Market Structure, Fragmentation and Market Quality
- Evidence from Recent Listing Switches

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Abstract

Have structural changes in the U.S. equities markets, such as decimalization, the growth of ECNs, and improvements in order routing technologies, altered the well-documented advantage of stock exchange order flow concentration over fragmented OTC trading? We examine a range of market quality indicators for equities that switched listings from Nasdaq to the NYSE in 2002-3. We find that these stocks immediately experienced significant improvements in price volatility, as measured in several different ways, including daily and shorter-term volatilities. We also find a significant negative autocorrelation of short-term returns on Nasdaq, but these pricing inefficiencies are eliminated when companies switch to the NYSE. Consistent with these results about volatility and pricing efficiency, we find that the switching stocks experience significant tightening of their quoted spreads and of their effective spreads. To better identify the causal linkages between market structure and market quality, we show that higher price volatilities and greater transaction costs are associated with a greater degree of order flow fragmentation on the OTC market, and with larger subsequent reductions in volatility and transaction cost when the firms switch to the NYSE. We conclude that despite the technological enhancements to market mechanisms the basic principle that the high degree of direct interaction and competition among orders in a stock exchange results in measurably superior market quality, compared to what a decentralized dealer/ECN market can provide.

1. Introduction

How financial market structure influences the quality of the market is of a high degree of importance to investors, securities issuers, regulators, and market operators. Past research has continually shown that, compared with a fragmented market structure, a stock exchange that requires all orders to interact and compete produces higher quality price formation, lower volatility, and lower execution costs. These issues have been examined persuasively in past literature, with the conclusion that a stock exchange structure provides better prices and cheaper executions.[1] Structural changes in markets and trading mechanisms have again raised these issues, however. One of the changes is the introduction of decimals pricing in the U.S. equity market in early 2001, which has significantly influenced equity trading.[2] Other changes include dramatic shifts in the over-the-counter (OTC) market toward ECN trading; the widening practice of automated order routing technologies; and the increased use of automated trading strategies. Some evidence shows that the alternative trading mechanisms, such as ECNs, though fragmenting the market, contribute to market efficiency for very liquid securities (see Huang (2002) and Hendershott and Jones (2003)).[3]

Strategies that rely on fast order submissions and, if necessary, fast cancellations and resubmissions are also growing in popularity. On the New York Stock Exchange (NYSE) there has been a rapid growth in small order automatic executions, in computer-supported "program trading," and in the use of real-time limit order book data by trading desks.[4] Such changes carry the potential to alter the comparative advantages of different market structures.

[1] See Lee (1993), Christie and Huang (1994), Barclay (1997), Bessembinder and Kaufman (1997), Bessembinder (1999), Heidle and Huang (1999), Huang and Stoll (1999), Venkataraman (2000), Jones and Lipson (1999), Bessembinder (2003), Boehmer (2003), Boehmer, Jennings and Wei (2003), among others.

[2] Jones and Lipson (1999) and Bollen and Busse (2003) show that the $1/16 tick size and the decimalization have changed the institutional trading and raised their trading costs.

[3] Huang (2002) shows that the proliferation of ECNs promotes Nasdaq quote quality rather than fragmenting the market. Hendershott and Jones (2003) find evidence that the Island ECN significantly contributes to the price discovery of the three most active ETFs. After Island stopped posting quotes on September 23, 2002, trading cost rose and quotes adjusted more slowly for the ETFs.

[4] See Boehmer, Saar and Yu (2002). The automatic execution system on the NYSE executed an average of 120 million shares daily in August 2003.

A basic question for researchers is how and whether these changes have affected the previously documented advantages of a stock exchange mechanism such as the NYSE relative to the OTC markets for Nasdaq listings. In addition now there are more public data available for making comparisons of order executions across markets. In this paper, we employ a sample of stocks that transferred from Nasdaq to the New York Stock Exchange (NYSE) in 2002-3, in conjunction with new data and measures, to gauge how a company's choice of market for its equity influences the quality of its stock prices and the cost of trading in its shares. For the stocks that switch from Nasdaq to the NYSE we find distinct improvements in price volatility and efficiency, quoted spreads, and execution costs, and we provide evidence linking these improvements to the reduction in fragmentation associated with the stock exchange listing.

1.1 Previous Literature

Previous studies have found that the NYSE has a lower execution cost. Christie and Huang (1994), Barclay (1997), Bessembinder (1999), and Heidle and Huang (1999) find that when Nasdaq stocks switch to the NYSE, their effective and quoted spreads are significantly reduced. Using matched samples, Huang and Stoll (1996), LaPlante and Muscarella (1997), Keim and Madhavan (1996), Bessembinder and Kaufman (1997), SEC (2000), and Boehmer (2003) find that Nasdaq has higher execution costs than the NYSE.

Studies have also shown that prices on the NYSE better reflect relevant information than prices on the OTC market. Bessembinder (1999) examines 190 companies that switch from Nasdaq to the NYSE during 1996 – 1997 and finds that stocks have lower daily volatility on the NYSE. Jones and Lipson (1999) show that Nasdaq quotes adjust more slowly to new information, compared to the NYSE quotes.

A number of papers have also shown that market fragmentation can reduce liquidity and harm market quality. Cohen, Maie, Schwartz and Whitcomb (1982) point out that off-exchange executions may benefit brokers but harm the market as a whole. Cohen, Conroy and Maier (1985) show that a fragmented market may result in a wider bid-ask spread because of decreased opportunity for order interaction. Mendelson (1987) finds that the fragmented market has less liquidity and increases price variances faced by investors. Madhavan (1995) demonstrates that fragmentation results in higher price volatility and violations of price efficiency. Empirically, Amihud, Lauterbach and Mendelson (2002) provide evidence that trading consolidation improves liquidity and adds value to investors.

1.2 This Study

This study fills several gaps. First, it examines whether the findings about the advantages of stock exchanges still hold, given rapid structural changes in recent years. Second, we are also able to take advantage of different measures of market quality than those available for earlier studies. During 2001 most U.S. stock exchanges, dealers, ECNs, and other markets began reporting uniform, SEC mandated measures designed to permit cross-market comparisons of execution rates and costs (e.g., effective spreads based on order-arrival-time quotes), and order flow distribution across size and type categories. These data permit alternative measures of execution costs and quality, and of the degree of market fragmentation.

This article documents the improvement in several measures of price volatility and efficiency, quotes, and execution costs for firms that changed listings in 2002-3. We also investigate the source of these improvements, using regression analysis to examine how the extent of order flow fragmentation affects price volatility and execution quality. Holding other factors equal, we find that the more fragmented is the trading on Nasdaq, the higher is the stock's price volatility and quoted and effective spread. In turn, the stocks with more fragmented trading then benefit relatively more when they switch to the NYSE.

In short, we conclude that the greater competition and interaction among orders on a stock exchange such as the NYSE continues to provide prices that are structurally less volatile than prices on the fragmented OTC market, and that this leads to tighter spreads, more efficient pricing and lower execution costs on the NYSE.

Our paper proceeds as follows. Section 2 introduces our sample and data for the stocks that switched markets. Section 3 presents our findings about volatility using several alternative measures, and relates these to order flow fragmentation. Section 4 presents the findings on price efficiency. Section 5 shows that quoted and effective spreads fall when stocks switch to NYSE, and again relates these to the volatility improvements associated with different market structures. Section 6 concludes and provides additional observations about methodology and the data.

2. Sample and Data

The sample in our study is 39 U.S. companies that switched their listings from Nasdaq to the NYSE between January 2002 and March 2003. No firms switched from the NYSE to Nasdaq during this period. We have used several publicly available data sources in our study. Data on each company's market capitalization and share outstanding are from the CRSP database. Stock prices, trading volumes, numbers of trades, and trade sizes are from the TAQ database. The sample statistics are summarized and reported in **Table 1** for the 39 companies in our study. Appendix A presents more detailed information for the companies that switched to the NYSE.[5]

As Table 1 shows, the sample of 39 stocks that switched listings has an average market capitalization of $1.5 billion. The largest firm is the Regions Financial Corporation, which transferred to the NYSE on May 3, 2002 with an $8 billion market capitalization (Appendix A). The smallest firm is Cantel Medical Corp with a market capitalization of about $160 million. The daily volatility of our sample stocks is about 3%, slightly below the average for Nasdaq stocks.[6] The average daily closing prices for the 39 stocks range from $10 to $58, and with the mean of $24.

[5] We will treat the timing of these switches as exogenous. Although one might hypothesize that switches are timed to increase their effect on market quality, the selection bias correction applied later in our study mitigates any such hypothetical effect. In any case, it is unlikely to be significant because the timing of switches is planned in advance and not well suited to capture short-term fluctuations in the relative trading conditions between the two markets, even if these were foreseeable.

[6] The average daily volatility for Nasdaq stocks is 4 – 5 % during 2002 based on the daily CRSP data.

Quoted spreads are available from the National Best Bid and Offer (NBBO) derived from the consolidated quote files (CQ) from the TAQ database. Data on execution quality and measures of market fragmentation are derived from the data reported by market centers under the SEC Rule 11Ac1-5.[7] Since we require three months of pre-switching observations, we include in our study only the firms that switch to the NYSE starting in 2002.[8] The execution quality data from the 11Ac1-5 reports on the switching firms is summarized and reported in **Table 2**.

Table 2 reports information of order flows and market fragmentation measures. One is the total number of shares that are covered in the 11Ac1-5 reports. Within the covered shares, the shares that are executed, cancelled, and executed away, and their ratios, are also reported. The 11Ac1-5 statistics show that Nasdaq has lower execution and higher cancellation; on average 35% of the placed shares are cancelled and 61.7% shares are executed. The comparable numbers on the NYSE are an 11% cancellation rate and an 88% execution rate.

In addition, Nasdaq has a significantly higher rate for executing shares away from the market centers to which orders are originally routed. Within the executed shares, 20% of Nasdaq executions are done away from the reported market centers, while on the NYSE the ratio is only 1%.[9] In addition, the cancellation rates increase more rapidly as orders get larger on Nasdaq than on the NYSE. For orders between 5,000 and 9,999 orders on Nasdaq, the cancellation rate is 55% and the execution rate is 35.8%.

Panel B in Table 2 reports the market fragmentation information on Nasdaq and on the NYSE. We present four proxies to measure the degree of market fragmentation. We first

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[7] Rule 11Ac1-5 requires market centers to make available to the public monthly electronic reports that include uniform statistical measures of execution quality. For every security and month, each market center is required to report execution quality measures, including effective spreads, realized spreads, and execution speed, for various order types and sizes. While 65 firms transferred from Nasdaq to NYSE after decimal pricing was introduced, 39 of these (36 in 2002 and 3 in the first quarter of 2003) transferred after sufficient 11Ac1-5 data were available.

[8] For listed companies, the reports became available since June 2001. For Nasdaq listed companies, most reports were available by Oct 2001, the originally scheduled date, but the deadline was postponed in the wake of September 11, 2001, so the October report is missing some of the reponses.

[9] Moreover, limit orders have much higher cancellation rates than market orders, and lower execution-away rates. The cancellation rate is are higher on Nasdaq when comparing the same type orders.

compute the Herfindahl-Hirschman Index (HHI) across market centers.[10] Second, market centers are grouped by category of market participants, such as Nasdaq dealers, ECNs, and regional stock exchanges, and we recompute the Herfindahl-Hirschman Index across these types of market participants (HHI_P). Third and fourth, we report the number of all market centers that file Dash-5 report, and the number of market centers with at least 1% of market volume.

The statistics of the above measures show the that Nasdaq is more fragmented market compared to the NYSE. The Nasdaq's Herfindahl-Hirschman Index by market center is 21%, computed as an average across the 39 sample stocks, as compared with an average of 90% for the NYSE. In addition, the average number of market centers that receive order flow and provide execution is 22 per stock on Nasdaq, with a maximum of 59 market centers. In comparison, the NYSE has on average 7 market centers in the 11Ac1-5 reports. Furthermore, with a 1% market share limit, the number of market centers drops to 9 on Nasdaq, implying that 13 out of 22 market centers have lower than 1% market of volume for the 39 sample stocks.[11]

Comparing the four measures of market fragmentation, we find that the number of market centers in the 11Ac1-5 report has the largest cross sectional variation, measured by the ratio of the sample standard deviation to the sample mean.[12] This variation best captures the different magnitude of market fragmentation across the sample stocks. We thereby use it as the proxy of market fragmentation in our study.

3. Effects of Switching Listings on Volatility

[10] The market center in the Dash-5 reports is defined as the market venue that provides execution service.

[11] The SEC grants the following two exemptions from the 11Ac1-5 rule, one for very inactively traded securities and one for small market centers that do not focus their business on the most actively traded securities. First, the SEC is exempting any national market system security that did not average more than 5 reported transactions per trading day, as disseminated pursuant to an effective transaction reporting plan, for each of the preceding six months (or such shorter time that the security has been designated a national market system security). Second, the SEC is exempting any market center that reported fewer than 200 transactions per trading day on average over the preceding six-month period in securities that are covered by the Rule. For further information, please see SEC, 2001**, "**Exemptive Order: NASD Small Firm Advisory Board on Rule 11Ac1-5," June 22, 2001.

[12] In Table 2, the ratio of sample standard deviation to the sample mean is about 45% for the fragmentation index measured by the number of market center, as compared to 10% - 14% of other measures.

In this section we examine price volatilities. First, we demonstrate that volatility drops when firms switch from Nasdaq to the NYSE. Then we present evidence linking the magnitude of volatility in a Nasdaq-listed stock to its degree of order flow fragmentation on the Nasdaq market.

