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It's SHO Time! Short-Sale Price Tests and Market Quality

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ABSTRACT

We examine the effects of the Securities and Exchange Commission (SEC)-mandated temporary suspension of short-sale price tests for a set of Pilot securities. While short-selling activity increases both for NYSE- and Nasdaq-listed Pilot stocks, returns and volatility at the daily level are unaffected. NYSE-listed Pilot stocks experience more symmetric trading patterns and a slight increase in spreads and intraday volatility after the suspension while there is a smaller effect on market quality for Nasdaq-listed Pilot stocks. The results suggest that the effect of the price tests on market quality can largely be attributed to distortions in order flow created by the price tests themselves.

REGULATION SHO (REG SHO) PROVIDES a new regulatory framework governing short-selling of securities in U.S. equity markets. The rules were passed on September 7, 2004 and became effective on January 3, 2005.[1] Reg SHO is intended to establish uniform locate and delivery requirements, create uniform marking requirements for sales of all equity securities, and establish a procedure to temporarily suspend the "provisions of Rule 10a-1 under the Securities Exchange Act of 1934 and any short-sale price test of any exchange or national securities association for short sales of certain securities for certain time periods" in order to "evaluate the overall effectiveness and necessity of such restrictions."[2]

In this paper, we study the effect on market quality of the Securities and Exchange Commission's (SEC) mandated temporary suspension of short-sale price tests for a set of designated pilot securities (Rule 202T—Pilot Program).[3]

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[1] Securities Exchange Act Release No. 50103 (July 28, 2004), 69 FR 48008 (August 6, 2004).

[2] Division of market regulation: Responses to frequently asked questions concerning regulation SHO (January 4, 2004).

[3] Securities Exchange Act Release No. 50104 (July 28, 2004), 69 FR 48032 (August 6, 2004).

On May 2, 2005,[4] roughly 1,000 U.S. stocks—so called Pilot stocks—began to trade without short-sale price tests (Uptick test for the NYSE and bid price test for Nasdaq). These stocks were selected by the SEC to represent a broad cross-section of the U.S. equity market. The Pilot stocks were drawn from the Russell 3000 index, comprising every third stock ranked by volume. We label the remaining Russell 3000 index securities Control stocks. The experiment was designed by the SEC to investigate whether Rule 10a-1, NYSE's Uptick rule, and Nasdaq's bid price test affect market quality, and to develop uniform price tests if such rules were deemed necessary going forward. The temporary suspension was originally set to expire on April 28, 2006, but was extended to August 6, 2007.[5]

The extent to which specific price tests are likely to have an effect depends on what fraction of overall trading activity is represented by short sales. Recent empirical evidence shows that short-selling is much more common than most market observers previously imagined. For example, Boehmer, Jones, and Zhang (2008) find that short sales represent 13% of NYSE (SuperDOT) share volume during 2000 to 2004. Even more striking, Diether, Lee, and Werner (2008) find that short sales represent 31% of share volume for Nasdaq-listed stocks and 24% of share volume for NYSE-listed stocks in 2005. Hence, there is a potential for short-sale price tests to affect price levels, volatility, as well as high-frequency measures of market quality. Short-sale price tests may affect price levels if they create frictions that are strong enough to limit the extent to which prices reflect the views of pessimists, that is, the investors who think stocks are overvalued (e.g., Miller (1977) and Diamond and Verrecchia (1987)). They may also reduce volatility if they make it more difficult for short-sellers to engage in downward manipulation of stock prices. Finally, short-sale price tests may affect the mix of passive and active trading strategies employed by short-sellers, which in turn could affect market quality measures such as spreads, depth, and order imbalances.

Restrictions on short-selling activity were introduced in the United States in the 1930s following the stock market crash of 1929. Jones (2003) shows that short-selling in NYSE-listed stocks was more difficult after the introduction of shorting restrictions. He also finds that these events were associated with positive abnormal returns, consistent with the notion that optimists have more influence on prices in the presence of short-sale restrictions. By contrast, shorting restrictions had no effect on the volatility of returns. Based on the historical experience, we predict that stock prices will fall on the announcement of a suspension of short-sale price tests, or at least after the suspension itself. However, we find no evidence that NYSE or Nasdaq Pilot stocks experience significantly lower average returns compared to their respective Control samples around

[4] The Pilot Program was originally intended to commence on January 3, 2005, but in response to information received by the SEC from market participants, the Pilot was postponed until May 2, 2005 (Securities and Exchange Act Release No. 50747 (November 29, 2004), 69 FR 70480 (December 6, 2004)).

[5] Securities and Exchange Act Release No. 53684 (April 20, 2006).

the announcement of the Pilot Program (July 28, 2004) or on the date the Pilot Program became effective (May 2, 2005). Moreover, we do not detect any change in daily volatility measures for Pilot compared to Control stocks. Hence, it appears that there is no significant effect of suspending short-sale price tests on price levels or volatility at the daily frequency.

The effect of short-selling on high-frequency market quality measures depends on the specific form of the price test that each market uses. NYSE uses a tick test to determine whether a short sale is permitted (NYSE Rule 440B, also called the Uptick rule). Consequently, a short sale is only allowed on a plus tick or on a zero tick, where the most recent price change preceding the trade was a plus tick (called a zero-plus tick).[6] The way the specialist adjusts orders to ensure compliance with the Uptick rule means that short-sellers effectively become liquidity providers. As a result, we expect to see a disproportionate amount of limit orders on the offer side of the market, inflating the depth at the ask quotes and a disproportionate amount of trades executing above the midquote, creating a buy order imbalance. As suggested by Jones (2003), these trading strategies may also produce narrower quoted (and possibly effective) spreads. Finally, we argue that this bias toward passive short-sale order strategies may dampen short-term volatility.

Nasdaq uses a bid price test to determine whether a short sale is allowed (Nasdaq Rule 3350). Short sales in Nasdaq National Market Securities (NM) are not allowed at or below the (inside) bid when the current inside bid is at or below the previous inside bid. We argue that the bid price test permits short-sellers to use a more natural mix of marketable limit order and limit order strategies than the NYSE's Uptick rule. Moreover, Archipelago and INET, who together are responsible for a significant fraction (over 40%) of share volume in Nasdaq-listed stocks, did not enforce the bid price test during the sample period. As a result, we predict that the effect of short-selling activity on market quality will be smaller for Nasdaq-listed stocks.

We find that the temporary suspension of short-sale price tests affects short-selling activity for both NYSE- and Nasdaq-listed securities. For NYSE-listed stocks, there is no significant change in short-sale share volume or short interest, but short-sale trade size decreases significantly and short-sale trade frequency increases significantly for Pilot relative to Control stocks. In other words, NYSE short-sellers split their orders more as they switch from passive to more active trading strategies. Moreover, short sales relative to share volume on the NYSE increase significantly after the suspension of the price tests. For Nasdaq-listed stocks, both short-sale share volume and the short-sale frequency increase significantly for Pilot relative to Control stocks. However, there is no evidence of increased order splitting for Nasdaq Pilot stocks. In sum, short sales relative to share volume increase significantly for Pilot relative to Control

[6] Types of short sales that are exempt from short-sale rules include certain odd-lot short-sales, certain sales by registered specialists or market makers, certain sales necessary to equalize prices on a nonprimary market with the primary market, certain sales in special arbitrage accounts, and certain sales by underwriters (see SEC Rule 10a-1, section e (3), (4), (5), (6), (7), (8), (9), and (10)).

stocks. Thus, it appears that suspension of NYSE's Uptick rule and Nasdaq's bid price test makes it somewhat easier to execute short sales.

We argue that NYSE's Uptick rule causes short-sellers to engage in more passive trading strategies, which results in narrower spreads, lower volatility, higher ask depth, and a disproportionate amount of order flow executing above the midquote. Thus, we predict that the suspension of the Uptick rule will significantly reduce the quote and order flow asymmetries, and that it may result in wider spreads and higher short-term volatility. We also argue that the impact of short sales on Nasdaq is smaller for two reasons: The bid price test is not very restrictive, and Archipelago and INET permitted unfettered short sales in Nasdaq-listed stocks. Consequently, we predict that the suspension of the bid price test will have more limited impact on market quality for Nasdaq Pilots.

We find strong evidence supporting our hypotheses. The relative bid depth increases significantly for NYSE-listed Pilot stocks but there is no significant change for Control stocks. The buy order imbalance declines significantly for Pilot stocks while it actually increases significantly for Control stocks. Relative to Control stocks, NYSE-listed Pilot stocks experience a slight but statistically significant increase in both quoted and effective spreads. Trade-to-trade returns are significantly more volatile for NYSE Pilot relative to Control stocks after May 2, 2005. However, there is no evidence of a disproportionate increase in downside volatility. Lower-frequency intraday volatility measures (at 5, 15, and 30 minutes) suggest that the increase in volatility for Pilot stocks relative to Control stocks disappears as returns are measured over longer intervals (30 minutes). Finally, variance ratio tests suggest that short-term volatility increases relative to longer-term volatility for NYSE Pilot stocks compared to Control stocks.

As predicted, we find smaller differences between the changes in market quality measures such as quote asymmetries and spreads for Nasdaq-listed Pilot stocks relative to Control stocks. There is also no significant change in trade-to-trade volatility, or in midquote volatility at lower frequencies (5, 15, and 30 minutes), for Nasdaq-listed Pilot stocks relative to Control stocks. These findings are confirmed by variance ratio tests, which show no significant changes for Nasdaq-listed Pilot stocks relative to Control stocks.

Throughout the paper, we conduct cross-sectional tests to examine how the suspension of price tests affects less liquid stocks. While we do find evidence that the magnitude of the effects of the suspension of the Uptick rule are in some cases larger for less liquid NYSE-listed stocks, we attribute this mostly to the fact that the distortions in order flow are more severe for stocks with wider spreads and lower price. The evidence on how suspending the bid price test affects small, less liquid Nasdaq-listed stocks is more mixed.

Our paper proceeds as follows. In Section I, we outline the short-sale rules for the NYSE and Nasdaq and develop our testable hypotheses. We describe the data in Section II. We test whether the level of short sales changed significantly between the period before and after the suspension of price tests in Section III. In Section IV, we examine the effect of suspension of price tests on daily returns and volatility. Section V is devoted to testing for changes in market quality measures. In Section VI, we investigate whether intraday volatility increased for Pilot stocks. We discuss robustness tests in Section VII. Section VIII concludes. A short epilogue can be found in Section IX.

I. Testable Hypotheses

In this paper we first test whether the actual form of price tests used by NYSE or Nasdaq constrain short-selling activity. Angel (1997) and Alexander and Peterson (1999) conclude that the Uptick rule impedes short-selling activity on the NYSE by examining the fill rate of short-sale orders.[7] We provide an alternative test of the effect of the Uptick rule by examining the overall volume of short-selling after price tests are lifted. In addition, we test whether Nasdaq's bid price test impedes short-selling. If the applicable short-sale rules are restricting market participants from executing their desired trades, we predict that short-selling activity for Pilot stocks will increase significantly after the suspension of the price tests. Of course, there could be a secular trend in short-selling activity, so we need to express our hypothesis relative to what happens to Control stocks, for which there is no change in rules. Hence, our first hypothesis is that the suspension of price tests will increase short-selling activity in Pilot stocks relative to Control stocks.

Much of the empirical short-selling literature focuses on how short-sale constraints affect stock prices and returns. Theoretical papers such as Miller (1977), Harrison and Kreps (1978), Morris (1996), Scheinkman and Xiong (2003), and Duffie, Gârleanu, and Pedersen (2002) develop models in which the presence of short-sale constraints and opinion divergence leads to overpricing and abnormally low subsequent returns. Empirically, the previous literature finds that stocks are sometimes expensive to short and that there is a link between short-selling and subsequent returns. Using data from April 2000 through September 2001, D'Avolio (2002) reports that about 9% of the stocks in his sample have loan fees greater than 1% per year. Jones and Lamont (2002), Ofek, Richardson, and Whitelaw (2004), and Cohen, Diether, and Malloy (2007) find that subsequent average returns are low for stocks that are expensive to short. Figlewski and Webb (1993), Dechow et al. (2001), Desai et al. (2002), Boehmer, Jones, and Zhang (2008), Diether, Lee, and Werner (2008), and Asquith, Pathak, and Ritter (2005) find a negative relation between short-selling activity and subsequent returns. If short-sale price tests help push stock prices above fundamental value, then suspending them should result in negative returns. Hence, our second hypothesis is that the suspension of price tests will be associated with lower returns for Pilot stocks relative to Control stocks.

