Information Shocks and Stock Market Liquidity: A Comparison of the New York Stock Exchange and Nasdaq

Kenneth Lehn, Sukesh Patro and Kuldeep Shastri

Joseph M. Katz Graduate School of Business
University of Pittsburgh
Pittsburgh, PA 15260

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Abstract

This paper compares the performance of the New York Stock Exchange and Nasdaq on four days in 2001 and 2003 when securities markets received important new information that resulted in rapid stock price movements and heavy trading volume. We refer to the periods surrounding the release of this information as periods of "stress." The results document that liquidity is impaired for both NYSE and Nasdaq securities during the periods of stress. However, we find that bid-ask spreads on NYSE stocks increase by significantly more than they do for Nasdaq stocks during stress periods, after controlling for various attributes of NYSE and Nasdaq stocks that are associated with spreads. This difference is most significant for stocks with large market capitalizations. We also find that within Nasdaq, spreads increase by more for traditional Nasdaq market makers than they do for ECNs, suggesting that ECNs account for the relatively strong performance of Nasdaq during recent periods of market stress.

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1. Introduction

A major issue currently facing the Securities and Exchange Commission ("SEC") is its regulation of securities market structure. Recently, the SEC issued proposed Regulation NMS, in which it observes that the historical divisions between traditional auction exchanges (e.g., the New York Stock Exchange ("NYSE")) and dealer markets (e.g., the "old" Nasdaq) are eroding as new forms of competition from automated quote-driven market centers emerge (e.g., Archipelago, Inet ATS).[1] In its release, the Commission acknowledges that "the intensified competition … has benefited investors by reducing trading costs and prompting better, more efficient services," but also goes on to state that "the objective of market center competition can be difficult to reconcile with the objective of investor order interaction." In short, the SEC is grappling with the issue of whether investors are better served by competition among market centers that may fragment order flow and reduce liquidity, or by consolidation of order flow in a centralized market that may enhance liquidity but reduce competition among market centers.

This paper attempts to contribute to the controversy over securities market structure by examining the comparative performance of the NYSE and Nasdaq during times of recent market stress. Many studies have compared the performance of the two marketplaces generally, but few have examined their comparative performance under stress, which we define as information shocks that result in rapid stock price movements and high trading volume. One exception is the 1988 *Report of the Presidential Task Force on Market Mechanisms* (i.e., "the Brady Report"), which found that the NYSE performed relatively better than Nasdaq during the 1987 stock market crash. In a recent report on securities market structure, the NYSE referred to the Brady Report to support its view that "to a large extent, the NYSE is the market most looked to during periods of market distress."[2]

An updated study of the comparative performance of the NYSE and Nasdaq during periods of stress is especially timely in light of the growth of electronic

[1] U.S. Securities and Exchange Commission, *Proposed Rule: Regulation NMS*, Release No. 34-49235; File No. S7-10-04.

[2] *Market Structure Report of the New York Stock Exchange Special Committee on Market Structure, Governance and Ownership*, New York Stock Exchange, Inc., 2000, p. 16.

communications networks ("ECNs") in recent years. At the time of the Brady Report, Nasdaq securities were traded chiefly through a traditional dealer market, whereas today they are traded in a variety of competing market centers, including the Nasdaq Stock Market and various ECNs, including Archipelago, Instinet, and Brut. The contrast in the marketplaces within which NYSE and Nasdaq securities trade is perhaps more stark today than it has ever been. Whereas NYSE securities trade in a centralized market, Nasdaq securities trade in a decentralized structure of market centers with different modalities. The sharp difference in the two models provides an opportunity to test whether one model performs better than the other during periods of market stress.

To examine this issue, we focus on two days in 2001 and two days in 2003 when stock prices changed rapidly in response to new macroeconomic information. Using a matched sample of 388 NYSE and Nasdaq stocks that span various size categories, we examine several measures of market quality before and after the release of the relevant information on the four days to gauge how the two marketplaces perform under stress, and whether their performance changed from 2001 to 2003.

The results reveal several interesting findings. First, during both the calm and stress periods, quoted and effective bid-ask spreads are significantly lower for NYSE versus Nasdaq stocks, a result generally consistent with the existing literature. However, the difference in NYSE and Nasdaq spreads is small for stocks with large market capitalizations and the difference declined from 2001 to 2003. Within Nasdaq, ECN spreads are approximately 30-40% lower than the corresponding spreads of traditional Nasdaq dealers across all firms of all size categories.

Second, we find that quoted and effective bid-ask spreads increase significantly for both NYSE and Nasdaq securities during stress periods, but relatively more so for NYSE securities. This result holds after controlling for various attributes of securities, including firm size, stock price, volatility, and trading volume. The result appears to contradict the position that the NYSE is better able to handle stress than other marketplaces. The relatively better performance of Nasdaq during the stress periods is most pronounced among large capitalization stocks. Furthermore, we find that within Nasdaq, ECN spreads increase significantly less than spreads of more traditional market

makers. This suggests that the relatively better performance of Nasdaq during periods of market stress is driven largely by the performance of the ECNs.

An illustrative example of the more general results is seen in the experience of IBM, an NYSE-listed stock, and Microsoft, a Nasdaq stock, on the two days under study. We select these two companies to follow Stoll and Schenzler (2004), who present evidence on various measures of market quality for the two securities during 1993-2003. As table 2 shows, on January 2, 2003, the average quoted relative spread for IBM is 0.042 percent during the calm period and 0.093 percent during the stress period. The corresponding average spreads for Microsoft are 0.025 percent and 0.028 percent, respectively. Hence, Microsoft has substantially lower quoted spreads during both periods, and the quoted spreads increase substantially less during the stress period. Similar results hold for relative effective spreads on January 2, 2003. Furthermore, for Microsoft the average relative spreads for ECNs are 60 percent of the corresponding non-ECN spreads during the calm period. This ratio falls to 45 percent during the stress period, suggesting that ECN spreads increase less than spreads quoted by traditional market-makers and NYSE specialists during the stress period.[3]