3.1. Volatility Measures

For every switching stock, we examine several measures of volatility. One commonly used measure is the daily return volatility, i.e., the standard deviation of its day-to-day percent price change. Slight variants are computed during the 60 trading days before and 60 trading days after switches. These are based alternately on opening, and closing prices for each day. We report our results of the volatility change in **Table 3.** Panel A of Table 3 shows mean and median values of these three daily return measures for the 39 sample stocks.

The daily return volatilities in Table 3, Panel A show declines that are generally statistically significant after listing switches. Although daily return volatility is a key measure of stock performance, in a given period it is also likely to be affected not only by market structure but also by the arrival of news or information during each day. Therefore, we also examine volatility in much shorter time intervals, such as 5-minute interval, thereby lowering the probability of news arrival during the volatility measurement intervals and better isolating the effect of market structure differences. In Panel B, we show sample return volatilities computed for non-overlapping 5-minute periods throughout the 60 trading day periods before and after the switches, for the 39 switching stock sample. While the daily volatilities reported in Panel A decline and usually the declines are statistically significant, the 5-minute return volatilities are all highly significant for all three measures.

We next compute the intraday short-term price high-low ranges and the relative price ranges, measured in basis points by dividing the dollar price range by the opening, or closing prices for each 5-minute interval. We report the results in Table 3 Panel C. Using either mean or median changes, these high-low volatility measures fall significantly after the listing switches.

The average price range falls more than half, from 8.5 to 4 cents, when stocks move from Nasdaq to the NYSE. The percentage of drop is even larger if median is used.

This high-low range volatility measure can be interpreted slightly differently from the return volatilities because it gives more weight to extreme or outlying observations. Note that using the price range as a volatility measure raises measurement issues that must be handled particularly carefully. The price range measure would be sensitive to trades that are out-of-sequence or mistakenly reported. Therefore, we have thoroughly screened our trade data to exclude any problematic transactions or transactions that might have effects on the high-low range measure. In our study, we have excluded the following trades:[13]

1.) Trades are done outside of the regular market hours between 9:30AM – 4:00PM.
2.) Cancelled Trades (CORR = 7 – 12 in TAQ): trades cancelled due to errors, such as wrong time stamps or prices.
3.) Bunched trades (COND = B in TAQ): a trade representing an aggregate of two or more regular trades.
4.) Bunched sold trade (COND = G in TAQ): a bunched trade not reported within 90 seconds of execution.
5.) Sold last trade (COND = L in TAQ): a transaction that occurs in sequence but is reported to the tape at a later time.
6.) Opened last trade (COND = O in TAQ): an opening trade that occurs in sequence but is reported to the tape at a later time.
7.) Pre- and Post-Market Close Trades (COND = T in TAQ): a Nasdaq trade that occurred within the current trading day, but is reported outside of the current market hours.
8.) Average Price Trades (COND = W in TAQ): A trade where the price reported is an average of the prices for transactions during all or any portion of the trading day.
9.) Sold Sale (COND = Z in TAQ): a transaction that is reported to the tape at a time later than it occurred.
10.) A trade in regular market hours whose price is 20% more or less than the previous trade.

[13] We also exclude the following quotes in our analysis:
1.) Quotes outside the regular market hours between 9:30AM – 4:00PM.
2.) Quotes whose spread is greater than $2.00 or 10% greater than the quote midpoint.
3.) Quotes whose midpoint rose or fell 20% or more from the previous quote midpoint.
4.) Quotes associated with special market conditions, such as trading halt, news pending, or news dissemination.

Overall, we have deleted less than 0.1% of the trades and quotes from the CT and CQ files.

As a comparison of Panel B and C of Table 3 shows, the two 5-minute volatility measures tell a very similar story, that firms have a lower volatility of returns when they switch their listings from Nasdaq to the NYSE. **Figure 1** depicts the daily average of the 5-minute interval price range for the 60-day window before and 60-day window after the switch. As shown on the figure, the daily average of the 5-minute interval price range across 60 trading day window is 8.3 cents (33.2 bps) on Nasdaq, much higher if compared to the 4.0 cents (17.1 bps) on the NYSE.

The reduction in volatility may partly reflect the effect of the NYSE opening auction. The opening auction can effectively aggregates information and reduce volatility of prices at the beginning of a trading day relative to the fragment market, where it takes longer for prices to converge. To examine this, we also compute the average high-low price ranges for each 5-minute interval in a trading day across all 39 stocks. As expected, the opening interval has the largest volatility differential between the two markets. Nonetheless, as clearly shown in **Figure 2**, the average volatility is lower on the NYSE in all 5-minute intervals during the trading day. Weaver (2002) conclude the same using matched sample studies.

3.2. Impact of Market Fragmentation on Price Volatility

If it is true that market fragmentation is responsible for the higher price volatility of Nasdaq-listed stocks, then differing degrees of fragmentation might also be associated with differing amounts of price volatility. The greater the number of market centers trade a stock, then the more dispersed or fragmented will liquidity in that stock be. Liquidity is also influenced by the overall amount of trading in the stock and the company’s capitalization, so we also control for these factors in our cross sectional study. We use the following cross sectional regression to investigate the impact of degrees of market fragmentation on volatility.

First, we examine the effect of market fragmentation on the level of volatility:

$$\text{DSTD}_{Nasdaq,j} = \alpha_1 + \beta_{11}\ln(\text{MCAP}_{Nasdaq,j}) + \beta_{12}\ln(\text{VOLUME}_{Nasdaq,j}) + \beta_{13}\text{Findex}_{Nasdaq,j} + \beta_{14}\lambda + e_j \quad (1)$$

$$ISTD_{Nasdaq,j} = \alpha_2 + \beta_{21} \ln(MCAP_{Nasdaq,j}) + \beta_{22} \ln(VOLUME_{Nasdaq,j}) + \beta_{23} Findex_{Nasdaq,j} + \beta_{24} \lambda + e_j \quad (2)$$

$$IPR_{Nasdaq,j} = \alpha_2 + \beta_{31} \ln(MCAP_{Nasdaq,j}) + \beta_{32} \ln(VOLUME_{Nasdaq,j}) + \beta_{33} Findex_{Nasdaq,j} + \beta_{34} \lambda + e_j \quad (3)$$

In the above equation, $DSTD_{Nasdaq,j}$ is the daily volatility measured as the standard deviation of daily close-to-close return. $ISTD_{Nasdaq,j}$ is the 5-minute interval volatility measured as the standard deviation of 5-minute close-to-close return. $IPR_{Nasdaq,j}$ is the 5-minute price range, measured as the ratio of the interval price range to the interval closing price. All of the above three variables are computed in the (-60, -1) window relative to each stock's transfer date. $Findex_{Nasdaq,j}$ is the degree of fragmentation, measured as the number of market centers reporting activity in the stock under SEC Rule 11Ac1-5. We use a (-3, -1) window relative to each stock's transfer month to compute the variable Findex. e_j is the error term assumed to be a standard normal variable with zero mean and constant variance σ^2. λ is the inverse Mills ratio derived from the PROBIT regression for correcting the selection bias. Appendix B provides detailed description of the PROBIT regression and the derivation of λ.

Thus β_{13}, β_{23}, and β_{33} measure the impact of market fragmentation on volatility after controlling for market cap, trading volume, and selection bias. The regression results for the 39 stocks while they are traded on Nasdaq are reported in **Table 4.**

Panel A of Table 4 shows that the impact of fragmentation on the level of volatility. The cross sectional regression relates each stock's pre-switch volatility (using alternate measures, as shown) to the stock's fragmentation, plus its market capitalization, and its volume. We again include a Mills Ratio correction for possible selection bias (see Appendix B). The regressions provide evidence that the degree of volatility of Nasdaq stocks depends on how fragmented is their trading, with more market centers adding more price volatility. The coefficient on the fragmentation measure is positive with strong statistical significance, and this holds for all three measures of volatility.

It is notable that the R^2 for the 5-minute price range regression is 0.76, much higher than the other two regressions. In addition, the statistical significance of the coefficient β_{33} of the 5-minute price range regression is 0.004, much higher for the two return standard deviation measures. The evidence suggests that fragmentation well explains the variation of the 5-minute interval price range across sample stocks.

Next, we examine the extent to which the decline in stock price volatility when companies switch to the NYSE depends on the extent of market fragmentation of the stock's trading while it is listed on Nasdaq.

$$\Delta DSTD_j = \alpha_1 + \theta_{11} \ln(MCAP_{Nasdaq,j}) + \theta_{12} \ln(VOLUME_{Nasdaq,j}) + \theta_{13} Findex_{Nasdaq,j} + \theta_{14}\lambda + e_j$$

$$\Delta ISTD_j = \alpha_2 + \theta_{21} \ln(MCAP_{Nasdaq,j}) + \theta_{22} \ln(VOLUME_{Nasdaq,j}) + \theta_{23} Findex_{Nasdaq,j} + \theta_{24}\lambda + e_j$$

$$\Delta IPR_j = \alpha_2 + \theta_{31} \ln(MCAP_{Nasdaq,j}) + \theta_{32} \ln(VOLUME_{Nasdaq,j}) + \theta_{33} Findex_{Nasdaq,j} + \theta_{34}\lambda + e_j$$

$$\Delta PDSTD_j = \alpha_1 + \varphi_{11} \ln(MCAP_{Nasdaq,j}) + \varphi_{12} \ln(VOLUME_{Nasdaq,j}) + \varphi_{13} Findex_{Nasdaq,j} + \varphi_{14}\lambda + e_j$$

$$\Delta PISTD_j = \alpha_2 + \varphi_{21} \ln(MCAP_{Nasdaq,j}) + \varphi_{22} \ln(VOLUME_{Nasdaq,j}) + \varphi_{23} Findex_{Nasdaq,j} + \varphi_{24}\lambda + e_j$$

$$\Delta PIPR_j = \alpha_2 + \varphi_{31} \ln(MCAP_{Nasdaq,j}) + \varphi_{32} \ln(VOLUME_{Nasdaq,j}) + \varphi_{33} Findex_{Nasdaq,j} + \varphi_{34}\lambda + e_j$$

In the above regression equations, $\Delta DSTD_j$, $\Delta ISTD_j$, and ΔIPR_j measure the reduction of volatility, and computed as:

$\Delta DSTD_j = DSTD_{Nasdaq,j} - DSTD_{NYSE,j}$ (the reduction of the daily volatility)

$\Delta ISTD_j = ISTD_{Nasdaq,j} - ISTD_{NYSE,j}$ (the reduction of the intraday volatility)

$\Delta IPR_j = IPR_{Nasdaq,j} - IPR_{NYSE,j}$ (the reduction of the intraday price range)

Alternatively, the variables $\Delta PDSTD_j$, $\Delta PISTD_j$, and $\Delta PIPR_j$ measure the proportional reduction of the volatility, and they are computed as:

$$\Delta PDSTD_j = (DSTD_{Nasdaq,j} - DSTD_{NYSE,j}) / DSTD_{Nasdaq,j} = 1 - DSTD_{NYSE,j} / DSTD_{Nasdaq,j}$$

$$\Delta ISTD_j = (ISTD_{Nasdaq,j} - ISTD_{NYSE,j}) / ISTD_{Nasdaq,j} = 1 - ISTD_{NYSE,j} / ISTD_{Nasdaq,j}$$

$$\Delta IPR_{j} = (IPR_{Nasdaq,j} - IPR_{NYSE,j}) / IPR_{Nasdaq,j} = 1 - IPR_{NYSE,j} / IPR_{Nasdaq,j}$$

Similar to the volatility variables for the Nasdaq trading, the volatility variables for the trading NYSE are computed in the (0, +59) window relative to each stock's transfer date. The error term e_j is assumed as before. The effect of the market fragmentation on the reduction of volatility is estimated by θ_{13}, θ_{23}, θ_{33}, φ_{13}, φ_{23}, and φ_{33}.

Panel B of Table 4 shows that the coefficients on fragmentation are positive and significant, indicating that a higher degree of dispersal of trading across market centers on the OTC market is associated with a greater improvement in volatility upon switching to the NYSE. Panel C of Table 5 measures the volatility improvement in proportional terms, and the degree of pre-switching fragmentation is again significant as a determinant of the amount of improvement that occurs in the post-switch period. Note that in Table 4 the constant term is also large and generally significant. The fragmentation index may be an imperfect measure, but qualitatively it provides evidence that the change in market structure is responsible for the lower volatility when the stocks switch to the NYSE.

To summarize the findings on volatility, the 39 companies that switch from Nasdaq to the NYSE experience a significant reduction of their price volatility, measured several different ways. The amount of the reduction is directly related to the degree of order flow fragmentation on Nasdaq. The listing switch to the NYSE leads a greater subsequent improvement for the stocks with a greater fragmentation on Nasdaq.

4. Effects of Switching on Price Efficiency

Besides price volatility, price efficiency is also a dimension of market quality. A measure we use to examine the price efficiency is the autocorrelation of short-term price returns from one period to the next. In a well-functioning market, information that moves prices should be incorporated fully and completely, so that there should be relatively little correlation or predictability of prices from one time interval to the next. A positive autocorrelation between price returns might indicate that prices incorporate information slowly or incompletely. A negative autocorrelation, on the other hand, would signal that prices tend to overshoot and move up or down due to the market structure and its associated liquidity characteristics.