The price tests for listed stocks were developed by the SEC in the 1930s to prevent short sales from executing in declining markets (see, e.g., Jones (2003)).

[7] Ferri, Christophe, and Angel (2004) argue that the Nasdaq bid price test is not effective and does not curtail short-selling activity.

The Nasdaq bid price test is much newer, and was approved as a temporary rule by the SEC in September of 1994.[8] If these price tests are effective, they should dampen downside volatility of returns. However, the literature has not generally found the rules to be effective. SEC (1963) finds that the Uptick rule is ineffective at relieving pressure from short-sellers. Ferri, Christophe, and Angel (2004) find no significant difference in the level of shorting activity during down markets for Nasdaq stocks that are subject to the bid price test (National Market stocks) and those (small cap stocks) that are not. Moreover, Jones (2003) finds that the introduction of the tick tests has no effect on volatility at the daily frequency. For completeness, we reexamine the question of the impact of price tests on volatility at the daily frequency. We hypothesize that if the price tests are effective in reducing volatility, we should find that Pilot stocks experience a significant increase in volatility relative to Control stocks after the price tests are suspended.

To develop testable hypotheses regarding the effect of price tests on market quality measures, we rely on the specific form of the rules used by NYSE and Nasdaq. NYSE uses a tick test to determine whether a short sale is allowed, and short sales are only allowed on a plus tick or a zero-plus tick. A plus tick occurs when the last sale price is above the price of the previous trade. A zero-plus tick occurs when the last sale price is the same as the price of the previous trade, but the most recent different price is below the last sale. Whether a price is a plus tick, zero-plus tick, zero-minus tick, or minus tick is determined by comparing the price with the last sale on the NYSE.[9] There are a few rare situations where the Rule permits short sales without regard to the tick test.[10] Generally speaking, NYSE specialists, option market makers, and third-market market makers for NYSE-listed stocks are subject to the tick-test. However, there is an exemption (Rule 10a-1 (e)(5)) for a short sale by a market maker for his own account effected at a price equal to or above the last sale *or* effected at a price equal to that participant's most recent offer if the offer, when quoted, was equal to or above the last sale.

We hypothesize that the Uptick rule significantly affects how short-sellers' orders are presented to the market. Specifically, the NYSE specialist has to ensure that an order is compliant with the Uptick rule and he does so by relying on the display book software. Whatever order type (market or limit) the short-seller submits, the display book software adjusts the order so that it is compliant. Effectively, this means that short-sale orders are changed into non-marketable limit orders. Suppose that the last sale is at \$28.05 on a plus tick and the quotes are \$28.00 to \$28.05. If the short-seller submits a market sell

[8] The bid test has been reapproved annually as a temporary rule ever since (SEC (2006)).

[9] Rule 10a-1 uses a tick test based on the consolidated transaction reporting system as a default, but permits each market center to use its own tape as the reference for short-sale compliance provided that this is a real-time reporting system.

[10] These include: odd lot transactions that change the market maker's position by less than a unit of trading, domestic arbitrage, and international arbitrage. The SEC has also granted exemptive relief for certain eligible volume weighted average price (VWAP) transactions, exchange traded funds, and certain short sales executed at the closing price in after-hours crossing sessions.

order, the order cannot be executed at the bid ($28.00) because of the Uptick rule. Instead, the order will be treated by the display book software as an effective limit order to sell at $28.05. Similarly, if the short-seller submits a limit order to sell at $28.03 (or anywhere below $28.05) the limit price will be changed to $28.05 before being displayed in the book. Note that the effective limit prices of short-sale orders have to be adjusted over time as prices move in such a way that they remain compliant. For example, if the following trade takes place at $28.00 then the short-sell limit order is cancelled and replaced by a new limit sell order at $28.03 (the original limit price). The new order will carry a time stamp of the price change that triggered the adjustment to the order.

Similarly, short-sale orders in NYSE-listed stocks that are routed to ArcaEx are altered by the system so that they are compliant with the Uptick rule. To illustrate, suppose the market is at $20.00 to $20.03 and last sales are $20.00 followed by $20.03. A short limit sell order arrives to ArcaEx priced at $20.02. The Uptick rule implies that the order cannot fill right away. Instead, ArcaEx would quote the short limit order at $20.03, because, with a last sale sequence of $20.00 and $20.03, the lowest "tick" available for shorting is $20.03 (zero-plus tick). If the order didn't execute at $20.03 and the next trade was at $20.00, ArcaEx would move the short limit order back to its original limit price, since the order could now be executed at $20.02 (plus tick). By contrast, INET's trading system simply rejects short-sale orders in NYSE-listed stocks at prices that would execute at a "bad" tick.

As a result of how short-sale orders are handled by the main venues trading NYSE-listed stocks, we expect to see a disproportionate amount of limit orders on the offer side of the market. We also expect that a disproportionate amount of trades will occur above the midquote, which results in buy orders exceeding sell orders on average (buy order imbalance) when trades are classified using the Lee and Ready (1991) algorithm. The Uptick rule is also likely to produce narrower quoted (and possibly effective) spreads, and dampened short-term volatility, as short-sellers shadow the last sale to remain compliant with the rule.[11]

The suspension of the Uptick rule permits short-sellers in NYSE-listed Pilot stocks to use more aggressive marketable orders. As short-sellers switch from being (forced) liquidity providers to demanding liquidity, their incentives to engage in order-splitting to price discriminate among liquidity providers on the bid side of the market increases. In addition, short-sellers are more likely to be perceived by other traders in the market as aggressive sellers and this implies that they are more susceptible to order anticipators. As a result, we predict that short-sellers will engage more heavily in order-splitting to reduce the price impact of their trades after the suspension of the Uptick rule.

The usage of more aggressive marketable orders also means that the asymmetric patterns that we expect to see for NYSE-listed stocks will attenuate. Specifically, we predict that the suspension of the Uptick rule will result in a

[11] Angel (1997) finds that the national best bid and offer for NYSE-listed stocks is typically lowered after the placement of a short-sell order.

reduction in the depth at the offer relative to the bid, a reduction in the buy order imbalance, a widening of quoted and effective spreads, and an increase in short-term volatility for NYSE-listed Pilot stocks relative to Control stocks.

Nasdaq uses a bid price test to verify whether a short sale is permitted (Nasdaq Rule 3350), and short sales in Nasdaq National Market Securities (NM) are not allowed at or below the (inside) bid when the current inside bid is at or below the previous inside bid. To execute a "legal" short-sale in a NM security on a down bid, the short sale must be executed at a price at least $0.01 above the current inside bid. As of February 1, 2004, all market participants should use the Nasdaq (SuperMontage) inside bid to verify compliance with the bid price test. Registered market makers for a Nasdaq-listed stock, as well as market makers in options on this stock, are exempt from the bid price rule when trading the stock. To illustrate, suppose again that the last sale is $28.05 on a plus tick and that the quotes are $28.00 to $28.05. A Nasdaq short-seller can place a marketable limit sell order at $28.00 and still be in compliance with the bid price test as long as the most recent bid was $28.00 or below. Moreover, a short-seller can always place a limit sell order at $28.01 regardless of past bids and past trade prices. By contrast, as described above, on the NYSE the short-sale order would in this case enter the display as a limit sell order at $28.05, which is 4 cents higher. Of course, a Nasdaq short-seller may also want to be more passive and place the order at $28.05 (or even higher), but the point is that he is not forced to do so by the rules. He has more freedom to choose the optimal limit price for his order than his NYSE counterpart. The only situation for which the price tests are equally restrictive is if the last sale is at $28.00 on a down bid and a down tick. In this case, both Nasdaq and NYSE rules permit a limit sell order at $28.01.

Note that neither ArcaEx[12] nor INET[13] enforced price tests for these stocks during our sample period. Granted, NASD member firms may have felt bound by NASD Rule 3350 and could have verified that their orders were compliant through third-party systems. These two venues were responsible for a significant fraction of trading volume in Nasdaq-listed stocks during our sample period. For example, during May 2005 (the first month of the Pilot), ArcaEx executed 18.2% and INET executed 24.8% of Nasdaq share volume.[14]

Thus, even though we expect to see some effect of the bid price test on Nasdaq depth, order flow, spreads, and volatility, it is likely to be smaller than in the case of the NYSE. It follows that the suspension of the bid price test should

[12] See http://www.tradearca.com/faqs_gen.asp.

[13] INET's ECN printed their trades on the National Securities Exchange (NSX) (previously the Cincinnati Stock Exchange) during our sample period. Since INET quotes and trade-reports through NSX, and NSX does not have a short-sale rule for Nasdaq-listed stocks, INET believes that the NASD short-sale rule may not be applicable to orders sent to INET in Nasdaq-listed securities. (See: www.inetats.com/subcribers/emailarchive/2003/20030625.asp.) However, as of January 23, 2006, INET enforces the bid price test for Nasdaq-listed stocks because it has migrated its trade reporting from the National Stock Exchange (NSX) to Nasdaq's ACT (see: www.isld.com/subscribers/emailarchive/2006/20060118_2.asp).

[14] See http://www.nasdaq.com.

have a smaller effect on order-splitting, the depth at the offer relative to the bid, the buy imbalance, quoted and effective spreads, and short-term volatility. Again, note that all these predictions need to be evaluated relative to Control stocks.

Regulators have expressed concerns that small-capitalization, low-liquid and low-priced stocks will be most adversely affected by the suspension of the price tests. Less liquid stocks may be more vulnerable to the effects of more active short-selling since the order book is likely to be thinner. Low-price stocks may also be relatively more affected by more active short-selling since a penny tick may be a more significant impediment to shorting for these stocks. At the same time, it is important to recognize that less liquid stocks tend to have wider spreads, and often also lower prices. To the extent that short-sale volume is still significant for less liquid stocks, we expect the distortions introduced by the price tests to be larger.

To see why, consider two NYSE-listed stocks L(iquid) and I(lliquid). Stock L has a spread of 1 cent and Stock I has a spread of 5 cents. Start by assuming that they both have the same bid price, $30.00, and that the last sale was at the bid on a down tick. An aggressive short-seller in stock L (that is someone who would have submitted a market sell order absent the Uptick rule) will have to place a limit order at $30.01 to be compliant. Since the quoted spread for stock L is 1 cent, this short-sale order will not affect the quoted spread. Similarly, an aggressive short-seller in stock I will place a limit order at $30.01 to be compliant. However, in this case the short-sale order narrows the quoted spread from 5 cents to 1 cent or from 16.67 to 3.33 basis points. Thus, if aggressive short-sellers are equally active in both stocks, that is, they represent the same fraction of order flow, the Uptick rule would have a larger effect on stock I's quoted spread than on stock's L's quoted spread. Now change the assumptions so that the bid price for stock I is $15, while the price remains $30 for stock L. Then the basis point spread for stock I would go from 33.33 to 6.67. In other words, the Uptick rule affects stocks with wider spreads disproportionately, and the effect is exacerbated if stocks *also* have a lower price.[15] Hence, we should expect a larger increase in spreads and intraday volatility for less liquid stocks after price tests are suspended simply because the price tests cause larger distortions in order flow for these securities.

II. Data and Methodology

Our study covers the period from February 1, 2005 through July 31, 2005. The initial sample includes all Pilot stocks as defined by the Securities Exchange Act Release No. 50104 (July 28, 2004), 69 FR 48032 (August 6, 2004). The remaining Russell 3000 securities are included as Control stocks. To eliminate the potential confounding influence of index inclusion or index exclusion, we require that sample stocks be members of the Russell 3000 index after the June 2004 reconstitution and remain members of the Russell 3000 index

[15] A similar example can easily be created for the Nasdaq bid test.