On May 1, 2003, the day on which bad news was released, IBM's average quoted relative spread was 0.035 percent during the calm period and 0.076 percent during the stress period. The corresponding average spreads for Microsoft are 0.043 percent and 0.040 percent, respectively. Hence, Microsoft had a slightly higher quoted spread during the calm period, but a significantly lower quoted spread during the stress period. The results are less dramatic when one examines effective spreads on May 1, 2003, but they too show that spreads on IBM increased more than spreads on Microsoft during the stress period.[4] On this day during both calm and stress periods average ECN spreads are on average 20 percent of non-ECN spreads. Although not reported in the table, the median ECN to non-ECN spread declines from 40 percent during the calm period to 28 percent

[3] Although Nasdaq spreads are based on best bids and offers, the ECN and non-ECN spreads within Nasdaq are not. Therefore, while it is appropriate to directly compare Nasdaq spreads with the NYSE spreads, it is difficult to compare the ECN and non-ECN spreads within Nasdaq with the NYSE spreads. . We discuss this further in Section 3.

[4] Consistent with Stoll and Schenzler (2004), we find that effective spreads for IBM are lower than the quoted spread while the opposite holds for Microsoft.

during the stress period, again suggesting that ECNs perform better under stress than more traditional market makers and the NYSE.

The remainder of this paper is organized as follows. Section 2 provides a brief review of the literature on the comparative performance of the NYSE and Nasdaq. Section 3 describes our sample selection criteria and the methodology used to compare the performance of the NYSE and Nasdaq. The results are presented in section 4. Section 5 provides concluding comments.

2. Literature on the performance of the NYSE v. Nasdaq

Interest in the comparative performance of the NYSE and Nasdaq was sparked in recent years by Christie and Schultz's ("CS") influential 1994 paper. CS found that bid prices, ask prices and bid-ask spreads on Nasdaq stocks were typically posted on even-eighths, in contrast to posted spreads on NYSE-listed stocks. This quoting behavior on Nasdaq stocks also was accompanied by wider spreads and less frequent quote revisions. CS suggested that collusion among market makers may account for these results. Subsequent to CS, several papers have examined this issue and concluded that spreads on Nasdaq are higher than those on the NYSE.[5]

In January 1997, a number of reforms were introduced in the Nasdaq stock market in response to this controversy. The reforms included the requirement that customer limit order books be displayed and superior quotes on proprietary trading systems be disseminated to investors. Barclay, Christie, Harris, Kandel and Schultz (1999) and Bessembinder (1999) analyze the impact of these reforms on trading costs of Nasdaq-listed stocks. They both find that bid-ask spreads declined after the implementation of the reforms. Bessembinder also reports that even though the spreads on NYSE were still lower than that on Nasdaq, the gap has narrowed over time.

In June 1997, the tick size was reduced to $1/16^{th}$. Goldstein and Kavajecz (2000) examine the impact of reducing the tick size on the liquidity of the NYSE. They find that spreads and depth declined after the change and conclude that the reduction in tick size has made individuals trading small orders better off. On the other hand, they argue that

[5] A partial list includes Huang and Stoll (1996), Barclay (1997), Bessembinder (1997) and Bessembiner and Kaufman (1997).

since the change in tick size declined throughout the limit order books, some traders were worse off after the change. Jones and Lipson (2001) report similar results based on their analysis of realized execution costs for institutional trades. Specifically they find that even though quoted and effective spreads declined the execution costs for a variety of institutional traders increase after the change suggesting that smaller tick sizes can result in a reduction in market liquidity.

Finally, in January 2001, all securities began trading in decimals. Bacidore, Battalio and Jennings (2003) (BBJ) and Chung, Chuwonganant and McCormick (2004) (CCM) examine the impact of decimalization on NYSE and Nasdaq-listed stocks, respectively. BBJ find that average quoted spreads decrease by approximately 4 cents after NYSE-listed stocks began trading in decimals. For Nasdaq-listed stocks, CCM report that quoted (effective) spreads fell significantly from a pre-decimalization level of 3.3 (3.11) cents to a post-decimalization level of 2.54 (2.24) cents..

More recently, Stoll and Schenzler (2004) (SS) examine trends in market quality for the NYSE and Nasdaq over the period starting January 1993 and ending December 2003. They find that market quality (as measured by the quoted and effective half-spread) have improved on both exchanges with the change being much more dramatic for the Nasdaq. They also report that as spreads have fallen the relation between quoted spreads and effective spreads have changed on the Nasdaq. In contrast to the NYSE, where quoted spreads are larger than effective spreads for all stocks, SS find that after 1999, quoted spreads on the Nasdaq are smaller than effective spreads for actively traded large stocks.

3. Sample selection and methodology

3.1. Sample selection

We use data from the Center for Research in Security Prices (CRSP) database to form a sample of matched NYSE and Nasdaq stocks. From the CRSP universe we pick all firms that survive continuously between the beginning of year 1998 and ending of year 2003. From this sample we exclude all that change the exchange on which they are listed. We then eliminate all financial firms (2 digit SIC code between 60 and 69), utilities (2 digit SIC code 49), and American Depositary Receipts. We also eliminate all

stocks whose average share price between January 1, 1998 and December 31 2002 is less than five dollars per share. For this set of firms we use daily returns in year 1998 through 2002 to calculate return volatility. We then match every NYSE firm to every Nasdaq firm**.** This results in over 100,000 pairs. We then compute the following distance measure for each pair

$$Distance = \sum_{i=1}^{n} | (factor_{iNasdaq} - factor_{iNYSE}) / (factor_{iNasdaq} + factor_{iNYSE}) |$$

The factors used are market value of equity (average for the period January 1, 1998 through December 31, 2002), stock price (average for the period January 1, 1998 through December 31, 2002), volatility of daily returns (calculated as above) and average daily turnover during the period January 1, 1998 through December 31, 2002, computed as the ratio of the number of shares traded daily to the number of shares outstanding. For Nasdaq stocks we use half the daily turnover to account for inter-dealer trades. We select the pairs with the minimum distance and ensure that there is no duplication of firms in any of the pairs. We then retain those firms for which the average market equity of the Nasdaq firm is within 30% of the corresponding characteristic of the NYSE firm. We do not do this with turnover, volatility and price since it sharply reduces sample size. This gives us 668 pairs of firms. We then choose all firms where the market value of the NYSE firm is greater than $100 million. We then intersect this sample with the TAQ database. We use the TAQ names to further identify ADRs and ADSs. We ensure that the CRSP firm name and the TAQ security name are identical. This gives us a final set of 388 pairs of CRSP firms that intersect with the NYSE Trades and Quotes (TAQ) database.

