While the Pilot study was designed to facilitate a natural experiment in a controlled environment, the results might not be entirely representative of removing the rule permanently for all stocks. It is possible that traders might behave differently if a rule were permanently and completely removed than if it is only temporarily or incompletely removed. Moreover, it is possible that traders with manipulative intentions might be on good behavior if they believe that heightened scrutiny during the Pilot increases their chances of getting caught.

References

Albert, Robert Jr, Timothy R. Smaby, and David H. Robison, 1997, Short selling and trading abuses on Nasdaq. Financial Services Review 6:27-39.

Alexander, Gordon J. and Mark A. Peterson, 1999, Short selling on the New York Stock Exchange and the effects of the uptick rule. Journal of Financial Intermediation 8:90-116.

Alexander, Gordon J. and Mark A. Peterson, 2002, Implications of a reduction in tick size on short-sell order execution. Journal of Financial Intermediation 11:37-60.

Alexander, Gordon J. and Mark A. Peterson, 2006, (How) Do Price Tests Affect Short Selling? Working paper, University of Minnesota.

Angel, James J., 1997, Short selling on the NYSE, working paper, Georgetown University.

Au-Yeung, Siu Pang and Gerard Gannon, 2003, Regulatory change and structural effects in HSIF and HIS Volatility. Proceedings of the 13th Annual Asia-Pacific Futures Research Symposium.

Bris, Arturo, William N. Goetzmann, and Ning Zhu, 2004, Efficiency and the bear: Short sales and markets around the world. Working paper, Yale University.

Diether, Karl, Kuan Hui Lee, and Ingrid Werner, 2006, It's SHO Time! Short-Sale Price-Tests and Market Quality. Working paper, Ohio State University.

Ferri, Michael G., Stephen E. Christophe, and James J. Angel, 2004, A short look at bear raids: Testing the bid test. Working paper, George Mason University.

Gallmeyer, Michael and Burton Hollifield, 2006, An examination of heterogeneous beliefs with a short sale constraint, working paper, Texas A&M and Carnegie Mellon University.

House Report, 1991, Short-selling activity in the stock market: market effects and the need for regulation (part I), House report 102-414.

Jones, Charles M., 2003, Shorting restrictions, liquidity and returns. Working paper, Columbia University.

Lintner, John, 1969, The aggregation of investors' diverse judgements and preferences in purely competitive strategy markets, Journal of Financial and Quantitative Analysis 4: 347-400.

Macaulay, Fred R. and David Durand, 1951, Short selling on the New York Stock Exchange. Twentieth Century Fund, New York.

Macey, Jonathan R., Mark Mitchell, and Jeffry Netter, 1989, Restrictions on short sales: An analysis of the uptick rule and its role in view of the October 1987 stock market crash. Cornell Law Review 745:799-835.

Marcotte, Raymond H. and Peter G. Martin, 1977, An evaluation of short sale regulation and rule 10a-1. Working paper, Securities and Exchange Commission.

McCormick, D. Timothy and Lorraine Reilly, 1996, The economic impact of the Nasdaq short sale rule. Working paper, NASD Economic Research.

McCormick, D. Timothy and Zeigler, Bram, 1997, The Nasdaq short sale rule: Analysis of market quality effects and the market maker exemption. Working paper, NASD Economic Research.

Meeker, James Edward, 1932, Short Selling. New York: Harper Brothers.

Miller, Edward, 1977, Risk, Uncertainty and the Divergence of Opinion, Journal of Finance 32: 1151-1168.

Scheinkman, José and Wei Xiong, 2003, Overconfidence and Speculative Bubbles, Journal of Political Economy 111: 1183-1219.

Securities and Exchange Commission, 1935, First annual report of the Securities and Exchange Commission.

Securities and Exchange Commission, Fourth annual report of the Securities and Exchange Commission, Release No. 1548, January 24, 1938.

Securities and Exchange Commission, Concept Release: Short Sales, Release No. 34-42037, October 20, 1999.

Twentieth Century Fund, 1935, *The Securities Markets*. New York.

Wu, J. Julie, 2006, Uptick rule, short selling and price efficiency, working paper, Texas A& M University.

Tables

Table 1: Sample characteristics

This table shows the number of sample stocks categorized by whether they are in the Pilot, their listing status, and whether they have tradable options on them. The Pilot stocks are those designated in the first Pilot Order that are trading on Amex, Nasdaq NM, or NYSE as of May 2, 2005. The Control stocks are the ones that were eligible to be selected for the Pilot but were not. The Control stocks are limited to those trading on Amex, Nasdaq NM, and NYSE as of May 2, 2005. Listed Stocks are stocks listed on NYSE or Amex. This table shows the sample sizes as of October 31, 2005 as well. To avoid survivor biases, we retain stocks in the sample even if they stocks cease trading on Amex, Nasdaq NM, or NYSE before the end of our sample period on October 31, 2005. This table shows the sample sizes as of October 31, 2005 as well. Stocks are considered optionable if they have traded options at some point in the four months prior to the start of the Pilot. Short-term options are options with experations within one year.,

Variable	Listed Stocks		Nasdaq Stocks	
	Pilot	Control	Pilot	Control
# Stocks (first day of the Pilot)	504	973	439	917
# Stocks (last day of the Sample Period)	496	949	423	877
# Optionable Stocks (all options)	350	690	278	573
	(69.44%)	(70.77%)	(63.33%)	(62.28%)
# Optionable Stocks (short-term options)	350	688	277	567
	(69.44%)	(70.56%)	(63.10%)	(61.63%)

Table 2: Comparison of Pilot and Control Stocks Before Initiation of Pilot

This table compares the Pilot and Control stocks in several statistics over the four month period prior to the start of the Pilot on May 2, 2005. The statistical difference between the samples is tested using a two-sample t-test. * and ** indicates that the Pilot stocks are statistically different from the Control stocks at the 5% and 1% levels in a two-tailed test.

Variable	Listed Stocks		Nasdaq Stocks	
Market Characteristics	Pilot	Control	Pilot	Control
Trades / day	1,539.30	1,514.40	2,690.6	2,713.8
Daily Share Volume	1,134.70	1,135.30	1,075.20	1,122.70
Turnover	1.77	1.85	2.56	2.49
VWAP	38.43	36.04	23.01	22.20
Market Capitalization	7,013.30	7,376.10	1,631.50	1,963.20
Short Interest (% of Shares Outstanding)	3.62	3.75	5.23	5.00
Short Interest (Days to Cover)	6.14	6.28	6.64	6.49
The Nature of Short Selling				
Short Selling Volume (% of Volume)	24.41	24.27	36.08	35.57
Short Selling Trades (% of Trades)	27.37	27.15	37.74	37.21
Nasdaq Market Share of Short Sales	10.74	10.42	47.45	47.91
Put Volume	838.56	935.66	726.08	664.03
Call Volume	1,306.91	1,322.83	1,194.10	1,103.75
Put + Call Volume	2,145.47	2,258.49	1,920.18	1,767.78
Put Open Interest	28,325.87	33,315.65	16,933.98	18,536.20
Call Open Interest	32,878.21	34,761.23	27,741.65	27,776.23
Put + Call Open Interest	61,204.08	68,076.88	44,675.63	46,312.43
Mechanical Issues				
% trades on a downtick or zero downtick	45.87	45.84	50.61	50.60
Time-weighted downbids	38.82	38.74	47.06	47.44
Liquidity				
Quoted Spread (¢)	6.82	5.64	5.44	5.59
% Quoted Spread	0.19	0.18	0.27	0.28
Effective Spread (¢)	4.92	4.48	5.22	5.29
% Effective Spread	0.16	0.15	0.27	0.29
Ask Depth	15.04	18.81	21.23	26.91
Bid Depth	12.16	15.96	21.41	27.41
Return Distributions				
Daily Price Range (100*(log high – log low))	2.45	2.43	3.64	3.76
5 Minute Returns (%)	-0.001	-0.002*	-0.003	-0.003
Average Absolute Returns	0.114	0.112	0.147	0.144
Skewness of Returns	0.084	0.238	0.282	0.193
Standard Deviation of Returns	0.191	0.198	0.258	0.270
30 Minute Returns (%)	-0.008	-0.010*	-0.019	-0.020
Average Absolute Returns	0.286	0.282	0.389	0.397
Skewness of Returns	0.128	0.134	0.204	0.129
Standard Deviation of Returns	0.449	0.445	0.615	0.634
Daily Returns (%)	-0.063	-0.084	-0.172	-0.195
Average Absolute Returns	1.340	1.330	1.804	1.853
Skewness of Returns	0.061	0.174	0.264	0.160
Standard Deviation of Returns	2.106	1.997	2.724	2.821
Variance Ratios				
6 x Var(5 min) /Var(30 min)	1.13	1.12	1.24	1.26*
288 x Var(5 min)/Var(daily)	3.12	3.02	4.09	4.17
48 x Var(30 min)/Var(daily)	2.71	2.64	3.24	3.25

Table 3: Changes in Short Selling Activity

This table summarizes how short selling changes when the tick and bid tests are removed. The four months prior to the Pilot start date (May 2, 2005) are called the "Pre-Pilot" and the six months following the start date are called the "Pilot". The table shows the average change in short selling for Pilot and Control stocks and estimates whether the Pilot stocks changed more than the Control stocks. Short Volume is the number of shares in short sale transactions divided by total share volume. Short Trades is the number of short sale transactions divided by total transactions. Short Interest is the monthly short interest times 100 divided by the shares outstanding. Days to Cover is the monthly short interest divided by the average daily share volume during the corresponding month. Nasdaq market share is Nasdaq's share of the volume of short selling. Paired t-tests determine whether the changes are significant. Tests of the difference between the changes are two-sample t-tests. **, * indicates statistical significance at the 1 and 5% level in a two-tailed test. We test whether the Difference in the Change for Listed Stocks is statistically different from that of Nasdaq NM Stocks using a regression framework. During the Pilot Period, we run daily cross-sectional regressions of each variable on an indicator for Pilot Securities and the variable's pre-Pilot level (equation 1). We run the regression separately for Listed and Nasdaq NM Stocks and test whether the coefficients on the Pilot indicator are similar. [a, b] indicates that the average coefficient for Nasdaq NM Stocks is statistically different from the average coefficient for Listed Stocks at the 1% and 5% level in a two-tailed test.