Table I

Sample Selection

The sample includes all NYSE- and Nasdaq-listed stocks that are part of the Russell 3000 index on June 30, 2004 and are still part of the index as of June 30, 2005. Stocks that change listing venue, go private, are involved in a merger or an acquisition, or change ticker during the period are excluded. Nasdaq small cap stocks and stocks with a price exceeding $100 or an average quoted spread exceeding $1.00 for February 1 to April 30, 2005 are also excluded. To avoid undue influence of the open, we exclude data from 9:30 to 10:00 am. Pilot stocks are stocks that were designated as Pilot A securities by Reg SHO. All other NYSE- and Nasdaq-listed Russell 3000 index stocks are labeled Control stocks.

	Pilot Stocks	Control Stocks	Total	Percent
NYSE	448	904	1,352	54.4
Nasdaq	376	757	1,133	45.6
Total	824	1,661	2,485	

after the June 2005 reconstitution.[16] In other words, we exclude stocks that were added to the index (IPOs) during the period June 2004 through June 2005 and stocks that were eliminated during the year due to corporate events such as mergers, bankruptcies, etc., plus stocks that were added or eliminated in the June 2005 index reconstitution. We also exclude 22 stocks that experienced ticker changes during the sample, 13 stocks that were listed on Nasdaq's small cap market at any point during the sample, 17 stocks that were acquired, merged, or privatized during the year, and 4 stocks that changed listing venue. Further, we exclude 32 stocks with an average price above $100.00 or an average quoted spread exceeding $1.00 during the February 1 to April 30 period to reduce the likelihood that our results will be influenced by outliers. Finally, we exclude the 34 stocks that were listed on AMEX due to the small sample size for this market. These filters bring the total sample down to 2,485 from the total of 3,402 stocks that appear on Russell's membership lists between June 2004 and June 2005.

To determine which securities are Pilot securities, we use NYSE, Nasdaq, and AMEX daily Pilot lists, which are posted on the Web. A total of 964 stocks appear on these lists between April 29, 2004 and July 31, 2005, and of these, 928 are Pilot stocks for the entire sample period. After applying our filters, we are left with 824 Pilot stocks and 1,661 Control stocks. Our final sample is summarized in Table I and includes 2,485 stocks, 1,352 from the NYSE and 1,133 from Nasdaq. There are 448 NYSE-listed and 376 Nasdaq-listed Pilot stocks in our sample. Note that we use the entire set of Control stocks from the

[16] This filter eliminates 796 Russell stocks. Only 267 of these stocks were in the index in December 2004 and have CRSP and TAQ data for the entire sample period. We analyze this sample of "index exclusions," which is composed of 58 Pilot (10 NYSE and 48 Nasdaq) and 209 Control stocks (55 NYSE and 154 Nasdaq). While the results are noisier, our conclusions generally hold also for this sample: short-selling activity increases, quoted spreads widen, asymmetries are reduced, and short-term volatility increases for Pilot relative to Control stocks.

Russell 3000, so we have roughly twice as many Control stocks as Pilot stocks both for the NYSE and for Nasdaq.[17]

We first match our sample of stocks with CRSP data, and calculate daily returns, daily trade price range ($(high_t - low_t)/high_t$), and volatility based on closing trade prices. We also calculate positive and negative semivariances, which are computed as the average squared positive and negative returns, respectively (Markowitz (1959)). Based on NYSE TAQ data, we calculate the quote range ($(high_t - low_t)/high_t$), close–close midquote returns ($close_t - close_{t-1}/close_{t-1}$), and open–close midquote returns ($open_t - close_t/close_t$). We then use the NYSE's TAQ data to calculate a battery of average daily market quality-related statistics for each of our sample firms:

- quoted spreads ($ask_t - bid_t$),
- relative quoted spreads ($100 * (ask_t - bid_t)/((ask_t + bid_t)/2)$),
- effective spreads ($I * 2 * (price_t - (ask_t + bid_t)/2)$, where $I = 1$ for buyer-initiated trades and $I = -1$ for seller-initiated trades),[18]
- relative effective spreads ($100 * I * 2 * (price_t - (ask_t + bid_t)/2)/((ask_t + bid_t)/2)$, where $I = 1$ for buyer-initiated trades and $I = -1$ for seller-initiated trades),
- realized spreads ($I * 2 * (price_t - (ask_{t+5} + bid_{t+5})/2)$, where $I = 1$ for buyer-initiated trades, $I = -1$ for seller-initiated trades, and t is measured in minutes),
- relative realized spreads ($100 * I * 2 * (price_t - (ask_{t+5} + bid_{t+5})/2)/((ask_{t+5} + bid_{t+5})/2)$, where $I = 1$ for buyer-initiated trades, $I = -1$ for seller-initiated trades, and t is measured in minutes),
- quoted depth at the bid and ask,
- relative bid depth ($100 * (bid\ depth - ask\ depth)/(bid\ depth + ask\ depth)$),
- buy order imbalance ($(buy\ volume - sell\ volume)$, where trades are classified into buys and sells based on the Lee and Ready (1991) algorithm),
- relative buy order imbalance ($100 * (buy\ volume - sell\ volume)/volume$, where trades are classified into buys and sells based on the Lee and Ready (1991) algorithm),
- standard deviation of trade-to-trade returns (defined as $\log(price_\tau/price_{\tau-1})$, where τ is trade time), and
- standard deviation of midquote returns (defined as $\log((ask_\kappa + bid_\kappa)/(ask_{\kappa-1} + bid_{\kappa-1}))$, where κ represents 5-, 15-, and 30-minute intervals).

Note that quoted spread measures are time-weighted whereas effective and realized spreads are weighted by share volume.

Our daily measures are computed based on all intraday trades and quotes in the TAQ data that are time stamped between 10:00 am and 4:00 pm. The first

[17] Alexander and Peterson (2008) match Pilot and Control stocks using characteristics and analyze a final sample of 224 NYSE and 183 Nasdaq pairs during April and May 2006. Their results are qualitatively the same as ours. The SEC (2006) analyzes all stocks for the January to October 2005 period, and again the results and conclusions are qualitatively the same as those found here.

[18] We use the Lee and Ready (1991) algorithm to characterize trades as buyer- or seller-initiated.

half-hour is excluded to reduce the influence of the relatively noisy opening process.[19] Our results are qualitatively the same if market quality statistics are computed starting at 9:30 am. We merge the trade with the inside quotes in effect at the time of the trade. All statistics are computed with reference to the National best bid and offer (NBBO) quotes. The intradaily NBBO is calculated by creating a complete order book (bid and ask sides) of all quotes posted by any U.S. market center for a particular stock, cumulating volume at each price level. We also download intradaily data from all self-regulatory organizations (SROs) that report short sales for NYSE- and Nasdaq-listed securities and compute the daily number of shares sold short both in absolute terms and as a fraction of daily share volume. We call the latter relative short sales. Daily share volume comes from CRSP. We obtain monthly short interest data from NYSE and Nasdaq, and shares outstanding from CRSP. Finally, the short-sale and short interest data are merged with the CRSP and the TAQ data.

For each variable, we first report the time-series average of the daily cross-sectional means over the pre (February 1, 2005 to May 1, 2005) and the post (May 2, 2005 to July 31, 2005) period separately. To test whether returns, volatility, and market quality measures change significantly for Pilot stocks relative to Control stocks we need to take into account the fact that there is likely to be significant cross-sectional correlation, as well as time-series correlation, in the sample. To deal with both these issues, we conduct our tests as follows.[20] We first compute the daily cross-sectional averages of each variable, and then run time-series regressions to test for changes over time for each subsample using a dummy variable that takes a value of zero in the preperiod and one in the post-period. We account for potential serial dependence by computing Newey–West standard errors based on a lag length of 20 days. The estimated coefficient on the dummy is labeled "Diff" in the tables. To test whether a variable changes significantly for Pilot *relative* to Control stocks, we also use a time-series test. For each day, we compute the difference in the cross-sectional average variable between Pilot and Control stocks. We then run a time-series regression of this daily difference on an intercept and a dummy variable that takes a value of zero for the preperiod and a value of one for the postperiod. Again, we account for potential serial dependence by computing Newey–West standard errors based on a lag length of 20 days. The estimated coefficients are labeled "Diff–Diff" in the tables.

As mentioned in the hypothesis section, regulators have expressed concerns that less liquid stocks will be most adversely affected by the suspension of price tests. To address this concern, we first rank all stocks within each subsample (NYSE Pilot, NYSE Control, Nasdaq Pilot, Nasdaq Control) based on a series of characteristics: end-of-2004 market capitalization (size); share price on February 2, 2005; volatility; and turnover. We then form equally weighted quintile

[19] We follow the methodology suggested by the Memorandum from Office of Economic Analysis (SEC), *Analysis of Volatility for Stocks Switching from Nasdaq to NYSE*, December 15, 2004. We also exclude trades and quotes with special condition codes.

[20] We are grateful to our referee for suggesting this approach.

portfolios and conduct our time-series tests of differences (Diff) between the pre- and the postperiods and test for differences-in-differences (Diff–Diff) between Pilot and Controls as described above. We formally test (F-test) whether the difference-in-differences is significantly larger for the first quintile compared to the fifth quintile portfolios using seemingly unrelated regressions (SUR).

Sample characteristics by market are summarized in Table II, and Panel A reports the results for NYSE-listed stocks while Panel B reports the results for Nasdaq-listed securities. The results for Pilot stocks are in the left panels and the results for Control stocks are in the right panels. Table II shows that Pilot and Control stocks in each market are well matched based on characteristics such as price, trade frequency, trade size, and volume (see the column labeled "Pre").

There is no significant change in the average stock price for NYSE-listed or Nasdaq-listed stocks. However, we find significant changes in order flow for both samples. Average trade size and share volume decrease significantly both for NYSE-listed Pilot and Control stocks, indicating an increased level of order-splitting. Moreover, the last column shows that trade frequency increases and average trade size decreases significantly for Pilot relative to Control stocks. By contrast, there is no direct evidence of increased order-splitting for Nasdaq-listed stocks. While share volume declines for both Pilot and Control stocks due to a significantly lower trade frequency in the postperiod, there are no statistically significant changes in order flow for Nasdaq-listed Pilot *relative* to Control stocks.

Hence, we find a significant increase in order-splitting for NYSE-listed Pilot stocks relative to Control stocks, but no similar changes in order flow for Nasdaq-listed Pilot stocks relative to Controls. In the next section, we explore whether this increase in order-splitting for NYSE-listed stocks is related to changes in short-selling patterns after the Uptick rule was suspended in May 2005.

III. Does Short-Selling Activity Increase for Pilot Stocks?

Recent academic papers show that even in the presence of short-sale price tests, there is a tremendous amount of short-selling activity in U.S. equity markets (Boehmer, Jones, and Zhang (2008), and Diether, Lee, and Werner (2008)). However, the price tests may still dampen overall short-selling activity. If that is the case, we expect to see short-selling activity increase significantly for Pilot relative to Control stocks after the price tests are suspended.

We formally test for significant changes in short-selling activity in Table III. Shares sold short decrease for NYSE-listed Pilot and Control stocks between the pre- and postperiods, but the changes are not significant and there is no significant difference between the two samples. Short-sale size decreases and short-sale frequency increases significantly for NYSE-listed Pilot stocks and the last column shows that these changes are significant for NYSE-listed Pilot relative to Control stocks. For Nasdaq-listed stocks, shares sold short increases significantly for Nasdaq-listed Pilot relative to Control stocks. The frequency of short

Table II

Changes in Sample Characteristics around Reg SHO by Market

The numbers in the pre and post columns are the time-series average of the cross-sectional average of each variable for the preperiod (February 1, 2005 to May 1, 2005) and for the postperiod (May 2, 2005 to July 31, 2005). The Diff column reports the postperiod dummy variable coefficient from a time-series regression of each variable on an intercept (not reported) and the postperiod dummy. The postperiod dummy equals one from May 2, 2005 to July 31, 2005 and zero otherwise. The Diff–Diff column reports the postperiod dummy variable coefficient from a time-series regression of the difference between Pilot and Control stocks for each variable on an intercept (not reported) and the postperiod dummy. An asterisk (two asterisks) indicates 5% (1%) level of significance. We compute significance using Newey–West (1987) standard errors with 20 lags. The stock price is the volume-weighted average trade price.