3.2. Selection of calm and stress periods

We choose the calm and stress periods in the following manner. Using the TAQ database we track the average price (we use quote-midpoints) of an equal-weighted portfolio of the Dow Jones Industrial Average ("DJIA") over 10 minute intervals for the period 1 Jan 1998 to 31 Dec 2003. Using these average prices we compute returns over 30 minute, 45 minute and 60 minute intervals. We then rank these returns in descending order based on absolute value to identify periods when there are sharp increases or

decreases in the market. We then examine news stories on Reuters (we use www.factiva.com to access the stories) to identify an information release associated with the sharp stock price movements. We do this in order to ensure that the sharp movements we identify are associated with new information. For each year 1999, 2001 and 2002 we select the days in which the DJIA experienced its largest positive 45-minute return and its largest negative 45 minute return provided we can tie these movements to arrival of macroeconomic news.

As an example the information released on both January 2 and May 1 was the Institute of Supply Management's ("ISM") report on the index of manufacturing business conditions. On both days the information was released at 10 a.m. and had a sharp impact on the market. On January 2 the news was positive and on May 1 the news was negative. We define the stress period on January 2, 2003 as a 45-minute period, from 9:45 a.m. through 10:30 a.m., surrounding the release of the ISM report. Because potentially important labor data also was released on before the markets opened on May 1, 2003, we define the stress period on this day as the 45 minute period of 9:30 through 10:15, which surrounds the release of the ISM report. Hence, the stress period on each day is defined as a 45 minute period surrounding the ISM release. We match the stress period on each day with an equally long, 45 minute period on the same day when the stock prices were relatively flat. For both days this period is defined as 12:30 p.m. to 1:15 p.m. A similar method is followed for each of the remaining two years. A more detailed description of these two days is provided in Table 1.

3.3. TAQ and NASTRAQ data filters

3.3.1 TAQ Data

We use quote and trade data from the NYSE's TAQ database. Because we focus on quotes that originate in the primary market and trades that occur in the primary market, we use the following filters for quotes. All quotes with non-zero bids/offers and bid/offer depths and with a quote condition of 12 are retained**.** We lose less than 2% of the quotes due to this filter. Using only primary market quotes means we retain about one-third of the quotes on average for our sample of stocks. We then eliminate quotes

with a spread of greater than 20% of the quote mid-point (for stocks with a price greater than $10 we eliminate quotes with a spread of greater than $2). We also eliminate quotes that have a return of greater than 50% return based on the last quote mid-point. We lose about 5% of the observations due to this filter. When there are multiple quotes with the same time-stamp we form the prevailing quote by picking the highest bid and the lowest offer. This reduces the number of observation by about one-third. This forms our final set of quotes.

In the case of trades, we lose about 40% of the trades that occur outside the primary market. We employ the following filters for the trade data. We retain trades with a correction indicator of 0 and with a trade condition that is regular way**.** We lose about 5% of the observations due to this filter. We bunch trades that carry the same time stamp and the same price. This reduces the number of observations by about 20%. This forms our final set of trades.

3.3.2. NASTRAQ Data

We identify ECN and non-ECN quotes using the NASTRAQ dealer database. This is a compilation of all quotes by all market-participants in NASDAQ. We obtain a list of ECNs from the NASDAQ website. Using this list we classify quotes into two groups -- ECN quotes and non-ECN quotes based on the market participant ID in the NASTRAQ dealer dataset. Non-ECN quotes are presumed to be quotes of traditional Nasdaq market makers. For each stock we then compute the ECN and non-ECN spreads as the average spread across all quotes that originate from ECNs and non-ECNs, respectively. It should be noted that spreads computed this way, not being best bid and offer, are upward biased and therefore should not be interpreted as measures of actual trading costs. Specifically, a comparison of these spreads to spreads of matching NYSE stocks would be biased in favor of the NYSE stocks. However, since this is a characteristic of both ECN and non-ECN quotes a comparison of the two is relevant.

3.4. Methodology

3.4.1. Calm and stress periods

We compute duration weighted average absolute and relative spreads during each 45 minute interval. Effective spreads are calculated using quotes and trades from each 45 minute interval. The effective spread is computed as twice the absolute difference between the trade price and the prevailing quote mid-point at that time. We follow the literature in lagging trades by five seconds in order to account for delays in trade reporting. We also calculate other measures of quote and trade activity. These include frequency of quote updates, quote durations and the frequency of trades. We compute the variance in stock price during each 45 minute interval as follows. For each 10 minute interval during the 45 minutes we compute the ratio of the high quote mid-point to the low quote mid-point. Therefore, for each stock in each interval we have 4 observations. The average of these 4 observations is used as a measure of intra-period volatility.

4. Empirical results

This section presents the results and discusses their implications. We compare various measures of market quality for the sample of 388 matched pairs of NYSE-listed stocks and Nasdaq stocks during the calm and stress periods listed in Table 1. Among the 388 Nasdaq stocks, we also examine the comparative performance of ECNs versus traditional Nasdaq market makers during periods of market stress.

4.1. The impact of market shocks on NYSE versus Nasdaq stocks

To determine whether the results for Microsoft and IBM described in the introduction generalize to a larger sample, we compare spreads and other measures of market quality for the sample of NYSE and Nasdaq stocks on the two days under study.