Panel A: Univariate Changes

		Pilot Sample			Control Sample			Pilot Δ minus
Variable	Market	Pre-Pilot	Pilot	Δ	Pre-PIlot	Pilot	Δ	Control Δ
Short Volume	Listed	24.41	26.32	1.91**	24.27	24.16	-0.11	2.02**
Short Volume	Nasdaq	36.08	37.76	1.68**	35.55	35.75	0.20	1.48**
Short Trades	Listed	27.37	33.67	6.30**	27.15	26.79	-0.36*	6.66**
Short Trades	Nasdaq	37.74	39.98	2.24**	37.20	37.57	0.37*	1.87**
Short Interest	Listed	3.62	4.01	0.39**	3.75	4.25	0.49**	-0.10
Short Interest	Nasdaq	5.23	5.94	0.71**	5.00	5.60	0.60**	0.11
Days to Cover	Listed	6.14	6.87	0.73**	6.28	7.03	0.75**	-0.02
Days to Cover	Nasdaq	6.64	7.91	1.27**	6.49	8.07	1.58**	-0.31
Nasdaq Market Share	Listed	10.74	10.28	-0.46*	10.42	11.17	0.75**	-1.21**
Nasdaq Market Share	Nasdaq	47.45	51.34	3.88**	47.86	49.20	1.34**	2.55**

Panel B: Average Regression Coefficients

$$\text{Market Quality}_i = \alpha + \beta_1 \text{Pilot}_i + \beta_2 \text{Pre Pilot Market Quality}_i$$

Variable	Market	Pilot	PrePilotControl	R-squared
Short Volume	Listed	2.05**	0.61**	0.09
Short Volume	Nasdaq	1.67** [a]	0.67**	0.08
Short Trades	Listed	6.75**	0.63**	0.16
Short Trades	Nasdaq	2.08** [a]	0.67**	0.10
Short Interest	Listed	-0.11	0.89**	0.83
Short Interest	Nasdaq	0.14 [a]	0.91**	0.79
Days to Cover	Listed	-0.05	0.74**	0.49
Days to Cover	Nasdaq	-0.31 [b]	0.97**	0.62
Nasdaq Market Share	Listed	-1.18**	0.77**	0.15
Nasdaq Market Share	Nasdaq	2.34** [a]	0.69**	0.11

Table 4: Changes in Option Trading

This table summarizes how option trading and open interest changes when the tick and bid tests are removed. The four months prior to the Pilot start date (May 2, 2005) are called the "Pre-Pilot" and the six months following the start date are called the "Pilot". The table shows the average change in option trading and open interest for Pilot and Control stocks and estimates whether the Pilot stocks changed more than the Control stocks. Panel A reports statistics on all options. Panel B reports statistics on short-term options. The data includes securities that had put and call option volume in both the Pre-Pilot and Pilot periods. There were a total of 690 Control stocks and 350 Pilot stocks included in the Listed sample and 573 Control stocks and 278 Pilot stocks in the Nasdaq sample. Open interest and volume are adjusted for stock splits. New option listings after May 1, 2005 were excluded from the analysis. The data source for the options data is the Options Price Reporting Authority (OPRA). Short-term options are identified using the Options Clearing Corporation directory. Paired t-tests determine whether the changes are significant. Tests of the difference between the changes are two-sample t-tests. **, * indicates statistical significance at the 1 and 5% level in a two-tailed test. We also test whether the difference in the change for Listed Stocks is statistically different from that of Nasdaq NM Stocks using two sample t-tests. [a, b] indicates that the difference for Nasdaq NM Stocks is statistically different from the difference for Listed Stocks at the 1% and 5% level in a two-tailed test.

Panel A: All Options

		Pilot Sample			Control Sample			Pilot Δ minus
Variable	Market	Pre-Pilot	Pilot	Δ	Pre-Pilot	Pilot	Δ	Control Δ
Put Volume	Listed	838.56	851.73	13.17	935.66	916.72	-18.94	32.11
Put Volume	Nasdaq	726.08	530.68	-195.40	664.03	589.89	-74.15	-121.25
Call volume	Listed	1,306.91	1,386.73	79.82	1,322.83	1,348.89	26.06	53.75
Call Volume	Nasdaq	1,194.10	925.01	-269.09	1,103.75	996.88	-106.87	-162.22
Put + Call Vol	Listed	2,145.47	2,238.46	92.98	2,258.49	2,265.61	7.13	85.86
Put + Call Vol	Nasdaq	1,920.18	1,455.69	-464.49	1,767.78	1,586.77	-181.02	-283.47
Put OI	Listed	28,325.87	32,150.11	3,824.24	33,315.65	40,602.82	7,287.17	-3,462.93
Put OI	Nasdaq	16,933.98	17,646.25	712.27	18,536.20	20,475.08	1,938.88	-1,226.61
Call OI	Listed	32,878.21	38,919.53	6,041.32	34,761.23	43,566.95	8,805.72	-2,764.40
Call OI	Nasdaq	27,741.65	28,724.87	983.22	27,776.23	30,522.55	2,746.32	-1,763.10
Put + Call OI	Listed	61,204.08	71,069.64	9,865.57	68,076.88	84,169.77	16,092.89	-6,227.32
Put + Call OI	Nasdaq	44,675.63	46,371.12	1,695.49	46,312.43	50,997.63	4,685.21	-2,989.72
Signed Volume	Listed	468.35	535.00	66.65	387.17	432.17	45.00	21.65
Signed Volume	Nasdaq	468.02	394.33	-73.69	439.72	406.99	-32.72	-40.97

Panel B: Short-term Options

		Pilot Sample			Control Sample			Pilot Δ minus
Variable	Market	Pre-Pilot	Pilot	Δ	Pre-Pilot	Pilot	Δ	Control Δ
Put Volume	Listed	700.03	767.71	67.68	716.48	768.70	52.22	15.46
Put Volume	Nasdaq	654.98	489.10	-165.88	588.95	537.18	-51.78	-114.10
Call Volume	Listed	1,115.26	1,282.91	167.65	1,102.02	1,216.46	114.44	53.21
Call Volume	Nasdaq	1,080.07	860.41	-219.66	982.65	913.85	-68.79	-150.87
Put + Call Vol	Listed	1,815.29	2,050.62	235.33	1,818.50	1,985.16	166.65	68.68
Put + Call Vol	Nasdaq	1,735.05	1,349.51	-385.54	1,571.60	1,451.03	-120.57	-264.97
Put OI	Listed	15,320.64	23,979.47	8,658.82	16,378.07	27,621.72	11,243.65	-2,584.83
Put OI	Nasdaq	11,269.07	14,017.99	2,748.92	11,421.44	16,088.30	4,666.85	-1,917.93
Call OI	Listed	20,778.67	30,380.74	9,602.08	19,994.13	31,654.27	11,660.15	-2,058.07
Call OI	Nasdaq	18,788.25	22,951.64	4,163.39	18,070.89	23,567.80	5,496.91	-1,333.52
Put + Call OI	Listed	36,099.31	54,360.21	18,260.90	36,372.20	59,275.99	22,903.80	-4,642.90
Put + Call OI	Nasdaq	30,057.32	36,969.63	6,912.31	29,492.33	39,656.10	10,163.76	-3,251.45
Signed Volume	Listed	415.23	515.20	99.97	385.54	447.76	62.22	37.75
Signed Volume	Nasdaq	425.09	371.31	-53.79	393.69	376.68	-17.01	-36.78

Table 5: Changes in Trading and Quoting Mechanics

This table summarizes how trading and quoting mechanics change when the tick and bid tests are removed. The four months prior to the Pilot start date (May 2, 2005) are called the "Pre-Pilot" period and the six months following the start date are called the "Pilot" Period. The table shows the average change in the number of down ticks and the percent of time on a down bid for pilot and control stocks and estimates whether the pilot stocks changed more than the control stocks. Paired t-tests determine whether the changes are significant. Tests of the difference between the changes are two-sample t-tests. **, * indicates statistical significance at the 1 and 5% level in a two-tailed test. We test whether the difference in the change for Listed Stocks is statistically different from that of Nasdaq NM Stocks using a regression framework. During the Pilot Period, we run daily cross-sectional regressions of each variable on an indicator for Pilot Securities and the variable's pre-Pilot level (equation 1). We run the regression separately for Listed and Nasdaq NM Stocks and test whether the coefficients on the Pilot indicator are similar. [a, b] indicates that the average coefficient for Nasdaq NM Stocks is statistically different from the average coefficient for Listed Stocks at the 1% and 5% level in a two-tailed test.