One challenge in measurement is that trade prices bouncing between bid and ask usually tend to make the return autocorrelation a negative value. While decimalization may have reduced this source of statistical bias, we also compute autocorrelations of the midpoints of the quoted prices. In all, we measure autocorrelation in three ways and the results are reported in Panel 5 A, B, and C in **Table 5**.

As noted, autocorrelation results in Panel A and B of Table 5 are based on transaction prices. Panel A of Table 5 reports the autocorrelations of daily returns, measured as open-to-open and close-to-close returns, and Panel B presents the results for the intraday 5-minute intervals. In Panel C, we measure the return autocorrelation using the quote midpoint at the opening or closing of 5-minute intervals. The autocorrelations of daily returns and of 5-minute interval returns are all significantly negative on Nasdaq, implying price reversals on the dispersed market. When the stocks begin trading in the NYSE, the negative autocorrelation becomes insignificant or disappears completely, as shown in the short-term return. In addition, the changes in the return autocorrelation coefficients are highly significant.

In Panel C, the results using quote midpoints are very similar. In particular, the autocorrelation of short-term quote midpoint returns is very small and not significantly different from zero on the NYSE, suggesting that the NYSE quotes are efficient in incorporating and adjusting to new information.

Besides the short-term return autocorrelation, we also use the variance decomposition method as suggested in Hasbrouck (1993) to study price efficiency. This approach assesses the quality of a security market by measuring the deviations between actual transaction prices and implicit efficient prices, as well as the transaction cost for investors. We use Hasbrouck's statistical model, computing the variance of deviation. We normalize our results of this measure in two ways. The first way is to take the ratio of the variance of Hasbrouck's pricing error to the variance of the logarithm of the transaction price. The second way is to take the ratio of the standard deviation of Hasbrouck's pricing error to the average log transaction price. We report our results in panel A, B, and C in **Table 6.**

In Panel A of Table 6, the variance of deviation, or the noise term of the transaction, is reduced significantly, both economically and statistically, when the stocks transfer from Nasdaq to the NYSE. The average variance of the noise term decreases by more than half after the stocks transfer. Panel B and C confirm the results in Panel A, showing that normalized results present the same picture as the variance itself.

In addition, Hasbrouck (1993) also suggests a method of calculating the expected transaction cost using the variance decomposition. Following this method, we calculate the expected transaction costs to be 0.141% on Nasdaq and 0.048% on the NYSE.[14]

Throughout Table 5 and Table 6, the conclusions are consistent. After stocks shift to the NYSE, price reversals disappear, deviations between transaction and efficient prices decline, and transaction costs fall. This is evidence that the stronger competition among orders on a stock exchange produces better pricing that is less subject to temporary distortions, compared with the dispersed trading structure of Nasdaq listings.

5. Effects of Switching Listings on Quoted Spreads and Effective Spreads

A quoted spread compensates a dealer, or a specialist, or a limit order submitter for providing liquidity and bearing risk due to adverse selection. The literature has shown that higher

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[14] In Hasbrouck (1993), the expected transaction cost can be computed as the expected value of the deviation, E$|s_t| = \sqrt{\frac{2}{p}} s_s$. Using the average variance of deviation reported in table 6, we can get the expected transaction cost for Nasdaq is: E$|s_t| = \sqrt{\frac{2}{p}} s_s$ = 0.8 * (SQRT (1.384e-6)) = 0.8 * (0.00176) = 0.00141; and the expected transaction cost for the NYSE is: E$|s_t| = \sqrt{\frac{2}{p}} s_s$ = 0.8 * (SQRT (0.374e-6)) = 0.8 *(0.0006) = 0.00048.

volatility usually is associated with higher spread. The fact that volatility falls when a stock switches to the NYSE implies that its quoted spread would narrow as well. Similarly, the effective spread, which is a measure of execution cost and indicates the actual execution price relative to the quote midpoint, should also be narrower in a market with a lower price volatility and a tighter quoted spread. In this section we test for these implications.

The National Best Bid and Offer (NBBO), usually also called the inside market quoted spread, for every stock is derived from the CQ file of the TAQ database. We weight the quote values by how long they are in effect. The NBBO quoted spread provides the market inside spread, and it is the unconditional spread for any kinds of orders.

We also have an effective spread from the 11Ac1-5 report. These effective spreads are conditional on order type (market or marketable limit) and order size. The effective spread is weighted by the number of shares bought or sold at each value.

As in the preceding section, we use a 60-trading day pre- and post-switch window in studying the quoted spreads from the NBBO files. Because the 11Ac1-5 data are only available as monthly averages for effective spreads, we compare 3 months of data prior to and after each of the switches. Since switches of stocks from Nasdaq to the NYSE listings can occur at any time during a month, we adopt the practice of excluding the transfer month itself from the statistical analysis. As a result, our investigation window for effective spreads is notated (-3, -1), measured in months rather than days, for the Nasdaq listed trading, and (+1, +3) for the NYSE-listed trading.

5.1. Changes in Quoted Spreads

We first present the unconditional changes in the quoted spreads when the stocks switch to the NYSE. Then we examine the effects of fragmentation on these quotes. We employ the t test and the Wilcoxon non-parametric test to study the statistical significance of the mean and the median differences.

The evidence in **Table 7** is strong that quoted spreads fall, both in cents and in basis points. This corroborates the earlier findings that volatility declines when stocks switch to the NYSE, since price uncertainty is a key factor affecting quoted spread.

The results are also shown in **Figure 3** and **Figure 4**. In Figure 3, we depict the time series of daily time-weighted NBBO quoted spread during (-60, -1) and (0, +59). We also report the daily averages for Nasdaq as well as for the NYSE. As shown in the figure, the quoted spreads on average drop by 3.5 cents, or 40% when the stocks switch to the NYSE. The picture is similar if the quoted spread is measured in relative terms (i.e. divided by price).

In addition, the daily quoted spread has a larger day-to-day variation on Nasdaq compared to the quotes on the NYSE. This holds even though we adjust for the smaller NYSE quote size by using the coefficient variation. The coefficient of variation for Nasdaq's quote is 69.8%, compared with 46.7% for the NYSE quote.[15]

Figure 4 shows the intraday comparison of quoted spreads for each of the 78 5-minute intervals between Nasdaq and the NYSE. The two "smile" curves confirm that the NYSE tighter spreads hold throughout the trading day. As is true with price volatility, the NYSE improvement is strongest at the opening and closing of trading.

5.2. Changes in Effective Spreads

We next examine the effects of switching listings on execution costs, using effective spreads from the 11Ac1-5 data. We use a similar approach to what we have done with quoted spreads. We compute the share-weighted average effective spread for each transferred stock. We also separate our analysis by two order types, market or marketable limit, and four order sizes from 100 shares up to 9,999 shares. We report our results in **Table 8 and Figure 5**.

Table 8 shows that average effective spreads decline significantly, in terms of cents or basis points, when the stocks shift to NYSE. On average, the per-share effective spread across

[15] The standard deviation for the daily NBBO quote spread is 0.00641 for Nasdaq and 0.00279 for the NYSE. The coefficient of variation for Nasdaq quote is 0.00641 / 0.0919 = 69.8%, and the coefficient of variation for NYSE quote is 0.00279 / 0.0597 = 46.7%.

the 39 stocks decreases by half, from 11.2 cents to 5.7 cents. Figure 5 illustrates the drop and shows that the monthly average of the share-weighted effective spread across our sample stocks drops sharply when the stocks move to the NYSE. The reduction is comparable if the effective spread is measured in relative to the stock price.

Further investigation by order size reveals that the NYSE overall effective spread advantage stems from its better execution of the smaller order sizes. For the order size of 5,000-9,999 share range, more than half the volume on the NYSE floor executions not covered by 11Ac1-5, which thus tends to cover orders selecting the faster SuperDot system rather than more patient pricing on the floor.[16] Our finding is consistent with Boehmer (2003) who finds similar results using matched samples.

Our findings of the decrease of effective spread are again consistent with the evidence of the reduction of volatility, fragmentation, and quoted spread. Overall, average effective spreads are lower for the stocks after they switch to the NYSE, as illustrated in Figure 5.[17]

5.3. Impact of Volatility on Quoted Spreads

After documenting the reduction of quoted spreads and effective spreads after stocks move from Nasdaq to the NYSE, we next examine the reason behind the improvement. We run a cross sectional regression model to study how volatility, measured in different ways, affects the quoted spreads and the change of the quoted spreads after the switch.

Specifically, we run the following regressions to study the impact of volatility on quoted spreads and effective spread:

$$QS_{Nasdaq,j} = \alpha_1 + \beta_{11} \ln(MCAP_{Nasdaq,j}) + \beta_{12} \ln(VOLUME_{Nasdaq,j}) + \beta_{13} STD_{Nasdaq,j} + \beta_{14} Findex_{Nasdaq,j} + \beta_{15} \lambda_{Nasdaq,j} + e_j \quad (1)$$

[16] We obtain the estimation using the NYSE proprietary data.

[17] In Table 2, small orders, with 100 – 1,999 shares, account for 65% of the Dash-5 total executed shares on Nasdaq, 66% on the NYSE. This reflects the growth of trading strategies that break larger amounts into smaller orders.

$$\Delta QS_j = \alpha_2 + \beta_{21} \ln(MCAP_{Nasdaq,j}) + \beta_{22} \ln(VOLUME_{Nasdaq,j}) + \beta_{23} STD_{Nasdaq,j} + \beta_{24} Findex_{Nasdaq,j} +$$

$$\beta_{25} \lambda_{Nasdaq,j} + e_j \quad (2)$$

$$\Delta PQS_j = \alpha_2 + \beta_{31} \ln(MCAP_{Nasdaq,j}) + \beta_{32} \ln(VOLUME_{Nasdaq,j}) + \beta_{33} STD_{Nasdaq,j} + \beta_{34} Findex_{Nasdaq,j}$$

$$\beta_{35} \lambda_{Nasdaq,j} + e_j \quad (3)$$

where ΔQS and ΔPQS change of quoted spreads and the proportional change of the quoted spread when the stocks move to the NYSE. They are computed as:

$$\Delta QS_j = QS_{Nasdaq,j} - QS_{NYSE,j}$$

$$\Delta PQS_j = (QS_{Nasdaq,j} - QS_{NYSE,j}) / QS_{Nasdaq,j} = 1 - QS_{NYSE,j} / QS_{Nasdaq,j}$$

The above regressions are also applied to the studies of the effective spread (ES), and the changes of the effective spread (ΔES) and the proportional changes of the effective spread (ΔPES) are computed similarly. The impact of the volatility on the level and the change of quoted spread and effective spread is measured by β_{13}, β_{23}, and β_{33}. **Table 9** reports the results for quoted spread, and **Table 10** for effective spread.

Panel A of Table 9 shows that volatility has a significant impact on Nasdaq quoted spread (QS) and the improvement of the quoted spread (ΔQS). Estimates that are statistically significant at the 5 percent or better level are shown in bold. The impact is weaker in a statistical sense for the relative quoted spread and the proportional change of the quoted spread (ΔPQS). Further analysis of the 11Ac1-5 quoted spreads reveals that the impact is stronger and more significant for market orders and for small size orders, as shown in Panel B. Included along with the volatility, the fragmentation index effect has the expected sign but its effect is diluted by the inclusion of volatility. This supports that more fragmentation and higher volatility widen quoted spreads. In addition, the improvement of the quoted spread after the stocks move to the NYSE also relates to stocks' volatility and fragmentation on Nasdaq. In general, stocks with higher volatility and fragmentation on Nasdaq experience a larger improvement in quoted spread.

The results for effective spreads reported in Table 10, resemble those for quoted spreads above. We find that volatility has a negative effect on effective spreads, and the results are more statistically significant for small market orders. The sign of the effect of fragmentation on effective spreads and on the improvement of effective spreads is the same as that of volatility, but the impact is of weaker statistical significance. This is consistent with the notion that the NYSE market structure lowers quoted and effective spreads largely by its reduction of volatility and uncertainty because orders interact more competitively.

5.4. The Conditional Changes of Effective Spreads (ES) and Quoted Spreads (QS)

Market quality of switching stocks might also be affected if other variables such as firm market capitalization and trading volume changed around the time of the transfers. This points to an alternative method of measuring and testing for changes in market quality indicators when companies switch listings. We run the following cross sectional regressions to separate the market structure effect from the effects due to the changes of the firm characteristics:

$$\Delta ES_j = \alpha_{ES} + \beta_1 \Delta \ln(MCAP_j) + \beta_2 \Delta \ln(VOLUME_j) + \beta_3 \Delta VOLATILITY_j + e_j$$

$$\Delta QS_j = \alpha_{QS} + \beta_1 \Delta \ln(MCAP_j) + \beta_2 \Delta \ln(VOLUME_j) + \beta_3 \Delta VOLATILITY_j + e_j$$

The intercept, α_{ES} and α_{QS}, measures the conditional difference of effective spread and quoted spread due to the change of market structure from Nasdaq to the NYSE, after controlling the changes of market capitalization, trading volume, and daily volatility. In the above regression, the variables are defined as follows:

$$\Delta ES_j = ES_{Nasdaq,j} - ES_{NYSE,j}$$

$$\Delta QS_j = QS_{Nasdaq,j} - QS_{NYSE,j}$$

$$\Delta \ln(MCAP_j) = \ln(MCAP_{Nasdaq,j}) - \ln(MCAP_{NYSE,j})$$

$$\Delta \ln(VOLUME_j) = \ln(0.70 * VOLUME_{Nasdaq,j}) - \ln(0.90 * VOLUME_{NYSE,j})$$

$$\Delta VOLATILITY_j = VOLATILITY_{Nasdaq,j} - VOLATILITY_{NYSE,j}$$

$ES_{Nasdaq,j}$ and $QS_{Nasdaq,j}$ are computed during (-3, -1) relative to each stock's transfer month; $ES_{NYSE,j}$ and $QS_{NYSE,j}$ are computed during (+1, +3) relative to each stock's transfer month. The control variables of ln ($MCAP_{Nasdaq,j}$), ln ($VOLUME_{Nasdaq,j}$), and $VOLATILITY_{Nasdaq,j}$ are computed from the CRSP daily data during (-60, -1) relative to each stock's transfer date, and ln ($MCAP_{NYSE,j}$), ln ($VOLUME_{NYSE,j}$), and $VOLATILITY_{NYSE,j}$ are computed using the CRSP daily data during (0, +59).