		Pilot			Control			
		Pre	Post	Diff	Pre	Post	Diff	Diff–Diff
Panel A: NYSE								
Price	Dollars	34.24	34.68	0.43	34.55	34.93	0.38	0.05
Number of trades		1,472.83	1,487.22	14.39	1,422.26	1,402.21	−20.05	34.44**
Trade size	Shrs	484.14	438.63	−45.51**	493.48	457.26	−36.22**	−9.29**
Volume	1,000 shrs	1,209.86	1,121.56	−88.30**	1,187.26	1,106.95	−80.32*	−7.99
No. Obs.			448			904		
Panel B: Nasdaq								
Price	Dollars	24.32	24.28	−0.04	23.72	23.63	−0.09	0.05
Number of trades		2,470.37	2,271.60	−198.77**	2,541.29	2,323.77	−217.52**	18.75
Trade size	Shrs	238.77	237.00	−1.78	252.21	250.49	−1.71	−0.06
Volume	1,000 shrs	1,150.11	1,075.13	−74.98**	1,211.00	1,102.34	−108.66**	33.68
No. Obs.			376			757		

Table III

Short-Selling Activity

The numbers in the pre and post columns are the time-series average of the cross-sectional average of each variable for the preperiod (February 1, 2005 to May 1, 2005) and for the postperiod (May 2, 2005 to July 31, 2005). The Diff column reports the postperiod dummy variable coefficient from a time-series regression of each variable on an intercept (not reported) and the postperiod dummy. The postperiod dummy equals one from May 2, 2005 to July 31, 2005 and zero otherwise. The Diff–Diff column reports the postperiod dummy variable coefficient from a time-series regression of the difference between Pilot and Control stocks for each variable on an intercept (not reported) and the postperiod dummy. An asterisk (two asterisks) indicates 5% (1%) level of significance. We compute significance using Newey–West (1987) standard errors with 20 lags except for the short interest variable. Relative short sales is the number of short-sold shares divided by daily trading volume. Short interest is based on monthly observations and Pre (Post) for short interest denotes the cross-sectional average of each stock's time-series average during February, March, and April (May, June, and July). Diff for short interest reports the difference in the cross-sectional average of each stock's time-series average during the post- and preperiod. Diff–Diff for short interest reports the difference between Diff for Pilot and Control stocks.

		Pilot			Control			
		Pre	Post	Diff	Pre	Post	Diff	Diff–Diff
Panel A: NYSE								
Shares sold short	1,000 shrs	264.91	258.86	−6.05	262.01	248.27	−13.75	7.69
Number of short sales		444.17	542.49	98.32**	425.45	421.43	−4.02	102.34**
Average trade size	Shrs	821.78	754.01	−67.77**	834.73	789.06	−45.67**	−22.10**
Relative short sales	%	24.87	26.28	1.40*	24.61	24.20	−0.41	1.81**
Short interest	1,000 shrs	4,563.40	4,954.50	391.11**	4,936.27	5,300.49	361.19**	29.92
No. Obs.			448			904		
Panel B: Nasdaq								
Shares sold short	1,000 shrs	396.03	405.02	8.99	421.97	412.04	−9.93	18.91*
Number of short sales		1,078.16	1,081.75	3.59	1,111.35	1,063.19	−48.15	51.74*
Average trade size	Shrs	465.55	473.75	8.21	477.36	475.39	−1.97	10.18
Relative short sales	%	36.58	39.34	2.76**	36.15	37.32	1.17**	1.59**
Short interest	1,000 shrs	3,019.79	3,342.28	322.49**	3,653.97	4,009.67	355.70**	−33.21
No. Obs.			376			757		

sales increases significantly for Nasdaq-listed Pilot relative to Control stocks, but there is no significant change in short-sale size. Hence, as predicted in the hypothesis section, we find that short-sellers in NYSE-listed stocks engage more heavily in order-splitting when trading without the Uptick rule. Order-splitting helps short-sellers price discriminate among liquidity providers and avoid order anticipators. By contrast, there is no evidence of increased order-splitting by short-sellers in Nasdaq-listed stocks after the suspension of the bid price test.

Short-sale volume is highly positively correlated to overall trading volume in our sample, both in the cross-section and in the time series. We find that share volume on average declines between the pre- and the postperiods (Table II), so even though short-sale volume does not increase significantly for NYSE-listed stocks, it may be rising significantly relative to overall trading activity. To test for changes in normalized short-selling activity, we compute relative short sales defined as short-sale volume divided by total share volume. Relative short sales increase significantly for NYSE-listed Pilot stocks and decrease (insignificantly) for NYSE-listed Control stocks. The last column shows that relative short sales increase significantly by 1.81 percentage points for NYSE-listed Pilot stocks relative to Control stocks. For Nasdaq-listed stocks, there is a significant increase in relative short sales for both Pilot and Control stocks and relative short sales increase significantly by 1.59 percentage points for Nasdaq-listed Pilot stocks relative to Control stocks.

A commonly used measure of short-selling activity is short interest, which is the stock of shares sold short as reported by the exchanges around the middle of each month. Since these numbers are monthly, we only have three observations per stock in the preperiod and three observations per stock in the postperiod. Moreover, these monthly observations are unlikely to be independent. Hence, we cannot use our time-series methodology. Instead, we compute the average short interest for each stock in the pre- and the postperiod, and run a simple (cross-sectional) pair-wise t-test of changes in the mean. For the difference-in-difference test, we first compute the post–pre short interest variable for each stock, and then run a standard t-test for differences in group means. Short interest increases significantly for NYSE-listed Pilot and Control stocks. The increase is larger for Pilot stocks than for Control stocks (391,110 compared to 361,190 shares). However, we cannot reject the hypothesis that these changes are the same for Pilot and Control stocks. For Nasdaq-listed Pilot and Control stocks, short interest also increases significantly. The increase based on short interest is actually larger for Control stocks (355,700 shares) than for Pilot stocks (322,490 shares). Again, we are unable to reject the hypothesis that the changes are the same for both Pilot and Control stocks.

We note that short-sale volume relative to share volume for both the NYSE and Nasdaq securities in our sample is surprisingly high: 24.9% (24.6%) for NYSE-listed Pilot (Control) stocks and 36.6% (36.2%) for Nasdaq-listed Pilot (Control) stocks in the preperiod. The main reason for this is that the Russell 3000 stocks are larger, more liquid stocks, with higher institutional ownership than the average stock on the NYSE and Nasdaq. The previous literature (see

D'Avolio (2002) and Cohen, Diether, and Malloy (2007)) predicts that short-selling will be less costly for these securities than for the average stock in each market, and hence it should not be surprising that we find a higher level of short-selling activity. In addition, Boehmer, Jones, and Zhang (2008) use NYSE SuperDOT data to capture short-selling activity, that is, they do not capture NYSE floor trading activity, nor do they capture short-selling in NYSE-listed stocks away from the NYSE that is on regional exchanges, third markets, and Electronic Communication Networks (ECNs). Hence, it is quite likely that their numbers underestimate the overall short-selling activity substantially.[21] Finally, short-selling has been trending upward over time as more hedge funds and other players with long–short strategies have entered the market.

IV. Daily Returns and Volatility

If price tests curtail short-selling activity, theoretical models by Miller (1977), Harrison and Kreps (1978), Morris (1996), Scheinkman and Xiong (2003), and Duffie, Gârleanu, and Pedersen (2002) predict that stock prices may exceed fundamental value. If that is the case, suspending the price tests should cause stock prices for Pilot stocks to fall. The actual price reaction could take place at the announcement of the Pilot Program (July 28, 2004) or following the effective (event) date of the suspension (May 2, 2005). We examine both possibilities in Table IV.

We look at average daily returns from day $t-2$ to day $t+2$ around both the announcement and the effective dates of the Pilot Program. Therefore, we run the following pooled regression of daily returns (in percent) on announcement window and event window dummy variables and pilot stock interactions by exchange using the data from July 26, 2004 to May 4, 2005

$$\begin{aligned} R_{it} = a + b_1 * ANN + b_2 * ANN * Pilot + b_3 * EVENT \\ + b_4 * EVENT * Pilot + \varepsilon_{it}, \end{aligned} \tag{1}$$

where *ANN* (*EVENT*) is a dummy variable that equals one if the date is between July 26, 2004 and July 30, 2004 (April 28, 2005 and May 4, 2005), inclusive, and zero otherwise, and *Pilot* is a dummy variable that equals one if a given stock is a Pilot stock, and zero otherwise. The regressions cluster standard errors by both day and stock to control for cross-correlation and serial correlation (Thompson (2006)). In Panel A (Panel B), the Pilot column reports average returns for pilot stocks during the announcement (event) window, $a+b_1+b_2$ ($a+b_3+b_4$), the Control column reports the same measures for controls stocks, $a+b_1$ ($a+b_3$), and the Diff column reports the difference between the two, b_2 (b_4). Clearly, there is no evidence of significant average returns for NYSE-listed Pilot or Control stocks around either the announcement date or the event date. Moreover, the column labeled Diff shows that there is no significant difference in average returns between Pilot and Control stocks around either the announcement date or the event date. The results are very similar for Nasdaq stocks.

[21] Diether, Lee, and Werner (2008) show that for the sample of all NYSE-listed common stocks, 24% of consolidated share volume is short sales during January 2 to December 31, 2005.

Table IV

Average Returns around the Reg SHO Announcement and Effective Dates

We run the following pooled regression of daily returns (in percentage) on announcement window and event window dummy variables and Pilot stock interactions by exchange using the data from July 26, 2004 to May 4, 2005: $R_{i,t} = a + b_1 \cdot ANN + b_2 \cdot ANN \cdot Pilot + b_3 \cdot EVENT + b_4 \cdot EVENT \cdot Pilot + \varepsilon_{i,t}$. The dummy variable, *ANN* (*EVENT*) equals one if the date is in between July 26, 2004 and July 30, 2004 (April 28, 2005 and May 4, 2005), inclusive, and zero otherwise and *Pilot* is a dummy variable that equals one if a given stock is Pilot stock, and zero otherwise. The regressions cluster standard errors by both day and stock to control for both cross-correlation and serial correlation (Thompson (2006)). In Panel A (Panel B), the Pilot column reports average returns for pilot stocks during the announcement (event) window, $a+b_1+b_2$ ($a+b_3+b_4$); the Control column reports the same measures for control stocks, $a+b_1$ ($a+b_3$); and the Diff column reports the difference between the two, b_2 (b_4).

	Panel A: Announcement Date (July 28, 2004)			Panel B: Event Date (May 2, 2005)		
	Pilot	Control	Diff	Pilot	Control	Diff
NYSE						
Average daily return ($t-2, t+2$)	0.332	0.281	0.051	0.273	0.286	−0.013
t -statistic	0.98	0.85	1.00	0.56	0.59	0.44
NASDAQ						
Average daily return ($t-2, t+2$)	0.523	0.563	−0.040	0.357	0.383	−0.026
t -statistic	0.79	0.82	−0.67	0.60	0.68	0.55

Price tests were developed to prevent short sales from executing in declining markets. In other words, they were intended to limit downside volatility. If the price tests are effective, they should reduce volatility. Therefore, we expect that Pilot stocks will experience a significant increase in volatility relative to Control stocks after the price tests are suspended. We examine this question in Table V. For completeness, we compute several daily volatility measures based on both TAQ and CRSP data.

The intraday price range declines significantly for NYSE-listed stocks based on both CRSP trade price and TAQ quote data. By contrast, we detect no significant changes in volatility computed based on close-to-close or open-to-close returns for NYSE-listed stocks. We also compute positive and negative semivariances (see Markowitz (1959)). The only significant change is a *decrease* in negative semivariance for NYSE-listed Pilot stocks. However, there are no statistically significant changes in any of these daily volatility measures for NYSE-listed Pilot relative to Control stocks. The results for Nasdaq-listed stocks (Panel B) are very similar to the ones for NYSE-listed stocks with one exception: the reduction in negative semivariance is significant both for Nasdaq-listed Pilot and Control stocks. Again, the last column shows that there are no statistically significant changes in any of these daily volatility measures for Nasdaq-listed Pilot relative to Control stocks.