Panel A: Univariate Changes

		Pilot Sample			Control Sample			Pilot Δ minus
Variable	Market	Pre-Pilot	Pilot	Δ	Pre-Pilot	Pilot	Δ	Control Δ
Downticks	Listed	45.87	49.65	3.78**	45.84	45.01	-0.83**	4.61**
Downticks	Nasdaq	50.61	50.10	-0.52**	50.60	49.60	-1.01**	0.49**
Downbids	Listed	38.82	39.76	0.94**	38.74	39.50	0.76**	0.18
Downbids	Nasdaq	47.06	45.64	-1.42**	47.44	48.02	0.58**	-2.00**

Panel B: Average Regression Coefficients

$$\text{Market Quality}_i = \alpha + \beta_1 \text{Pilot}_i + \beta_2 \text{Pre Pilot Market Quality}_i$$

Variable	Market	Pilot	PrePilotControl	R-squared
Downticks	Listed	4.64**	0.46**	0.15
Downticks	Nasdaq	0.49** [a]	0.47**	0.02
Downbids	Listed	0.24**	0.87**	0.27
Downbids	Nasdaq	-2.06** [a]	0.84**	0.23

Table 6: Liquidity Measures

This table summarizes how liquidity changes when the tick and bid tests are removed. The four months prior to the Pilot start date (May 2, 2005) are called the "Pre-period" and the six months following the start date are called the "Pilot Period". The table shows the average change in various liquidity measures for Pilot and Control stocks and estimates whether the Pilot stocks changed more than the Control stocks. Paired t-tests determine whether the changes are significant. Tests of the difference between the changes are two-sample t-tests. **, * indicates statistical significance at the 1 and 5% level in a two-tailed test. We test whether the Difference in the Change for Listed Stocks is statistically different from that of Nasdaq NM Stocks using a regression framework. During the Pilot Period, we run daily cross-sectional regressions of each variable on an indicator for Pilot Securities and the variable's pre-Pilot level (equation 1). We run the regression separately for Listed and Nasdaq NM Stocks and test whether the coefficients on the Pilot indicator are similar. [a, b] indicates that the average coefficient for Nasdaq NM Stocks is statistically different from the average coefficient for Listed Stocks at the 1% and 5% level in a two-tailed test.

Panel A: Univariate Changes

		Pilot Sample			Control Sample			Pilot Δ minus
Variable	Market	Pre-Pilot	Pilot	Δ	Pre-Pilot	Pilot	Δ	Control Δ
Ask Depth	Listed	15.04	12.24	-2.80**	18.81	22.02	3.21**	-6.00**
Ask Depth	Nasdaq	21.23	26.63	5.40*	26.90	34.36	7.46**	-2.05
Bid Depth	Listed	12.16	12.89	0.73	15.96	18.71	2.76**	-2.03
Bid Depth	Nasdaq	21.41	28.44	7.04**	27.77	37.45	9.68**	-2.65
Quoted Spread (¢)	Listed	6.82	7.25	0.43	5.64	6.02	0.37	0.06
Quoted Spread (¢)	Nasdaq	5.44	5.38	-0.06	5.59	5.93	0.34	-0.40
% Quoted Spread	Listed	18.82	19.74	0.92	18.10	18.18	0.08	0.80
% Quoted Spread	Nasdaq	26.61	27.90	1.29	28.40	29.62	1.22**	0.07
Effective Spread (¢)	Listed	4.92	5.22	0.29	4.48	4.67	0.19	0.11
Effective Spread (¢)	Nasdaq	5.22	4.92	-0.31**	5.29	5.27	-0.02	-0.29
% Effective Spread	Listed	16.28	17.56	1.29	14.83	15.63	0.80	0.50
% Effective Spread	Nasdaq	26.91	26.98	0.07	28.84	28.47	-0.37	0.40

Panel B: Average Regression Coefficients

$$\text{Market Quality}_i = \alpha + \beta_1 \text{Pilot}_i + \beta_2 \text{Pre Pilot Market Quality}_i$$

Variable	Market	Pilot	PrePilotControl	R-squared
Ask Depth	Listed	-5.26**	1.18**	0.82
Ask Depth	Nasdaq	-2.01** [a]	1.11**	0.79
Bid Depth	Listed	-1.42**	1.16**	0.82
Bid Depth	Nasdaq	-2.47** [b]	1.13**	0.75
Quoted Spread (¢)	Listed	-0.36*	1.35**	0.74
Quoted Spread (¢)	Nasdaq	-0.31**	1.37**	0.75
% Quoted Spread	Listed	0.86*	1.13**	0.62
% Quoted Spread	Nasdaq	0.28**	1.11**	0.68
Effective Spread (¢)	Listed	-0.12	1.51**	0.80
Effective Spread (¢)	Nasdaq	-0.25**	1.31**	0.63
% Effective Spread	Listed	0.26	1.24**	0.43
% Effective Spread	Nasdaq	0.62**	1.12**	0.50

Table 7: Volatility

This table summarizes how volatility changes when the tick and bid tests are removed. The four months prior to the Pilot start date (May 2, 2005) are called the "Pre-Pilot" period and the six months following the start date are called the "Pilot" period. The table shows the average change in various volatility measures for pilot and control stocks and estimates whether the pilot stocks changed more than the control stocks. Daily Price Range is 100*(log high – log low). Absolute return and standard deviation are reported in percentage points. While standard deviation is reported, tests were run on variances to avoid Jensen's inequality. Paired t-tests determine whether the changes are significant. Tests of the difference between the changes are two-sample t-tests. **, * indicates statistical significance at the 1 and 5% level in a two-tailed test. We test whether the difference in the change for Listed Stocks is statistically different from that of Nasdaq NM Stocks using a regression framework. During the Pilot Period, we run daily cross-sectional regressions of each variable on an indicator for pilot securities and the variable's Pre-Pilot level (equation 1). We run the regression separately for Listed and Nasdaq NM Stocks and test whether the coefficients on the pilot indicator are similar. [a, b] indicates that the average coefficient for Nasdaq NM Stocks is statistically different from the average coefficient for Listed Stocks at the 1% and 5% level in a two-tailed test.

Panel A: Univariate Changes

		Pilot Sample			Control Sample			Pilot Δ minus
Variable	Market	Pre-Pilot	Pilot	Δ	Pre-Pilot	Pilot	Δ	Control Δ
Daily Price Range	Listed	2.45	2.42	-0.03	2.43	2.36	-0.07**	0.04
Daily Price Range	Nasdaq	3.64	3.36	-0.28**	3.76	3.41	-0.35**	0.07
Absolute Return – 5m	Listed	0.11	0.12	0.00	0.11	0.11	-0.01**	0.01**
Absolute Return – 5m	Nasdaq	0.14	0.13	-0.01**	0.15	0.13	-0.02**	0.01**
Absolute Return – 30m	Listed	0.29	0.28	-0.01*	0.28	0.27	-0.01**	0.00
Absolute Return – 30m	Nasdaq	0.39	0.36	-0.03**	0.40	0.36	-0.04**	0.01
Absolute Return – day	Listed	1.34	1.29	-0.05**	1.33	1.30	-0.04**	-0.01
Absolute Return – day	Nasdaq	1.80	1.69	-0.11**	1.85	1.71	-0.14**	0.03
Return Standard Deviation – 5m	Listed	0.19	0.20	0.00	0.20	0.19	-0.01	0.01
Return Standard Deviation – 5m	Nasdaq	0.26	0.25	-0.01	0.27	0.26	-0.01**	0.02
Return Standard Deviation – 30m	Listed	0.45	0.44	-0.01	0.44	0.43	-0.01*	-0.00
Return Standard Deviation – 30m	Nasdaq	0.61	0.58	-0.03**	0.63	0.59	-0.04**	0.01
Return Standard Deviation – day	Listed	2.11	1.97	-0.14	2.00	2.03	0.03	-0.01
Return Standard Deviation – day	Nasdaq	2.72	2.75	0.03	2.82	2.72	-0.10	-0.13
Variance Ratio 5/30	Listed	1.12	1.23	0.11**	1.11	1.15	0.04**	0.07**
Variance Ratio 5/30	Nasdaq	1.23	1.30	0.06**	1.26	1.29	0.03**	0.03*
Variance Ratio 5/day	Listed	3.09	3.30	0.21**	2.98	3.08	0.10	0.11
Variance Ratio 5/day	Nasdaq	4.08	4.09	0.01	4.15	4.62	0.47	-0.45
Variance Ratio 30/day	Listed	2.71	2.62	-0.08	2.64	2.57	-0.07	0.01
Variance Ratio 30/day	Nasdaq	3.24	3.02	-0.22*	3.25	3.28	0.03	-0.25