Before presenting the results, we first examine data that documents the similarities between the NYSE and Nasdaq firms in the sample. Table 3 provides descriptive statistics on firm size (market value of stock), beta, turnover, volatility and

price per share. The matching procedure yields stocks that are well matched in terms of size. The mean market values of equity are $4.4 billion for both the NYSE and Nasdaq stocks. The median value is slightly but significantly higher for the NYSE stocks ($717 million) than the Nasdaq stocks ($683 million). The NYSE and Nasdaq shares turn over at a similar rate; no significant difference exists in the median value of this variable. The volatility of daily returns is significantly higher for Nasdaq stocks and is an artifact of our matching process - similar sized NASDAQ firms are more volatile than NYSE firms. Finally, the average and median stock price is significantly higher on the NYSE than Nasdaq.

Univariate comparisons of various measures of market quality during the calm and stress periods are presented in Tables 4a through 4d for the four days of market stress. Panel A of each table provides the results for the entire sample, while panel B presents the results broken down by size terciles.

Tables 4a to 4d indicates that quoted and effective bid-ask spreads generally increased significantly on both the NYSE and Nasdaq during the stress periods in 2001 and 2003. For example, on January 3, 2001, the mean quoted spread increased from 0.771% to 0.881% on the NYSE and from 0.713% to 0.83% on Nasdaq during the stress period. Mean effective spreads also increased during the stress period in the two markets, but more dramatically so for Nasdaq. Other variables associated with market quality also changed significantly in the two markets during the stress period. For example, the frequency of quote updates, intra-period volatility, and the number of trades all increased significantly during the stress period, while quote duration decreased significantly in both marketplaces. With a few exceptions, the direction of these variables is the same during

the other stress periods. One notable exception is that both quoted and effective spreads *fall* on Nasdaq during the stress period on March 22, 2001 (Table 4b). .

Several results from Tables 4 and 5 are worth noting. First, mean spreads in both marketplaces declined substantially from 2001 to 2003. For example, quoted spreads drop from 0.6% to 0.771% on the NYSE during calm periods in 2001 to approximately 0.29% during calm periods in 2003. Similarly, quoted spreads drop from approximately 0.7% on Nasdaq during calm periods in 2001 to 0.46% during calm periods in 2003. Similarly, effective spreads fall from approximately 0.4% on the NYSE during calm periods in 2001 to 0.2% during calm periods in 2003. The corresponding decline in effective spreads on Nasdaq is from approximately 0.6% in 2001 to 0.3% in 2003.

Second, as expected, both quoted and effective spreads generally are lower for firms with larger market capitalizations. For example, in 2003, average quoted spreads on the NYSE during calm periods are approximately 0.5%, 0.25%, and 0.15% for the smallest, medium, and largest sized firms in the sample, respectively. The corresponding spreads for the smallest, medium, and largest sized firms on Nasdaq are 0.8%, 0.4%, and 0.17%. Similarly, effective spreads on the NYSE during calm periods are 0.32%, 0.19%, and 0.10%, respectively, for the smallest, medium, and largest firms. The corresponding effective spreads on Nasdaq are 0.55%, 0.30%, and 0.13%, respectively. Hence, across all terciles, spreads are lower on the NYSE. The difference between the NYSE and Nasdaq spreads is the smallest for the largest stocks.

Table 5 presents corresponding and similar results for May 2, 2003. Panel A documents that both relative quoted and relative effective spreads are significantly lower for NYSE versus Nasdaq stocks during the calm and stress periods on May 2. However,

Nasdaq stocks fare significantly better in terms f frequency of quote updates and number of trades. Quote duration is longer, but not significantly so, for Nasdaq stocks during calm periods, but shorter (not significantly so) during stress periods. Intra-period volatility is significantly higher for Nasdaq stocks during both periods, perhaps because the Nasdaq stocks are simply more volatile generally.

Tables 5a-5d present regression results in which the dependent variable is the change in quoted spreads, measured as the natural logarithm of the ratio of mean relative spread during the stress period to mean relative spread during the calm period. Tables 6a-6d present the corresponding regression results for effective spreads. In panel A of the tables we present results of a univariate regression, in which the only independent variable is a dummy variable that takes the value of 1 for Nasdaq-listed stocks and 0 for NYSE-listed stocks.

Panel B of the tables contains results of a regression in which the same dependent variable is regressed on several independent variables include size, price, volatility, turnover, the change in volatility over the stress period, the change in quote frequency over the stress period and the Nasdaq dummy variable. Our main interest is in the coefficient of the Nasdaq dummy. A positive (negative) coefficient for the Nasdaq dummy would indicate that spreads on the Nasdaq increased by a larger (smaller) amount than spreads on the NYSE during the stress periods.

As can be seen from panel A of tables 5a-5d, the coefficient on the Nasdaq dummy is negative and statistically significant at the one percent level on all four days in 2001 and 2003, indicating that quoted spreads on Nasdaq increase during the stress period by a smaller amount as compared to quoted spreads on the NYSE. Panel A also

presents the regression coefficients with the sample stratified on size terciles. The results indicate that the magnitude and significance of the coefficient of the Nasdaq dummy generally is largest for larger firms. This suggests that the larger firms on Nasdaq experience a smaller increase in spreads during the stress period as compared to similar size firms on the NYSE, reinforcing the results presented earlier for IBM and Microsoft. Panel B of tables 5a-5d indicates that the coefficient on the Nasdaq dummy variable becomes more negative and more highly significant after controlling for differences in the attributes of NYSE and Nasdaq stocks.

Tables 6a-6d reveals the corresponding results for effective spreads. The coefficient on the Nasdaq dummy variable is not robust in the univariate regressions, but it is negative and statistically significant in the multivariate regressions for 2003. This indicates that effective spreads also increased less significantly during stress periods on Nasdaq than they did on the NYSE during 2003. Interestingly, in 2001, the coefficient on the Nasdaq dummy variable in the multivariate regression is positive and significant in one equation and negative and not significant in the other. It appears that the narrower effective spreads on Nasdaq during periods of stress are a recent phenomenon.

