MEMORANDUM

TO: File

FROM: The Division of Economic and Risk Analysis[1]

DATE: July 28, 2017

RE: FINRA's Pilot Program Amending Minimum Quotation Size Requirements for OTC Equity Securities (SR-FINRA-2011-058)

Summary

On June 15, 2012, the Securities and Exchange Commission ("the Commission") approved a pilot program that amended FINRA Rule 6433, which governs the minimum quotation size requirements for over-the-counter ("OTC") equity securities. The pilot reduced the minimum quotation size requirements for most price tiers, although for some tiers the minimum quotation size requirement increased or remained the same. The pilot began on November 12, 2012, and it is currently scheduled to end on December 8, 2017.

In the approval order for the pilot, the Commission noted that FINRA committed to provide the Commission with the data necessary to assess the impact of the revised tier sizes on the OTC equity market. In particular, the Commission noted that this data would afford the Commission an opportunity to assess the impact of the revised tier sizes on liquidity of OTC equity securities.

In this memo, using the data provided by FINRA, we assess the impact of the pilot on liquidity as measured by quoted and effective spreads.[2] For stocks in price tiers where the minimum quotation size requirement decreased, we find that both quoted and effective spreads decreased between the pre-pilot period and the pilot period. Furthermore, our analysis suggests that these decreases in spreads may reflect causal effects of the pilot.

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[2] Lower (higher) spreads indicate higher (lower) level of liquidity.

For stocks in the price tier where the minimum quotation size requirement increased, we find that both quoted and effective spreads increased between the pre-pilot period and the pilot period. However, we do not find sufficient evidence that these increases in spreads were caused by the pilot.

For price tiers where the minimum quotation size requirement remained the same, we find that between the pre-pilot period and the pilot period, quoted and effective spreads decreased for stocks in one tier but did not change for stocks in another tier. We also find that for the former group of stocks, the decreases in spreads may have been caused by factors unrelated to the pilot.

Our findings are similar to the findings of a FINRA-commissioned study conducted by Cornerstone Research ("the FINRA/Cornerstone Study").[3] In particular, our findings are consistent with FINRA's assessment that the pilot had a neutral to positive impact on liquidity (i.e., had no effect on spreads or reduced spreads in the context of our study) for the majority of OTC equity securities and price tiers. At the same time, like the FINRA/Cornerstone Study, we find inconclusive evidence regarding the effects of the pilot on liquidity for the price tier where the minimum quotation size requirement increased.

[3] FINRA Assessment of Rule 6433 and Cornerstone Research, "OTC Tier Size Analysis," September 13, 2013 (the "FINRA/Cornerstone Study"), available at http://www.sec.gov/comments/sr-finra-2011-058/finra2011058-15.pdf.

I. Background

FINRA Rule 6433 sets forth a minimum quotation size that may be displayed on any inter-dealer quotation system for over-the-counter (OTC) equity securities. The minimum quotation size in Rule 6433 also determines the minimum size at or above which market makers are required to display OTC customer limit orders. The minimum quotation size varies as a function of the stock price, according to a schedule known as the "tier structure".

On October 14, 2011, the Commission published notice of FINRA's proposed rule change[4] ("Notice") that would modify the tier structure in Rule 6433 by decreasing the number of tiers from nine to six and reducing the minimum quotation sizes for most tiers. In the Notice, FINRA stated that lower minimum quotation sizes would facilitate the display of customer limit orders, which would in turn increase quote competition, reduce bid-ask spreads, and improve liquidity.

The Commission solicited comments from the public on FINRA's original proposal, on the Commission's order instituting proceedings to determine whether to approve or disapprove the proposed rule change, and on FINRA's subsequent amendments to the original proposal.[5] On June 15, 2012, the Commission approved the rule change as a one-year pilot program,[6] and its implementation started on November 12, 2012. The pilot was subsequently extended and is currently scheduled to end on December 8, 2017.[7]

Table 1 compares the minimum quotation size requirements under the pre-pilot rule and under the pilot rule for each price range. The minimum quotation size increased for prices below $0.10 (Tier 1), remained the same for prices between $0.10 and $0.20 (Tier 2), decreased for prices between $0.20 and $100.00 (Tiers 3, 4, 5a, and 5b), remained the same for prices between $100.00 and $175.00 (Tier 5c), decreased for prices between $175.00 and $2,500.00 (Tiers 6a, 6b, 6c, and 6d), and remained the same for prices higher than $2,500.00 (Tier 6e).

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4 Federal Register, Release No. 34-65568, "Self-Regulatory Organizations; Financial Industry Regulatory Authority, Inc.; Notice of Filing of Proposed Rule Change To Amend FINRA Rule 6433 (Minimum Quotation Size Requirements for OTC Equity Securities)," October 14, 2011, available at http://www.sec.gov/rules/sro/finra/2011/34-65568.pdf.

5 In addition to the original Federal Register release cited in note 4, see subsequent Release No. 34-66168 (Order Instituting Proceedings to Determine Whether to Disapprove, January 17, 2012); and Release No. 34-66819 (Notice of Filing of Amendment 1 to Proposed Rule Change, April 17, 2012).

6 Federal Register, Release No. 34-67208, "Notice of Filing of Amendment No. 2 and Order Granting Accelerated Approval of a Proposed Rule Change, as Modified by Amendment Nos. 1 and 2, to Amend FINRA Rule 6433 (Minimum Quotation Size Requirements for OTC Equity Securities)," June 15, 2012 ("Approval Order"), available at http://www.sec.gov/rules/sro/finra/2012/34-67208.pdf.

7 The latest extension to the pilot (to December 8, 2017) was published in the Federal Register as Release No. 34-80727, "Self-Regulatory Organizations; Financial Industry Regulatory Authority, Inc.; Notice of Filing and Immediate Effectiveness of a Proposed Rule Change to Extend the Tier Size Pilot of FINRA Rule 6433 (Minimum Quotation Size Requirements for OTC Equity Securities)," May 18, 2017, available at http://www.sec.gov/rules/sro/finra/2017/34-80727.pdf.

In the approval order for the pilot, the Commission noted that, in its filing describing Amendment No. 2 to the proposed pilot,[8] FINRA committed to provide the Commission with the data necessary to assess the impact of the revised tier sizes on the OTC equity market.[9] In particular, the Commission noted that this data would afford the Commission an opportunity to assess the impact of the revised tier sizes on liquidity of OTC equity securities.[10]

In this memo, using the data provided by FINRA, we present a statistical analysis that assesses the impact of the pilot on liquidity as measured by quoted and effective spreads.[11] We conduct the analysis for OTC stocks in different price tiers: tiers where the minimum quotation size requirement decreased, tiers where the minimum quotation size requirement increased, and tiers where the minimum quotation size requirement remained the same. Where relevant, we compare our methodology and empirical findings to those in the FINRA/Cornerstone Study.[12]

II. Data and Methodology

We use the data provided to the Commission by FINRA in accordance with the Amendment No. 2 Filing: aggregated daily market data by symbol for OTC equity securities subject to the pilot.[13] Our analysis covers the 37 months between November 2011 and November 2014. The period between November 2011 and October 2012 corresponds to the "pre-pilot period" for our analysis. For each month in this period, FINRA provided data for five randomly selected trading days (for a total of 60 days for the pre-pilot period). The period between November 2012 and November 2014 corresponds to the "pilot period" for our analysis. For this period, FINRA provided data for all trading days after the start of the pilot on November 12, 2012.[14] Overall, our data covers a total of 15,986 stocks and 576 trading days.

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8 See FINRA Letter to U.S. Securities and Exchange Commission, re: File No. SR-FINRA-2011-058 (June 4, 2012), Attachment: Amendment No. 2, Proposed Rule Change by Financial Industry Regulatory Authority, SR-FINRA- 2011-058 (the "Amendment No. 2 Filing"), at 6. A copy of the Amendment No. 2 Filing is located in the Commission's public file for SR-FINRA-2011-058 at http://www.sec.gov/comments/sr-finra-2011-058/finra2011058-14.pdf.

9 See Approval Order, supra note 6, at 25. FINRA specified the categories of data that it would provide to the Commission on a monthly basis, starting no later than 90 days after the start of the pilot, including price and volume information, execution data, and liquidity metrics and the time frame within which FINRA would submit the data. See Amendment No. 2 Filing, supra note 8, at 6-7.

10 See Approval Order, supra note 6, at 41.

11 It is beyond the scope of this memo to study the specific mechanisms through which the revised minimum quotation sizes may have affected liquidity.

12 See FINRA/Cornerstone Study, supra note 3.

13 If an OTC equity security was not quoted on an inter-dealer quotation system during the pilot period, it was not subject to the pilot. See FINRA/Cornerstone Study, supra note 3, at 4.