Panel B: Average Regression Coefficients

$$\text{Market Quality}_i = \alpha + \beta_1 \text{Pilot}_i + \beta_2 \text{Pre Pilot Market Quality}_i$$

Variable	Market	Pilot	PrePilotControl	R-squared
Daily Price Range(bps)	Listed	3.68**	0.86**	0.27
Daily Price Range(bps)	Nasdaq	2.92*	0.79**	0.21
Absolute Return – 5m(bps)	Listed	0.68**	0.84**	0.37
Absolute Return – 5m(bps)	Nasdaq	0.34**[a]	0.73**	0.21
Absolute Return – 30m(bps)	Listed	0.33**	0.83**	0.16
Absolute Return – 30m(bps)	Nasdaq	0.20	0.82**	0.18
Absolute Return – day(bps)	Listed	-0.91	0.80**	0.09
Absolute Return – day(bps)	Nasdaq	0.47	0.71**	0.06
Return Variance – 5m ($x10^6$)	Listed	0.49**	0.29**	0.10
Return Variance – 5m($x10^6$)	Nasdaq	0.22	0.84**	0.17
Return Variance – 30m($x10^5$)	Listed	-0.66*	0.89**	0.01
Return Variance – 30m($x10^5$)	Nasdaq	-0.34*	1.03**	0.07
Return Variance – day($x10^4$)	Listed	-0.33	0.21**	0.12
Return Variance – day ($x10^4$)	Nasdaq	0.38	0.44**	0.12
Variance Ratio 5/30	Listed	0.08**	0.68**	0.44
Variance Ratio 5/30	Nasdaq	0.01 [a]	0.54**	0.21
Variance Ratio 5/day	Listed	0.12	1.03**	0.42
Variance Ratio 5/day	Nasdaq	-0.82	0.03	0.00
Variance Ratio 30/day	Listed	0.02	0.49**	0.16
Variance Ratio 30/day	Nasdaq	-0.26	0.17	0.00

Table 8: Returns around the May 2, 2005 Start of the Pilot

This table shows the returns surrounding the May 2 initiation of the pilot. The raw returns are equally-weighted averages of the returns for each stocks, as collected from CRSP. The Cumulative Returns are set to be zero on the day prior to the start of the pilot. The Cumulative returns represent the compounded returns on an investment made at the April 29 closing price. * indicates that the control stock returns are statistically different from the pilot stock returns at the 5% significance level in a two-tailed test. None of the returns are statistically different at the 1% level.

Panel A: Listed Sample Stocks

	Daily Returns		Cumulative Returns	
Date	Pilot	Control	Pilot	Control
April 18	0.005	0.007	0.007	0.015
April 19	0.012	0.011	0.019	0.025
April 20	-0.015	-0.015	0.003	0.009
April 21	0.019	0.018	0.021	0.026
April 22	-0.009	-0.011	0.011	0.015
April 25	0.010	0.011	0.021	0.026
April 26	-0.010	-0.012	0.010	0.013
April 27	0.000	-0.001	0.009	0.011
April 28	-0.016	-0.016	-0.007	-0.006
April 29	0.008	0.006	0.000	0.000
May 2	0.007	0.009*	0.007	0.009*
May 3	-0.001	-0.001	0.005	0.008
May 4	0.015	0.016	0.020	0.024
May 5	0.000	0.001	0.020	0.025
May 6	0.002	0.001	0.022	0.026
May 9	0.010	0.008	0.032	0.034
May 10	-0.012	-0.010	0.020	0.024
May 11	0.001	0.002	0.021	0.026
May 12	-0.015	-0.014	0.006	0.011
May 13	-0.010	-0.010	-0.003	0.001
May 16	0.013	0.014	0.010	0.015

Panel B: Nasdaq Sample Stocks

	Daily Returns		Cumulative Returns	
Date	Pilot	Control	Pilot	Control
April 18	0.006	0.007	0.019	0.017
April 19	0.016	0.018*	0.035	0.035
April 20	-0.018	-0.018	0.015	0.016
April 21	0.025	0.026	0.039	0.041
April 22	-0.018	-0.019	0.019	0.020
April 25	0.009	0.010	0.027	0.030
April 26	-0.012	-0.016*	0.014	0.013
April 27	0.001	0.001	0.014	0.012
April 28	-0.021	-0.019	-0.009	-0.008
April 29	0.009	0.009	0.000	0.000
May 2	0.008	0.009	0.008	0.009
May 3	0.001	0.001	0.008	0.010
May 4	0.019	0.020	0.027	0.030
May 5	0.000	0.001	0.027	0.031
May 6	0.001	0.000	0.028	0.031
May 9	0.012	0.012	0.040	0.043
May 10	-0.012	-0.013	0.028	0.030
May 11	0.001	-0.001	0.029	0.029
May 12	-0.008	-0.009	0.020	0.020
May 13	-0.004	-0.005	0.016	0.015
May 16	0.015	0.016	0.032	0.031

Table 9: Six Month Returns

The table summarizes tests of whether the six month returns of the pilot stocks differ from the six month returns of the control stocks. The raw returns are compounded cumulative returns from CRSP. If a stock is not in the sample for the entire six months, its return from its last day is compounded to six months. The market adjusted returns is simply the raw return minus the CRSP equally-weighted index. The alpha is estimated in-sample by regressing the raw return for a stock on the equally-weighted CRSP index return. A stock's alpha is considered "negative" if it is statistically below zero at the 5% level in a two-tailed test. Likewise, a stock's alpha is considered "positive" if it is statistically above zero at the 5% level in a two-tailed test. ** indicates that the control stock returns are statistically different from the pilot stock returns at the 5% significance level in a two-tailed test.

Panel A: Univariate Differences

Variable	Market	Pilot	Control	Difference
Raw Return	Listed	9.18%	11.56%	-2.38%
Raw Return	Nasdaq	14.21%	16.30%	-2.09%
Market Adjusted Return	Listed	-2.10%	-0.00%	-2.07%
Market Adjusted Return	Nasdaq	2.26%	4.01%	-1.74%
Alpha	Listed	-0.05%	-0.04%	-0.01%
Alpha	Nasdaq	-0.04%	-0.02%	-0.01%
Negative Alpha	Listed	5.56%	4.93%	0.60%
Negative Alpha	Nasdaq	2.73%	1.53%	1.20%
Positive Alpha	Listed	0.00%	0.92%	-0.92%**
Positive Alpha	Nasdaq	0.91%	1.20%	-0.29%

Panel B: Regression Tests

$$\text{Market Model Alpha} = \alpha + \beta\,\text{Pilot}$$

Variable	Market	Pilot	R-squared
Alpha	Listed	-0.0001	0.009
Alpha	Nasdaq	-0.0001	0.005

Table 10: Skewness

This table summarizes how skewness changes when the tick and bid tests are removed. The four months prior to the pilot start date (May 2, 2005) are called the "Pre-Pilot" period and the six months following the start date are called the "Pilot" period. The table shows the average levels and changes in various skewness measures for pilot and control stocks and estimates whether the pilot stocks changed more than the control stocks. Sample skewness is computed for each stock in the pilot and contol sample in the Pre-Pilot and Pilot period, for five-minute, thirty-minute, and one day return intervals. Paired t-tests determine whether the changes are significant. Tests of the difference between the changes are two-sample t-tests. **, * indicates statistical significance at the 1% and 5% level in a two-tailed test.

		Pilot Sample			Control Sample			Pilot Δ minus
Variable	Market	Pre-Pilot	Pilot	Δ	Pre-Pilot	Pilot	Δ	Control Δ
Skewness—5m	Listed	0.08	-0.05	-0.13	0.24	0.01	-0.23	0.10
Skewness—5m	Nasdaq	0.28	0.51	0.23	0.19	0.39	0.20	0.03
Skewness—30m	Listed	0.13	-0.02	-0.15	0.13	0.11	-0.02	-0.12
Skewness—30m	Nasdaq	0.20	0.32	0.11	0.13	0.23	0.10	0.01
Skewness—day	Listed	0.06	0.15	0.09	0.17	0.21	0.04	0.06
Skewness—day	Nasdaq	0.26	0.35	0.09	0.16	0.29	0.13	0.05

Table 11: Extreme Price Reversals

This table summarizes how the frequency of large negative and positive short-horizon price reversals differs across pilot and control stocks. The numbers in the table represent the number of reversals per 100,000 stock/intervals. A negative (positive) reversal is defined as a negative (positive) return immediately followed by a positive (negative) return. The "size" of the reversal is defined as the minimum absolute value of the two adjacent returns, normalized by the pre-pilot standard deviation of the stock's holding-period return, where the second return is computed as a percentage of the lagged price, and the holding period is five minutes or thirty minutes. The frequency of reversals is computed based on a six-month period following the pilot start date (May 2, 2005). The pre-pilot standard deviation used to normalize the returns is computed over a four-month period prior to the start date. Nonparametric statistical tests based on a bootstrapping procedure determine whether the number of reversals observed in the pilot sample would be statistically rare in the control sample. **, * indicates statistical significance at the 1% and 5% level in a two-tailed test.