Table V

Changes in Daily Volatility Measures around Reg SHO by Market

The numbers in the pre and post columns are the time-series average of the cross-sectional average of each variable for the preperiod (February 1, 2005 to May 1, 2005) and for the postperiod (May 2, 2005 to July 31, 2005). The Diff column reports the postperiod dummy variable coefficient from a time-series regression of each variable on an intercept (not reported) and the postperiod dummy. The postperiod dummy equals one from May 2, 2005 to July 31, 2005 and zero otherwise. The Diff–Diff column reports the postperiod dummy variable coefficient from a time-series regression of the difference between Pilot and Control stocks for each variable on an intercept (not reported) and the postperiod dummy. An asterisk (two asterisks) indicates 5% (1%) level of significance. We compute significance using Newey–West (1987) standard errors with 20 lags. Daily quote range is the difference between the highest quote and the lowest quote on a given day divided by the highest quote. Close–close (open–close) volatility is the square of daily returns based on closing prices (closing to next day opening price). Daily traded price range is similarly computed with daily quote range but based on the CRSP daily traded price. Positive (up) semivariance is calculated as $(1/N)\Sigma\max[0, \log(x_t/x_{t-k})]^2$ and the negative (down) semivariance is calculated as $(1/N)\Sigma\min[0, \log(x_t/x_{t-k})]^2$ where N is the number of observations, and x_t is a daily closing price from CRSP.

		Pilot			Control			
		Pre	Post	Diff	Pre	Post	Diff	Diff–Diff
			Panel A: NYSE					
I. TAQ Measures								
Daily quote range	(High − low)/high	4.9018	4.3875	−0.5143*	4.7811	4.2395	−0.5416*	0.0273
Volatility (close–close)	Squared absolute return	0.0411	0.0394	−0.0017	0.0418	0.0411	−0.0007	−0.0010
Volatility (open–close)	Squared absolute return	0.0387	0.0356	−0.0031	0.0382	0.0364	−0.0018	−0.0014
II. CRSP Measures								
Daily traded price range	(High − low)/high	2.3297	2.1562	−0.1735*	2.3059	2.1222	−0.1837*	0.0102
Volatility (close–close)	Squared absolute return	0.0363	0.0313	−0.0050	0.0376	0.0342	−0.0034	−0.0016
Semivariance	$P_t - P_t{-}1 > 0$	0.0181	0.0191	0.0011	0.0181	0.0218	0.0037	−0.0026
Semivariance	$P_t - P_t{-}1 < 0$	0.0182	0.0122	−0.0061*	0.0195	0.0124	−0.0070	0.0010
No. Obs.			448			904		

(*continued*)

Table V—*Continued*

		Pilot			Control			
		Pre	Post	Diff	Pre	Post	Diff	Diff–Diff
		Panel B: NASDAQ						
I. TAQ Measures								
Daily quote range	(High − low)/high	3.5355	3.3061	−0.2294*	3.6228	3.3687	−0.2542*	0.0248
Volatility (close–close)	Squared absolute return	0.0740	0.0683	−0.0057	0.0792	0.0675	−0.0117	0.0059
Volatility (open–close)	Squared absolute return	0.0497	0.0461	−0.0035	0.0521	0.0496	−0.0025	−0.0010
II. CRSP Measures								
Daily traded price range	(High − low)/high	3.2881	3.0520	−0.2361*	3.3670	3.1013	−0.2657**	0.0295
Volatility (close–close)	Squared absolute return	0.0675	0.0653	−0.0022	0.0715	0.0613	−0.0102	0.0080
Semivariance	$P_t - P_t{-}1 > 0$	0.0338	0.0403	0.0065	0.0363	0.0396	0.0033	0.0031
Semivariance	$P_t - P_t{-}1 < 0$	0.0337	0.0250	−0.0087*	0.0352	0.0217	−0.0135**	0.0049
No. Obs.			376			757		

We repeat the daily volatility analysis for quintile portfolios of stocks sorted by size, price, volatility, and turnover to discern whether small-capitalization and less liquid stocks are more adversely affected by the suspension of the price tests. The results (not reported) for quintile portfolios for NYSE-listed stocks are somewhat mixed. Small-capitalization Pilot stocks experience significantly larger increases in volatility relative to Control stocks than high-capitalization Pilot stocks based on six of the seven measures of volatility. For example, the difference-in-differences for the daily CRSP-based trade range is 0.118 for small capitalization compared to −0.051 for large-capitalization stocks (F-value = 22.5). By contrast, only the price range measures suggests that low-priced Pilot stocks experience significantly larger relative increases in volatility than high-priced Pilot stocks respectively. The difference-in-differences for the daily CRSP-based trade range is 0.056 for low price compared to −0.274 for high-price stocks (F-value = 6.62). For quintile portfolios sorted by volatility, three (TAQ quote range, CRSP trade price range, and negative semivariance) out of our seven daily volatility measures point to a significantly larger relative increase in volatility for high-volatility Pilot stocks compared to low-volatility Pilot stocks. The evidence is even weaker based on quintile portfolios sorted by turnover.

For Nasdaq-listed stocks, we only reject equality for the difference-in-difference across quintile portfolios in one single case (out of 28!): The relative increase in negative semivariance is larger for high-volatility stocks compared to low-volatility stocks. The difference-in-differences for the negative semivariance is 0.013 for high-volatility stocks compared to −0.011 for low-volatility stocks (F-value = 6.59).

Thus, the suspension of price tests seems to have had a relatively limited impact on overall daily returns and volatility levels. To the extent that we see any evidence that the suspension of NYSE's Uptick rule is associated with an increase in daily volatility measures, it is concentrated primarily in small-capitalization stocks, and to a lesser extent in stocks with low price and/or high volatility. This is not a surprising result because, as we illustrate in our example with I(lliquid) and L(iquid) stocks in Section II, we expect a larger effect of price tests on small-capitalization stocks. By contrast, the evidence does not suggest that the suspension of Nasdaq's bid price test is associated with daily volatility increase that is concentrated in small-capitalization, low-price, high-volatility, or low-turnover Nasdaq-listed stocks. Our results on daily returns and volatility corroborate the findings of two subsequent studies that use different samples and methodologies to study the Reg SHO Pilot. Alexander and Peterson (2008) analyze a smaller matched sample of Pilot and Control stocks for April and May 2005 and SEC (2006) uses a virtually complete sample of Pilot and Control stocks for January through October 2005.

V. Market Quality

While we do not detect any significant changes in daily returns and overall volatility around the Reg SHO Pilot, the suspension of price tests may affect higher frequency measures of market quality. We now turn to testing whether the suspension of price tests for Pilot stocks is associated with significant changes in measures of market quality.

Formal tests for changes in market quality for NYSE-listed (Panel A) and Nasdaq-listed (Panel B) Pilot and Control stocks around the suspension of price tests are reported in Table VI. First, note that Pilot and Control stocks in each market are well matched (see the columns labeled "Pre"). Second, note the quote and order flow asymmetries that we hypothesized would result from the Uptick rule (Section I) are clearly evident for NYSE-listed stocks in the preperiod. For example, the average quoted depth on the bid is 918.2 shares compared to an average quoted depth on the offer of 1214.7 shares for NYSE-listed Pilot stocks in the preperiod. The relative bid depth for NYSE-listed Pilot stocks is −11.41%. The order flow asymmetries are equally striking, with an average buy imbalance relative to volume of 9.58% for NYSE-listed Pilot stocks in the preperiod. These asymmetries are very similar for NYSE-listed Control stocks in the preperiod. By comparison, as predicted, the asymmetries for Nasdaq-listed Pilot stocks are smaller: Nasdaq-listed Pilot stocks actually have a *positive* average relative bid depth of 2.08% and a *negative* buy imbalance relative to volume of −1.91% in the preperiod, and the asymmetries for Nasdaq-listed Control stocks are of similar magnitude. In order for us to show that these asymmetries have something to do with the short-sale-related price tests, however, we also need to show that these asymmetries disappear for Pilot stocks but not for Control stocks after the suspension of the price tests.

Panel A of Table VI shows that the relative bid depth increases significantly for NYSE-listed Pilot stocks from −11.41% to 0.11%. By contrast, relative bid depth hardly changes at all for Control stocks. In other words, the asymmetry in the quote depths disappears for Pilot stocks. Similarly, as hypothesized, the buy imbalance relative to volume declines significantly for Pilot stocks from 9.58% to 1.34%. By contrast, the buy imbalance relative to volume increases significantly for Control stocks. The last column shows that the changes in quote and order flow asymmetries we observe for Pilot stocks are significantly different from those we observe for Control stocks. Hence, the evidence supports our hypothesis that the Uptick rule produces significant biases in how short-sale orders are represented in the quotes and how short sales execute relative to the midquote.

As mentioned in the hypothesis section, Nasdaq's bid price test is less likely to significantly constrain the order submission strategies of short-sellers and we predict that the effect of suspending the bid price test on quoted depth and order flow will be smaller as a result. Panel A of Table VI shows that there is no significant change in the relative bid depth for either Nasdaq-listed Pilot or Control stocks. However, we do find that the relative buy imbalance increases from −1.91 to 0.49 for Pilot stocks and from −1.83 to 1.17 for Control stocks between periods. Note that the changes, while in both cases statistically significant, are economically smaller in magnitude than for NYSE Pilot stocks. Moreover, both Pilot and Control stocks actually experience an *increase* in the relative buy imbalance as opposed to the anticipated decrease that we argued

Table VI

Changes in Market Quality Measures around Reg SHO by Market

The numbers in the pre and post columns are the time-series average of the cross-sectional average of each variable for the preperiod (February 1, 2005 to May 1, 2005) and for the postperiod (May 2, 2005 to July 31, 2005). The Diff column reports the postperiod dummy variable coefficient from a time-series regression of each variable on an intercept (not reported) and the postperiod dummy. The postperiod dummy equals one from May 2, 2005 to July 31, 2005 and zero otherwise. The Diff–Diff column reports the postperiod dummy variable coefficient from a time-series regression of the difference between Pilot and Control stocks for each variable on an intercept (not reported) and the postperiod dummy. An asterisk (two asterisks) indicates 5% (1%) level of significance. We compute significance using Newey–West (1987) standard errors with 20 lags. Quoted depth is cumulative depth at the NBBO. Relative bid depth is defined as $100 * (\textit{bid depth} - \textit{ask depth})/(\textit{ask depth} + \textit{bid depth})$. Buy imbalance is daily buys minus sells, where buys and sells are defined as in Lee and Ready (1991). Quoted spread in cents [bps] is defined as $(ask - bid)$ $[(ask - bid)/midquote]$; it is based on quote updates (a change in bid, ask, or quoted volume). Effective spread in cents [bps] is defined as $2(price_t - midquote_t)$ $[2(price - midquote_t)/midquote_t]$ for buys and $2(midquote_t - price_t)[2(midquote_t - price_t)/midquote_t]$ for sells, where trades are matched to contemporaneous quotes (same second, t). Realized spread in cents ([bps]) is defined as $2(price_t - midquote_{t+5})$ $[2(price_t - midquote_{t+5})/midquote_{t+5}]$ for buys and $2(midquote_{t+5} - price_t)$ $[2(midquote_t - price_t)/midquote_{t+5}]$ for sells, where trades are matched to quotes in force 5 minutes following the trade. Time-weighted statistics weigh each observation by the number of seconds that it was in force. Volume-weighted statistics weigh each observation by the number of shares in the trade.