14 In terms of trading days, the data for the pre-pilot period ranges from November 14, 2011 to October 31, 2012, while the data for the pilot period ranges from November 12, 2012 to November 28, 2014.

To assess the impact of the pilot on liquidity, we use two daily measures of liquidity as our outcome variables: time-weighted quoted spread and volume-weighted effective spread. In the dataset provided by FINRA, these variables are defined as follows. The time-weighted quoted spread is defined as the intraday average difference between the best bid and offer ("BBO") prices for a stock, where each BBO quote observed during trading hours is weighted by the amount of time that the quote is active. The volume-weighted effective spread is defined as the intraday average difference between the trade price and the midpoint of the BBO at the time of the trade for a stock (in absolute value and multiplied by 2), where each trade observed during trading hours is weighted by the share volume of the trade.[15]

The time-weighted quoted spread and the volume-weighted effective spread variables provided by FINRA are measured in dollars. However, for the purposes of our analysis, we redefine these variables in terms of basis points relative to the stock's average price on a given day. Specifically, for each stock-day observation, we divide the time-weighted quoted spread and the volume-weighted effective spread *in dollars* by the volume-weighted average price ("VWAP")[16], and then multiply each of these ratios by 10,000. This yields the time-weighted quoted spread and the volume-weighted effective spread *in basis points*, which are the measures of liquidity that we use in our empirical analysis. For brevity, in the rest of this memo, we often refer to these measures of liquidity simply as "quoted spread" and "effective spread".

The quoted spread and the effective spread represent standard measures of liquidity, with lower (higher) spreads indicating higher (lower) level of liquidity. Furthermore, defining these variables in basis points relative to the VWAP makes it easier to compare spreads across stocks with different prices, as well as to compare spreads of the same stock over time (when the price of the stock is changing).

We seek to explain changes in quoted and effective spreads with the *Pilot* variable. This is an indicator variable equal to 1 for stock-day observations in the pilot period and equal to 0 for stock-day observations in the pre-pilot period.

Because the changes in the minimum quotation size requirements due to the pilot varied by price tier, our goal is to assess the effects of the pilot on spreads separately within each tier. Therefore, we need to assign each stock-day observation to one of the price tiers shown in Table 1. To do this, we consider three types of prices for a given stock in a given day: the price of the first trade of the trading day, the price of the last trade of the trading day, and the VWAP during the trading day.[17] If each of the three

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[15] The dataset provided by FINRA included several variants of the time-weighted quoted spread and the volume-weighted quoted spread variables. First, FINRA provided spread variables for each of the two quoting and trading platforms for OTC securities: OTC Link and the OTC Bulletin Board. Second, for each platform, FINRA provided spread variables based on either raw BBO data or "filtered" BBO data (where certain "non-meaningful" BBOs, including crossed BBOs, were eliminated from the calculation). In our analysis, we use the "filtered" spreads from OTC Link (which had significantly more quoting and trading activity than the OTC Bulletin Board during the period that we analyze). The FINRA/Cornerstone Study also used "filtered" spreads from OTC Link for its analysis.

[16] For a given stock-day observation, the VWAP is defined as the ratio of the daily dollar volume to the daily share volume.

[17] FINRA's rule 6433 defines price tiers based on the bid and offer prices. Because we do not have data on the bid and offer prices, we use the actual transaction prices as an approximation. As a consequence of

prices falls within the price range of a single tier, we assign the stock-day observation to that tier. In contrast, if at least two of the three prices fall within the price ranges of different tiers, this indicates to us that the stock changed tiers within the same day, and we exclude the stock-day observation from our analysis.[18]

For each tier, we estimate the following regression equation:

$$Y_{st} = \beta * Pilot_{st} + \mu_s + \theta_s t + \varepsilon_{st} \quad (1)$$

Y_{st} is the quoted or effective spread for stock *s* on day *t*. $Pilot_{st}$ is our independent variable for stock *s* on day *t*. The parameters μ_s and $\theta_s t$ denote stock fixed effects and stock-specific linear time trends respectively.

The inclusion of stock fixed effects in our regressions allows us to compare spreads in the pilot and the pre-pilot periods *within stocks*. This is important because the composition of stocks in any given price tier could have changed between the pre-pilot period and the pilot period (e.g., due to changes in stock prices), which could potentially confound the analysis. By comparing spreads within stocks, we effectively control for such changes in the composition of stocks. We include stock-specific linear time trends in our regressions to control for stock-specific changes in spreads that might be unrelated to the pilot.

Our main parameter of interest is β, the coefficient on the *Pilot* indicator variable. For a given tier, β measures the average within-stock change in spreads between the pre-pilot period and the pilot period, where this average is computed across all stocks that have at least one observation in that tier in each of the two periods. Stocks that do not have any observations for a particular tier in either the pre-pilot period or the pilot period are excluded from the regression analysis for that tier, because they do not provide within-tier and within-stock variation in spreads that can be used to identify the effect of the pilot for that tier.[19]

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this approximation, we cannot assign to a tier stock-day observations with zero trading volume. These observations are therefore excluded from our analysis.

[18] 56,030 stock-day observations (2.55% of all stock-day observations) are excluded from the analysis because at least two of the three prices fall within the price ranges of different tiers. Such exclusion allows for cleaner interpretation of the within-tier results. The FINRA/Cornerstone Study also excluded stock-day observations where the bid and/or offer prices crossed the border between multiple tiers within the same day.

As a robustness test, we redid the analysis using an alternative methodology that avoids this loss of observations. Specifically, we assigned each stock-day observation to a price tier based only on the stock's VWAP during the trading day (while ignoring the prices of the stock's first and last trades of the trading day). The results were very similar to those reported in the memo.

[19] We also exclude from our analysis trading days in which the market closed early, because these days could have lower levels of trading activity. This results in the exclusion of 16,495 stock-day observations (across all price tiers combined).

Table 2 shows summary statistics for our dependent variables by tier. For each dependent variable and each tier, the table shows the number of stocks and stock-day observations used in the regression analysis, the mean value of the dependent variable across all stock-day observations in the tier, and the average within-stock standard deviation of the dependent variable in that tier. The average within-stock standard deviations capture typical fluctuations in quoted or effective spreads over time for stocks in a given tier. These standard deviations will provide a useful benchmark when we assess the economic magnitude of our regression coefficients in the next section.[20]

For example, Table 2 shows that when we estimate the regression for time-weighted quoted spreads in Tier 3, the regression uses data for 1,114 stocks and has 107,878 stock-day observations. Table 2 also shows that for stock-day observations in Tier 3, the time-weighted quoted spread variable has the mean of 1,678 basis points and the within-stock standard deviation of 1,116 basis points. Other summary statistics in Table 2 can be interpreted accordingly.[21]

We confine our analysis (and the description of summary statistics in Table 2) to Tiers 1 to 5c. This is because for Tiers 6a to 6e only a small number of stocks have at least one observation in both the pre-pilot and the pilot periods. Regression analysis based on such a small number of stocks would not be very reliable.[22]

Before proceeding to discuss our regression results, we briefly summarize the differences between our methodology and the methodology used in the FINRA/Cornerstone Study.

The FINRA/Cornerstone Study utilized a series of "t-tests" that compared quoted or effective spreads before and after the start of the pilot. Although these tests were performed separately for each price tier, they did not control for changes in the composition of stocks in any given tier. Furthermore, the t-tests did not control for stock-specific time trends in spreads that might have been unrelated to the pilot. As discussed above, our regression methodology allows us to control for these confounding factors.

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[20] The average within-stock standard deviation of the dependent variable is computed as follows. First, we compute the time-series standard deviation of the dependent variable for each individual stock in a given tier. Then we compute the weighted average of these individual standard deviations, weighting each stock by its number of observations in that tier.

[21] The mean spreads reported in Table 2 are large, which is consistent with the academic literature on OTC stocks. For example, Eraker and Ready (2015) report the average quoted spread of 1,316 basis points for a sample of OTC stocks with market capitalization of at least $1 million, the share price of at least $0.01 and the monthly dollar volume of at least $2,000 in 2000-2008. See Bjorn Eraker and Mark Ready, "Do Investors Overpay for Stocks with Lottery-Like Payoffs? An Examination of the Returns of OTC Stocks", Journal of Financial Economics 115 (2015) 486-504. In addition, we computed the mean values of quoted and effective spreads (by tier) as measured in dollars (not shown), and found them to be of the same order of magnitude as those reported in the FINRA/Cornerstone Study.