Panel A: Five-Minute Return Reversals

	Listed Stocks				Nasdaq Stocks			
	Negative Reversals		Positive Reversals		Negative Reversals		Positive Reversals	
Reversal Size	Pilot	Control	Pilot	Control	Pilot	Control	Pilot	Control
> 2	338.4**	281.3	339.1**	281.1	273.4**	257.4	284.1**	267.8
> 3	76.7**	65.1	75.4**	63.5	71.9**	62.8	72.7**	67.0
> 4	25.0**	20.4	24.4**	19.3	25.1**	22.4	27.6**	24.6
> 5	10.0**	8.8	11.3**	8.4	10.5	9.1	13.2**	11.2
> 6	4.9	4.6	5.8**	4.8	5.3	4.2	6.9*	5.9
> 7	2.8	2.8	3.4	3.1	3.0	2.2	3.6	3.6
> 8	1.7	1.8	2.0	2.2	1.9	1.2	2.2	2.2
> 9	1.1	1.3	1.2(**)	1.7	1.2	0.6	1.6	1.4

Panel B: Thirty-Minute Return Reversals

	Listed Stocks				Nasdaq Stocks			
	Negative Reversals		Positive Reversals		Negative Reversals		Positive Reversals	
Reversal Size	Pilot	Control	Pilot	Control	Pilot	Control	Pilot	Control
> 2	251.4	240.8	240.5	231.4	215.3	218.7	224.3	221.5
> 3	53.2*	47.1	44.3	45.9	38.3	41.0	41.6	45.5
> 4	9.2	11.0	12.6	12.0	12.1	10.3	12.1	13.4
> 5	3.3	4.3	4.2	5.4	4.8	4.1	5.3	4.6
> 6	1.0	1.6	1.3(*)	2.3	1.5	2.2	3.2	2.2
> 7	0.4	0.8	0.6(*)	1.3	0.3	0.9	1.3	1.3
> 8	0.1	0.4	0.1(**)	0.7	0.2	0.5	0.7	0.8
> 9	0.0(*)	0.2	0.1	0.4	0.0(*)	0.3	0.5	0.7

Table 12: Semi-Autoregression Results

This table reports average regression coefficients of returns on lagged positive and negative component returns, for pilot and control stocks before and after the start of the pilot. The four months prior to the Pilot start date (May 2, 2005) are called the "Pre-Pilot" period and the six months following the start date are called the "Pilot" period. The coefficients reported in the table are the mean coefficients across all stocks in the subsample, estimated over the designated period, of the autoregressive model:

$$R_t = \sum_{n=1}^{5} \alpha_n R_{t-n}^{-} + \sum_{n=1}^{5} \beta_n R_{t-n}^{+} .$$

where R_t represents the stock return in period t, and

$$R_t^{-} = \min(0, R_t) \qquad R_t^{+} = \max(0, R_t) .$$

Paired t-tests determine whether the changes are significant. Tests of the difference between the changes are two-sample t-tests. **, * indicates statistical significance at the 1 and 5% level in a two-tailed test.

Panel A: Five-minute Returns

		Pilot Sample			Control Sample			Pilot Δ minus
Lag/Sign	Market	Pre-Pilot	Pilot	Δ	Pre-PIlot	Pilot	Δ	Control Δ
1 / Negative	Listed	-0.048	-0.071	-0.022**	-0.048	-0.049	-0.001	-0.021**
2 / Negative	Listed	-0.019	-0.007	0.012**	-0.015	-0.002	0.013**	-0.001
3 / Negative	Listed	-0.004	-0.005	-0.001	-0.005	-0.003	0.002	-0.003
4 / Negative	Listed	-0.001	-0.010	-0.008**	-0.001	-0.004	-0.003	-0.005*
5 / Negative	Listed	-0.005	-0.004	0.000	-0.003	0.000	0.003	-0.003
1 / Positive	Listed	-0.033	-0.056	-0.022**	-0.034	-0.031	0.003	-0.026**
2 / Positive	Listed	-0.005	-0.013	-0.008**	-0.004	-0.004	0.000	-0.008**
3 / Positive	Listed	-0.003	0.003	0.006**	-0.002	0.007	0.009**	-0.003
4 / Positive	Listed	-0.003	-0.004	-0.001	-0.001	-0.002	-0.001	0.000
5 / Positive	Listed	-0.004	-0.005	-0.001	-0.002	-0.002	0.000	-0.001
1 / Negative	Nasdaq	-0.027	-0.046	-0.019**	-0.030	-0.042	-0.012**	-0.007
2 / Negative	Nasdaq	-0.014	-0.007	0.007	-0.014	-0.006	0.009**	-0.002
3 / Negative	Nasdaq	-0.004	-0.006	-0.002	-0.007	-0.006	0.001	-0.003
4 / Negative	Nasdaq	0.000	-0.004	-0.004	0.001	-0.003	-0.004**	0.000
5 / Negative	Nasdaq	-0.002	-0.002	0.000	-0.004	-0.002	0.002	-0.003
1 / Positive	Nasdaq	-0.032	-0.030	0.002	-0.034	-0.024	0.009**	-0.007
2 / Positive	Nasdaq	-0.011	-0.012	0.000	-0.011	-0.008	0.004	-0.004
3 / Positive	Nasdaq	-0.004	0.002	0.006*	-0.004	0.004	0.008**	-0.002
4 / Positive	Nasdaq	-0.002	-0.003	-0.001	-0.004	-0.001	0.004**	-0.005
5 / Positive	Nasdaq	-0.008	-0.001	0.006**	-0.006	0.000	0.007**	-0.001

Panel B: Thirty-minute Returns

		Pilot Sample			Control Sample			Pilot Δ minus
Lag/Sign	Market	Pre-Pilot	Pilot	Δ	Pre-PIlot	Pilot	Δ	Control Δ
1 / Negative	Listed	-0.030	-0.021	0.009	-0.020	-0.008	0.012**	-0.003
2 / Negative	Listed	-0.004	-0.008	-0.004	-0.008	-0.010	-0.002	-0.002
3 / Negative	Listed	-0.003	0.018	0.021**	-0.002	0.017	0.019**	0.001
4 / Negative	Listed	-0.001	-0.029	-0.029**	-0.001	-0.024	-0.023**	-0.006
5 / Negative	Listed	-0.010	-0.005	0.006	-0.010	0.000	0.010**	-0.004
1 / Positive	Listed	0.002	-0.022	-0.024**	0.007	-0.008	-0.015**	-0.009
2 / Positive	Listed	0.013	0.000	-0.013**	0.011	0.003	-0.008**	-0.006
3 / Positive	Listed	0.008	0.006	-0.002	0.012	0.012	0.000	-0.002
4 / Positive	Listed	-0.008	0.009	0.018**	-0.005	0.004	0.009**	0.009*
5 / Positive	Listed	-0.008	0.002	0.010**	-0.002	-0.001	0.001	0.008
1 / Negative	Nasdaq	-0.026	-0.019	0.007	-0.022	-0.018	0.003	0.004
2 / Negative	Nasdaq	-0.009	-0.015	-0.006	-0.010	-0.010	0.001	-0.007
3 / Negative	Nasdaq	0.001	0.009	0.008	-0.001	0.008	0.009**	-0.001
4 / Negative	Nasdaq	-0.010	-0.025	-0.015**	-0.014	-0.021	-0.007*	-0.008
5 / Negative	Nasdaq	-0.016	0.000	0.016**	-0.014	-0.002	0.012**	0.004
1 / Positive	Nasdaq	-0.017	-0.001	0.016**	-0.020	-0.005	0.015**	0.001
2 / Positive	Nasdaq	0.006	-0.007	-0.014**	0.006	-0.004	-0.010**	-0.004
3 / Positive	Nasdaq	0.003	0.004	0.001	-0.002	0.006	0.008**	-0.007
4 / Positive	Nasdaq	-0.017	0.004	0.021**	-0.010	0.004	0.014**	0.007
5 / Positive	Nasdaq	-0.002	-0.005	-0.003	-0.006	-0.002	0.005	-0.007

Table 13: Sample Deciles

This table shows the number of stocks in each market capitalization, turnover, and short selling decile. The deciles are set so that each decile contains the same number of stocks for the full sample. This table reports the subsample sizes separately for pilot and control stocks and for Listed and Nasdaq NM Stocks. It also gives the proportion of stocks in that decile and market that are pilot or control stocks.