We include three control variables in the above regressions due to the small sample size in the cross sectional regressions. In fact, the results are robust if we add an additional control variable, such as the change of price level, into the regression. The error terms in the above regression, e_j, is assumed to be a standard normal variable with zero mean and constant variance.

We report our results in **Table 11**. Overall, our findings of the conditional changes of quoted and effective spreads are consistent with the unconditional changes. The spread reductions are economically significant, and more statistically significant for smaller market order categories. Controlling for the changes of the firms' own characteristics does not affect the earlier results much. The improvement of quoted spread and effective spread due to market structure is 4.11 cents and 4.05 cents respectively for small size market orders. The conditional improvements have comparable magnitude for marketable limit orders, 2.18 cents for quoted spread and 4.01 cents for effective spread, but with weaker significance in statistical sense. The magnitude for the conditional improvement of quoted and effective spreads is smaller for larger order categories and marketable limit orders. This is similar with our previous findings about market limit orders and again consistent with the findings in Peterson and Sirri (2002) about marketable limit orders.[18]

[18] Peterson and Sirri (2002) find that marketable limit orders behave differently than market orders.

6. Summary and Conclusion

Examining the stocks of companies that switched listings during 2002-3, after the introduction of decimals and the rapid growth of ECNs, this article provides strong evidence that the NYSE market structure continues to provide significantly tighter bid-ask spreads, less volatility, and lower execution costs. These results are consistent with earlier research findings that the NYSE provides lower volatility and cheaper executions.

In addition, using the cross-sectional variation in the degree of market fragmentation of trading in Nasdaq-listed stocks prior to their listing switches, the paper provides evidence linking a higher volatility and wider quotes on Nasdaq with a higher degree of order flow fragmentation. The publication of order level execution quality measures across market venues in the 11Ac1-5 reports enable us to measure the degree of order flow fragmentation.

Despite a relatively small sample (39 transferring stocks during 2002 and the first quarter of 2003), the results are generally both statistically and economically significant, and we explicitly correct for the possibility of a sample selection bias for firms that have switched listings.

In short, the evidence from recent stock listings switches strongly supports the view that the positive impact of direct competition among orders on a stock exchange significantly outweighs the benefits of competition among decentralized market centers, and that this fundamental relationship, documented in several earlier studies, has solidly outlasted technological and regulatory changes.

Some other observations emerge from our study as well. When stocks shift from Nasdaq to the NYSE, the distribution of order sizes and order types changes noticeably. This reflects different trading strategies for traders accessing stocks on an exchange like the NYSE versus a decentralized market. An important implication is that research comparing market quality across different market structures should not focus only on specific order size categories or types but rather market quality for broader order flow measures.

A related observation deriving from our investigation is that the measurement of execution speed is still highly problematical, since the newly available data show very different cancellation rates across different market structures. Although a successfully executed transaction at an ECN may be swift, if it is preceeded by many submitted and cancelled orders, it does not reflect the amount of time and other resources an order requires. These may also create biases in comparisons based on speed-sensitive market quality measures, such as effective spreads that are based on order arrival times, since cancellation rates are significantly higher in Nasdaq-listed trading.

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Appendix A: Detailed Information for the Transferred Stocks

We report sample statistics for the 39 firms that swtich from Nasdaq to NYSE. Our sample window is 60 days prior to the swtiches. Our investigation period is October 2001 to Janaury 2003.

Company Name	Transfer Date	Market Cap ($ 000)	Volatility * (%)	Closing Price ($)	Daily Volume (share)	Medium Trade Size (share)	Mean Trade Size (share)	Daily Number of Trades
RailAmerica, Inc.	1/2/2002	345,507	2.628	12.65	195,527	309	1,019	194
Network Associates, Inc.	2/12/2002	4,152,265	4.108	25.99	3,870,573	227	799	4,957
Old National Bancorp	2/15/2002	1,474,259	0.846	24.46	49,445	170	545	93
Action Performance Group	2/20/2002	696,643	3.867	34.66	424,148	117	461	893
The Bisys Group Inc.	3/6/2002	3,741,776	6.652	58.81	539,655	112	487	1,131
Clark/Bardes, Inc.	3/7/2002	420,218	2.883	24.83	45,150	148	439	100
Regions Financial Corporation	5/3/2002	8,054,141	0.972	33.66	562,085	103	340	1,635
Tom Brown, Inc.	5/16/2002	1,135,582	1.461	27.66	150,718	126	380	400
Astoria Financial Corporation	5/17/2002	2,890,475	1.174	30.86	555,388	128	517	1,075
The Nautilus Group, Inc.	5/21/2002	1,567,853	2.974	37.37	966,672	162	356	2,684
Cantel Medical Corp	5/29/2002	159,748	4.804	24.52	36,053	194	414	82
Province Healthcare Company	6/5/2002	1,214,086	4.955	29.38	552,492	158	461	1,204
The CATO Corporation	6/13/2002	523,859	2.466	24.97	105,593	148	505	217
Remington Oil & Gas Co.	6/20/2002	503,502	2.662	19.62	153,780	148	438	346
Emulex Corporation	6/24/2002	2,458,602	5.819	29.11	8,521,118	202	422	20,163
Oshkosh Truck Corporation	7/12/2002	973,246	3.328	58.32	82,577	103	287	283
Christopher & Banks Co.	7/17/2002	1,077,889	3.107	39.92	357,183	100	289	1,218
CACI International Inc.	8/16/2002	973,895	4.054	33.91	518,490	102	288	1,777
Select Medical Corporation	8/28/2002	674,228	2.819	14.45	142,488	112	313	402
Valmont Industries, Inc.	8/30/2002	523,109	3.527	20.30	59,138	108	274	208
Genesse & Wyoming Inc.	9/27/2002	289,238	3.645	20.68	61,750	109	326	175
BearingPoint, Inc.	10/3/2002	1,224,357	5.263	9.78	1,399,358	177	551	2,271
Greif Bros. Corporation	10/7/2002	259,259	3.276	26.15	16,042	106	276	60
Webster Financial Corp.	10/17/2002	1,610,396	2.378	35.39	278,221	100	294	936
Stewart & Stevenson Services	10/18/2002	1,124,613	2.218	24.94	330,586	102	280	1,137
Waste Connections, Inc.	10/24/2002	967,440	2.409	33.79	265,037	105	297	878
Banknorth Group, Inc.	11/4/2002	3,428,326	2.306	24.43	824,466	123	363	2,211
Getty Images, Inc.	11/5/2002	1,532,737	4.792	20.17	439,202	115	316	1,405
Concord EFS, Inc	11/7/2002	7,326,140	5.581	16.74	9,869,623	222	644	14,044
Right Management Consultants	11/15/2002	298,646	5.873	19.79	171,485	107	263	610
St Mary Land & Exploration Co.	11/20/2002	705,896	2.170	24.34	124,143	100	284	428
H.B. Fuller Company	12/2/2002	821,386	2.565	28.20	88,341	100	198	447
Interactive Data Corporation	12/10/2002	1,430,755	2.060	13.91	210,244	114	336	607
Alliance Gaming Corporation	12/12/2002	845,261	3.464	16.33	588,430	152	391	1,472
New York Community Bancorp	12/20/2002	2,988,178	2.351	28.23	887,826	107	357	2,294
CPB Inc.	12/31/2002	412,946	6.846	36.59	18,008	102	193	96
AMERIGROUP Corporation	1/3/2003	619,203	3.534	30.41	331,506	100	298	1,091
Offshore Logistics, Inc	3/12/2003	493,222	2.871	20.27	109,989	100	251	417
Regis Corporation	3/27/2003	279,012	3.301	11.88	222,738	107	382	533

* Volatility is measured as the standard deviation of daily return.

Appendix B: Control for Selection Bias

In our study, we control for potential selection bias in our estimates, in case the factors influencing the probability that a firm will switch listing are correlated with the improvements in volatility (and other measures, below), confounding our estimates.

We use the two-stage regression method, also used in Heckman (1979), Maddala (1983), and Amemiya (1985), to control for the possibility of selection bias. The first stage PROBIT regression requires a sample of Nasdaq stocks that meet the NYSE listing standards. Guided by the NYSE listing requirement, we obtain the company information that relates to the NYSE listing standards, such as the number of round-lot shareholder, monthly volume, market capitalization, the number of share outstanding, pretax earnings, operating cash flow, and so on and so forth, from the CRSP and COMPUSTA dataset.[1]

For market capitalization, share outstanding, and trading volume, we compute their monthly averages during January 2001 – December 2001. For earning and operating cash flow, we calculate the annual averages during 2001 – 2002. Using the above information, we have identified 1,822 Nasdaq stocks that meet the NYSE listing requirement and are eligible to transfer until December 2001.

In the selection process, we find that market capitalization, price level, and trading volume are the most binding variables. The selected sample, however, is not sensitive to accounting variables, such as operating cash flow and pre-tax earning. We also ignore the listing requirement of a minimum number of round-lot shareholders, since it is not binding.[2]

In the first stage probit regression, we run the following equation across the firms that meet the NYSE listing requirement until December 2002:

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[1] For the detailed NYSE listing standards for the domestic companies, please see Section 102.00 of the NYSE Listed Company Manual.

[2] The NYSE listing standards requires that the company have to have at least 500 round-lot shareholders if it has at least 1,000,000 shares monthly trading volume in the last 12 months, or 2,200 round-lot shareholders if the average monthly trading volume is at least 100,000, or 2,200 round-lot shareholders.

$$\text{Prob}_j(\text{transfer}=1) = \alpha + \beta_1 \ln(\text{mcap}_j) + \beta_2 \ln(\text{shareout}_j) + \beta_3 \ln(\text{volume}_j) + \beta_4 \ln(\text{price}_j) + \beta_5 (\text{MM\_num}_j) + \beta_6 (\text{volatility}_j) + e_j$$

where price is the daily close price, measured as the daily average in the period between July 2002 and December 2002. Volatility is measured as the daily return standard deviation in during the same period as daily closing price. All the rest variables, mcap (market capitalization), shareout (the number of share outstanding), volume (month trading volume), and MM_num (the number of registered market maker), are monthly averages in the same period between July 2002 and December 2002.

In the first stage PROBIT regression, we have found out the fitted values of the regression, namely ρ_j = Prob (transfer = 1), are not very sensitive to the log transformation of the independent variables. In addition, we also replace the daily return volatility with the daily average price range, measured as the ratio of the difference of daily high and low price to the daily closing price, and find out the results do not change materially. Furthermore, we find out regression results are not sensitive to the sample period in which we have used to compute the values of the independent variables. We expand the current sample period from July 2002 – December 2002 to the entire year of 2002, and find that the influence is very small.

After we obtain the fitted value of ρ_j for each stock in the first stage PROBIT regression, we then compute the inverse Mills ratio:

$$\lambda_j = \varphi(\rho_j) / \Phi(\rho_j) \tag{4}$$

where $\varphi(\rho_j)$ is the standard normal density function, and $\Phi(\rho_j)$ is the standard normal distribution function.

We insert the inverse Mills ratio in the regressions that need to control for the selection bias.

Table 1: Sample Descriptive Statistics

We report the mean, median, maximum, and minimum of the daily averages of the sample stocks. Our sample includes the 39 stocks that have transferred their listings from the Nasdaq to the NYSE during January 2002 to March 2003. Volatility is defined as the standard deviation of the daily return. Data is from the CRSP and TAQ databases. Our event window is 60 trading days before the switching date, and the sample period is from October 2001 to January 2003.

	Sample	Market Cap ($ 000)	Volatility (%)	Close Price ($)	Trading Volume (shares)	Mean Trade Size (shares)	Medium Trade Size (shares)	Daily Number of Trades
Mean	39	1,575,589	3.405	27.23	892,888	377	129	1,842
Median	39	973,570	3.191	25.48	271,629	348	112	885
Max	39	8,054,141	6.846	58.81	9,869,623	799	227	20,163
Min	39	159,748	0.846	9.78	16,042	193	100	60

Table 2: 11Ac1-5 Report Summary

We report the monthly averages of the descriptive statistics in the Dash5 data. Our sample includes the 39 stocks that have transferred their listings from the Nasdaq to the NYSE during January 2002 to March 2003. Our Dash5 data only includes market order and marketable limit order. We obtain separate results by order type (type 11 = market order, type = 12 marketable limit order) and by order size (size 21 = 100 – 499 shares, 22 = 500 – 1999 share; 23 = 2000 – 4999 shares; 24 = 5000 – 9999 shares). Executed Percentage is the ratio of the Executed Share to the Covered Share; Cancelled Percentage is the ratio of the Cancelled Shares to the Covered Shares; Executed Away Percentage is the ratio of the Executed Away Shares to the Executed Shares. HHI_ID is computed as the sum of the squared market share of each market center; HHI_P is the sum of the squared market share of each type of market participant. The investigation window is (-3, -1) for the Nasdaq and (+1, +3) for the NYSE, relative to the switching month of each stock, and our sample period is from October 2001 to June 2003.