			Pilot			Control			
	Weight	Unit	Pre	Post	Diff	Pre	Post	Diff	Diff–Diff
				Panel A: Asymmetries					
				NYSE (Pilot: 448, Control: 904)					
Quoted bid depth	Time	100 shrs	9.182	8.655	−0.527**	9.599	9.480	−0.118	−0.409*
Quoted ask depth	Time	100 shrs	12.147	8.786	−3.361**	12.778	12.844	0.066	−3.427**
Relative bid depth	Time	%	−11.410	0.113	11.523**	−11.254	−11.925	−0.672	12.194**
Buy imbalance		1,000 shrs	98.196	16.725	−81.471**	101.324	101.357	0.033	−81.505**
Buy imbalance/volume		%	9.576	1.344	−8.233**	9.569	10.858	1.289**	−9.522**
				NASDAQ (Pilot: 376, Control: 757)					
Quoted bid depth	Time	100 shrs	5.969	8.995	3.026**	8.821	10.612	1.791*	1.234
Quoted ask depth	Time	100 shrs	6.051	8.964	2.913**	9.041	10.623	1.582	1.330
Relative bid depth	Time	%	2.084	1.346	−0.738	1.882	1.186	−0.696	−0.042
Buy imbalance		1,000 shrs	−8.890	2.902	11.793**	−1.247	8.091	9.339**	2.454
Buy imbalance/volume		%	−1.910	0.493	2.403**	−1.827	1.172	3.000**	−0.597**

(*continued*)

Table VI—*Continued*

	Weight	Unit	Pilot Pre	Pilot Post	Pilot Diff	Control Pre	Control Post	Control Diff	Diff–Diff
Panel B: Spreads									
NYSE (Pilot: 448, Control: 904)									
Quoted spread	Time	Cents	2.967	3.059	0.091	3.183	3.087	−0.095	0.187**
	Time	Bps	11.191	11.729	0.538*	11.474	11.101	−0.373	0.910**
Effective spread	Volume	Cents	2.649	2.658	0.009	2.770	2.618	−0.153**	0.161**
	Volume	Bps	10.141	10.300	0.159	10.175	9.636	−0.539**	0.698**
Realized spread	Volume	Cents	2.262	2.301	0.038	2.397	2.289	−0.108*	0.146**
	Volume	Bps	8.678	8.966	0.287	8.804	8.425	−0.379*	0.666**
NASDAQ (Pilot: 376, Control: 757)									
Quoted spread	Time	Cents	4.643	4.650	0.007	4.621	4.515	−0.106	0.113*
	Time	Bps	20.526	20.681	0.156	22.261	21.792	−0.469	0.625**
Effective spread	Volume	Cents	4.096	3.947	−0.149	4.072	3.878	−0.193	0.045
	Volume	Bps	18.764	18.175	−0.590	20.414	19.433	−0.980**	0.391*
Realized spread	Volume	Cents	3.704	3.558	−0.146	3.664	3.484	−0.180	0.034
	Volume	Bps	16.792	16.224	−0.568	18.234	17.318	−0.916**	0.348**

would be associated with an elimination of "involuntary" passive short-sale orders. The increase in relative buy imbalance is significantly smaller for Pilot relative to Control stocks and the magnitude of the difference-in-differences is small (−0.60) compared to the situation for NYSE-listed stocks (−9.52).

Recall that we conjecture in Section I that the price tests, particularly the Uptick rule, might not only result in quote and order flow asymmetries but also in artificially low spreads and dampened volatility. Consequently, we hypothesize that quoted and effective spreads will widen for NYSE Pilot compared to Control stocks in the postperiod as the Uptick rule is eliminated. In Panel B of Table VI we find a significant increase in NYSE basis point quoted spreads between the pre- and the postperiods for Pilot stocks, but there is no significant change in other spread measures. By contrast, Control stocks experience a significant decline in effective and realized spreads. More importantly, the last column shows that all our spread measures increase significantly for NYSE-listed Pilot relative to Control stocks after the suspension of the Uptick Rule. However, the magnitudes of the increases in spreads are relatively minor. For example, the increase in quoted spreads is 0.187 cents (0.910 basis points) and the increase in effective spreads is 0.161 cents (0.698 basis points).

As we explain in the hypothesis section, only to the extent that Nasdaq short-sellers are forced to use passive order submission strategies as a result of the bid price test do we expect spreads to be narrower and volatility dampened in the preperiod. The lack of economically significant changes in the quote and order flow asymmetries for Nasdaq stocks in Panel A suggests that the effect of the bid price test on spreads and volatility is smaller for Nasdaq-listed stocks. Consequently, we expect any effects of the suspension of the price test to be more limited. Indeed, the results in Table VI show that spreads for Nasdaq-listed Pilot stocks do not change significantly. By contrast, basis point effective and realized spreads decline significantly for Control stocks between periods. Moreover, the last column shows that quoted cent spreads and all spreads measured in basis points for Pilot stocks increase significantly relative to Control stocks also for Nasdaq-listed stocks. As predicted, however, the magnitude of the increase in spreads is smaller than for NYSE-listed stocks. The increase in quoted spreads is 0.113 cents (0.625 basis points) and the increase in effective spreads is 0.045 cents (0.391 basis points).

To address the concern of regulators that less liquid stocks are more likely to be adversely affected by the suspension of price tests, we proceed to investigate the effect of the suspension of price tests on market quality for portfolios grouped by: size, price, volatility, and turnover. Table VII reports the results. Quote and order flow asymmetries disappear and spreads widen for NYSE-listed Pilot relative to Control stocks for virtually all the characteristic portfolios. Thus, the effect of the Uptick rule on quote and order flow asymmetries and spreads is pervasive across stock characteristics.

Moreover, we generally reject that the difference-in-differences in market quality are the same for the first- and fifth-quintile NYSE size portfolios based on our F-tests (SUR analysis). With the exception of the relative bid depth and cent effective spreads, the effects of suspending the Uptick rule on market

Table VII

Changes in Market Quality Measures around Reg SHO by Market and Portfolios

Stocks are sorted into quintile portfolios based on the market capitalization at the end of year 2004, price at the beginning of sample period, average volatility over the sample period, or average turnover over the sample period. Relative bid depth is defined as 100 ∗ (bid depth − ask depth)/(ask depth + bid depth). Buy imbalance is daily buys minus sells, where buys and sells are defined as in Lee and Ready (1991). Quoted spread in cents [bps] is defined as (ask − bid) [(ask −bid)/midquote]; it is based on quote updates (a change in bid, ask, or quoted volume). Effective spread in cents [bps] is defined as $2(price_t - midquote_t)$ $[2(price_t - midquote_t)/midquote_t]$ for buys and $2(midquote_t - price_t)$ $[2(midquote_t - price_t)/midquote_t]$ for sells, where trades are matched to contemporaneous quotes (same second, t). Realized spread in cents [bps] is defined as $2(price_t - midquote_{t+5})$ $[2(price_t - midquote_{t+5})/midquote_{t+5}]$ for buys and $2(midquote_{t+5} - price_t)$ $[2(midquote_t - price_t)/midquote_{t+5}]$ for sells, where trades are matched to quotes in force 5 minutes following the trade. Time-weighted statistics weigh each observation by the number of seconds that it was in force. Volume-weighted statistics weigh each observation by the number of shares in the trade. In the column "Diff–Diff"—"small/low" ("large/high") we report the postperiod dummy variable coefficient from the regression of differences of each variable between Pilot and Control stock portfolios in the lowest (highest) quintile on intercept (not reported) and the postperiod dummy, where the postperiod dummy equals one from May 2, 2005 to July 31, 2005 and zero otherwise. Here, F reports the SUR test of equality between the coefficients from the lowest and highest quintile portfolios. An asterisk (two asterisks) indicates 5% (1%) level of significance. We compute significance using Newey–West (1987) standard errors with 20 lags.

			Size Portfolios			Price Portfolios			Volatility Portfolios			Turnover Portfolios		
	Weight	Units	Small Diff–Diff	Large Diff–Diff	*F*	Low Diff–Diff	High Diff–Diff	*F*	Low Diff–Diff	High Diff–Diff	*F*	Low Diff–Diff	High Diff–Diff	*F*
Panel A: Asymmetries														
NYSE														
Relative bid depth	Time	%	9.92**	13.68**	19.22**	12.72**	12.57**	0.04	13.37**	10.63**	10.23**	10.87**	15.12**	29.35**
Buy imbalance/volume		%	−10.34**	−8.56**	6.97**	−9.59**	−8.98**	1.04	−8.38**	−10.24**	6.96**	−10.20**	−10.87**	1.18
NASDAQ														
Relative bid depth	Time	%	−1.81*	0.96	17.92**	−0.37	0.92	3.24	0.10	1.24	2.82	2.00*	−0.76**	14.09**
Buy imbalance/volume		%	−0.70	−1.04**	0.23	−0.66	−1.46*	1.68	−1.05**	0.53	4.12*	−0.88	−0.90*	0.00

(*continued*)

Table VII—*Continued*

	Weight	Units	Size Portfolios Small Diff–Diff	Size Portfolios Large Diff–Diff	Size Portfolios F	Price Portfolios Low Diff–Diff	Price Portfolios High Diff–Diff	Price Portfolios F	Volatility Portfolios Low Diff–Diff	Volatility Portfolios High Diff–Diff	Volatility Portfolios F	Turnover Portfolios Low Diff–Diff	Turnover Portfolios High Diff–Diff	Turnover Portfolios F
Panel B: Spreads														
NYSE														
Quoted spread	Time	Cents	0.28**	0.12**	14.00**	0.26**	0.23**	1.20	0.14**	0.25**	4.21*	0.40**	0.20**	18.52**
	Time	Bps	2.98**	0.12**	272.71**	2.68**	0.58**	237.62**	0.19**	2.96**	218.19**	1.88**	1.15**	20.35**
Effective spread	Volume	Cents	0.19**	0.15**	0.74	0.21**	0.21**	0.02	0.16**	0.16*	0.00	0.36**	0.22**	8.68**
	Volume	Bps	2.07**	0.21**	54.12**	1.93**	0.46**	30.90**	0.22**	1.95**	38.95**	1.35**	1.21**	0.35
Realized spread	Volume	Cents	0.21**	0.09**	13.15**	0.18**	0.19**	0.51	0.12**	0.18**	2.55	0.30**	0.17**	14.25**
	Volume	Bps	2.14**	0.08**	182.15**	1.85**	0.44**	125.78**	0.14**	2.08**	133.67**	1.32**	0.96**	4.58*
NASDAQ														
Quoted spread	Time	Cents	0.24	0.07**	1.97	0.02	−0.01	0.08	0.13**	0.18	0.15	0.12	0.01	0.67
	Time	Bps	1.70	0.23**	14.49**	1.02**	0.07	9.68**	0.37**	1.46	5.88*	1.15	0.45**	2.61
Effective spread	Volume	Cents	0.08	0.08**	0.00	0.00	−0.04	0.15	0.11**	−0.19	4.62*	−0.18	0.03	2.51
	Volume	Bps	1.21	0.13	4.42*	0.71	0.01	2.83	0.21**	0.42	0.13	0.23	0.59**	0.54
Realized spread	Volume	Cents	0.02	0.04*	0.05	0.01	−0.10	1.68	0.08**	−0.11	2.99	−0.11	0.01	1.13
	Volume	Bps	0.86	0.15**	5.01*	0.84**	−0.12	17.42**	0.22**	0.44	0.40	0.49	0.47**	0.01

quality are larger for small-capitalization stocks. Since small-capitalization stocks also have wider spreads, this is what we expect to observe based on our example of I(lliquid) and L(iquid) stocks in Section II. The results are weaker in the case of quintile portfolios sorted by price; only for basis point spreads do we find that low-price Pilot stocks are more significantly affected by the suspension of the Uptick rule. The F-tests also suggest that stocks in the high-volatility and low-turnover portfolios experience significantly larger difference-in-differences in most spread measures, but the evidence on quote and order flow asymmetries is more mixed.

Table VII also shows that the effect of suspending the Nasdaq bid price test on market quality is less pervasive. While the magnitudes of the difference-in-differences in spreads are generally larger for small-capitalization, low-price, high-volatility, and low-turnover stocks, they are almost never statistically significant. By contrast, large-capitalization, low-volatility, and high-turnover (that is highly liquid) Nasdaq-listed Pilot stocks tend to experience a significant reduction in buy imbalance and a widening of spreads relative to Control stocks. These observations should be kept in mind when interpreting the results from the SUR analysis.

According to the F-test for Nasdaq-listed stocks reported in the last column of Table VII, we reject the hypothesis that the difference-in-differences is the same across characteristic quintile portfolios in a few cases. For example, based on the SUR analysis, we reject the hypothesis that basis point quoted spreads are the same for small-capitalization and large-capitalization Nasdaq stocks. After comparing the difference-in-differences for small capitalization stocks (1.70 basis points) and large-capitalization stocks (0.23 basis points) this does not come as a surprise. However, the difference-in-differences for small-capitalization stocks is not significantly different from zero so these results should be interpreted with caution. The evidence suggesting that low-price stocks experience a significantly larger widening of basis point spreads than high-price stocks after the suspension of the bid price test is not subject to the same caveat.