[22] The number of stocks that we could use in the regression analysis for Tiers 6a to 6e is as follows: 10 for Tier 6a, 37 for Tier 6b, 16 for Tier 6c, 20 for Tier 6d, and 16 for Tier 6e. The FINRA/Cornerstone Study also excluded Tiers 6a to 6e from its analysis due to the small number of stocks in each of these tiers. We also note that it would be difficult to interpret the results of a regression analysis that combined stocks in Tiers 6a to 6e. This is because stocks in these tiers experienced very different changes in minimum quotation size as a result of the pilot (see Table 1).

In addition, the FINRA/Cornerstone Study used the time-weighted quoted spread and the volume-weighted effective spread variables as measured in dollars. In contrast, we redefine these variables in terms of basis points relative to the VWAP. As discussed above, this makes it easier to compare spreads across stocks with different prices, as well as to compare spreads of the same stock over time.[23]

Finally, and perhaps most importantly, the FINRA/Cornerstone Study does not address the issue of causality. We attempt to shed more light on causality in Section IV below, where we analyze the timing of changes in quoted and effective spreads around the implementation of the pilot.[24]

III. Regression Results

Table 3 presents the regression results for quoted and effective spreads by tier. For each regression, we report the point estimate and the standard error of β.[25]

Table 3 shows that for Tiers 3, 4, 5a and 5b, where the pilot decreased the minimum quotation size, the pilot is associated with lower quoted and effective spreads. Specifically, the point estimates in Table 3 imply that between the pre-pilot period and the pilot period, quoted spreads decreased by 473 basis points for Tier 3, by 286 basis points for Tier 4, by 258 basis points for Tier 5a, and by 98 basis points for Tier 5b. Likewise, the point estimates in Table 3 imply that between the pre-pilot period and the pilot period, effective spreads decreased by 346 basis points for Tier 3, by 207 basis points for Tier 4, by 218 basis points for Tier 5a, and by 80 basis points for Tier 5b. All these point estimates are statistically significant at the 1% level.

Table 3 also shows that for Tier 1, where the pilot increased the minimum quotation size, the pilot is associated with higher quoted and effective spreads. In particular, the point estimates in Table 3 imply that between the pre-pilot period and the pilot period, quoted and effective spreads for Tier 1 increased by 1,874 basis points and by 2,064 basis points respectively. Both point estimates are statistically significant at the 1% level.

Table 3 shows mixed results for tiers where the minimum quotation size requirement remained the same. In the regressions for Tier 5c, the point estimates of β are small and statistically insignificant

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[23] In addition to the time-weighted quoted spread and the volume-weighted effective spread, the FINRA/Cornerstone Study also considered other measures of liquidity such as the time-weighted quoted depth within a set range of prices around the BBO midpoint or the time-weighted price impact of hypothetical market orders. We could not use these alternative measures of liquidity in our analysis because they were not required to be included as part of the data submitted by FINRA consistent with the Amendment No. 2 Filing. See Amendment No. 2 Filing, supra note 8).

[24] Our analysis also covers a longer time period than the FINRA/Cornerstone Study. In particular, while both studies use data for the same pre-pilot period of November 2011 to October 2012, our analysis covers a longer period after the implementation of the pilot (November 2012 to November 2014 in our analysis versus November 2012 to June 2013 in the FINRA/Cornerstone Study). However, we do not think that the longer time coverage represents a significant difference between the two studies.

[25] We cluster standard errors at the stock level.

suggesting that the pilot had no effect on quoted and effective spreads for stocks in this tier. In contrast, Table 3 shows that for stocks in Tier 2, the pilot is associated with lower quoted and effective spreads. The point estimates imply that between the pre-pilot period and the pilot period, quoted and effective spreads for Tier 2 decreased by 393 basis points and by 391 basis points respectively. Both of these point estimates are statistically significant at the 1% level.

The changes in quoted and effective spreads associated with the pilot are economically important, when evaluated relative to the average values of these dependent variables in our data.[26] For example, a 346 basis point reduction in effective spreads for Tier 3 is sizable relative to the average effective spread of 1,480 basis points for stocks in this tier. Likewise, a 2,064 basis point increase in effective spreads for Tier 1 is important when compared to the average effective spread of 5,394 basis points for stocks in Tier 1.

Another way to interpret the magnitude of the changes in quoted and effective spreads documented in Table 3 is to compare them to typical fluctuations in these variables over time. We provide such comparison in Table 4. Specifically, in Table 4 we reproduce the point estimates of β (from Table 3) along with the average within-stock standard deviations of quoted or effective spread (from Table 2). Then, for each tier and each dependent variable, we compute the ratio of β to the corresponding standard deviation.[27]

Table 4 shows that for Tiers 3, 4, 5a and 5b, where the pilot decreased the minimum quotation size, the point estimates of β imply that the pilot is associated with a decrease of 0.42 to 0.60 standard deviations in quoted spread and a decrease of 0.31 to 0.52 standard deviations in effective spread. Table 4 also shows that for Tier 1, where the pilot increased the minimum quotation size, the point estimates of β imply that the pilot is associated with an increase of 0.31 standard deviations in quoted spread and an increase in 0.25 standard deviations in effective spread. Finally, Table 4 shows that for Tier 2, where the minimum quotation size remained the same, the pilot is associated with a decrease of 0.27 standard deviations in quoted spread and a decrease of 0.26 standard deviations in effective spreads. We interpret these changes in spreads as economically important.

Overall, the regression results in Table 3 indicate that for stocks for which the minimum quotation size requirement decreased (Tiers 3, 4, 5a, and 5b) the pilot is associated with lower spreads, while for stocks for which the minimum quotation size requirement increased (Tier 1) it is associated with higher spreads. These results are theoretically consistent in the sense that in both cases lower (higher) minimum quotation size is associated with lower (higher) spreads. In particular, the results for Tiers 3, 4, 5a, and 5b indicate improvement in liquidity. In contrast, the results for Tier 1 indicate deterioration in liquidity.

We also note that the regression results for Tier 2 are somewhat puzzling, because they indicate a decrease in spreads for stocks that did not experience any change in the minimum quotation size requirement. This brings us to the issue of causality.

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[26] Table 2 shows the mean values of quoted and effective spreads in our data (by tier).

[27] Tier 5c is excluded from Table 4, because in Table 3 the point estimates of β for this tier were statistically insignificant.

An important question for the assessment of the pilot is whether the changes in spreads that we document in Table 3 capture causal effects of the pilot or whether they might be driven by changes in some other determinants of liquidity between the pre-pilot period and the pilot period. Although by including stock fixed effects and stock-specific time trends in our regressions we control for some of the confounding factors that could have affected our results, we still cannot be sure that the point estimates of β identify causal effects of the pilot on spreads.

To shed more light on the issue of causality, in the next section we analyze the timing of changes in quoted and effective spreads around the implementation of the pilot.

IV. The Timing of Changes in Quoted and Effective Spreads

In order to study the timing of changes in quoted and effective spreads around the implementation of the pilot, we estimate the following modified version of equation (1) for each tier:

$$Y_{st} = \sum_{k=1}^{13} \beta^k * Month_{st}^k + \mu_s + \theta_s t + \varepsilon_{st} \qquad (2)$$

As before, Y_{st} is the quoted or effective spread for stock *s* on day *t*, while μ_s and $\theta_s t$ denote stock fixed effects and stock-specific linear time trends respectively. However, the single indicator variable $Pilot_{st}$ is now replaced with a set of 13 indicator variables $Month_{st}^k$ (with index *k* running from 1 to 13). The first six of these indicator variables (with *k* running from 1 to 6) correspond to each of the six months immediately preceding the implementation of the pilot (the months of May 2012 to October 2012). The next six of the indicator variables (with *k* running from 7 to 12) correspond to each of the six months immediately following the implementation of the pilot (the months of November 2012 to April 2013).[28] The last indicator variable (with *k* equal 13) corresponds to the remainder of the pilot period covered by our data (the months of May 2013 to November 2014). Each indicator variable is equal to 1 for stock-day observations in the corresponding month(s) and is equal to 0 otherwise.

Our parameters of interest are now β^k (with *k* running from 1 to 13), which are the 13 coefficients on the indicator variables $Month_{st}^k$. Each of the 13 coefficients measures the quoted or effective spread in the corresponding month(s) relative to the average value of one of these dependent variables in the reference period of November 2011 to April 2012 (which are the first 6 months of the pre-pilot period covered by our data).

In Figures 1a to 3b, we plot the estimated coefficients β^k from the regressions for quoted and effective spreads. For easier comparison, we also plot the data points for the reference period, with relative spreads being equal to 0 by construction. The results for each price tier are presented in a separate figure.

A. Tiers Where Minimum Quotation Size Decreased (Tiers 3, 4, 5a, and 5b)

[28] Our data for November 2012 includes only the trading days after the start of the pilot on November 12, 2012.