PANEL A: Shares Covered, Executed, and Cencelled in Dash5

	Sample	Order Type or Size	Covered Shares	Weight of Covered Shares	Executed Shares	Weight of Executed Shares	Executed Percentage	Cancelled Shares	Cancelled Percentage	Executed Away Shares	Executed-Away Percentage
						Overall					
Nasdaq	39		15,532,449	1.000	9,402,594	1.000	0.617	5,952,427	0.353	1,499,942	0.200
NYSE	39		5,283,117	1.000	4,677,901	1.000	0.879	571,196	0.112	41,766	0.010
						by Order Type					
Nasdaq	39	11	1,883,886	0.121	1,810,218	0.193	0.898	43,377	0.057	377,091	0.221
Nasdaq	39	12	13,648,562	0.879	7,592,376	0.807	0.577	5,909,050	0.396	1,122,852	0.197
NYSE	39	11	2,361,153	0.447	2,319,427	0.496	0.982	30,797	0.012	30,863	0.019
NYSE	39	12	2,921,964	0.553	2,358,474	0.504	0.812	540,398	0.177	10,903	0.003
						by Order Size					
Nasdaq	39	21	2,936,963	0.189	2,130,746	0.227	0.825	843,170	0.184	311,087	0.200
Nasdaq	39	22	7,131,419	0.459	4,540,763	0.483	0.649	2,534,793	0.327	665,296	0.197
Nasdaq	39	23	3,111,898	0.200	1,686,506	0.179	0.495	1,356,472	0.450	292,255	0.196
Nasdaq	39	24	2,352,168	0.151	1,044,579	0.111	0.358	1,217,993	0.552	231,303	0.199
NYSE	39	21	1,173,371	0.222	1,066,680	0.228	0.918	104,667	0.080	5,192	0.005
NYSE	39	22	2,195,508	0.416	1,965,077	0.420	0.894	220,111	0.099	18,778	0.012
NYSE	39	23	1,182,241	0.224	1,035,299	0.221	0.834	136,012	0.152	10,877	0.011
NYSE	39	24	731,998	0.139	610,845	0.131	0.771	110,406	0.199	6,919	0.010

PANEL B: Market Concentration: Herfindahl-Hirschman Index (HHI)

		Nasdaq				NYSE			
Sample		HHI_ID	HHI_P	Number of Market Center	Number of MC with >1% Market Share	HHI_ID	HHI_P	Number of Market Center	Number of MC with >1% Market Share
39	Mean	0.214	0.746	22.517	8.769	0.900	0.900	7.150	2.573
39	STD	0.033	0.086	10.069	1.107	0.078	0.077	2.726	1.180
39	Median	0.218	0.755	21.333	8.667	0.926	0.926	6.333	2.333
39	MAX	0.307	0.882	58.667	11.000	0.981	0.981	16.000	5.667
39	MIN	0.150	0.532	10.000	6.667	0.616	0.619	3.333	1.000

Note: We note that the sum of the cancellation rate and the execution rate is less than 100%.

Table 3: Change of Volatility

We report the daily volatility, 5-minute volatility, and 5-minute price range in the table. Our sample includes the 39 stocks that have transferred their listings from the Nasdaq to the NYSE during January 2002 to March 2003. The tick-by-tick trading data is obtained from the TAQ database. Daily volatility is measured as the standard deviation of the daily return computed from the close-to-close, and open-to-open. We divide the daily trading session (9:30AM - 4:00PM) into 78 5-minute intervals. For each stock in each interval, we compute the interval close-to-close, open-to-open, and VWAP-to-VWAP return. We then calculate the standard deviation of the three 5-minute return series. Interval price range is measured as the difference between the interval high and low price. We obtain the relative interval price range by dividing the price range by the interval open or close price. We also conduct the t tests for the mean difference and the Wilcoxon test for the median difference, and provide p values (the numbers underneath the differences).
Our computation window is (-60, -1) for Nasdaq trading and (0, 59) for the NYSE trading relative to each stock's transfer date. Our sample period is from October 2001 to June 2003.

PANEL A: Daily Volatility							
		Daily Open-to-Open Return			Daily Close-to-Close Return		
	Sample	Nasdaq (%)	NYSE (%)	NYSE - Nasdaq (%)	Nasdaq (%)	NYSE (%)	NYSE - Nasdaq (%)
Mean	39	3.429	2.799	-0.630	3.385	2.706	-0.679
				0.033			0.012
Median	39	3.178	2.427	-0.560	3.107	2.499	-0.562
				0.065			0.021
PANEL B: 5-Minute Interval Volatility							
		Interval Open-to-Open Return			Interval Close-to-Close Return		
	Sample	Nasdaq (%)	NYSE (%)	NYSE - Nasdaq (%)	Nasdaq (%)	NYSE (%)	NYSE - Nasdaq (%)
Mean	39	0.403	0.248	-0.156	0.429	0.259	-0.170
				0.000			0.000
Median	39	0.378	0.206	-0.135	0.415	0.225	-0.144
				0.000			0.000
PANEL C: 5-Minute Price Range							
		Interval Price Range			Relative to Interval Open		
	Sample						
		Nasdaq ($0.01)	NYSE ($0.01)	NYSE -Nasdaq ($0.01)	Nasdaq (bps)	NYSE (bps)	NYSE -Nasdaq ($0.01)
Mean	39	8.468	4.097	-4.370	33.821	17.354	-16.467
				0.000			0.000
Median	39	6.786	3.001	-4.036	28.461	13.028	-15.308
				0.000			0.000

Table 4: The Impact of Market Fragmentation on Volatility

We report the results of the regressing the volatility, the reduction of volatility, and the proportional reduction of volatility on the fragmentation index and other control variables in Panel A, B, and C of the following table. Our sample includes the 39 stocks that have transferred their listings from the Nasdaq to the NYSE during January 2002 to March 2003. Market capitalization and the trading volume are from the CRSP database, and are the monthly average during (-3, -1). The fragmentation index is measured as the number of the market venues in the Dash5 monthly report as shown in Table 2 of the paper. The Inverse Mills Ratio is obtained from the first stage probit regression. Each regression has 39 observations. We report the regression coefficients, the p values, and the R Square in the table. Our investigation window is (-3, -1) for the Nasdaq and (+1, +3) for the NYSE relative to each stock's switching month, and our sample period is from October 2001 to June 2003.

PANEL A: Volatility

Independent Variables	Daily Volatility (Standard Deviation of the Daily Close-to-Close Return)	P Value	5-Minute Interval Volatility (Close-to-Close Interval Return Standard Deviation)	P Value	5-Minute Price Range (Interval High-Low Price Range Relative to Interval Close Price)	P Value
Intercept	10.007	0.013	2.019	<.0001	34.786	0.127
log (Market Cap)	-0.748	0.112	-0.079	0.058	-6.365	0.023
log (Trading Volume)	-0.321	0.493	-0.095	0.026	2.501	0.362
Fragmentation Index	0.131	0.023	0.011	0.029	0.997	0.004
Inverse Mills Ratio	-2.681	0.537	-0.905	0.023	-77.027	0.004
R2	0.290		0.290		0.763	

PANEL B: Reduction of Volatility

	Change of Daily Volatility (Nasdaq - NYSE)	P Value	Change of Interval Volatility (Nasdaq - NYSE)	P Value	Change of Interval Price Range (Nasdaq - NYSE)	P Value
Intercept	13.314	0.004	1.970	<.0001	78.697	0.003
log (Market Cap)	0.008	0.987	-0.001	0.977	-1.826	0.539
log (Trading Volume)	-1.371	0.012	-0.164	0.000	-5.347	0.081
Fragmentation Index	0.186	0.005	0.013	0.006	1.028	0.006
Inverse Mills Ratio	1.673	0.729	-0.555	0.126	-49.727	0.080
R2	0.248		0.588		0.326	

PANEL C: Proportional Reduction of Volatility

	Proportional Change of Daily Volatility (1 - NYSE / Nasdaq)	P Value	Proportional Change of Interval Volatility (1 - NYSE / Nasdaq)	P Value	Proportional Change of Interval Price Range (1- NYSE / Nasdaq)	P Value
Intercept	3.602	0.002	3.090	<.0001	2.361	<.0001
log (Market Cap)	-0.135	0.300	-0.006	0.935	-0.011	0.857
log (Trading Volume)	-0.299	0.027	-0.254	0.002	-0.171	0.008
Fragmentation Index	0.049	0.003	0.022	0.017	0.017	0.023
Inverse Mills Ratio	0.420	0.729	-0.601	0.395	-0.558	0.326
R2	0.279		0.448		0.335	

Table 5: Price Reversals: the Autocorrelation Analysis

We report the autocorrelation of the daily return, the interval 5-minute return, and the interval 5-minute quote-midpoint return in Panel A, B, and C in the table. Our sample includes the 39 stocks that have transferred their listings from the Nasdaq to the NYSE during January 2002 to March 2003. The tick-by-tick trading data is obtained from the TAQ database. We recompile the National Best Bid and Offer (NBBO) from the CQ file. We divide the daily trading session (9:30AM - 4:00PM) into 78 5-minute intervals. For each stock in each interval, we compute the interval close-to-close and open-to-open return as well as the quote-midpoint return measured by interval open-to-open and close-to-close quote. We then calculate the autocorrelation of the daily return series, and average daily results to obtain the autocorrelation for a sample stock. We also conduct the t tests for the mean difference and the Wilcoxon test for the median difference, and provide p values. Our computation window is (-60, -1) for Nasdaq trading, and (0, 59) for the NYSE trading, and our investigation period is from October 2001 to June 2003.

PANEL A: Autocorrelation of the Daily Return							
		Open-to-Open Return			Close-to-Close Return		
	Sample	Nasdaq	NYSE	NYSE - Nasdaq	Nasdaq	NYSE	NYSE - Nasdaq
Mean	39	-0.117	-0.062	0.054	-0.110	-0.035	0.075
p-value		0.000	0.035	0.000	0.000	0.203	0.000
Median	39	-0.083	-0.041	0.130	-0.094	-0.014	0.144
p-value		0.000	0.044	0.000	0.000	0.276	0.000
PANEL B: Autocorrelation of 5-Minute Interval Return							
		Open-to-Open Return			Close-to-Close Return		
	Sample	Nasdaq	NYSE	NYSE - Nasdaq	Nasdaq	NYSE	NYSE - Nasdaq
Mean	39	-0.123	0.017	0.141	-0.159	-0.008	0.151
p-value		0.000	0.104	0.000	0.000	0.462	0.000
Median	39	-0.111	0.009	0.130	-0.157	-0.005	0.144
p-value		0.000	0.061	0.000	0.000	0.612	0.000
PANEL C: Autocorrelation of 5-Minute Quote-Midpoint Return							
		by Interval Open Quote			by Interval Close Quote		
	Sample	Nasdaq	NYSE	NYSE - Nasdaq	Nasdaq	NYSE	NYSE - Nasdaq
Mean	39	-0.028	0.008	0.036	-0.040	0.010	0.050
p-value		0.002	0.575	0.005	0.000	0.376	0.000
Median	39	-0.016	0.001	0.037	-0.038	-0.002	0.062
p-value		0.002	0.555	0.003	0.000	0.356	0.000

Table 6: Variance Decomposition

We report the results for the variance decomposition using the Hasrouch (1993) method for the sample stocks in the following table. Our sample includes the 39 stocks that have transferred their listings from the Nasdaq to the NYSE during January 2002 to March 2003. Var(S) is the variance and STD(S) is the standard deviation of the variance of noise. VAR(P) is the variance of log price. We conduct the t tests for the mean difference and the Wilcoxon test for the median difference, and provide p values. Our computation window is (-60, -1) for Nasdaq trading, and (0, 59) for the NYSE trading. The number under the difference is the p-value of the t test or median test.

PANEL A: Variance of the Noise (VAR(S))						
	Mean			Median		
Sample	Nasdaq (1e-6)	NYSE (1e-6)	NYSE - Nasdaq (1e-6)	Nasdaq (1e-6)	NYSE (1e-6)	NYSE - Nasdaq (1e-6)
39	1.384	0.374	-1.010	0.603	0.303	-0.300
			0.000			0.000
PANEL B: Variance of Noise Relative to the Variance of Price (VAR(S) / VAR(P))						
	Mean			Median		
Sample	Nasdaq (1e-6)	NYSE (1e-6)	NYSE - Nasdaq (1e-6)	Nasdaq (1e-6)	NYSE (1e-6)	NYSE - Nasdaq (1e-6)
39	322.712	119.719	-202.993	104.842	53.377	-56.773
			0.004			0.000
PANEL C: Standard Deviation of Noise Relative to Price (STD(S)/P)						
	Mean			Median		
Sample	Nasdaq (1e-6)	NYSE (1e-6)	NYSE - Nasdaq (1e-6)	Nasdaq (1e-6)	NYSE (1e-6)	NYSE - Nasdaq (1e-6)
39	324.069	183.824	-140.245	235.712	160.473	-88.453
			0.000			0.000

Table 7: Change of Quoted Spread

We report the unconditional changes of the quoted spread and the relative quoted spread in the table. Our sample includes the 39 stocks that have transferred their listings from the Nasdaq to the NYSE during January 2002 to March 2003. The tick-by-tick quote data is obtained from the CQ file in the TAQ database. We recompile the National Best Bid and Offer (NBBO) from the CQ file. Panel A reports the change of the NBBO quoted spread. We compute the time-weighted average quote spread and the time-weighted average relative quoted spread from the NBBO file. For each stock in each month, we compute the share-weighted quoted spread using the Dash5 data. We obtain separate results by order size (size 21 = 100 – 499 shares, 22 = 500 – 1999 share; 23 = 2000 – 4999 shares; 24 = 5000 – 9999 shares). Panel B reports the change details of the Dash5 quoted spread. We conduct the t tests for the mean difference and the Wilcoxon test for the median difference, and provide p values.