In sum, there is only weak evidence suggesting that suspending the bid price test disproportionately affects spreads for small, less liquid Nasdaq-listed stocks. However, as expected based on our example of I(lliquid) and L(iquid) stocks, small-capitalization, low-price, high-volatility, and low-turnover NYSE-listed stocks experience larger relative increases in spreads, although the magnitudes are quite small, ranging from two to three basis points.

VI. Intraday Volatility

When the Uptick rule was adopted by the SEC in 1938, the main concern was not that short-sellers would affect the asymmetry of trading, and perhaps not even that they would affect spreads. Instead, the main concern on the part of regulators was that unfettered short-selling would produce significant volatility. In particular, the concern was that short-sellers would jump in when there was downside momentum, thus exacerbating downward pressure in the market. We note that there is no empirical support for such behavior.

Indeed, Diether, Lee, and Werner (2008) find that short-sellers are on average contrarian, that is, they sell short following positive momentum. Hence, instead of exacerbating volatility, they have a tendency to reduce volatility. Consistent with this conjecture, we find no evidence of a significant increase in daily volatility measures (Table V).

Nevertheless, both the SEC and market participants have expressed concerns about the potential detrimental effect of suspending price tests on volatility, particularly on downside volatility. It is therefore important to provide a comprehensive picture of volatility during the sample period. Hence, we complement the daily volatility results with various measures of intraday volatility in this section. We start by computing the standard deviation of trade price returns. Since price tests were put in place to reduce the ability of short-sellers to sell in a declining market, we also calculate asymmetric semivariances defined as suggested by Markowitz (1959).[22] These measures should help us detect any asymmetric effects of the suspension of price tests on volatility, for example, an increase in downside volatility.

Trade-based volatility measures are quite noisy due to bid-ask bounce, and this problem is even worse for these very high-frequency measures. It is possible that trade-based volatility measures fail to detect changes in short-term (downside) volatility because trade prices and quotes tend to move in small increments. This is particularly true on the NYSE, which has a formal price continuity rule (NYSE (Rule 104.10(3), 1999)) that limits the NYSE specialists' ability to move quoted prices in discrete steps larger than the tick size. To capture potential changes in volatility that are not detected by these high-frequency measures, but could nevertheless be economically important, we complement the analysis with midquote returns based on fixed (5-, 15-, and 30-minute) time intervals during the day.

Table VIII reports the results for trade-based measures of volatility in Panel A and midquote-based volatility in Panel B. For NYSE-listed stocks, trade-based volatility measures increase for Pilot stocks, but decrease (insignificantly) for Control stocks. The final column shows that the changes are significantly larger for Pilot than for Control stocks. However, since both the positive and the negative semivariances increase significantly for NYSE-listed Pilot relative to Control stocks, we infer that the driving force is not an increase in downside volatility. Trade-based volatility measures decrease for Nasdaq-listed stocks regardless of whether the bid price test is enforced, but the difference is only significant for Control stocks (overall and downside volatility). Moreover, the last column shows that there is no significant difference in changes in trade-based volatility for Pilot stocks relative to Control stocks. In other words, there is no evidence that removing the bid price test contributes to an increase in downside volatility.

The results in Table VIII, Panel B show that there is no significant change in 5- and 15-minute midquote volatility for NYSE-listed Pilot or Control stocks. Nevertheless, the last column suggests that midquote volatility measures

[22] See Bond (1998) for a discussion on how to capture asymmetry in financial market data.

Table VIII

Changes in Trade-Based and Intraday Volatility Measures around Reg SHO by Market

The numbers in the pre and post columns are the time-series average of the cross-sectional average of each variable for the preperiod (February 1, 2005 to May 1, 2005) and for the postperiod (May 2, 2005 to July 31, 2005). The Diff column reports the postperiod dummy variable coefficient from a time-series regression of each variable on an intercept (not reported) and the postperiod dummy. The postperiod dummy equals one from May 2, 2005 to July 31, 2005 and zero otherwise. The Diff–Diff column reports the postperiod dummy variable coefficient from a time-series regression of the difference between Pilot and Control stocks for each variable on an intercept (not reported) and the postperiod dummy. An asterisk (two asterisks) indicates 5% (1%) level of significance. We compute significance using Newey–West (1987) standard errors with 20 lags. Volatility is based on trade-to-trade price. Positive (up) semivariance is calculated as $(1/N)\Sigma\ \max[0, \log(x_t/x_{t-k})]^2$ and the negative (down) semivariance is calculated as $(1/N)\Sigma\ \min[0, \log(x_t/x_{t-k})]^2$, where N is the number of observations, and x_t is a daily closing price from CRSP. Volatility (k-min return) is based on midquotes with k-minute ($k = 5, 10, 15$) intervals. The numbers for trade-based volatility are multiplied by 100.

		Pilot			Control			
		Pre	Post	Diff	Pre	Post	Diff	Diff–Diff
Panel A: NYSE (Pilot: 448, Control: 904)								
I. Trade-Based								
Volatility	Trade-to-trade	0.6600	0.7564	0.0963**	0.6278	0.5965	−0.0313	0.1276**
Semivariance	$P_t - P_t{-}1 > 0$	0.2640	0.3142	0.0502**	0.2503	0.2394	−0.0109	0.0611**
Semivariance	$P_t - P_t{-}1 < 0$	0.2836	0.3172	0.0335*	0.2734	0.2529	−0.0205	0.0541**
II. Midquote-Based								
Volatility (5-min)	Squared absolute return	0.0301	0.0273	−0.0027	0.0301	0.0252	−0.0049	0.0022**
Volatility (15-min)	Squared absolute return	0.0865	0.0744	−0.0121	0.0869	0.0721	−0.0148	0.0028*
Volatility (30-min)	Squared absolute return	0.1638	0.1381	−0.0257*	0.1658	0.1380	−0.0278*	0.0021
Panel B: Nasdaq (Pilot: 376, Control: 757)								
I. Trade-Based								
Volatility	Trade-to-trade	1.9852	1.8918	−0.0934	2.4095	2.1702	−0.2393*	0.1459
Semivariance	$P_t - P_t{-}1 > 0$	0.8994	0.8719	−0.0275	1.0657	0.9746	−0.0911	0.0636
Semivariance	$P_t - P_t{-}1 < 0$	0.9258	0.8373	−0.0885	1.1147	0.9608	−0.1540**	0.0655
II. Midquote-Based								
Volatility (5-min)	Squared absolute return	0.0569	0.0471	−0.0097**	0.0598	0.0476	−0.0122**	0.0025**
Volatility (15-min)	Squared absolute return	0.1625	0.1361	−0.0263**	0.1707	0.1388	−0.0319**	0.0056*
Volatility (30-min)	Squared absolute return	0.3068	0.2601	−0.0467**	0.3221	0.2680	−0.0541**	0.0074

increase significantly for NYSE-listed Pilot relative to Control stocks. At the 30-minute frequency, midquote volatility declines significantly for both Pilot and Control stocks, but there is no significant difference between the two samples. By contrast, for Nasdaq-listed stocks, midquote volatility at the 5-, 15-, and 30-minute frequency declines significantly for both Pilot and Control stocks. Moreover, the last column shows that variance at the 5- and 15-minute (but not the 30-minute) frequencies increases significantly for Pilot relative to Control stocks. Thus, the removal of the price tests seems to be associated with an increase in short-term volatility both for NYSE and Nasdaq Pilot stocks relative to their Controls.

To examine if less liquid stocks experience a larger increase in intraday volatility we study the impact of the suspension of price tests on short-term volatility for stocks grouped into quintile portfolios by characteristic in Table IX. For NYSE-listed stocks, trade-based volatility measures increase significantly for Pilot relative to Control stocks both for the first- and the fifth-quintile portfolios sorted by size, price, volatility, and turnover. Thus, the effects of removing the Uptick rule on trade-based volatility are pervasive. Moreover, as expected based on our example of I(lliquid) and L(iquid) stocks, the *F*-tests in the last column of each portfolio show that the difference-in-differences in trade-based volatility measures are significantly larger for small-capitalization, low-price, and high-volatility NYSE-listed stocks. However, there is no evidence that low-turnover stocks experience significantly larger increases in trade-based volatility or in downside volatility following the suspension of the Uptick rule.

The picture is somewhat more mixed when it comes to midquote returns at the 5-, 15-, and 30-minute frequencies. Small-capitalization stocks experience significant increases at all horizons, while large-capitalization stocks actually show a decrease in midquote volatility and the difference-in-differences is even significant at the 5-minute frequency. The *F*-tests show that the difference-in-differences in quote-based volatility at all three frequencies are significantly larger for small-capitalization stocks. For quintile portfolios by price (volatility) there is only a significant increase in midquote volatility for low-price (high volatility) stocks at the 5-minute (5- and 15-minute) frequency. The *F*-tests suggest that the difference-in-differences in quote-based volatility is significantly larger for low-price and high-volatility stocks at both the 5- and the 15-minute frequencies. Finally, the *F*-tests detect no significant differences-in-differences for quintile portfolios sorted by turnover.

For Nasdaq-listed stocks, the evidence is less clear. We generally only find significant positive difference-in-difference results for large-capitalization, low-volatility, and high-turnover stocks. The only case in which we see evidence of a significant difference-in-differences for stocks that are less liquid is for the portfolio of low-price stocks. Moreover, according to the *F*-tests, only in the case of size portfolios do we find a significant difference across quintile portfolios. Specifically, small-capitalization Pilot stocks experience a larger increase in trade-to-trade volatility and positive semivariances relative to their Control stocks than is the case for large-capitalization stocks. However, bear in mind the caveat that we mention in the previous section regarding relying on the

Table IX

Changes in Trade-Based and Intraday Volatility Measures around Reg SHO by Market and Portfolios

Stocks are sorted into quintile portfolios based on the market capitalization at the end of year 2004, price at the beginning of sample period, average volatility over the sample period, or average turnover over the sample period. Volatility measure is based on trade price: trade-based (trade-to-trade) price, bid-quote based (bid-to-bid), and offer-quote based (offer-to-offer). Positive (up) semivariance is calculated as $(1/N)\Sigma \max[0, \log(x_t/x_{t-k})]^2$ and the negative (down) semivariance is calculated as $(1/N)\Sigma \min[0, \log(x_t/x_{t-k})]^2$, where N is the number of observations, and x_t is a daily closing price from CRSP. Volatility (k-min return) is based on midquotes with k-minute (k = 5, 10, 15) intervals. In the column "Diff–Diff"—"small/low" ("large/high") we report the postperiod dummy variable coefficient from the regression of differences of each variable between Pilot and Control stock portfolios in the lowest (highest) quintile on intercept (not reported) and the postperiod dummy, where the postperiod dummy equals one from May 2, 2005 to July 31, 2005 and zero otherwise. Here, F reports the SUR test of equality between the coefficients from the lowest and highest quintile portfolios. An asterisk (two asterisks) indicates 5% (1%) level of significance. We compute significance using Newey–West (1987) standard errors with 20 lags. The numbers for trade-based volatility are multiplied by 100.