	Listed				Nasdaq			
	Pilot		Control		Pilot		Control	
	Count	Proportion	Count	Proportion	Count	Proportion	Count	Proportion
	Market Capitalization							
Decile								
Lowest	22	33.9	43	66.1	62	28.4	156	71.6
2	19	31.1	42	66.9	61	27.6	160	72.4
3	28	33.3	56	66.7	69	34.5	131	65.5
4	35	33.0	71	67.0	63	35.6	114	64.4
5	41	32.8	84	67.2	63	39.9	95	60.1
6	59	34.9	110	65.1	34	29.6	81	70.4
7	65	35.1	120	64.9	34	34.7	64	65.3
8	75	35.2	138	64.8	27	38.0	44	62.0
9	70	31.4	153	68.6	16	26.7	44	73.3
Highest	90	36.7	155	63.3	10	26.3	28	73.7
	Turnover							
Decile								
Lowest	36	35.3	66	64.7	49	27.2	131	72.8
2	54	32.0	115	68.0	47	41.2	67	58.8
3	61	32.4	127	67.6	36	37.5	60	62.5
4	71	37.6	118	62.4	23	24.5	71	75.5
5	62	33.5	123	66.5	33	33.7	65	66.3
6	53	32.5	110	67.5	39	32.2	82	67.8
7	71	44.7	88	55.4	42	33.9	82	66.1
8	39	31.0	87	69.0	59	37.3	99	62.7
9	36	30.0	84	70.0	46	28.2	117	71.8
Highest	21	28.0	54	72.0	65	31.3	143	68.8

Table 14: Changes in Short Selling Activity Across Market Cap and Turnover Deciles

This table shows the marginal effect of the pilot derived from the coefficients from the following daily cross-sectional regressions:

$$\text{Short Selling Volume}_i = \alpha + \sum_{k=1}^{9} \beta_k \text{Pilot}_i \times \text{Decile}_{ki} + \beta_{10}\text{Pilot}_i + \beta_{11}\text{Pre Short Selling Volume}_i$$

Reported is the average sum of $\beta_{10} + \beta_k$. The dependent variable is the number of shares sold short on a day divided by the total volume on that day. The regressions are estimated on each day during the Pilot Period. The statistical significance of the coefficients is determined by the distribution of the coefficients. We divide the stocks into deciles by market cap on May 2, 2005 and by the pre-Pilot turnover where decile 1 contains the smallest stocks and lowest turnover stocks. **,* indicates that the effect is statistically different from zero at the 1 and 5% level in a two-tailed test.

	Market Capitalization		Turnover	
	Listed	Nasdaq	Listed	Nasdaq
Decile				
Lowest	-0.26	-1.55**	2.84**	1.44**
2	4.83**	1.68**	2.84**	1.17**
3	1.92**	1.64**	1.45**	1.21**
4	4.38**	1.80**	2.39**	1.91**
5	3.23**	3.23**	1.12**	2.09**
6	3.87**	2.46**	2.57**	1.53**
7	3.36**	3.90**	2.03**	2.12**
8	0.89**	1.03**	1.00**	2.08**
9	1.27**	2.47**	1.61**	1.17**
Highest	0.05	1.28**	3.50**	1.93**
PrePilotControl	0.59**	0.64**	0.60**	0.67**
Average R^2	0.10	0.09	0.10	0.09

Table 15: Changes in Nasdaq Market Share Across Market Cap and Turnover Deciles

This table shows the marginal effect of the Pilot derived from the coefficients from the following daily cross-sectional regressions:

$$\text{Nasdaq Market Share}_i = \alpha + \sum_{k=1}^{9} \beta_k \text{Pilot}_i \times \text{Decile}_{ki} + \beta_{10}\text{Pilot}_i + \beta_{11}\text{Pre Nasdaq Market Share}_i$$

Reported is the average sum of $\beta_{10} + \beta_k$. The dependent variable is the Nasdaq share of short selling volume on a day. The regressions are estimated on each day during the Pilot Period. The statistical significance of the coefficients is determined by the distribution of the coefficients. We divide the stocks into deciles by market cap on May 2, 2005 and by the pre-Pilot turnover where decile 1 contains the smallest stocks and lowest turnover stocks. ** indicates that the effect is statistically different from zero at the 1 % level in a two-tailed test.

	Market Capitalization		Turnover	
	Listed	Nasdaq	Listed	Nasdaq
Decile				
Lowest	3.41**	3.56**	-2.04**	1.78**
2	-3.82**	2.57**	-1.76**	3.41**
3	-1.90**	3.01**	-0.61**	2.22**
4	-1.16**	2.37**	-1.06**	2.98**
5	-1.56**	1.80**	-0.82**	3.16**
6	-1.87**	1.87**	-0.72**	3.08**
7	-1.73**	1.71**	-1.56**	2.18**
8	-1.95**	2.04**	-1.41**	1.75**
9	-1.21**	0.05	-0.77**	1.74**
Highest	0.22	0.54	-1.46**	2.04**
PrePilotControl	0.75**	0.68**	0.77**	0.69**
Average R^2	0.16	0.11	0.16	0.12

Table 16: Changes in Ask Depth Across Market Cap and Turnover Deciles

This table shows the marginal effect of the Pilot derived from the coefficients from the following daily cross-sectional regressions:

$$\text{Ask Depth}_i = \alpha + \sum_{k=1}^{9} \beta_k \text{Pilot}_i \times \text{Decile}_{ki} + \beta_{10}\text{Pilot}_i + \beta_{11}\text{Pre Ask Depth}_i$$

Reported is the average sum of $\beta_{10} + \beta_k$. The dependent variable is the ask depth. The regressions are estimated on each day during the Pilot Period. The statistical significance of the coefficients is determined by the distribution of the coefficients. We divide the stocks into deciles by market cap on May 2, 2005 and by the pre-Pilot turnover where decile 1 contains the smallest stocks and lowest turnover stocks. **,* indicates that the effect is statistically different from zero at the 1 and 5% level in a two-tailed test.

	Market Capitalization		Turnover	
	Listed	Nasdaq	Listed	Nasdaq
Decile				
Lowest	0.55	0.80	-3.92**	-4.22**
2	-3.07**	-3.57**	-9.75**	-4.23**
3	-3.58**	-4.18**	-3.55**	-4.50**
4	-4.30**	-3.74**	-3.96**	-5.01**
5	-4.25**	-4.31**	-4.66**	-3.28**
6	-10.57**	20.44**	-3.75**	-4.06**
7	-4.01**	-3.04**	-6.60**	-7.22**
8	-3.48**	-7.55**	-2.83**	-12.46**
9	-4.53**	24.45**	-6.39**	-6.77**
Highest	-7.95**	-65.30**	-8.98**	21.76*
PrePilotControl	1.18**	1.12**	1.18**	1.11**
Average R^2	0.82	0.80	0.82	0.80

Table 17: Changes in Bid Depth Across Market Cap and Turnover Deciles

This table shows the marginal effect of the Pilot derived from the coefficients from the following daily cross-sectional regressions:

$$\text{Bid Depth}_i = \alpha + \sum_{k=1}^{9} \beta_k \text{Pilot}_i \times \text{Decile}_{ki} + \beta_{10} \text{Pilot}_i + \beta_{11} \text{Pre Bid Depth}_i$$

Reported is the average sum of $\beta_{10} + \beta_k$. The dependent variable is the bid depth. The regressions are estimated on each day during the Pilot Period. The statistical significance of the coefficients is determined by the distribution of the coefficients. We divide the stocks into deciles by market cap on May 2, 2005 and by the pre-Pilot turnover where decile 1 contains the smallest stocks and lowest turnover stocks. **,* indicates that the effect is statistically different from zero at the 1 and 5% level in a two-tailed test.

	Market Capitalization		Turnover	
	Listed	Nasdaq	Listed	Nasdaq
Decile				
Lowest	5.39**	2.02*	-2.27**	-5.44**
2	-3.23**	-5.09**	-8.32**	-5.72**
3	-2.36**	-5.24**	-1.03**	-6.11**
4	-2.07**	-4.28**	-0.38*	-7.12**
5	-1.41**	-5.14**	-1.21**	-4.16**
6	-7.74**	22.27**	-0.16	-4.83**
7	-1.28**	-4.19**	-1.91**	-8.99**
8	1.26**	-8.31**	5.04**	-12.96**
9	-0.49**	25.51**	-1.20**	-7.62**
Highest	-1.06**	-69.58**	-1.11*	25.35**
PrePilotControl	1.16**	1.14**	1.16**	1.13**
Average R^2	0.82	0.75	0.82	0.75

Table 18: Changes in Effective Spread Across Market Cap and Turnover Deciles

This table shows the marginal effect of the Pilot derived from the coefficients from the following daily cross-sectional regressions:

$$\text{Relative Effective Spread}_i = \alpha + \sum_{k=1}^{9} \beta_k \text{Pilot}_i \times \text{Decile}_{ki} + \beta_{10}\text{Pilot}_i + \beta_{11}\text{Pre Relative Effective Spread}_i$$

Reported is the average sum of $\beta_{10} + \beta_k$. The dependent variable is the relative effective spread. The regressions are estimated on each day during the Pilot Period. The statistical significance of the coefficients is determined by the distribution of the coefficients. We divide the stocks into deciles by market cap on May 2, 2005 and by the pre-Pilot turnover where decile 1 contains the smallest stocks and lowest turnover stocks. **,* indicates that the effect is statistically different from zero at the 1 and 5% level in a two-tailed test.

