

MEMORANDUM

TO: File
FROM: Office of Economic Analysis
DATE: April 6, 2005
RE: Supplemental Analysis of Volatility for Stocks Switching from Nasdaq to NYSE

In preparation for the re-proposal of Reg NMS in December, the Office of Economic Analysis performed an analysis of volatility changes for a sample of firms that switched from Nasdaq to NYSE.¹ That study found that on average, intraday volatility declined around the time the stocks switched. This result was found to hold when volatility is measured using any time interval between five and sixty minutes. In addition, the study used variance ratio tests to determine that the switch was associated with a decline in the “transitory” component of volatility. The “transitory” component represents pricing inefficiencies, or temporary deviations of the market price away from fundamental value.

To help the commission assess and respond to certain issues raised by commenters on the Regulation NMS reproposal, OEA has performed supplemental analysis. Specifically,

- The prior study analyzed volatility using Trades and Quotes (TAQ) data, obtained from the NYSE. The supplemental analysis uses data from the NASTRAQ database, obtained from Nasdaq, to analyze volatility during the period the stocks were trading on Nasdaq, and continues to use TAQ data during the period the stocks traded on the NYSE.
- The supplemental analysis excludes one stock mentioned in the Nasdaq comment letter (Cedar Shopping Centers) as being unduly influenced by confounding events.
- The prior study examined volatility during a three-month window surrounding the switch from Nasdaq to NYSE. For a small number of cases, the pre-event window contained some data that pre-dated the move to decimal trading. The supplemental analysis uses only data from the post-decimal trading environment.
- To test the robustness of our conclusions to alternate ways of measuring volatility, we expanded our analysis to look at trade data as well as quote data. Variance ratios computed using trade data confirm that the stocks that switched from Nasdaq to NYSE experienced a substantial decrease in transitory volatility. Indeed, the evidence from the last trade prices indicates that the volatility decrease was substantially larger than suggested by the quote midpoint evidence.

¹ Memorandum to File, from Office of Economic Analysis, dated December 15, 2004 (Analysis of volatility for stocks switching from Nasdaq to NYSE).

- Finally, the Nasdaq comment letter argued that variance was not a “valid” statistical measure, and suggested that OEA should have used standard deviation instead.² For reasons outlined in this memo, OEA disagrees with this assertion.

Supplemental Analysis of Prior Results

The results of OEA’s supplemental analysis confirm the basic conclusions reached in the prior analysis, that on average the stocks that switched from Nasdaq to NYSE during the sample period experienced a decrease in total volatility, as well as a decrease in transitory volatility.

The supplemental analysis also confirms the suggestion made by Nasdaq that the magnitude of the estimate was influenced by outliers (such as “Cedar”), or by the inclusion of some data prior to decimalization, and that methodological choices can affect substantially the magnitude of the estimates. The supplemental OEA analysis finds that when NASTRAQ data is used and the same screens are applied as were reported in the Nasdaq letter, the average standard deviation is essentially the same as those reported by Nasdaq. Therefore, the supplemental OEA analysis resolves the discrepancy between the numbers in the OEA study and those in the Nasdaq comment letter. However, we have not investigated the reasons why the results based on TAQ quote data are inconsistent with those based on the NASTRAQ data.

Although the exact magnitude of the measured effect is sensitive to methodological assumptions, the final conclusions are not altered by our supplemental analysis. We should note that despite the concerns raised in their letter, Nasdaq’s own analysis also confirms the basic conclusions of the OEA study, that on average in the sample of switchers, total volatility declines and the variance ratio declines. The same result is also confirmed by an NYSE study on the same topic,³ and also by academic research based on earlier samples.⁴

Nasdaq in their comment later reports additional results beyond the scope of the OEA study. For example, they report separately the volatility changes for low, medium, and high-volume sub-samples, with breakpoints defined at 100,000 and 1,000,000 shares of average daily trading volume. They report that the total volatility of intraday returns decreased for all three groups when the stocks moved to NYSE. They also report that the variance ratio declined for the low and medium volume groups. The vast majority of Nasdaq stocks fall into these low and medium volume groups. In this respect, the additional Nasdaq analysis further reinforces the conclusions of the OEA study.

The Nasdaq analysis also indicated an increase in the variance ratio for the high-volume group. However, the high-volume group contains only a small number of observations,

² Nasdaq comment letter, Appendix (January 25, 2005), pp. 16-17.

³ Paul Bennett and Li Wei, “Market Structure, Fragmentation, and Market Quality—Evidence From Recent Listing Switches,” working paper, New York Stock Exchange (2003).