		Size Portfolios			Price Portfolios			Volatility Portfolios			Turnover Portfolios		
		Small Diff-Diff	Large Diff–Diff	F	Low Diff–Diff	High Diff–Diff	F	Low Diff–Diff	High Diff–Diff	F	Low Diff–Diff	High Diff–Diff	F
Panel A: NYSE													
I. Trade-Based													
Volatility	Trade-to-trade	0.4928**	0.0077**	63.60**	0.4470**	0.0453**	46.74**	0.0068**	0.5027**	70.58**	0.2687**	0.2212**	0.57
Semivariance	$P_t - P_t{-}1 > 0$	0.2355**	0.0033**	62.58**	0.2054**	0.0233**	41.69**	0.0040**	0.2289**	58.60**	0.1429**	0.0802**	4.33*
Semivariance	$P_t - P_t{-}1 < 0$	0.2103**	0.0022**	36.89**	0.1756**	0.0227**	20.26**	0.0032**	0.2126**	39.90**	0.1308**	0.0739**	2.89
II. Midquote-Based													
Volatility (5-min)	Squared absolute return	0.0079**	−0.0006*	38.97**	0.0081**	0.0001	25.38**	0.0000	0.0082**	29.99**	0.0030**	0.0047**	0.80
Volatility (15-min)	Squared absolute return	0.0154**	−0.0019	16.33**	0.0103	−0.0014	5.64*	−0.0008	0.0130*	8.85**	0.0033	0.0082	0.78
Volatility (30-min)	Squared absolute return	0.0203*	−0.0040	8.11**	0.0104	−0.0048	2.17	−0.0020	0.0152	2.96	0.0014	0.0129	1.14
Panel B: Nasdaq													
I. Trade-Based													
Volatility	Trade-to-trade	0.6993	0.0038	7.54**	0.1421	0.0095	0.42	0.0126**	0.5696	3.19	0.5831	0.0409**	3.19
Semivariance	$P_t - P_t{-}1 > 0$	0.2860	0.0042	4.90*	0.0978*	0.0212	0.48	0.0074**	0.2465	2.41	0.2053	0.0193**	1.49
Semivariance	$P_t - P_t{-}1 < 0$	0.2473	0.0058*	2.13	0.1100**	−0.0347	2.22	0.0067**	0.2627	1.84	0.2338	0.0162**	1.43
II. Midquote-Based													
Volatility (5-min)	Squared absolute return	−0.0042	0.0006	3.26	0.0018	0.0013	0.04	0.0015	0.0033	0.41	0.0030	0.0054	0.52
Volatility (15-min)	Squared absolute return	−0.0090	0.0015	1.64	−0.0010	0.0058	0.66	0.0052	0.0128	0.69	0.0103	0.0079	0.08
Volatility (30-min)	Squared absolute return	−0.0175	0.0002	1.06	−0.0132	0.0121	2.07	0.0078	0.0257	0.94	0.0171	0.0019	0.72

F-test for inference when we cannot reject the hypothesis that volatility does not increase for Pilot stocks relative to Control stocks for either quintile portfolio.

There is no evidence of significant difference-in-differences in midquote volatility at the 5-, 15-, or 30-minute frequencies for Nasdaq quintile characteristic portfolios. Moreover, the F-tests show that we cannot reject that the difference-in-differences in these volatility measures are the same for the extreme quintile portfolios.

Our final volatility test is a simple variance ratio test as suggested by Lo and MacKinlay (1989). We define the variance ratio of midquote returns as

$$\textit{Variance Ratio} = \left(\sigma^2_{y-\text{min returns}} * (x/y)\right)/\sigma^2_{x-\text{min returns}} - 1, \tag{2}$$

where σ^2_z is midquote return variance with an interval of z minutes and we assume that $x > y$. If returns are random walks this ratio should be zero. If there is excess short-term volatility, and $x > y$, (x/y) times the y-minute return volatility will exceed the x-minute return volatility. Hence, if the variance ratio is significantly above zero, there is excess short-term volatility (due to reversals). We calculate the 5-to-15-minute, the 5-to-30-minute, and the 30-minute to daily variance ratios for each stock over the pre- and postperiods. Because we want to relate short-term variances to daily volatility, we are unable to use our regular methodology. Instead, we first compute the variance ratio over the pre- and postperiods, and then compute the cross-sectional average for the pre- and postperiods separately. These cross-sectional averages are reported under the columns pre and post. We conduct a pair-wise t-test for changes between the pre- and postperiods, labeled Diff in Table X. Diff–Diff reports the

Table X

Variance Ratio Tests Based on Midquote Volatility Measures around Reg SHO by Market

The numbers in the pre and post columns are the cross-sectional average of variance ratio for the preperiod (February 1, 2005 to May 1, 2005) and for the postperiod (May 2, 2005 to July 31, 2005). The variance ratio is computed as $((\sigma^2_{y-\text{min returns}} * (x/y))/\sigma^2_{x-\text{min returns}}) - 1$. The Diff column shows the cross-sectional average of differences in variance ratios between the preperiod and the postperiod. The Diff–Diff column shows the difference-in-the difference of the variance ratios of Pilot and Control stocks. An asterisk (two asterisks) indicates 5% (1%) level of significance.

	Pilot			Control			
	Pre	Post	Diff	Pre	Post	Diff	Diff–Diff
Panel A: NYSE (Pilot: 448, Control: 904)							
Five minutes vs. 15 minutes	0.055	0.108	0.053**	0.055	0.069	0.015**	0.038**
Five minutes vs. 30 minutes	0.063	0.131	0.068**	0.060	0.066	0.005	0.063**
Thirty minutes vs. open–close	0.163	0.282	0.119**	0.164	0.225	0.062**	0.057**
Panel B: Nasdaq (Pilot: 376, Control: 757)							
Five minutes vs. 15 minutes	0.062	0.055	−0.007	0.060	0.041	−0.020**	0.013
Five minutes vs. 30 minutes	0.077	0.057	−0.020	0.075	0.032	−0.042**	0.022
Thirty minutes vs. open–close	0.273	0.235	−0.037	0.249	0.219	−0.030*	−0.008

difference-in-differences of variance ratios between the Pilot and Control stocks and its significance is marked based on conventional t-test of mean comparisons.

There is generally a significant increase in variance ratios for both the NYSE-listed Pilot and Control stocks, but the difference-in-differences tests show that the variance ratio increases for Pilot relative to Control stocks. In other words, NYSE-listed Pilot stocks experience more short-term volatility (reversals) after the suspension of the Uptick rule. By contrast, there is generally a decline in variance ratios for Nasdaq-listed Pilot and Controls, and the decline is even significant for Control stocks. The last column shows that there is no statistically significant difference in the changes for Nasdaq-listed Pilot compared to Control stocks.

We repeat the variance ratio tests for quintile portfolios by size, price, volatility, and turnover (not reported). The results suggest that the increases in short-term volatility for NYSE-listed Pilot stocks compared to Control stocks at the 5- and 15-minute frequencies come from small-capitalization and low-price stocks. For example, the difference-in-differences for the (5/30)-minute variance ratio is 5.1% and 8.8% for small-capitalization and low-price stocks, respectively. By contrast, changes for NYSE-listed Pilot stocks are not significantly different from Control stocks for large-capitalization and high-price stocks at 1.3% and 2.0%, respectively. Generally, the difference-in-differences are significant for both extreme portfolios with NYSE-listed stocks sorted by turnover and volatility. By contrast, there is no evidence that variance ratios increase more for less liquid Nasdaq-listed Pilot stocks after the suspension of the bid price test.

VII. Robustness Checks

For robustness, we repeat all the tests in this paper with an alternative methodology. We run pooled cross-sectional time-series regressions of market quality measures on two dummy variables. The first dummy variable takes on a value of one if the stock is a Pilot stock and the date is during the postperiod and zero otherwise. The second dummy variable takes on a value of one if the stock is a Control stock and the date is during the postperiod and zero otherwise. The difference-in-difference tests are based on the difference between these two dummy variables. We include stock-level and calendar day fixed effects. To control for both serial correlation and cross-sectional dependence, we cluster standard errors by both date and stock using the estimator suggested by Thompson (2006). The results are very similar based on the alternative methodology, but on average the standard errors are slightly larger with fewer significant difference-in-differences as a result.

It is conceivable that there is a period of adjustment and confusion as traders get used to the new trading rules. While the adjustment is interesting in its own right, policy making should be based on permanent effects of rule changes. We therefore also check the robustness of the results for market quality (Table VI) by excluding an adjustment period of 2 weeks before and after the effective date of May 2, 2005. Our findings for NYSE-listed stocks are not affected by excluding the adjustment period (not reported). However, for Nasdaq-listed stocks there is generally no longer a significant effect on spreads when the adjustment period is excluded. In other words, any effects on spreads of suspending the bid price test on Nasdaq were short lived.

As we point out above, market quality and volatility statistics vary significantly in the cross-section. For example, large-capitalization stocks have narrower quoted and effective spreads than small-capitalization stocks. Yet, the SUR analysis that we use relies on comparing the absolute value of the difference-in-differences for small-capitalization stocks to those for large-capitalization stocks. This method does not account for the fact that the average level of market quality varies systematically across stocks. For robustness, we therefore also conduct the cross-sectional SUR analysis based on difference-in-differences expressed as a proportion of Control stock means, which should better control for the cross-sectional pattern in the levels of market quality. While some results are slightly weaker with this approach, our overall conclusions are not changed.

VIII. Conclusions

We study the effect of short-sale price tests on market quality in U.S. stock markets. The NYSE Uptick rule has a very different effect on the trading strategies of short-sellers compared to the Nasdaq bid price rule. NYSE short-sale orders are treated as liquidity-supplying orders regardless of their submitted form (market or limit). By contrast, short-sellers in Nasdaq-listed stocks use a more natural mixture of passive and aggressive orders.

Reg SHO dictates that short-sale price tests be suspended for a set of Pilot stocks starting May 2, 2005. We find that short sales as a fraction of share volume increase significantly for both NYSE- and Nasdaq-listed Pilot relative to Control stocks. However, there is no systematic evidence that short-sale share volume or short interest increase significantly. Neither the announcement of the Pilot Program, nor the event itself, is associated with a decrease in returns for Pilot relative to Control stocks. There is also no evidence of an increase in daily volatility for Pilot relative to Control stocks after May 2, 2005.

We find that the suspension of the NYSE Uptick Rule is associated with a large and significant reduction in the asymmetries of depth and order flow for Pilot stocks compared to Control stocks. It is also associated with a small but significant increase in quoted and effective spreads. By contrast, the suspension of Nasdaq's bid price rule is associated with smaller changes in market quality.

Regulators have expressed concern about the effect of short-selling activity on volatility, particularly downside volatility. We find that the suspension of short-sale price tests is associated with a slight increase in short-term volatility for NYSE-listed stocks but we detect no such change for Nasdaq-listed stocks. Variance ratio tests also suggest that NYSE-listed Pilot stocks experience an increase in short-horizon reversals once the Uptick rule is suspended. There is no evidence of relative increases in reversals for Nasdaq-listed stocks.

Finally, our evidence does not suggest that Pilot stocks experience an increase in downside volatility relative to Control stocks.

We also test whether certain groups of stocks are more affected by the suspension of price tests by forming quintile portfolios based on the characteristics size, price, volatility, and turnover. For NYSE-listed stocks, the evidence suggests that small-capitalization and low-price stocks experience a larger increase in spreads and some volatility measures than high-price stocks. However, we argue that this is to be expected given that the effect of the Uptick rule is larger for stocks with wide spreads and low price. For Nasdaq-listed stocks, the evidence instead tends to point to a larger effect on large-capitalization, more liquid stocks.

Our evaluation of the Reg SHO Pilot program suggests that the effect of the price tests on market quality can be attributed to the distortions in order flow created by the price tests themselves. Therefore, we conclude that both NYSE's Uptick rule and Nasdaq's bid price test can safely be permanently removed.

IX. Epilogue

The objective of this study is to carefully analyze the suspension of the tick test of Rule 10a-1 and Nasdaq's bid price test to help the SEC determine whether these rules are effective, and if they are needed going forward. Based on our empirical results, we argued at a Roundtable organized by the SEC (September 15, 2006) that price tests distort short-sale order flow, and that removing them would result in more natural order flow patterns. We also argued that the effects of suspending price tests on market quality for Pilot stocks were limited, and therefore the price tests could safely be suspended permanently.

In conjunction with the Roundtable, the SEC's Office of Economic Analysis released a research report (SEC (2006)) that further corroborated our findings. Based on empirical analyses by SEC staff and academic researchers like ourselves, and feedback from other Roundtable participants, the SEC voted on June 13, 2007 to adopt amendments to Rule 10a-1 (17 CFR 240.10a-1) and Regulation SHO (17 CFR 242.200 *et. seq.*) that will remove Rule 10a-1 as well as any existing exchange-mandated short-sale price test effective July 6, 2007. Moreover, the SEC voted to prohibit any SRO from having a price test in the future. In principle, this provides another randomized trial for the effect of a repeal of price tests that other researchers may want to explore. However, as exchanges are only required to provide public access to tick-level short-sale data until August 6, 2007, it would be difficult to examine the effects of the repeal of price tests on short-selling activity.

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