Figure 1a displays the coefficients from the regressions for Tier 3, one of the tiers where the pilot decreased the minimum quotation size. Figure 1a shows that quoted and effective spreads for Tier 3 remained relatively constant in the six months immediately preceding the implementation of the pilot (between the reference period of April 2012 and earlier and October 2012). Then, the spreads declined sharply in the first month of the pilot. Specifically, between October 2012 and November 2012, quoted and effective spreads for Tier 3 decreased by 378 basis points and by 293 basis points respectively. In the second month and in the third month of the pilot, the spreads continued to decline but not as sharply. Specifically, between November 2012 and January 2013, quoted and effective spreads for Tier 3 decreased by additional 182 basis points and 162 basis points respectively. The spreads stabilized at the new and lower levels in subsequent months.

Figures 1b to 1d display the coefficients from the regressions for Tiers 4, 5a and 5b, the other tiers where the pilot decreased the minimum quotation size. Figures 1b to 1d show that for Tiers 4, 5a and 5b the pattern of the changes in quoted and effective spreads was similar to that for Tier 3. For all these tiers, the spreads remained relatively constant prior to October 2012, declined sharply between October 2012 and November 2012 (i.e., in the first month of the pilot), continued to decline but at more moderate rates in the next two or three months, and then stabilized at the new and lower levels in subsequent months.[29]

The timing of the changes in quoted and effective spreads, as described in Figures 1a to 1d, is consistent with the existence of causal effects of the pilot on spreads for Tiers 3, 4, 5a, and 5b. This is because the sharpest declines in spreads occurred in the very first month after the implementation of the pilot, as expected under the causal interpretation. The more moderate declines in spreads in the following two or three months are also consistent with the causal interpretation and suggest that the market participants may have needed this additional time to adjust to the new rules. In contrast, Figures 1a to 1d show no evidence that these estimated decreases in spreads were driven by more general downward trends in spreads that could have reflected the effects of other determinants of liquidity.

B. Tiers Where Minimum Quotation Size Increased (Tier 1)

Figure 2 displays the coefficients β^k from the regressions for Tier 1, where the pilot increased the minimum quotation size. Figure 2 shows that quoted and effective spreads for Tier 1 exhibited strong upward trends in the six months immediately preceding the implementation of the pilot. In total, between the reference period of April 2012 and earlier and October 2012, quoted spreads increased by 2,929 basis points, while effective spreads increased by 4,752 basis points. In the first two months of the pilot (between October 2012 and December 2012), quoted and effective spreads continued with their upward trends, increasing by an additional 1,230 basis points and 362 basis points respectively.[30] Then, in January 2013 (the third month of the pilot), spreads plummeted, with quoted spreads decreasing by 2,059 basis points and effective spreads dropping by 2,328 basis points in a single month. Although these declines in spreads were quite substantial, they did not fully offset the even larger increases in

[29] Between October 2012 and November 2012, quoted (effective) spreads decreased by 243 (179) basis points for Tier 4, by 180 (169) basis points for Tier 5a, and by 69 (67) basis points for Tier 5b. Between November 2012 and January 2013, quoted (effective) spreads decreased by additional 123 (88) basis points for Tier 4, 65 (62) basis points for Tier 5a, and 44 (39) basis points for Tier 5b.

[30] Effective spreads temporarily declined in November 2012, before recovering in December 2012.

spreads that occurred in the previous eight months. Thus, while the spreads remained relatively constant after January 2013, they were still considerably higher than during most of the pre-pilot period.

In Table 3, we showed that quoted and effective spreads for Tier 1 were significantly higher in the pilot period than they were in the pre-pilot period. However, Figure 2 provides no evidence that these differences capture causal effects of the pilot on spreads. In particular, as discussed above, these differences are driven by the upward trends in spreads that started many months prior to the pilot rather than by changes in spreads that occurred after the implementation of the pilot. While the pilot could have caused market participants to change their behavior before the actual start of the pilot (i.e., in anticipation of the forthcoming increase in the minimum quotation size), it seems unlikely that such a change in behavior would begin as early as six months before the pilot. Furthermore, if the pilot caused a continuous increase in spreads in the months preceding the pilot, it is unclear why the spreads would sharply decline in January 2013, only three months after the pilot started. Instead, we think that the changes in spreads described in Figure 2 may have been caused by factors unrelated to the pilot.

C. Tiers Where Minimum Quotation Size Remained the Same (Tiers 2 and 5c)

Figure 3a displays the coefficients β^k from the regressions for Tier 2, one of the tiers where the minimum quotation size requirement remained the same. Figure 3a shows that quoted and effective spreads for Tier 2 exhibited strong downward trends in the four months immediately preceding the implementation of the pilot. In total, between June 2012 and October 2012, quoted spreads decreased by 552 basis points, while effective spreads decreased by 529 basis points. After the implementation of the pilot, the spreads continued with their downward trends, although at somewhat slower rates of decline. In the first two months of the pilot (between October 2012 and December 2012), quoted and effective spreads decreased by 169 basis points and 202 basis points respectively, while in the following three months (between December 2012 and March 2013) they decreased by additional 228 basis points and 151 basis points respectively.[31]

In Table 3, we showed that quoted and effective spreads for Tier 2 were significantly lower in the pilot period than they were in the pre-pilot period. We also noted that these regression results were somewhat puzzling, because they indicated a decrease in spreads for stocks that did not experience any change in the minimum quotation size requirement. Indeed, Figure 3a provides no evidence that the differences in spreads between the pre-pilot period and the pilot period capture causal effects of the pilot. This is because these differences are driven by the downward trends in spreads that started as early as four months prior to the implementation of the pilot. We think that such pre-existing trends in spreads were unlikely to be caused by the pilot and may instead reflect changes in other determinants of liquidity.

The results in Table 3 also suggested that the pilot had no effect on quoted and effective spreads for stocks in Tier 5c (another tier where the minimum quotation size requirement remained the same). Figure 3b which displays the coefficients β^k from the regressions for this tier, is consistent with this finding. Although quoted and effective spreads for Tier 5c fluctuated from month to month, there is no evidence that these fluctuations were related to the implementation of the pilot.

[31] Both quoted and effective spreads temporarily increased in January 2013, before continuing their decline in February 2013 and March 2013.

V. Conclusions

We conclude by summarizing our empirical findings and comparing them to the findings in the FINRA/Cornerstone Study.[32]

With respect to stocks for which the minimum quotation size requirement decreased (Tiers 3, 4, 5a, and 5b), we find that both quoted and effective spreads decreased between the pre-pilot period and the pilot period. Furthermore, our analysis of the timing of changes in spreads suggests that these decreases may reflect causal effects of the pilot.

The FINRA/Cornerstone Study also found that after the implementation of the pilot quoted spreads decreased for each of the four tiers (Tiers 3, 4, 5a, and 5b). However, it found that effective spreads decreased only for Tiers 5a and 5b, but did not change for Tiers 3 and 4. Thus, our results provide more uniform evidence of a reduction in spreads for tiers where the minimum quotation size requirement decreased. Furthermore, unlike the FINRA/Cornerstone Study, we provide evidence that this reduction in spreads was caused by the pilot.

With respect to stocks for which the minimum quotation size requirement increased (Tier 1), we find that both quoted and effective spreads increased between the pre-pilot period and the pilot period. However, we also find that these changes in spreads were driven by upward trends that started at least six months prior to the implementation of the pilot. This latter finding suggests that the increases in spreads between the pre-pilot period and the pilot period may have been caused by factors unrelated to the pilot.

The FINRA/Cornerstone Study also found an increase in effective spreads for Tier 1 between the pre-pilot period and the pilot period. However, it found no statistically significant change in quoted spreads for that tier. Thus, our results provide more consistent evidence of an increase in spreads for stocks in Tier 1. However, we find no evidence that this increase in spreads reflects causal effects of the pilot. (The FINRA/Cornerstone Study did not address the issue of causality.)

With respect to stocks for which the minimum quotation size requirement remained the same (Tiers 2 and 5c), we find that between the pre-pilot period and the pilot period, quoted and effective spreads decreased for stocks in Tier 2 but did not change for stocks in Tier 5c. However, for stocks in Tier 2, we also find that the decreases in spreads were largely driven by downward trends that started four months prior to the implementation of the pilot. This latter finding suggests that the decreases in spreads for stocks in Tier 2 may have been caused by factors unrelated to the pilot.

For stocks in Tier 5c, the FINRA/Cornerstone Study also found no change in spreads between the pre-pilot period and the pilot period. However, for stocks in Tier 2, it found a decrease in quoted spreads but no statistically significant change in effective spreads. Thus, our results provide more consistent evidence of a decrease in spreads for stocks in Tier 2. However, as noted in the preceding paragraph, we find no evidence that this decrease in spreads reflects causal effects of the pilot.