Our investigation window is (-3, -1) for the Nasdaq and (+1, +3) for the NYSE relative to each stock's transfer month, and our sample period is from October 2001 to June 2003.

Panel A: NBBO Quoted Spread										
			Quoted Spread ($0.01)				Relative Quoted Spread (bps)			
		OBS	Nasdaq	NYSE	NYSE-Nasdaq	p-value	Nasdaq	NYSE	NYSE-Nasdaq	p-value
Mean		39	9.192	5.942	-3.250	0.001	37.132	27.327	-9.805	0.006
Median			7.630	5.841	-1.705	0.000	31.567	23.371	-4.898	0.005
Panel B: Dash5 Quoted Spread										
by Stock										
		OBS	Nasdaq	NYSE	NYSE-Nasdaq	p-value	Nasdaq	NYSE	NYSE-Nasdaq	p-value
Mean		39	9.988	4.741	-5.248	0.101	39.254	21.764	-17.489	0.140
Median			5.695	4.337	-1.025	0.000	23.616	18.649	-3.336	0.006
by Order Size										
	Order Size	OBS	Nasdaq	NYSE	NYSE-Nasdaq	p-value	Nasdaq	NYSE	NYSE-Nasdaq	p-value
Mean	21	39	8.714	4.640	-4.074	0.027	34.492	21.232	-13.260	0.050
Median			5.737	4.073	-1.195	0.000	23.768	18.373	-4.929	0.001
Mean	22	39	10.547	4.728	-5.819	0.126	41.429	21.749	-19.681	0.164
Median			5.585	4.366	-1.127	0.000	24.075	18.377	-3.074	0.007
Mean	23	39	10.523	4.860	-5.663	0.122	41.140	22.220	-18.920	0.161
Median			5.829	4.523	-0.771	0.000	22.701	19.937	-1.782	0.057
Mean	24	38	6.451	5.040	-1.536	0.012	26.259	23.017	-2.569	0.296
Median			5.336	4.521	-0.428	0.008	21.757	19.603	-1.155	0.467

Table 8: Change of Effective Spread

We report the unconditional changes of the effective spread and the relative effective spread in the table. Our sample includes the 39 stocks that have transferred their listings from the Nasdaq to the NYSE during January 2002 to March 2003. We obtain the order level effective spread from the monthly Dash5 report. For each stock in each month, we compute the share-weighted effective spread and share-weighted relative effective spread from the Dash5 data. We also obtain separate results by order type (market order and marketable limit order) and by order size. Panel A reports the changes by stock, Panel B reports the changed by order size, and Panel C reports the changes by order type and order size (size 21 = 100 – 499 shares, 22 = 500 – 1999 share; 23 = 2000 – 4999 shares; 24 = 5000 – 9999 shares). We also conduct the t tests for the mean difference and the Wilcoxon test for the median difference, and provide p values. Our investigation window is (-3, -1) for the Nasdaq and (+1, +3) for the NYSE relative to each stock's transfer month, and our sample period is from October 2001 to June 2003.

Panel A: Share-Weighted Effective Spread across Stocks

	OBS	Effective Spread ($0.01) Nasdaq	NYSE	NYSE-Nasdaq	p-value	Relative Effective Spread (bps) Nasdaq	NYSE	NYSE-Nasdaq	p-value
Mean	39	11.263	5.734	-5.528	0.086	44.602	26.235	-18.367	0.126
Median		6.513	5.252	-1.067	0.000	29.259	23.503	-3.268	0.007

Panel B: Share-weighted Effective Spread across Order Size

	Order Size	OBS	Effective Spread ($0.01) Nasdaq	NYSE	NYSE-Nasdaq	p-value	Relative Effective Spread (bps) Nasdaq	NYSE	NYSE-Nasdaq	p-value
Mean	21	39	9.234	3.556	-5.678	0.003	36.511	15.889	-20.622	0.004
Median			6.075	3.003	-2.565	0.000	26.623	13.513	-11.713	0.000
Mean	22	39	11.569	5.302	-6.267	0.098	45.437	23.875	-21.562	0.127
Median			6.116	4.726	-1.680	0.000	27.734	20.084	-4.879	0.000
Mean	23	39	13.027	8.745	-4.282	0.232	51.896	38.888	-13.008	0.332
Median			8.042	8.265	0.132	0.989	32.615	31.845	4.080	0.282
Mean	24	38	9.831	11.571	1.395	0.207	40.932	52.268	12.385	0.064
Median			7.985	10.769	1.943	0.014	30.753	45.827	11.817	0.005

Panel C: Share-weighted Effective Spread across Order Type and Size (Effective Spread only)

	Order Size	Market Orders ($0.01) OBS	Nasdaq	NYSE	NYSE-Nasdaq	p-value	Marketable Limit Order ($0.01) OBS	Nasdaq	NYSE	NYSE-Nasdaq	p-value
Mean	21	39	8.152	4.087	-4.065	0.000	39	9.328	2.929	-6.399	0.003
Median			7.195	3.445	-2.636	0.000		6.018	2.650	-3.254	0.000
Mean	22	38	10.086	7.563	-2.724	0.003	39	10.966	3.528	-7.438	0.054
Median			7.723	6.700	-0.741	0.005		5.896	3.341	-2.730	0.000
Mean	23	38	15.972	16.535	-0.076	0.966	39	11.064	5.136	-5.929	0.097
Median			13.350	15.219	1.107	0.254		6.323	4.462	-1.778	0.000
Mean	24	36	15.595	27.329	12.197	0.004	38	7.346	6.650	-1.171	0.133
Median			11.583	22.629	5.819	0.000		5.965	5.793	-0.828	0.038

Table 9: Impact of Daily Volatility on Quoted Spread

We report the regression results between quoted spread and volatility and other control variables. Our sample includes the 39 transferred stocks from the Nasdaq to the NYSE during January 2002 to March 2003. We obtain the order level quoted spread from the Dash5 report. Market capitalization and the trading volume are from the CRSP database, and are the monthly average during (-3, -1). Daily volatility is measured as the standard deviation of the daily return during (-60, -1). The fragmentation index is measured as the number of the market venues in the Dash5 monthly report during (-3, -1). The Inverse Mill Ratio is obtained from the first stage Probit regression. We also conduct the t tests for the mean difference and the Wilcoxon test for the median difference. We report the regression coefficients and the R square in the table. Each regression has 39 observations. We organize the results by order type and order size. Panel A, B, C, and D report the results for each order size category. Our investigation window is (-3, -1) for the Nasdaq and (+1, +3) for the NYSE relative to each stock's transfer month, and our sample period is from October 2001 to June 2003.

PANEL A	NBBO Spread ($)			NBBO Spread Relative to Quote Midpoint (bps)		
Independent Variables	Nasdaq NBBO Spread	Spread Change (Nasdaq - NYSE)	Proportional Change (1 - NYSE / Nasdaq)	Nasdaq Relative NBBO Spread	Spread Change (Nasdaq - NYSE)	Proportional Change (1 - NYSE / Nasdaq)
Intercept	**0.592**	**0.475**	**2.436**	**295.225**	**202.298**	**3.442**
log (Market Cap)	0.008	0.010	0.003	-5.880	3.893	0.043
log (Trading Volume)	**-0.052**	**-0.050**	**-0.203**	**-19.475**	**-20.063**	**-0.306**
Daily Volatilty	**0.017**	**0.014**	0.045	2.542	2.092	-0.022
Fragmentation Index	0.001	0.002	0.001	0.992	**1.082**	0.008
Inverse Mill Ratio	0.012	0.021	0.186	-67.456	-24.688	-0.031
R2	0.740	0.720	0.635	0.771	0.651	0.565

PANEL B	Market Order Dash5 Quoted Spread			Marketable Limit Order Dash5 Quoted Spread		
Independent Variables	Nasdaq Spread (Nasdaq)	Spread Change (Nasdaq - NYSE)	Proportional Change (1 - NYSE / Nasdaq)	Nasdaq Spread (Nasdaq)	Spread Change (Nasdaq - NYSE)	Proportional Change (1 - NYSE / Nasdaq)
			Order Size = 21 (100 - 499 Shares)			
Intercept	**48.479**	**36.371**	**1.939**	**80.159**	**70.233**	**1.656**
log (Market Cap)	1.086	1.175	-0.031	-0.632	-0.347	-0.004
log (Trading Volume)	**-4.328**	**-3.932**	-0.132	-6.468	-6.155	**-0.111**
Daily Volatilty	**1.727**	**1.425**	**0.058**	1.338	1.134	**0.042**
Fragmentation Index	0.010	0.108	-0.005	0.283	0.331	-0.004
Inverse Mill Ratio	-2.079	-0.827	0.098	14.360	15.284	0.214
R2	0.748	0.764	0.663	0.331	0.289	0.665
			Order Size = 22 (500 - 1,999 Shares)			
Intercept	**43.611**	**32.343**	**1.790**	124.632	116.048	**2.252**
log (Market Cap)	0.744	0.995	-0.010	-1.933	-1.751	-0.008
log (Trading Volume)	**-3.685**	**-3.563**	**-0.142**	-10.050	-9.838	-0.172
Daily Volatilty	**1.581**	**1.356**	**0.069**	1.545	1.336	0.044
Fragmentation Index	-0.014	0.114	-0.003	0.620	0.689	0.004
Inverse Mill Ratio	-0.479	2.107	0.185	33.402	34.341	-0.163
R2	0.680	0.689	0.632	0.220	0.198	0.607
			Order Size = 23 (2000 - 4,999 Shares)			
Intercept	**47.195**	**38.595**	**1.962**	118.797	108.203	**2.075**
log (Market Cap)	1.634	2.279	0.074	-1.988	-1.797	-0.025
log (Trading Volume)	**-4.522**	**-4.883**	**-0.198**	-9.423	-9.069	**-0.162**
Daily Volatilty	**2.248**	**2.168**	**0.076**	1.490	1.260	**0.077**
Fragmentation Index	-0.048	0.094	-0.004	0.554	0.619	0.000
Inverse Mill Ratio	-3.387	-1.104	-0.227	31.588	30.744	-0.041
R2	0.704	0.655	0.593	0.217	0.192	0.628
			Order Size = 24 (5000 - 9,999 Shares)			
Intercept	17.403	-16.652	-2.308	**32.887**	**24.540**	1.703
log (Market Cap)	-1.073	1.518	0.100	1.231	0.918	-0.078
log (Trading Volume)	-0.380	0.903	0.177	**-3.099**	**-2.771**	-0.093
Daily Volatilty	0.850	0.611	-0.013	**1.166**	**0.980**	0.064
Fragmentation Index	-0.154	-0.312	-0.029	-0.004	0.096	-0.005
Inverse Mill Ratio	22.264	6.646	0.830	-6.495	-3.972	-0.335
R2	0.323	0.119	0.068	0.667	0.490	0.430

* Letter in bold indicates a statistical significance level better-than-5%.

Table 10: Impact of Volatility on Effective Spread

We report results of the regression between effective spread and its change against volatility, fragmentation index and other control variables. Our sample includes the 39 stocks that have transferred their listings from the Nasdaq to the NYSE during January 2002 to March 2003. Market capitalization and the trading volume are from the CRSP database, and are the monthly average during (-3, -1). Daily volatility is measured as the standard deviation of the daily return during (-60, -1) relative to each stock's transfer date. The fragmentation index is measured as the average number of the market venues in the Dash5 report during (-3, -1). The Inverse Mill Ratio is obtained from the first stage Probit regression. We also conduct the t tests for the mean difference and the Wilcoxon test for the median difference. Each regression has 39 observations. We report the regression coefficients and the R square in the table. We organize the results by order type and order size, and report them separately in Panel A, B, C, and D.
Our investigation window is (-3, -1) for Nasdaq and (+1, +3) for the NYSE relative to each stock's transfer month, and our sample period is from October 2001 to June 2003.