4.2. The performance of ECNs v. traditional Nasdaq market makers during stress

Huang (2002) finds that for active Nasdaq stocks, ECNs post quotes rapidly and have quoted spreads that are smaller than dealer spreads. In this section we explore the role played by the ECNs in spread changes during periods of market stress. Tables 7a and 7b present the ratio of the spreads quoted by ECNs to the spreads quoted by traditional Nasdaq dealers.

The results in Table 7a and 7b indicate that ECNs quote narrower spreads than traditional Nasdaq dealers during both calm and stress periods. Overall, the ratio of ECN to non-ECN spreads on Nasdaq during calm periods ranges from 0.63 to 0.78, indicating that ECN quotes are substantially narrower than non-ECN quotes. On two of the four days, the ratio declines significantly from the calm to stress period, indicating that ECNs widened quoted spreads by less than the non-ECN Nasdaq dealers. The decline in relative ECN spreads is especially pronounced among large capitalization stocks. For example, on May 1, 2003, the ratio of ECN to non-ECN spreads dropped from 0.729 during the calm period to 0.535 during the stress period. This decline is significant at the 0.01 level. The corresponding change in this ratio for the small and medium sized stocks on this day was not significant. On March 22, 2001, the other day on which the overall ratio of ECN to non-ECN spreads fell significantly, the ratio fell by a comparable amount for all three terciles of stocks. The results suggest that ECNs are an important reason why spreads on Nasdaq do not increase as much as those on the NYSE during the periods of stress under study.

4.3. Market depth across the NYSE and Nasdaq

In this section we examine whether market depth changes differently during times of stress on the NYSE and Nasdaq. We use Kyle's (1985) inverse market depth measure, λ. The quantity $1/\lambda$ measures the trade flow necessary to change the stock price by a unit amount. The smaller the value of λ the greater the amount of trade flow needed to change the price of the stock and therefore the greater the market depth. We follow Brennan & Subrahmanyam (1996) and estimate λ using the Glosten-Harris (1988) method. Specifically, we assume that the change in transaction price is given by

$$\Delta p_t = \lambda q_t + \psi(D_t - D_{t-1}) + e_t$$

where q_t is the signed order size of transaction t and D_t is the signed order type that takes on a value of +1 for a buyer-initiated trade and -1 for a seller initiated trade. We estimate the above equation for the 45-minute stress and normal periods for each stock

The relatively short 45-minute period of time used to estimate market depth potentially may result in significant estimation errors. To mitigate this problem, for this analysis we use only those matched NYSE-Nasdaq pairs for which λ can be estimated in each of the sample periods. This means we eliminate (i) pairs for which a sufficient number of observations are not available in any sample period and (ii) pairs for which the estimated λ is negative in any sample period. This results in a remaining sample of 65 pairs for this analysis.

Table 8 reports the mean and median values of λ on the NYSE and Nasdaq for each of the four days. We first note a decline in λ from 2001 to 2003, which is consistent across the two trading venues and holds for both calm and stress periods. The data reveals that there has been considerable improvement in market depth in both market venues over time. We next compare market depth during periods of stress versus calm periods - in periods of stress we expect a fall in the market depth and a corresponding increase in λ. The results show that the increase in the average λ of the NYSE stocks is smaller than that of the matched Nasdaq stocks. In fact in 3 out of the 4 sample periods the average value of λ for NYSE stocks is actually lower in the stress period. In contrast the average value of λ for the Nasdaq stocks is uniformly higher in the stress period and the difference is generally significant.

The results in Table 8 seem to suggest that, during periods of stress there is a greater fall in market depth for Nasdaq stocks than for NYSE stocks. In order to ensure that the differences in λ from the calm to stress period measured in table 8 are not driven by firm or trade characteristics we estimate regressions of the log of the ratio of λ in the stress period to λ in the calm period for each stock. The explanatory variables used to capture variation in stock characteristics are the log of market capitalization, daily turnover, volatility of daily returns and price. In order to capture variation in the trade characteristics from calm to stress periods we also include the following explanatory variables – the log of the ratio of quote frequency in the stress period to the quote frequency in the calm period, the ratio of the average trade size in the stress period to the average trade size in the calm period and the ratio of the intra-period volatility in the stress period to the intra-period volatility in the calm period. The Nasdaq dummy variable captures the difference in the changes in market depth between NYSE and Nasdaq stocks. Table 9 reports the regression results.

The results show that the coefficient on the Nasdaq dummy variable is not significant in any of the four regressions, and it is positive in only one of the regressions. The co-efficient on the ratio of average trade size from the calm to the stress period is consistently negative. This suggests that the change in the trade size from calm to stress periods is a significant determinant of the change in market depth during these periods. In contrast the quote frequency is not a significant determinant of the change in market depth. We use the number of trades as an alternative to quote frequency and find the same qualitative results. This is not surprising given the high correlation of trade and quote frequencies. Overall the results show that after controlling for differences in stock

and trade characteristics there is no significant difference in market depth during stress periods on the NYSE and Nasdaq.

5. Conclusion

This paper examines the comparative performance of the NYSE and Nasdaq on two days in 2003 when securities markets received important new information that induced large stock price movements and heavy trading volume. We find that the spreads on both NYSE and Nasdaq securities widen significantly around the time of the news releases, indicating that the information shocks impair liquidity in both markets. However, spreads widen less for Nasdaq securities, contradicting the view that the NYSE is more adept at providing liquidity during times of market stress. This result is especially strong for large capitalization stocks. Furthermore, Nasdaq's comparatively better performance during periods of stress appears due, at least in part, to the superior performance of ECNs. Finally, we find no significant difference in market depth on the NYSE and Nasdaq during periods of stress, after controlling for various firm and trade characteristics.