Overall, despite some methodological differences, our findings are broadly consistent with the findings of the FINRA/Cornerstone Study. In particular, our findings are consistent with FINRA's assessment that the pilot had a neutral to positive impact on liquidity for the majority of OTC equity securities and

[32] See FINRA/Cornerstone Study, supra note 3, at 5-7, 19-21, Tables 3-5.

tiers.[33] At the same time, like the FINRA/Cornerstone Study, we find inconclusive evidence regarding the effects of the pilot on liquidity of Tier 1 securities.[34,35]

[33] In the context of our study, a neutral to positive impact on liquidity corresponds to a decrease or no change in quoted and effective spreads as a result of the pilot. See supra note 2.

[34] The two studies have different reasons for finding inconclusive evidence for stocks in Tier 1. As discussed above, in our analysis we are uncertain that the increases in quoted and effective spreads for these stocks reflect causal effects of the pilot. In contrast, in the FINRA/Cornerstone Study, the evidence for stocks in Tier 1 is inconclusive because of inconsistent results for different measures of liquidity (the pilot is associated with larger effective spreads (indicating lower liquidity) but also with smaller price impact for hypothetical market orders (indicating higher liquidity)). The FINRA/Cornerstone Study does not address the issue of causality for any of its results.

[35] In addition, as discussed in Section II, neither our analysis nor the FINRA/Cornerstone Study could reliably assess the effects of the pilot on liquidity of stocks in Tiers 6a to 6e due to the small number of stocks in each of these tiers.

Table 1: Minimum Quote Size Comparison by Tier - Pre-Pilot Rule vs Pilot Rule

Tier	Price Range (Bid or Offer)	Minimum Quote Size (# of shares)		Quote Size Change
		Pre-Pilot Rule	Pilot Rule	
1	$0 < p < $0.10	5,000	10,000	Increase
2	$0.10 ≤ p < $0.20	5,000	5,000	Same
3	$0.20 ≤ p < $0.51	5,000	2,500	Decrease
4	$0.51 ≤ p < $1.00	2,500	1,000	Decrease
5a	$1.00 ≤ p ≤ $10.00	500	100	Decrease
5b	$10.00 < p ≤ $100.00	200	100	Decrease
5c	$100.00 < p < $175.00	100	100	Same
6a	$175.00 ≤ p ≤ $200.00	100	1	Decrease
6b	$200.00 < p ≤ $500.00	25	1	Decrease
6c	$500.00 < p ≤ $1,000.00	10	1	Decrease
6d	$1,000.00 < p ≤ $2,500.00	5	1	Decrease
6e	$2,500.00 < p	1	1	Same

Notes: "p" refers to the bid or offer price. "Quote size change" refers to the change in the minimum quote size from the pre-pilot rule to the pilot rule.

Table 2: Summary Statistics for Quoted and Effective Spreads by Tier (November 2011 - November 2014)

		Tier 1	Tier 2	Tier 3	Tier 4	Tier 5a	Tier 5b	Tier 5c
	Price Range	*$0<p<$0.10*	*$0.10≤p<$0.20*	*$0.20≤p<$0.51*	*$0.51≤p<$1.00*	*$1.00≤p≤$10*	*$10<p≤$100*	*$100<p<$175*
	Minimum Quotation Size Change	*Increased*	*Same*	*Decreased*	*Decreased*	*Decreased*	*Decreased*	*Same*
Time Weighted Quoted Spread (Basis Points)	Stocks	3,486	1,044	1,114	626	1,663	1,467	94
	Observations	611,659	71,555	107,878	57,742	291,390	348,905	7,417
	Mean	5,412	2,159	1,678	870	478	180	368
	Standard Deviation	6,063	1,441	1,116	561	428	193	435
Volume Weighted Effective Spread (Basis Points)	Stocks	3,471	1,038	1,110	625	1,656	1,465	94
	Observations	609,723	71,305	107,637	57,675	290,885	348,209	7,397
	Mean	5,394	1,941	1,480	759	412	151	334
	Standard Deviation	8,320	1,483	1,124	567	421	193	457

Notes: Stocks refer to the number of individual stocks in a given tier that have at least one non-missing observation for quoted or effective spread in both the pre-pilot period (November 2011 - October 2012) and the pilot period (November 2012 - November 2014). Observations refer to the total number of stock-day observations in a given tier that correspond to these stocks. Mean refers to the mean value of quoted or effective spread across these stock-day observations. Standard Deviation refers to the average within-stock standard deviation of quoted or effective spread. This Standard Deviation is computed as follows. First, we compute the time-series standard deviation of quoted or effective spread for each individual stock in a given tier. Then we compute the weighted average of these individual standard deviations, weighting each stock by its number of observations in that tier.

Table 3: Regression Results for Quoted and Effective Spreads by Tier

		Tier 1	Tier 2	Tier 3	Tier 4	Tier 5a	Tier 5b	Tier 5c
	Price Range	*$0<p<$0.10*	*$0.10≤p<$0.20*	*$0.20≤p<$0.51*	*$0.51≤p<$1.00*	*$1.00≤p≤$10*	*$10<p≤$100*	*$100<p<$175*
	Minimum Quotation Size Change	*Increased*	*Same*	*Decreased*	*Decreased*	*Decreased*	*Decreased*	*Same*
Time Weighted Quoted Spread (Basis Points)	β (Pilot vs Pre-Pilot)	1,874	-393	-473	-286	-258	-98	4
	Standard Error	(220)***	(112)***	(67)***	(47)***	(20)***	(12)***	(147)
Volume Weighted Effective Spread (Basis Points)	β (Pilot vs Pre-Pilot)	2,064	-391	-346	-207	-218	-80	22
	Standard Error	(438)***	(122)***	(65)***	(43)***	(18)***	(10)***	(147)

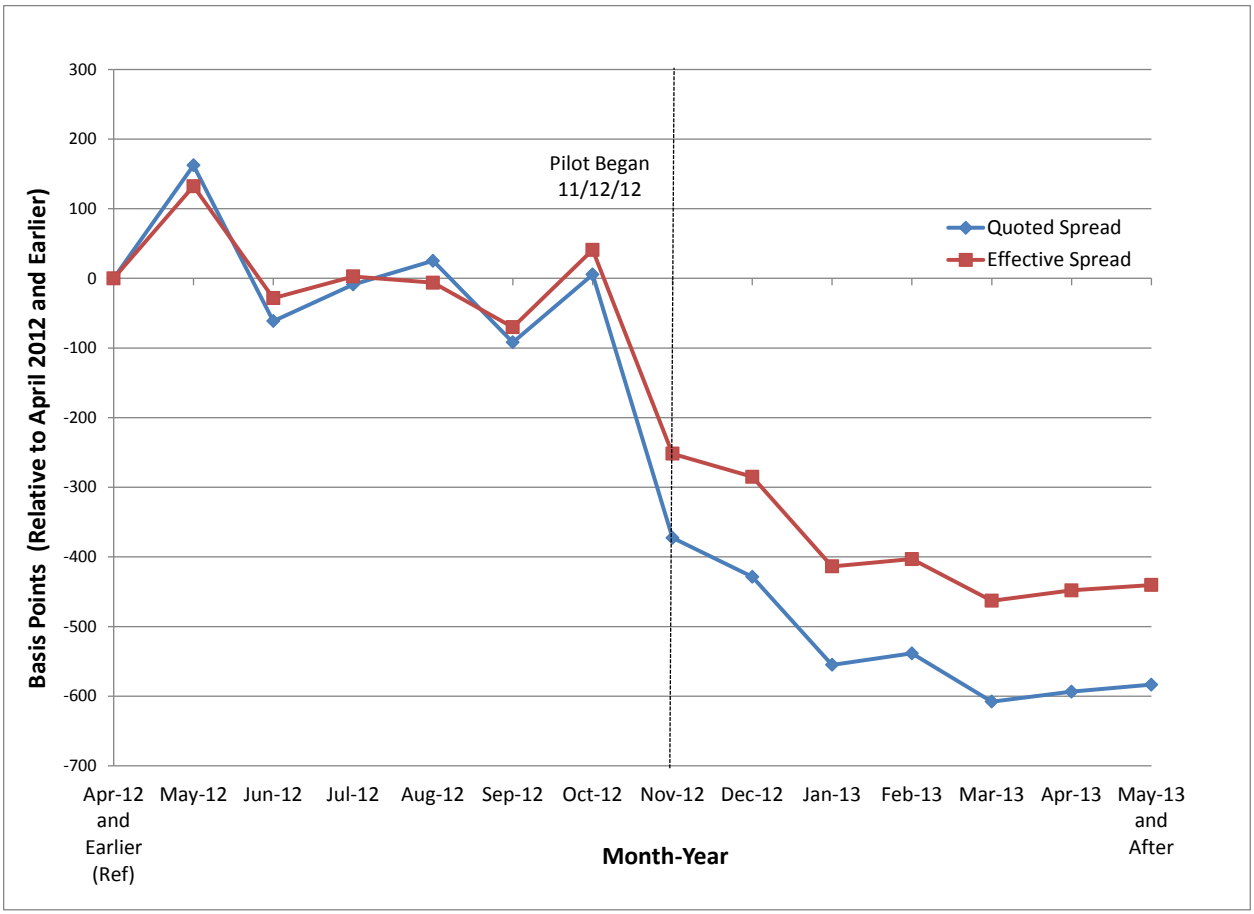
Notes: For each regression, the table shows the point estimate and the standard error of β, the coefficient on the *Pilot* indicator variable. For a given tier, β measures the average change in quoted or effective spread between the pre-pilot period (November 2011 - October 2012) and the pilot period (November 2012 - November 2014), controlling for stock fixed effects and stock-specific time trends. Standard errors are clustered at the stock level. *** denotes significance at the 1% level, ** at the 5% level, * at the 10% level.