⁴ See, for example, Hendrik Bessembinder and Subhrendu Rath, “Trading Costs and Return Volatility—Evidence from Exchange Listings,” working paper, University of Utah (2002).

and no test of statistical significance was performed. Moreover, the Nasdaq analysis finds the surprising result that the variance ratio for high-volume NYSE stocks is substantially higher than for low- and medium-volume NYSE stocks. Economic theory and other empirical evidence would lead us to expect the variance ratio to be a decreasing function of trading volume. Therefore, we believe that the number reported for the variance ratio of high volume stocks on NYSE is likely to be an overestimate of the true value. Consequently, we are reluctant to interpret Nasdaq's results as evidence that the variance ratio increased for high-volume stocks when they moved to NYSE. OEA believes that transitory volatility is likely to be substantially lower on Nasdaq or any other trading platform for the highest-volume stocks. OEA agrees in spirit with the view expressed in the Nasdaq comment letter that the large declines in transitory volatility observed for low- and medium-volume stocks are not likely to be representative of the higher-volume stocks—it is reasonable to expect little change in the variance ratio for the highest-volume stocks.

Supplemental Tests Based on Last Trade Prices

It should be noted that the OEA volatility study computed volatility using quote midpoints. Using quote midpoints, particularly when it comes to estimating the temporary component of volatility, is a very conservative approach that may underestimate the true amount of transitory volatility. Specifically, it does not count trades that occur far away from the market as contributing to transitory volatility, unless they cause the quote midpoint to change. A market could routinely trade at prices that fluctuate widely away from the fundamental value, and it will not necessarily show up in a volatility measure based on quote midpoints. Furthermore, quote midpoints will not pick up transitory volatility arising from trades that occur outside of the NBBO in an environment with poor trade through protection.

To get a broader picture of how volatility changed when these stocks switched from Nasdaq to NYSE, we repeated our volatility analysis using last trade prices instead of quote midpoints. The results confirm that trade prices on Nasdaq exhibit substantially more transitory volatility than on NYSE. Indeed, the difference in transitory volatility on the two markets is significantly greater when measured using trades than when using quote midpoints.

For example, the mean variance ratio (5-minute return variance divided by 60-minute return variance) for the Nasdaq sample was approximately 1.542 compared to 0.952 for the NYSE sample, and the median was 1.485 for the Nasdaq sample, compared to 0.919 for the NYSE sample. Using 10-minute variance in the numerator, OEA estimated the mean and median variance ratio to be approximately 1.334 and 1.274 for the Nasdaq sample, compared to 0.940 and 0.953 for the NYSE sample. This analysis utilizes NASTRAQ data, excludes "Cedar," and uses only data from the post-decimal period.

Variance vs. Standard Deviation as a Measure of Dispersion

In their comment letter, Nasdaq characterized variance as not being a “valid” statistical measure, and suggested that standard deviation was a superior measure. Standard deviation and variance are the same measure merely expressed in different units, so in this respect it is impossible for one of the two to be a valid statistical measure and one not valid. However, for purposes of comparing two markets, OEA believes that a comparison of sample variances is more appropriate than a comparison of sample standard deviations. While sample variance is an unbiased estimator of the true variance, the sample standard deviation will be a downwardly biased estimator of the true standard deviation, due to Jensen’s Inequality.⁵ In the current application, the amount of this bias will be related to the degree of dispersion of “true” volatility across stocks in the sample.

In certain cases, this bias can cause one to draw incorrect inferences about the relative volatility in two samples. To illustrate, consider the following hypothetical example in which we observe two samples, each including the variances of nine stocks.

	Sample 1	Sample 2
Variance(1)	0.13	0.02
Variance(2)	0.14	0.06
Variance(3)	0.15	0.1
Variance(4)	0.16	0.14
Variance(5)	0.17	0.18
Variance(6)	0.18	0.22
Variance(7)	0.19	0.26
Variance(8)	0.2	0.3
Variance(9)	0.21	0.34
Avg. Variance	0.17	0.18
Avg. Std Dev.	0.411	0.401

The variance is lower, on average, in sample one than in sample two (0.17 compared to 0.18). But because sample two has a higher dispersion of variances across stocks, the average standard deviation is more biased downwards due to Jensen’s Inequality, and the average standard deviation is actually smaller in sample two, leading the observer to the incorrect conclusion. This example is not calibrated to any real data, it is merely an illustrative example showing why averaging across variances is more appropriate than averaging across standard deviations. The average variance is a more theoretically sound basis for comparing two markets than the average standard deviation, because it is not subject to this Jensen’s Inequality bias.

For this reason, we disagree with Nasdaq’s assertion that the standard deviation is a superior measure. For those who are more comfortable viewing volatility measures in units of returns rather than squared returns, the appropriate comparison would be to look at the square root of the average variance, not the average standard deviation. In any case, we have verified that for the sample of stocks that switched from Nasdaq to NYSE, both measures lead to the same substantive conclusions.

⁵ See, for example, Stephen Figlewski, “Estimation Error in the Assessment of Financial Risk Exposure,” working paper, New York University (2004).