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Table 1
Dates and time periods used for the analysis

We study two days each in 2001 and 2003 on which significant macroeconomic news was released. For each year we pick significant rises and falls in the market. We do this by ranking returns over 45 minute intervals for the 30 stocks that constitute the Dow Jones Industrial Average.

Date	Time	Type of News	Event Description	Return Rank
January 3, 2001	1:30-2:15 p.m.	Positive	The Federal Reserve announced an unexpected cut of 50 basis points in the federal funds rate.	Largest positive 45 minute return
March 22, 2001	9:45-10:30 a.m.	Negative	The Conference Board released data on the U.S. index of leading economic indicators with a greater than expected decline. Labor data was negative. Market was disappointed with recent rate cut.	6^{th} largest negative 45 minute return**
January 2, 2003	9:45-10:30 a.m.	Positive	The Institute for Supply Management released its index of manufacturing business conditions at 10:00 a.m. The index was at a level of 54.7, above analysts' expectation of 50.3.	Largest postive 45 minute return
May 1, 2003	9:30-10:15 a.m.	Negative	The Institute for Supply Management released its index of manufacturing business conditions at 10:00 a.m. The index was at a level of 45.4, below analysts' expectation of 46.2.	Second largest negative 45 minute return

** We leave out five 45-minute returns larger than this because they all occur in the days following the re-opening of markets after September 11, 2001.

Table 2

Comparison of IBM and Microsoft during calm and stress periods

The stress periods are 9:45-10:30 a.m. for Jan 2, and 9:30-10:15 a.m. for May 1. Calm periods are 12:30 – 1:15 p.m. for both days. We compare relative spreads (defined as the spread divided by the quote mid-point), relative effective spreads (defined as the twice the absolute difference between the prevailing quote-midpoint and the trade price divided by the trade price), frequency of quote updates (number of valid quote updates that occur in the interval), quote duration (the time elapsed between consecutive quote updates), number of trades (the number of trades that occur in the interval), trade size (the average of the size across trades that occur in the interval) and intra-period volatility. Intra-period volatility is computed as follows. For each stock we first compute the ratio of the high quote-midpoint to the low quote-midpoint within ten-minute intervals throughout the sample time period. The average across these ten-minute intervals is used as a measure of the intra-period volatility.

Panel A –January 2, 2003

	IBM		Microsoft	
	calm	stress	calm	stress
Relative Spread (%)	0.042%	0.093%	0.025%	0.028%
Relative Effective Spread (%)	0.029%	0.070%	0.026%	0.038%
Frequency of Quote Updates	716	626	2716	3464
Quote Duration (seconds)	5.03	5.75	1.33	1.04
Number of Trades	469	513	2152	5941
Average Trade Size	916	2787	922	1243
Intra-period Volatility	1.00147	1.00510	1.00179	1.00554
Ratio of ECN spreads to Non-ECN spreads	-	-	0.60	0.45

Panel B –May 1, 2003

	IBM		Microsoft	
	calm	stress	calm	stress
Relative Spread (%)	0.035%	0.076%	0.043%	0.040%
Relative Effective Spread (%)	0.030%	0.041%	0.040%	0.043%
Frequency of Quote Updates	994	1141	2292	3487
Quote Duration (seconds)	3.62	3.13	1.57	1.03
Number of Trades	419	697	1268	3283
Average Trade Size	1205	1685	1293	1791
Intra-period Volatility	1.00147	1.00438	1.00167	1.00399
Ratio of ECN spreads to Non-ECN spreads	-	-	0.20	0.20

Table 3

Sample Characteristics

This table describes the matched sample of 388 NYSE and Nasdaq stocks that are used in the study. Descriptive characteristics include firm size (measured as the average market value of equity between January 1, 1998 and December 29, 2002), share price (the average of the closing stock price between January 1, 1998 and December 29, 2002), daily turnover (measured as ratio of the number of shares traded daily to the number of shares outstanding, averaged over January 1, 1998 through December 29, 2002), volatility of daily stock returns (measured as the standard deviation of daily returns between January 1, 1998 and December 29, 2002) are shown. For NASDAQ stocks we use half the daily turnover. Tests for differences in the means and medians are in the last two columns. Medians are tested using the Wilcoxon signed-rank test. P-values are in parentheses below the t-stat/z-stat.

	NYSE			Nasdaq			Pearson Correlation Between NYSE and Nasdaq	Paired Sample Difference of Means (t-stat)	Wilcoxon Signed Rank Test for Diff. of Medians (z-stat)
	Mean	Median	Std. Dev.	Mean	Median	Std. Dev.			
Size ($ m)	4,362.21	716.51	24,329	4,373.11	683.23	23,931	0.993***	-0.07	4.08
Turnover	0.00533	0.00452	0.00350	0.00568	0.00448	0.00423	0.809***	-2.77	0.25
Volatility	0.03091	0.03019	0.00806	0.04244	0.04171	0.01083	0.313***	-20.10	-15.76
Price ($)	27.25	24.22	14.54	28.36	25.38	14.14	0.891***	-3.24	-4.27

*, ** and *** denote the 10%, 5% and 1% significance level

Table 4a
Comparison of calm and stress periods NYSE vs. Nasdaq. Jan 3, 2001

PANEL A: Results for the whole sample

	NYSE			Nasdaq			NYSE vs Nasdaq calm period t-stat.	NYSE vs Nasdaq stress period t-stat.
	calm mean	stress mean	calm vs. stress t-stat	calm mean	Stress mean	calm vs. stress t-stat		
Relative Spread (%)	0.771%	0.881%	-6.33 (0.00)	0.713%	0.830%	-4.23 (0.00)	1.40 (0.16)	1.08 (0.28)
Relative Effective Spread (%)	0.444%	0.544%	-4.70 (0.00)	0.600%	0.887%	-8.90 (0.00)	-4.58 (0.00)	-9.21 (0.00)
Frequency of Quote Updates	57	76	-11.73 (0.00)	191	221	-4.19 (0.00)	-8.90 (0.00)	-11.33 (0.00)
Quote Duration (seconds)	275.82	125.68	6.92 (0.00)	187.42	111.47	2.41 (0.02)	3.02 (0.00)	0.57 (0.56)
Intra-period Volatility	1.00325	1.00859	-16.94 (0.00)	1.00663	1.01696	-17.06 (0.00)	-9.78 (0.00)	-11.32 (0.00)
Number of Trades	38.13	59.32	-11.55 (0.00)	278.24	559.06	-8.51 (0.00)	-8.10 (0.00)	-8.20 (0.00)