	Market Capitalization		Turnover	
	Listed	Nasdaq	Listed	Nasdaq
Decile				
Lowest	14.01	2.48**	4.94	0.46
2	2.33	-1.83**	-0.37	-3.32**
3	-2.30	0.29	-0.91	2.08*
4	0.24	-0.16	0.80	0.98
5	-1.40	0.32	-0.34	-0.24
6	-2.57*	0.80**	0.20	0.28
7	0.24	1.72**	-1.74	1.03**
8	-0.32	1.89**	4.72*	0.30
9	0.53	2.04**	-0.72	0.79**
Highest	0.52	2.92**	-2.04*	3.30**
PrePilotControl	1.20**	1.12**	1.22**	1.13**
Average R^2	0.44	0.49	0.43	0.50

Table 19: Changes in Five-Minute Return Variances across Market Cap and Turnover Deciles

This table shows the marginal effect of the Pilot derived from the coefficients from the following daily cross-sectional regressions:

$$\text{Variance (5 minute returns)}_i = \alpha + \sum_{k=1}^{9} \beta_k \text{Pilot}_i \times \text{Decile}_{ki} + \beta_{10}\text{Pilot}_i + \beta_{11}\text{Pre Variance(5 minute returns)}_i$$

Reported is the average sum of $\beta_{10} + \beta_k$ multiplied by 10^6. The dependent variable is the five-minute return variance. The regressions are estimated on each day during the Pilot Period. The statistical significance of the coefficients is determined by the distribution of the coefficients. We divide the stocks into deciles by market cap on May 2, 2005 and by the pre-Pilot turnover where decile 1 contains the smallest stocks and lowest turnover stocks. **,* indicates that the effect is statistically different from zero at the 1 and 5% level in a two-tailed test.

	Market Capitalization		Turnover	
	Listed	Nasdaq	Listed	Nasdaq
Decile				
Lowest	11.123**	1.571**	2.130**	0.114
2	2.693**	-0.393	-0.074	-0.350
3	1.840**	-0.001	1.182	0.385
4	0.968**	0.964	0.158**	0.968*
5	0.652**	-0.080	-0.253**	0.277
6	1.322	-0.460*	0.229**	0.095
7	-0.263**	0.052	0.151**	0.415*
8	-0.932**	-0.133	1.484**	1.076
9	-0.789**	-0.661**	0.427**	-0.232
Highest	-1.162**	-0.802**	0.535**	-0.182
PrePilotControl	0.253**	0.822**	0.283**	0.834**
Average R^2	0.156	0.173	0.111	0.173

Table 20: Changes in Daily Return Variance across Market Cap and Turnover Deciles

This table shows the marginal effect of the Pilot derived from the coefficients from the following daily cross-sectional regressions:

$$\text{Variance (Daily Return)}_i = \alpha + \sum_{k=1}^{9} \beta_k \text{Pilot}_i \times \text{Decile}_{ki} + \beta_{10}\text{Pilot}_i + \beta_{11}\text{Pre Variance (Daily Return)}_i$$

Reported is the average sum of $\beta_{10} + \beta_k$ multiplied by 10^4. The dependent variable is the daily return variance. The regressions are estimated on each day during the Pilot Period. The statistical significance of the coefficients is determined by the distribution of the coefficients. We divide the stocks into deciles by market cap on May 2, 2005 and by the pre-Pilot turnover where decile 1 contains the smallest stocks and lowest turnover stocks. **,* indicates that the effect is statistically different from zero at the 1 and 5% level in a two-tailed test.

	Market Capitalization		Turnover	
	Listed	Nasdaq	Listed	Nasdaq
Decile				
Lowest	7.529**	3.240*	0.720	-0.655
2	0.751	0.070	-1.093	-1.303
3	0.992	0.709	-1.081	0.146
4	0.332	2.713*	-0.971	1.711
5	0.061	-1.503	-0.556	0.632
6	-0.260	0.798	0.154	2.653
7	-0.146	-1.623	-0.052	-0.452
8	-1.452*	-1.965	0.449	2.513
9	-1.243*	-3.131	0.366	-0.173
Highest	-1.775**	-3.596	0.137	-0.391
PrePilotControl	0.179**	0.419**	0.206**	0.433**
Average R^2	0.161	0.129	0.126	0.122

Table 21: May 2 Market Adjusted Returns Across Market Cap and Turnover Deciles

This table shows the marginal effect of the Pilot derived from the coefficients from the following daily cross-sectional regressions:

$$\mathrm{R}_{May2i} = \alpha + \sum_{k=1}^{9} \beta_k \mathrm{Pilot}_i \times \mathrm{Decile}_{ki} + \beta_{10} \mathrm{Pilot}_i$$

Reported is the average sum of $\beta_{10} + \beta_k$. The dependent variable is the return from the close of trading on April 29, 2005 to the close of trading on May 2, 2005. We divide the stocks into deciles by market cap on May 2, 2005 and by the pre-Pilot turnover where decile 1 contains the smallest stocks and lowest turnover stocks. * indicates that the effect is statistically different from zero at the 5% level in a two-tailed test. None of the numbers presented below are significant at the 1% level.

	Market Capitalization		Turnover	
	Listed	Nasdaq	Listed	Nasdaq
Decile				
Lowest	-0.16%	-0.45%	-0.35%	0.48%*
2	-0.35%	0.00%	-0.17%	-0.06%
3	-0.20%	-0.29%	-0.43%	0.28%
4	0.08%	-0.50%	-0.42%	0.57%
5	-0.18%	0.72%	-0.27%	-0.97%
6	0.02%	-0.24%	0.06%	-0.06%
7	-0.01%	-0.55%	-0.31%	-0.27%
8	-0.38%	-0.19%	0.08%	0.14%
9	-0.41%	-0.54%	-0.17%	-0.59%
Highest	-0.47%*	0.05%	-0.16%	-0.81%*
Average R^2	0.006	0.006	0.006	0.008

Table 22: Six Month Market Model In-Sample Alphas Across Market Cap and Turnover Deciles

This table shows the marginal effect of the Pilot derived from the coefficients from the following daily cross-sectional regressions:

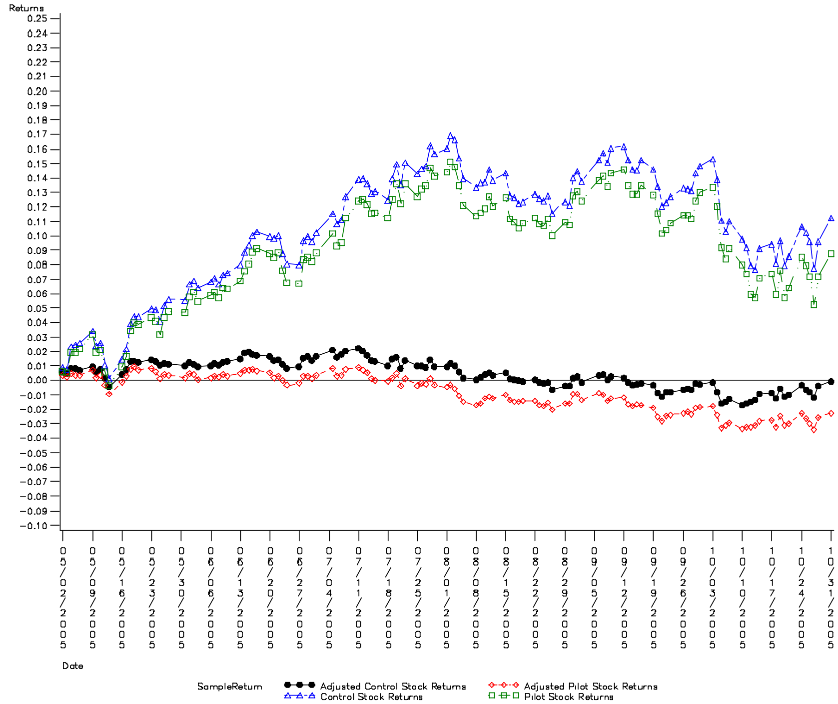
$$\text{Alpha}_i = \alpha + \sum_{k=1}^{9} \beta_k \text{Pilot}_i \times \text{Decile}_{ki} + \beta_{10} \text{Pilot}_i$$

Reported is the average sum of $\beta_{10} + \beta_k$. The dependent variable is in-sample alpha estimated for each stock based on the market model. The market model alpha was estimated over the six month period from May 2, 2005 to October 31, 2005 by regressing the daily stock returns on the daily market return, which is represented by the CRSP equally-weighted index returns. We divide the stocks into deciles by market cap on May 2, 2005 and by the pre-Pilot turnover where decile 1 contains the smallest stocks and lowest turnover stocks. None of the numbers presented below are significant at the 5% or 1% level.