Table 4: Magnitude of Regression Coefficients in Terms of Standard Deviations of Dependent Variables

		Tier 1	Tier 2	Tier 3	Tier 4	Tier 5a	Tier 5b
	Price Range	*$0<p<$0.10*	*$0.10≤p<$0.20*	*$0.20≤p<$0.51*	*$0.51≤p<$1.00*	*$1.00≤p≤$10*	*$10<p≤$100*
	Minimum Quotation Size Change	*Increased*	*Same*	*Decreased*	*Decreased*	*Decreased*	*Decreased*
Time Weighted Quoted Spread (Basis Points)	Pilot Coefficient (β)	1,874	-393	-473	-286	-258	-98
	Standard Deviation (SD)	6,063	1,441	1,116	561	428	193
	β/SD	**0.31**	**-0.27**	**-0.42**	**-0.51**	**-0.60**	**-0.51**
Volume Weighted Effective Spread (Basis Points)	Pilot Coefficient (β)	2,064	-391	-346	-207	-218	-80
	Standard Deviation (SD)	8,320	1,483	1,124	567	421	193
	β/SD	**0.25**	**-0.26**	**-0.31**	**-0.36**	**-0.52**	**-0.42**

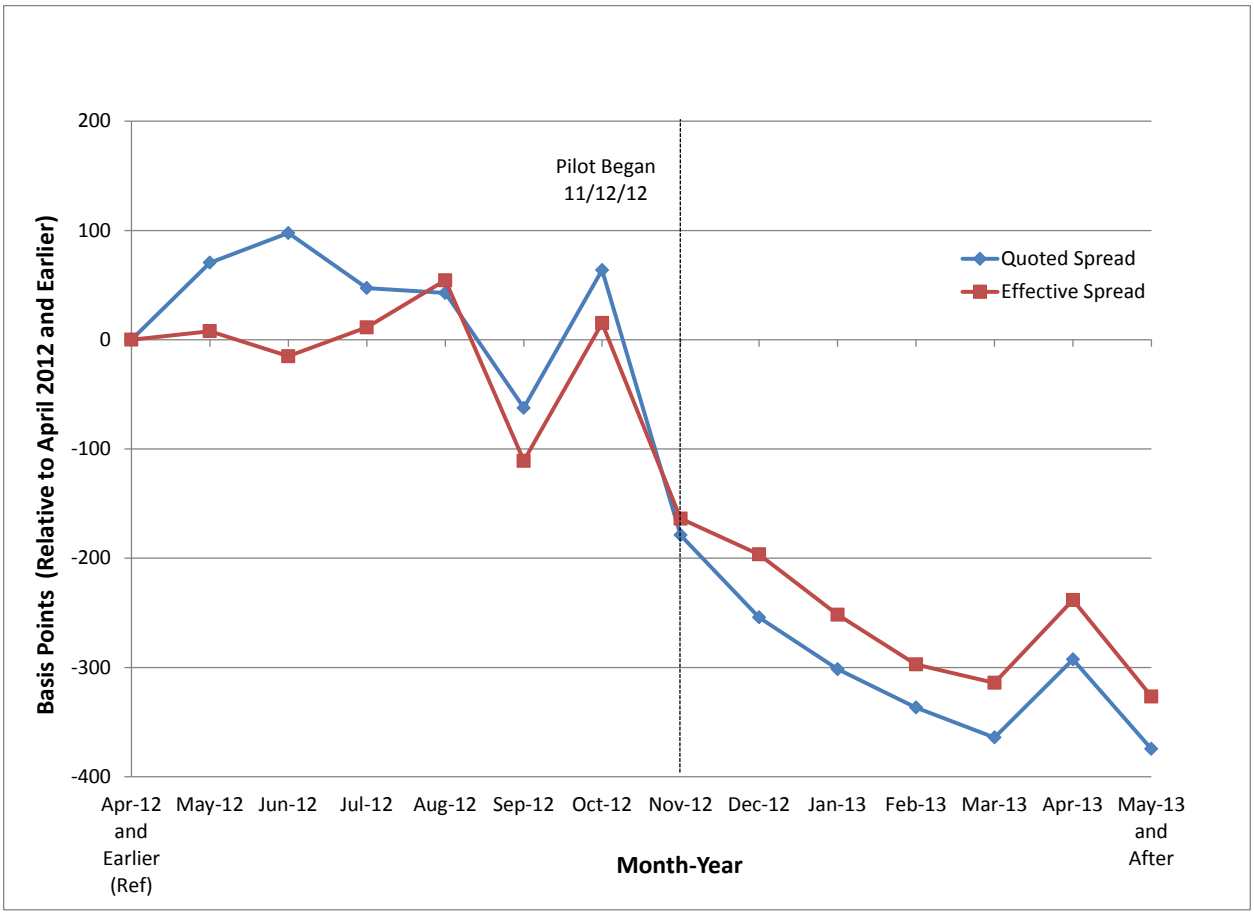
Notes: The table expresses the regression coefficients in Table 3 in terms of standard deviations of the dependent variables (from Table 2). The table excludes Tier 5c, because in Table 3 the regression coefficients for this tier were statistically insignificant. β is the coefficient on the *Pilot* indicator variable. For a given tier, β measures the average change in quoted or effective spread between the pre-pilot period (November 2011 - October 2012) and the pilot period (November 2012 - November 2014), controlling for stock fixed effects and stock-specific time trends. Standard Deviation is the average within-stock standard deviation of quoted or effective spread. This Standard Deviation is computed as follows. First, we compute the time-series standard deviation of quoted or effective spread for each individual stock in a given tier. Then we compute the weighted average of these individual standard deviations, weighting each stock by its number of observations in that tier.

Figure 1a: Tier 3 - Changes in Quoted and Effective Spreads Around the Start of the Pilot