PANEL B. Results for Terciles Based on Firm Size

	NYSE			Nasdaq			NYSE vs Nasdaq calm period t-stat.	NYSE vs Nasdaq stress period t-stat.
	calm mean	stress mean	calm vs. stress t-stat	calm mean	stress mean	calm vs. stress t-stat.		
Smallest Tercile								
Relative Spread (%)	1.161%	1.246%	-1.88 (0.06)	1.196%	1.398%	-2.65 (0.01)	-.35 (0.72)	-1.33 (0.19)
Relative Effective Spread (%)	0.698%	0.784%	-1.18 (.24)	0.968%	1.122%	-2.00 (0.05)	-2.81 (0.00)	-3.92 (0.00)
Middle Tercile								
Relative Spread (%)	0.786%	0.900%	-4.98 (0.00)	0.640%	0.811%	-4.92 (0.00)	2.03 (0.04)	1.19 (0.24)
Relative Effective Spread (%)	0.433%	0.541%	-3.29 (0.00)	0.566%	0.837%	-6.43 (0.00)	-2.69 (0.01)	-5.20 (0.00)
Largest Tercile								
Relative Spread (%)	0.387%	0.516%	-7.78 (0.00)	0.332%	0.317%	1.22 (0.22)	2.32 (0.02)	6.99 (0.00)
Relative Effective Spread (%)	0.236%	0.354%	-10.29 (0.00)	0.319%	0.743%	-9.41 (0.00)	-5.21 (0.00)	-7.91 (0.00)

Table 4b
Comparison of calm and stress periods NYSE vs. Nasdaq. Mar 22, 2001

PANEL A: Results for the whole sample

	NYSE			Nasdaq			NYSE vs Nasdaq calm period t-stat.	NYSE vs Nasdaq stress period t-stat.
	calm mean	stress mean	calm vs. stress t-stat	calm mean	stress mean	Calm vs. stress t-stat		
Relative Spread (%)	0.601%	0.645%	-2.32 (0.02)	0.716%	0.632%	2.96 (0.00)	-3.505 (0.00)	0.420 (0.67)
Relative Effective Spread (%)	0.370%	0.403%	-1.90 (0.05)	0.620%	0.577%	1.70 (0.08)	-8.82 (0.01)	-7.66 (0.00)
Frequency of Quote Updates	81	102	-9.59 (0.00)	192	337	-12.15 (0.00)	-7.11 (0.00)	-8.89 (0.00)
Quote Duration (seconds)	227.16	97.31	3.93 (0.00)	214.52	99.65	4.12 (0.02)	0.281 (0.77)	-0.103 (0.91)
Intra-period Volatility	1.00333	1.00651	-15.48 (0.00)	1.00538	1.0094	-11.154 (0.00)	-7.37 (0.00)	-6.35 (0.00)
Number of Trades	51.03	71.01	-12.49 (0.00)	284.08	548.34	-8.47 (0.00)	-7.47 (0.00)	-7.87 (0.00)

PANEL B. Results for Terciles Based on Firm Size

	NYSE			Nasdaq			NYSE vs Nasdaq calm period t-stat.	NYSE vs Nasdaq stress period t-stat.
	calm mean	stress mean	calm vs. stress t-stat	calm mean	stress mean	calm vs. stress t-stat.		
Smallest Tercile								
Relative Spread (%)	0.619%	0.681%	-1.82 (0.07)	0.765%	0.638%	2.02 (0.04)	-2.02 (0.04)	0.72 (0.47)
Relative Effective Spread (%)	0.378%	0.411%	-1.136 (0.25)	0.606%	0.570%	0.749 (0.45)	-4.29 (0.00)	-3.88 (0.00)
Middle Tercile								
Relative Spread (%)	0.566%	0.619%	-1.61 (0.10)	0.679%	0.627%	1.18 (0.23)	-2.61 (0.01)	-0.17 (0.86)
Relative Effective Spread (%)	0.355%	0.401%	-1.67 (0.09)	0.636%	0.581%	-1.01 (0.31)	-5.77 (0.00)	-4.77 (0.00)
Largest Tercile								
Relative Spread (%)	0.617%	0.633%	-0.52 (0.6)	0.703%	0.631%	2.00 (0.04)	-1.68 (0.09)	0.04 (0.96)
Relative Effective Spread (%)	0.382%	0.397%	-0.50 (0.61)	0.618%	0.578%	-4.58 (0.00)	-5.22 (0.09)	-4.58 (0.00)

Table 4c
Comparison of calm and stress periods NYSE vs. Nasdaq. Jan 2, 2003

PANEL A: Results for the whole sample

	NYSE			Nasdaq			NYSE vs Nasdaq calm period t-stat.	NYSE vs Nasdaq stress period t-stat.
	calm mean	stress mean	calm vs. stress t-stat	calm mean	stress mean	calm vs. stress t-stat		
Relative Spread (%)	0.284%	0.389%	-12.19 (0.00)	0.461%	0.635%	-7.60 (0.00)	-6.55 (0.00)	-6.37 (0.00)
Relative Effective Spread (%)	0.192%	0.271%	-8.30 (0.00)	0.319%	0.427%	-6.33 (0.00)	-6.07 (0.00)	-5.84 (0.00)
Frequency of Quote Updates	183	236	-12.89 (0.00)	398	710	-15.21 (0.00)	-9.34 (0.00)	-12.42 (0.00)
Quote Duration (seconds)	48.61	28.15	2.18	68.31	31.82	2.85	-1.06	-0.66
Intra-period Volatility	1.00332	1.00544	-14.70 (0.00)	1.00413	1.00759	-17.98 (0.00)	-3.87	-9.01 (0.00)
Number of Trades	66.44	101.94	-12.86 (0.00)	162.41	446.07	-10.05 (0.00)	-7.84 (0.00)	-9.14 (0.00)