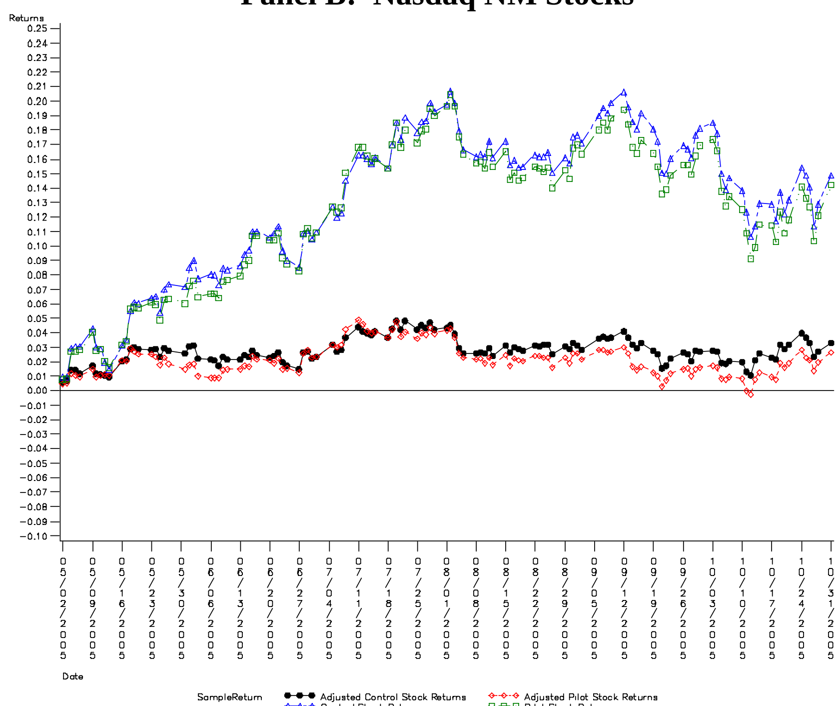
	Market Capitalization		Turnover	
	Listed	Nasdaq	Listed	Nasdaq
Decile				
Lowest	-0.06%	0.08%	-0.03%	-0.03%
2	-0.10%	-0.02%	-0.03%	0.02%
3	-0.05%	-0.05%	0.00%	0.00%
4	-0.02%	-0.08%	-0.03%	0.05%
5	-0.03%	0.02%	0.01%	-0.02%
6	0.01%	-0.01%	-0.01%	0.04%
7	-0.03%	0.00%	-0.02%	-0.02%
8	0.02%	-0.02%	-0.01%	-0.06%
9	-0.01%	0.01%	-0.02%	-0.02%
Highest	0.02%	0.00%	0.05%	-0.02%
Average R^2	0.011	0.012	0.005	0.006

Figure 1: Six Month Cumulative Returns During Pilot

Panel A: Listed Stocks



Panel B: Nasdaq NM Stocks



Appendix A: Concurrent Regulation SHO Pilot Studies

We have identified three concurrent studies that also examine the effect of removing the tick test and/or the bid test during the Regulation SHO Pilot. See the attached chart for a simplified comparison of the studies. Much of the analysis is similar to the analysis reported in this report, but the construction of the samples differs in important ways. Each approach has its merits. The main difference between the construction of the samples for this report and the sample construction in the concurrent papers is the incorporation of stocks that might be outliers. This report includes these stocks because they might be the ones most affected by the Pilot. The other studies exclude these stocks in order to improve matching between the pilot and control stocks or to remove the influence of confounding events. Despite the different decisions, many of the results of this report are supported by the results of the concurrent studies.

Study	**Diether, Lee, and Werner (2006)**	**Alexander and Peterson (2006)**	**Wu (2006)**	**SEC**
Construction				
Sample Period	2/1/05 to 7/31/05 minus 4 weeks around May 2 10 weeks before 10 weeks after	4/1/05 to 5/31/05 1 month before 1 month after	1/3/05 – 8/31/05 4 months before 4 months after	1/1/05 to 10/31/05 4 months before 6 months after
Sample Stocks	2004 Russell 3000 minus ● Amex and NASDAQ Small Cap stocks ● Stocks with ticker changes or changes in listing venue during sample period ● Stocks not in 2005 Russell ● Stocks with prices > $100 ● Stocks with spreads > $1 ● Stocks delisted before 7/31 NYSE: 448 pilot, 904 control Nasdaq: 376 pilot, 757 control	Original Pilot and Control minus ● Amex stocks ● Stocks delisted before 5/31 One-to-one matches based on: ● Listing market ● Option status ● 2 digit SIC code ● Price, market capitalization, book-to-market, trading volume, and past returns Keep best 50% of matches NYSE: 224 pairs Nasdaq: 183 pairs	NYSE stock in 2004 Russell 3000 minus ● Stocks not in 2005 Russell ● Stocks with prices > $900 One-to-one matches based on: ● Market cap ● Price ● Volume Exclude if no good control match NYSE: 332 pairs	2004 Russell 3000 minus ● IPOs after May 1, 2004 ● Stocks delisted before 5/2 Includes stocks delisted before 10/31 Listed: 504 pilot, 973 control Nasdaq: 439 pilot, 917 control
Findings				
Short Selling	Higher relative short sale volume. NYSE: higher number of short sale trades No impact on the number of NASDAQ short sale trades.	No significant impact on short sale volume for either NYSE or NASDAQ. NYSE: Pilot stocks had a higher number of short sales trades and a lower average short sale trade size. NASDAQ: No impact on number of short sales trades or average short sale trade size.	Examines only short selling on the NYSE Relative short selling increases for pilot stocks. Significant for small stocks but not large stocks.	Higher short sale volume and a higher number of short sale trades. No impact on short interest or days to cover. No impact on option trading volume or open interest. Trading is more balanced for pilot stocks. The increase in short selling is bigger for small stocks.

Study	Diether, Lee, and Werner (2006)	Alexander and Peterson (2006)	Wu (2006)	SEC
Liquidity	No impact on NASDAQ stocks. NYSE: Larger quoted, effective, and realized spreads, smaller quoted ask depth, higher relative bid depth, smaller buy imbalances.	NYSE: larger spreads, smaller quoted ask depth, smaller quoted bid depth, higher price impact NASDAQ: larger spreads No effect on effective spreads	Relative effective and quoted spreads increase with pilot by < 1 bps. This is statistically significant only for small stocks. Smaller buy imbalances across all market cap groups. Offer depth declines for most size groups.	Listed: smaller quoted ask depth in univariate and regression. Regression shows decrease in both bid and ask. Some tests show small increases or decreases in realized liquidity.
Volatility	No increase in the majority of the 26 different volatility measures for Pilot Stocks. NYSE: higher short term volatility (15/5 variance ratio), daily return volatility, trade to trade return volatility, offer to offer quote volatility, five-minute bid and offer volatility, daily up-side and down-side semi-variance. The authors examine semi-variance, trade returns, bid quote returns, and ask quote returns for various time lengths: trade to trade, quote to quote, five-minute, fifteen-minute, and daily. They also examine the 15/5 minute variance ratio.	No impact. The authors examine six volatility measures: 5 minute return volatility, semi-variance, daily relative price range, Fama-Franch three-factor model idiosyncratic risk, CAPM idiosyncratic risk, and implied volatility.	Variance ratios did not change with pilot. Daily price range and intraday price standard deviation do not change.	Some evidence of an increase in intraday volatility. This appears to be driven by smaller stocks as larger stocks saw a decline in intraday volatility during the pilot. While average daily volatility does not change, smaller stocks experienced lower volatility during the pilot as larger stocks experienced an increase.

Study	Diether, Lee, and Werner (2006)	Alexander and Peterson (2006)	Wu (2006)	SEC
Efficiency		No impact except for the following measures for NYSE stocks: higher autocorrelation of five-minute returns, greater likelihood of a lower price for the second trade after a short sale, and greater likelihood of a higher trade price for the first trade after a short sale. The authors examine the autocorrelation of five- and thirty-minute returns, upside minus downside r-squared, and price runs.	Hasbrouck pricing errors show no significant change with pilot. Intraday return autocorrelations (30 and 60 minute) did not change with pilot.	Higher five-minute return reversals. Higher five-minute semi-autoregression. No impact on thirty-minute return reversals, thirty-minute semi-autocorrelation, or on skewness in five-minute, thirty-minute, and daily returns.
Returns		No significant impact on returns surrounding the announcement date of the Pilot stocks, on the initiation day of the Pilot, or during the first month of the Pilot.		Listed pilot stocks had a 24 bps lower return than control stocks on the initiation day of the Pilot but had statistically similar cumulative return during the 6 months after the Pilot.
Conclusion	While the suspension of the NYSE tick test is found to be associated with larger spreads and higher short-term volatility, this evidence is consistent with the distorting effects of the tick test on short sellers (i.e., forcing them to be liquidity suppliers) rather than any benefit to investor welfare.	Concerns about the removal of the price tests leading to a degradation of market quality are unfounded. Price tests do not further the stated objectives of short sale regulation.	Tick test reduces short selling and narrows the spread primarily for small stocks. Tick test does not seriously constrain short sellers from trading on their information.	Most evidence shows that the pilot had a minor effect. The most intriguing results are in volatility. Some evidence that the tick test has a bigger effect in small stocks.