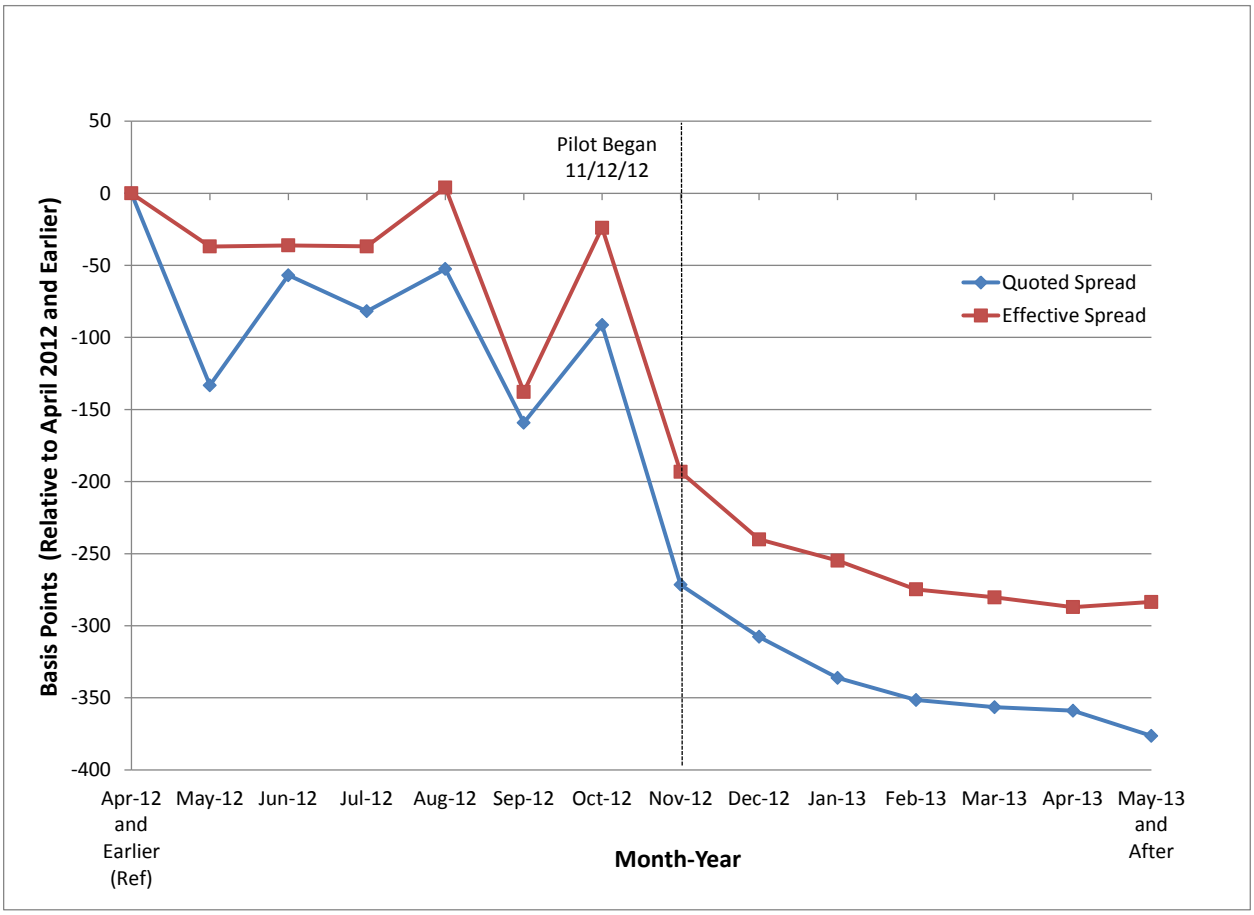
Notes: The figure plots the estimated coefficients for 13 indicator variables (one for each month or a group of months) from the regressions for quoted and effective spreads that control for stock fixed effects and stock-specific time trends. Each coefficient measures the quoted or effective spread in the corresponding month(s) relative to the average spread in the reference period of November 2011 to April 2012. "April-12 and Earlier" refers to the reference period itself, with the relative spreads being equal to 0 by construction. The pilot began on November 12, 2012. Data for November 2012 includes only trading days after the start of the pilot. "May-13 and After" refers to the months of May 2013 to November 2014.

Figure 1b: Tier 4 - Changes in Quoted and Effective Spreads Around the Start of the Pilot



Notes: The figure plots the estimated coefficients for 13 indicator variables (one for each month or a group of months) from the regressions for quoted and effective spreads that control for stock fixed effects and stock-specific time trends. Each coefficient measures the quoted or effective spread in the corresponding month(s) relative to the average spread in the reference period of November 2011 to April 2012. "April-12 and Earlier" refers to the reference period itself, with the relative spreads being equal to 0 by construction. The pilot began on November 12, 2012. Data for November 2012 includes only trading days after the start of the pilot. "May-13 and After" refers to the months of May 2013 to November 2014.

Figure 1c: Tier 5a - Changes in Quoted and Effective Spreads Around the Start of the Pilot

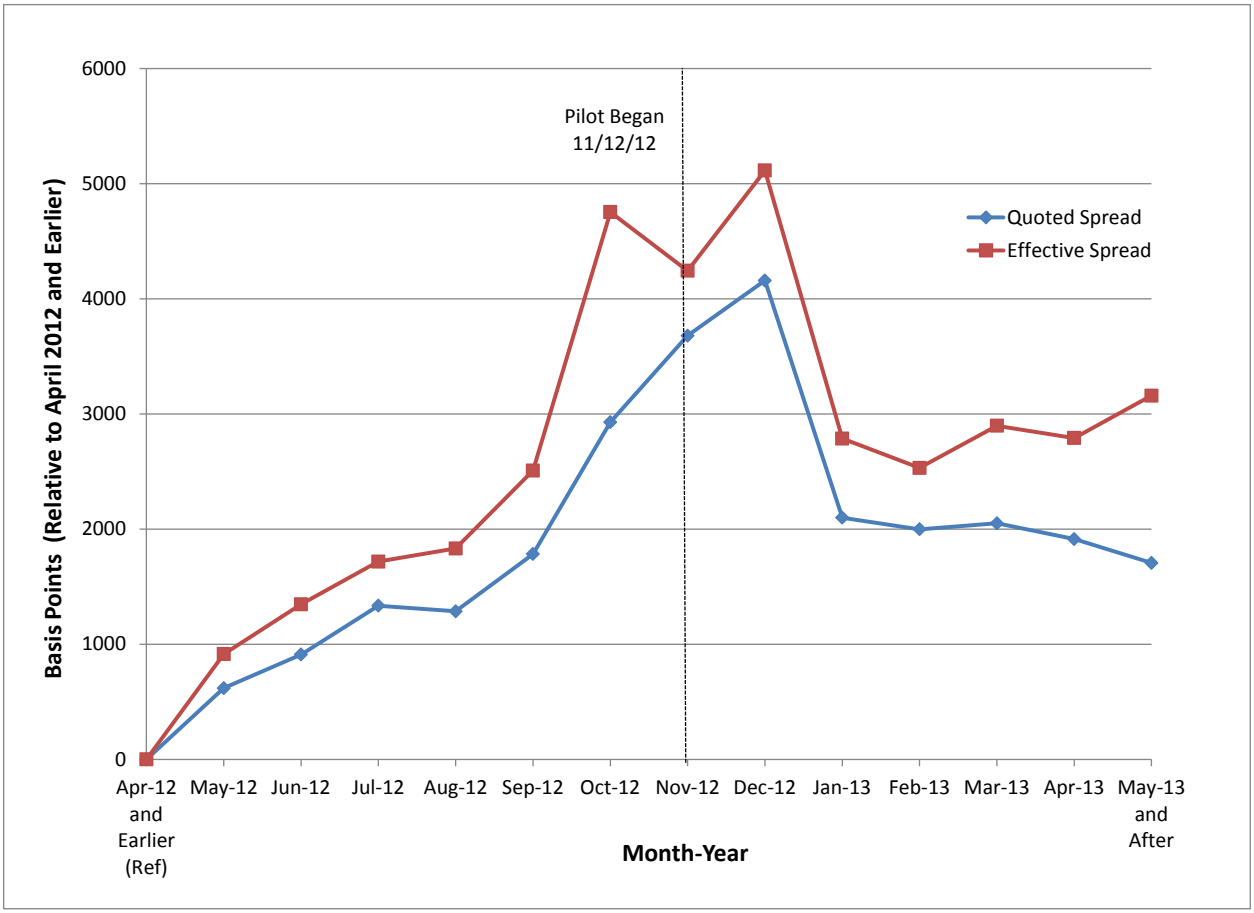


Notes: The figure plots the estimated coefficients for 13 indicator variables (one for each month or a group of months) from the regressions for quoted and effective spreads that control for stock fixed effects and stock-specific time trends. Each coefficient measures the quoted or effective spread in the corresponding month(s) relative to the average spread in the reference period of November 2011 to April 2012. "April-12 and Earlier" refers to the reference period itself, with the relative spreads being equal to 0 by construction. The pilot began on November 12, 2012. Data for November 2012 includes only trading days after the start of the pilot. "May-13 and After" refers to the months of May 2013 to November 2014.