	Market Order			Marketable Limit Order		
Independent Variables	Nasdaq Effective Spread (Nasdaq)	Change of Effective Spread (Nasdaq - NYSE)	Proportional Change of Effective Spread (1 - NYSE / Nasdaq)	Nasdaq Effective Spread (Nasdaq)	Change of Effective Spread (Nasdaq - NYSE)	Proportional Change of Effective Spread (1 - NYSE / Nasdaq)
PANEL A: Order Size = 21 (100 - 499 Shares)						
Intercept	**46.088**	**38.064**	**2.076**	**80.764**	**73.065**	1.663
log (Market Cap)	1.001	1.000	-0.055	-0.637	-0.212	0.047
log (Trading Volume)	**-4.136**	**-3.929**	-0.127	-6.479	-6.314	-0.122
Daily Volatilty	**1.491**	**1.292**	**0.054**	1.333	1.148	0.019
Fragmentation Index	0.031	0.121	0.001	0.297	0.317	-0.003
Inverse Mill Ratio	2.433	3.794	0.314	14.746	14.842	0.276
R2	0.746	0.802	0.597	0.327	0.297	0.318
PANEL B: Order Size = 22 (500 - 1,999 Shares)						
Intercept	**62.917**	**41.306**	1.481	126.709	115.311	**1.699**
log (Market Cap)	0.948	1.058	0.017	-1.944	-1.555	0.043
log (Trading Volume)	**-5.514**	**-4.538**	-0.145	-10.200	-9.738	-0.142
Daily Volatilty	**2.136**	**1.612**	**0.094**	1.607	1.389	0.043
Fragmentation Index	0.071	0.203	-0.001	0.640	0.659	0.005
Inverse Mill Ratio	-0.029	2.819	-0.031	33.280	31.785	-0.426
R2	0.688	0.681	0.473	0.217	0.193	0.074
PANEL C: Order Size = 23 (2000 - 4,999 Shares)						
Intercept	69.726	17.208	-0.580	123.620	102.937	1.460
log (Market Cap)	3.870	4.974	0.240	-1.759	-1.615	0.046
log (Trading Volume)	-6.488	-4.609	-0.100	-9.765	-8.522	-0.150
Daily Volatilty	2.413	1.729	0.076	1.484	1.195	**0.089**
Fragmentation Index	-0.259	0.051	-0.011	0.555	0.567	0.005
Inverse Mill Ratio	-24.782	-13.439	-0.938	23.067	23.099	-0.888
R2	0.382	0.111	0.052	0.223	0.176	0.312
PANEL D: Order Size = 24 (5000 - 9,999 Shares)						
Intercept	11.127	-147.331	-6.937	**39.025**	25.689	1.877
log (Market Cap)	0.464	8.252	-1.843	0.967	0.295	-0.206
log (Trading Volume)	1.444	8.956	1.153	**-3.432**	-2.662	-0.068
Daily Volatilty	-0.789	-3.833	-0.958	**1.265**	1.023	0.041
Fragmentation Index	-0.593	-0.742	0.188	0.056	0.188	0.023
Inverse Mill Ratio	-9.178	-43.262	28.738	-12.337	-10.268	-2.535
R2	0.166	0.273	0.122	0.561	0.279	0.142

* Letter in bold indicates a statistical significance level better-than-5%.

Table 11: Conditional Change of Effective Spread and Quoted Spread

We report the conditional changes of the effective spread and quoted spread in the table. Our sample includes the 39 stocks that have transferred their listings from Nasdaq to the NYSE during January 2002 to March 2003. Market Cap and volume are from the CRSP database, and are monthly average during (-3, -1) for Nasdaq and (+1, +3) for the NYSE. Daily volatility is measured as the standard deviation of the daily return during (-60, -1) for Nasdaq and (+0, +59) for the NYSE. ? [log(MCAP)] = [Log(Nasdaq_MCAP) – Log(NYSE_MCAP)], and ? [log(Volume)] = [Log(Nasdaq_Volume) – Log(NYSE_Volume)]. The change of the effective spread (? ES), the change of the relative effective spread (? RES), the change of the quoted spread (? QS), and the change of the relative quoted spread (? RQS) are computed as (Nasdaq – NYSE). The Inverse Mill Ratio is obtained from the first stage Probit regression. We also conduct the t tests for the mean difference and the Wilcoxon test for the median difference, and provide the p values. Each regression has 39 observations. We separate our analysis for order type and order size. Our investigation window is (-3, -1) and (+1, +3) relative to each stock's transfer month, and our investigation period is October 2001 and June 2003.

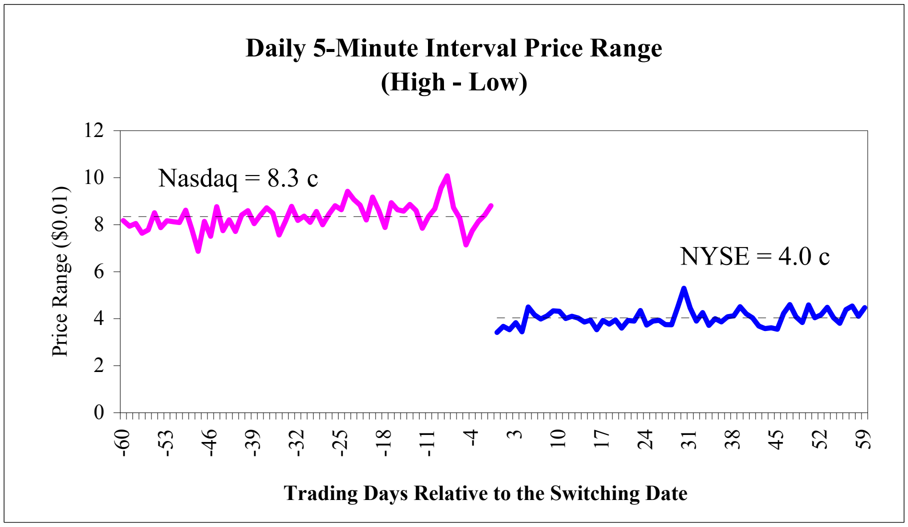
PANEL A: Market Order

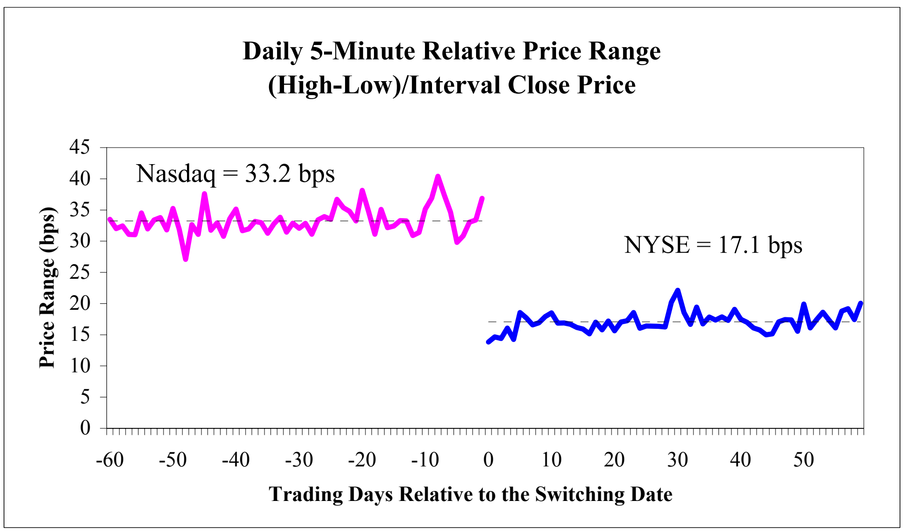
Independent Variables	? ES (Nasdaq - NYSE)	P Value	? RES (Nasdaq - NYSE)	P Value	? QS (Nasdaq - NYSE)	P Value	? RQS (Nasdaq - NYSE)	P Value
Order Size = 21 (100 - 499 Shares)								
Intercept	4.054	0.010	0.168	0.010	4.110	0.008	0.126	0.021
? [log (Mcap)]	-3.360	0.210	-0.191	0.091	-3.822	0.149	-0.244	0.013
? [log (Volume)]	-4.485	0.017	-0.101	0.186	-5.409	0.004	-0.124	0.059
? [Daily Volatilty]	1.159	0.007	0.024	0.160	1.204	0.005	0.024	0.107
Inverse Mill Ratio	3.299	0.740	-0.126	0.760	-3.035	0.757	-0.167	0.634
R2	0.383		0.218		0.426		0.355	
Order Size = 22 (500 - 1,999 Shares)								
Intercept	3.856	0.020	0.113	0.103	3.758	0.006	0.106	0.015
? [log (Mcap)]	-5.417	0.063	-0.313	0.015	-4.539	0.055	-0.275	0.001
? [log (Volume)]	-5.613	0.006	-0.123	0.141	-5.422	0.001	-0.128	0.015
? [Daily Volatilty]	1.330	0.004	0.023	0.228	1.016	0.007	0.017	0.142
Inverse Mill Ratio	-5.434	0.611	-0.255	0.580	-4.896	0.572	-0.222	0.426
R2	0.455		0.303		0.485		0.489	
Order Size = 23 (2000 - 4,999 Shares)								
Intercept	0.571	0.894	-0.089	0.713	3.936	0.053	0.128	0.100
? [log (Mcap)]	-0.020	0.998	-0.294	0.499	-5.112	0.155	-0.302	0.033
? [log (Volume)]	-5.077	0.329	-0.048	0.869	-5.006	0.042	-0.094	0.310
? [Daily Volatilty]	1.735	0.145	0.030	0.656	1.792	0.002	0.042	0.050
Inverse Mill Ratio	-2.096	0.942	0.199	0.902	-5.332	0.688	-0.358	0.487
R2	0.089		0.031		0.395		0.291	
Order Size = 24 (5000 - 9,999 Shares)								
Intercept	-17.675	0.071	-1.034	0.080	-0.475	0.796	-0.065	0.410
? [log (Mcap)]	22.469	0.201	0.636	0.544	-1.160	0.729	-0.104	0.471
? [log (Volume)]	8.066	0.528	0.242	0.753	0.607	0.805	0.115	0.281
? [Daily Volatilty]	-0.825	0.782	-0.078	0.666	0.179	0.756	-0.008	0.757
Inverse Mill Ratio	34.917	0.594	3.591	0.365	10.624	0.401	0.315	0.561
R2	0.083		0.042		0.037		0.052	

PANEL B: Marketable Limit Order

Independent Variables	? ES (Nasdaq - NYSE)	P Value	? RES (Nasdaq - NYSE)	P Value	? QS (Nasdaq - NYSE)	P Value	? RQS (Nasdaq - NYSE)	P Value
Order Size = 21 (100 - 499 Shares)								
Intercept	4.007	0.425	0.159	0.399	2.180	0.657	0.071	0.699
? [log (Mcap)]	3.249	0.714	0.106	0.750	4.172	0.632	0.098	0.764
? [log (Volume)]	-3.958	0.515	-0.077	0.734	-3.041	0.609	-0.049	0.828
? [Daily Volatilty]	1.223	0.375	0.037	0.473	1.269	0.348	0.034	0.505
Inverse Mill Ratio	23.272	0.486	0.622	0.618	23.745	0.468	0.768	0.532
R2	0.057		0.030		0.057		0.031	
Order Size = 22 (500 - 1,999 Shares)								
Intercept	1.167	0.900	0.041	0.906	-0.521	0.955	-0.033	0.925
? [log (Mcap)]	11.151	0.501	0.382	0.538	11.391	0.490	0.354	0.567
? [log (Volume)]	-1.634	0.885	0.006	0.989	-0.916	0.935	0.027	0.950
? [Daily Volatilty]	1.944	0.448	0.061	0.522	2.038	0.424	0.061	0.524
Inverse Mill Ratio	48.200	0.438	1.642	0.481	51.001	0.410	1.834	0.430
R2	0.046		0.037		0.051		0.040	
Order Size = 23 (2000 - 4,999 Shares)								
Intercept	0.635	0.942	0.015	0.963	-0.929	0.917	-0.051	0.876
? [log (Mcap)]	11.699	0.450	0.342	0.553	11.001	0.487	0.310	0.599
? [log (Volume)]	-0.755	0.943	0.018	0.963	-0.466	0.966	0.028	0.944
? [Daily Volatilty]	1.784	0.456	0.058	0.517	1.896	0.439	0.059	0.513
Inverse Mill Ratio	38.879	0.503	1.362	0.529	46.591	0.433	1.683	0.447
R2	0.043		0.033		0.048		0.038	
Order Size = 24 (5000 - 9,999 Shares)								
Intercept	3.631	0.035	0.097	0.165	2.735	0.038	0.085	0.162
? [log (Mcap)]	-1.538	0.606	-0.200	0.113	-2.840	0.218	-0.208	0.059
? [log (Volume)]	-3.696	0.073	-0.086	0.306	-3.453	0.030	-0.079	0.279
? [Daily Volatilty]	1.155	0.016	0.026	0.180	0.829	0.022	0.017	0.304
Inverse Mill Ratio	-19.331	0.091	-0.522	0.266	-7.142	0.406	-0.272	0.500
R2	0.257		0.188		0.308		0.201	

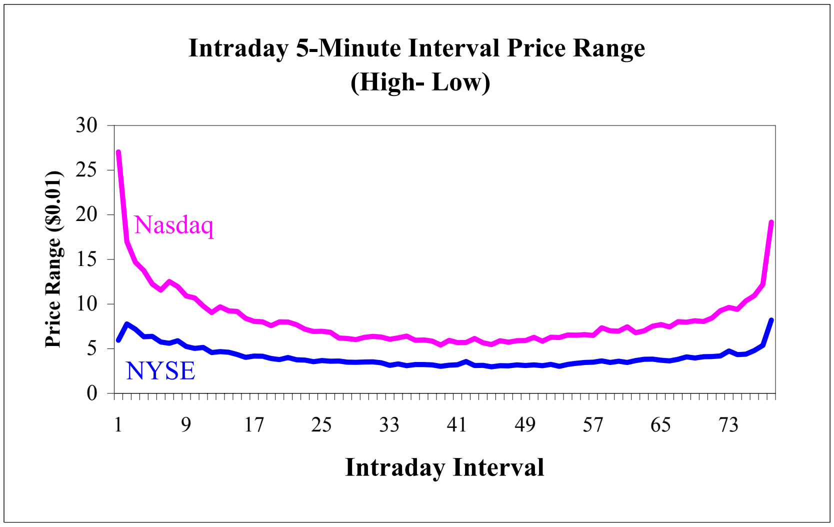
Figure 1: 5-Minute Price Range and Relative Price Range