Figure 1d: Tier 5b - Changes in Quoted and Effective Spreads Around the Start of the Pilot

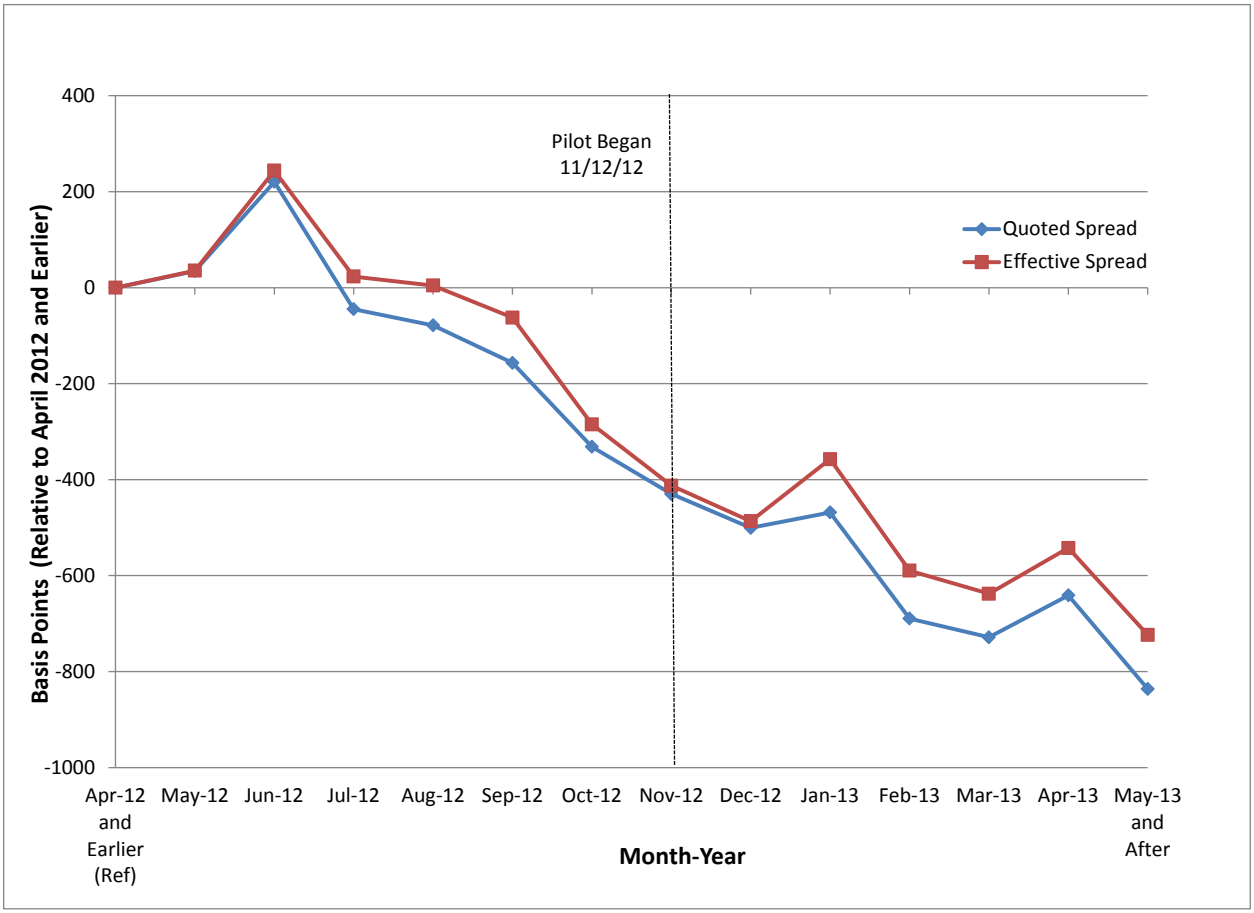
Notes: The figure plots the estimated coefficients for 13 indicator variables (one for each month or a group of months) from the regressions for quoted and effective spreads that control for stock fixed effects and stock-specific time trends. Each coefficient measures the quoted or effective spread in the corresponding month(s) relative to the average spread in the reference period of November 2011 to April 2012. "April-12 and Earlier" refers to the reference period itself, with the relative spreads being equal to 0 by construction. The pilot began on November 12, 2012. Data for November 2012 includes only trading days after the start of the pilot. "May-13 and After" refers to the months of May 2013 to November 2014.

Figure 2: Tier 1 - Changes in Quoted and Effective Spreads Around the Start of the Pilot



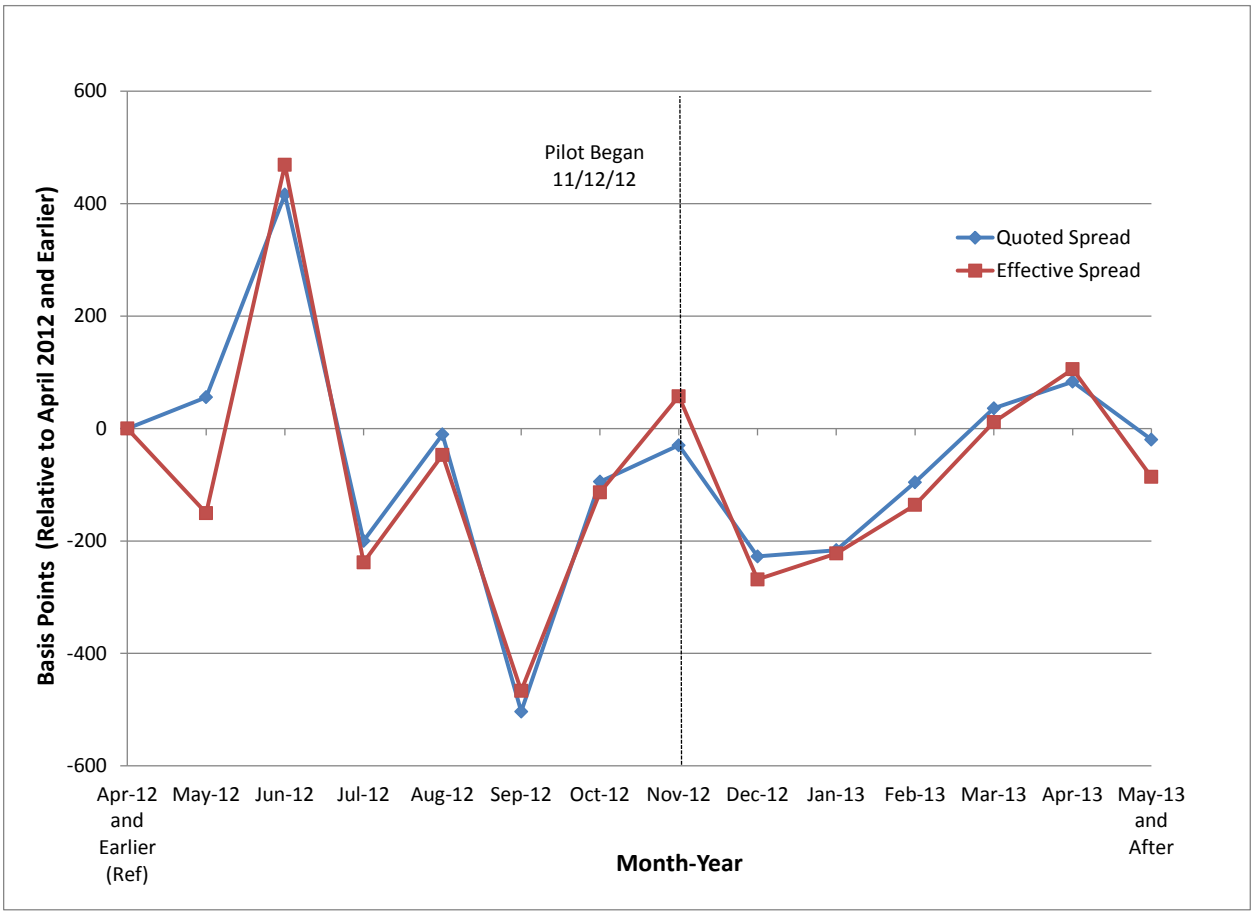
Notes: The figure plots the estimated coefficients for 13 indicator variables (one for each month or a group of months) from the regressions for quoted and effective spreads that control for stock fixed effects and stock-specific time trends. Each coefficient measures the quoted or effective spread in the corresponding month(s) relative to the average spread in the reference period of November 2011 to April 2012. "April-12 and Earlier" refers to the reference period itself, with the relative spreads being equal to 0 by construction. The pilot began on November 12, 2012. Data for November 2012 includes only trading days after the start of the pilot. "May-13 and After" refers to the months of May 2013 to November 2014.

Figure 3a: Tier 2 - Changes in Quoted and Effective Spreads Around the Start of the Pilot



Notes: The figure plots the estimated coefficients for 13 indicator variables (one for each month or a group of months) from the regressions for quoted and effective spreads that control for stock fixed effects and stock-specific time trends. Each coefficient measures the quoted or effective spread in the corresponding month(s) relative to the average spread in the reference period of November 2011 to April 2012. "April-12 and Earlier" refers to the reference period itself, with the relative spreads being equal to 0 by construction. The pilot began on November 12, 2012. Data for November 2012 includes only trading days after the start of the pilot. "May-13 and After" refers to the months of May 2013 to November 2014.

Figure 3b: Tier 5c - Changes in Quoted and Effective Spreads Around the Start of the Pilot



Notes: The figure plots the estimated coefficients for 13 indicator variables (one for each month or a group of months) from the regressions for quoted and effective spreads that control for stock fixed effects and stock-specific time trends. Each coefficient measures the quoted or effective spread in the corresponding month(s) relative to the average spread in the reference period of November 2011 to April 2012. "April-12 and Earlier" refers to the reference period itself, with the relative spreads being equal to 0 by construction. The pilot began on November 12, 2012. Data for November 2012 includes only trading days after the start of the pilot. "May-13 and After" refers to the months of May 2013 to November 2014.