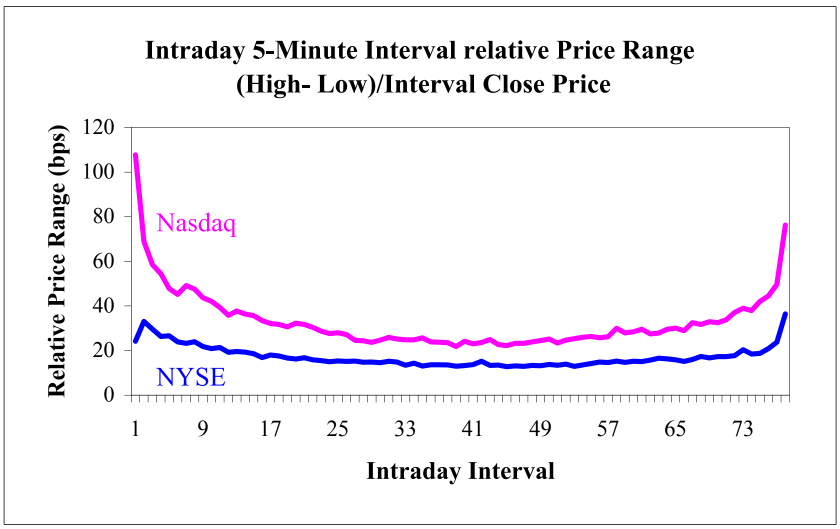




The figure is the daily average of the 5-minute interval price range and the relative price range across the sample stocks. We divide a trading day into 78 5-minute intervals. Interval #1 is from 9:30-9:35AM, and Interval #78 is between 3:55-4:00PM. For each stock, we compute its daily average of interval price range and relative price ranges across 78 intervals. Interval Price range is defined as the difference between the interval high price and the interval low price, and the interval relative price range is the ratio between the price range and the interval close price. Our sample includes the 39 stocks that have transferred their listings from the Nasdaq to the NYSE during January 2002 to March 2003. Our investigation window is (-60, -1) relative to each stock's transfer date, and our sample period is from October 2001 to January 2003.

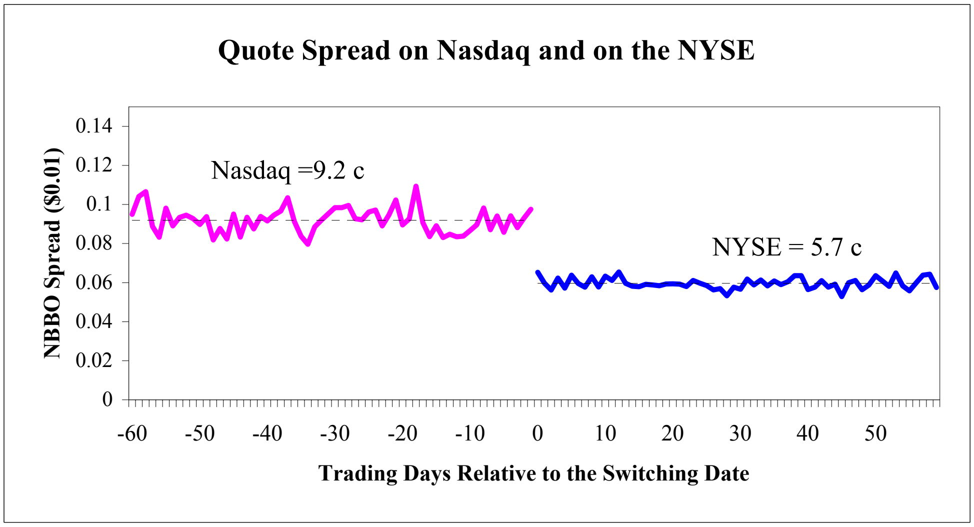
Figure 2: Intraday 5-Minute Price Range and Relative Price Range

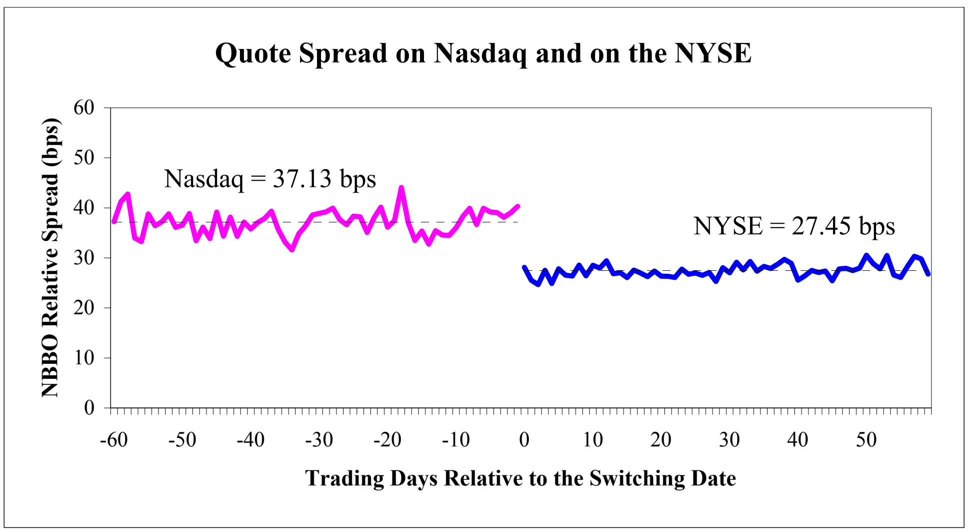




The figure is the average of the 5-minute interval price range and the relative price range across the sample stocks and sample period. We divide a trading day into 78 5-minute intervals. Interval #1 is from 9:30-9:35AM, and Interval #78 is between 3:55-4:00PM. For each stock, we compute its interval price range and relative price range in each of the 78 intervals. Interval Price range is defined as the difference between the interval high price and the interval low price, and the interval relative price range is the ratio between the price range and the interval close price. Our sample includes the 39 stocks that have transferred their listings from the Nasdaq to the NYSE during January 2002 to March 2003. Our investigation window is (-60, -1) relative to each stock's transfer date, and our sample period is from October 2001 to January 2003.

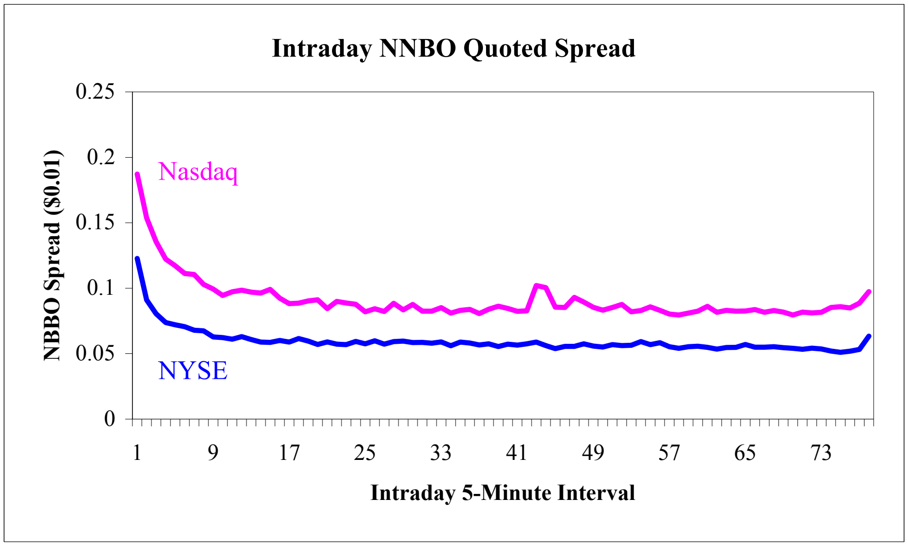
Figure 3: Daily Average of NBBO Quoted Spread and Relative Quoted Spread

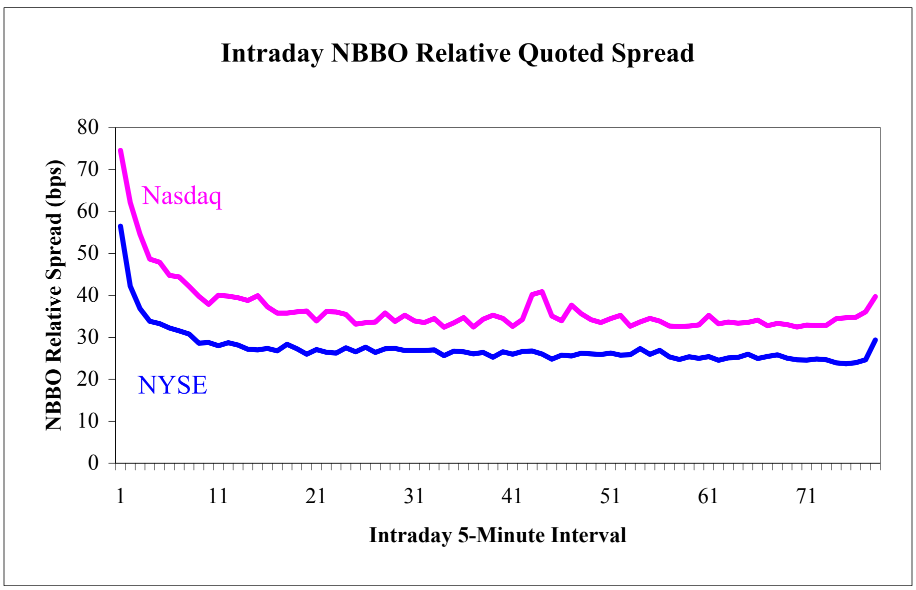




The figure is the daily average of NBBO quoted spread across sample stocks. For each stock, we compute its time-weighted daily average of the NBBO quoted spread. Our sample includes the 39 stocks that have transferred their listings from the Nasdaq to the NYSE during January 2002 to March 2003. Our investigation window is (-60, -1) relative to each stock's transfer date, and our sample period is from October 2001 to January 2003.

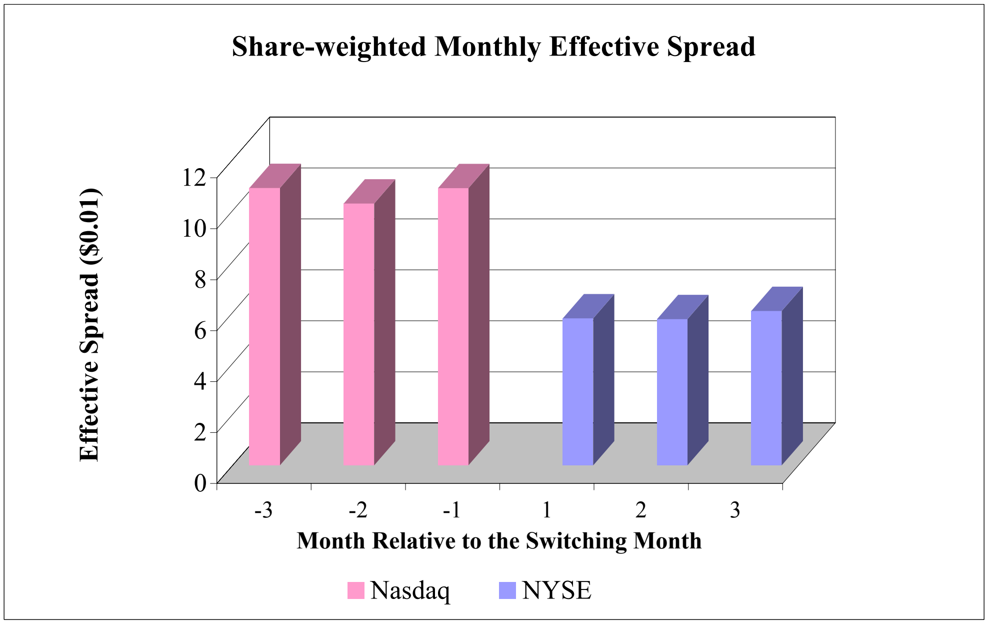
Figure 4: Intraday NBBO Quoted Spread and Relative Quoted Spread





The figure is the average of intraday NBBO quoted spread and relative NBBO quoted spread across sample stocks and sample period. We divide a trading day into 78 5-minute intervals. Interval #1 is from 9:30-9:35AM, and Interval #78 is between 3:55-4:00PM. For each stock, we compute its time-weighted NBBO quoted spread for each interval. The relative NBBO quoted spread is the ratio between the NBBO quoted spread to the interval closing quote midpoint. Our sample includes 39 stocks that have transferred their listings from the Nasdaq to the NYSE during January 2002 to March 2003. Our investigation window is (-60, -1) relative to each stock's transfer date, and our sample period is from October 2001 to January 2003.

Figure 5: Monthly Average of Effective Spreads



The figure shows the monthly average effective spread, weighted by shares that executed in all market centers in the Dash-5 report, across the 39 stocks around the transfer event. We compute the share-weighted effective spread for each stock in each month, and average them across stocks to obtain the monthly average share-weighted effective spread. Our sample includes the 39 stocks that have transferred their listings from the Nasdaq to the NYSE during January 2002 to March 2003. Our investigation window is (-3, -1) and (+1, +3) relative to each stock's transfer date, and our sample period is from October 2001 to June 2003.