PANEL B. Results for Terciles Based on Firm Size

	NYSE			Nasdaq			NYSE vs Nasdaq calm period t-stat.	NYSE vs Nasdaq stress period t-stat.
	calm mean	stress mean	calm vs. stress t-stat	calm mean	stress mean	calm vs. stress t-stat.		
Smallest Tercile								
Relative Spread (%)	0.450%	0.600%	-7.29 (0.00)	0.840%	1.192%	-5.78 (0.00)	-5.73 (0.00)	-5.95 (0.00)
Relative Effective Spread (%)	0.289%	0.422%	-4.82 (0.00)	0.582%	0.760%	-3.61 (0.00)	-5.08 (0.00)	-4.62 (0.00)
Middle Tercile								
Relative Spread (%)	0.254%	0.361%	-9.53 (0.00)	0.376%	0.491%	-5.23 (0.00)	-3.56	-3.39
Relative Effective Spread (%)	0.188%	0.258%	-7.07 (0.00)	0.269%	0.379%	-5.33 (0.00)	-3.45	-3.71
Largest Tercile								
Relative Spread (%)	0.146%	0.208%	-5.95 (0.00)	0.167%	0.221%	-4.26 (0.00)	-1.26	-0.56
Relative Effective Spread (%)	0.109%	0.149%	-7.26 (0.00)	0.135%	0.179%	-7.00 (0.00)	-1.78	-1.58

Table 4d

Comparison of calm and stress periods NYSE vs. Nasdaq. May 1, 2003

PANEL A: Results for the whole sample

	NYSE			Nasdaq			NYSE vs Nasdaq calm period t-stat.	NYSE vs Nasdaq stress period t-stat.
	calm mean	stress mean	calm vs. stress t-stat	calm mean	stress mean	calm vs. stress t-stat		
Relative Spread (%)	0.298%	0.318%	-1.67 (0.09)	0.484%	0.541%	-2.80 (0.00)	-6.16 (0.00)	-7.52 (0.00)
Relative Effective Spread (%)	0.200%	0.220%	-2.05 (0.04)	0.316%	0.350%	-2.20 (0.02)	-5.81 (0.01)	-6.39 (0.01)
Frequency of Quote Updates	169	270	-14.18 (0.00)	241	598	-14.46 (0.00)	-5.251 (0.00)	-10.05 (0.00)
Quote Duration (seconds)	43.19	25.02	4.57 (0.00)	86.01	27.29	5.72 (0.02)	-3.67 (0.00)	-0.67 (0.49)
Intra-period Volatility	1.00256	1.00513	-15.25 (0.00)	1.00276	1.00639	-20.16 (0.00)	-1.17 (0.23)	-5.17 (0.03)
Number of Trades	59.44	119.17	-15.39 (0.03)	101.151	334.582	-11.82 (0.02)	-5.86 (0.01)	-9.16 (0.02)

PANEL B. Results for Terciles Based on Firm Size

	NYSE			Nasdaq			NYSE vs Nasdaq calm period t-stat.	NYSE vs Nasdaq stress period t-stat.
	calm mean	stress mean	calm vs. stress t-stat	calm mean	stress mean	calm vs. stress t-stat.		
Smallest Tercile								
Relative Spread (%)	0.528%	0.505%	-0.78 (0.43)	0.811%	0.856%	-5.10 (0.00)	-3.58 (0.00)	-5.10 (0.00)
Relative Effective Spread (%)	0.336%	0.356%	-0.720 (0.47)	0.507%	0.540%	-0.84 (0.39)	-3.24 (0.00)	-3.95 (0.02)
Middle Tercile								
Relative Spread (%)	0.250%	0.291%	-2.45 (0.01)	0.470%	0.565%	-2.84 (0.00)	-5.40 (0.00)	-5.72 (0.02)
Relative Effective Spread (%)	0.197%	0.217%	-1.58 (0.11)	0.342%	0.398%	-4.55 (0.00)	-4.55 (0.00)	-4.55 (0.00)
Largest Tercile								
Relative Spread (%)	0.118%	0.158%	-7.204 (0.02)	0.175%	0.205%	-2.259 (0.02)	-3.457 (0.00)	1.861 (0.06)
Relative Effective Spread (%)	0.088%	0.106%	-4.228 (0.00)	0.126%	0.141%	-2.856 (0.00)	-2.893 (0.00)	-2.84 (0.00)

Table 5a
Regression Analysis of Change in Spreads from calm to stress periods, Jan 3, 2001

Panel A: Univariate Regressions

	Log Ratio of Relative Spreads (stress to calm)	Log Ratio of Relative Spreads (stress to calm)	Log Ratio of Relative Spreads (stress to calm)	Log Ratio of Relative Spreads (stress to calm)
	All Firms	Smallest Tercile	Middle Tercile	Largest Tercile
Intercept	0.2042 10.44	0.1177 2.97	0.1828 6.43	0.3091 10.15
Nasdaq Dummy	-0.0957 -2.99	0.0847 1.31	0.0385 0.72	-0.3960 -9.63
Adjusted R-Squared N	1.09% 718	0.31% 230	-0.20% 242	27.09% 246

Panel B: Multivariate Regressions

	Log Ratio of Relative Spreads (stress to calm)	Log Ratio of Relative Spreads (stress to calm)	Log Ratio of Relative Spreads (stress to calm)	Log Ratio of Relative Spreads (stress to calm)
	All Firms	Smallest Tercile	Middle Tercile	Largest Tercile
Intercept	0.1088 0.33	0.2586 0.18	2.2440 1.64	-0.1889 -0.51
Nasdaq Dummy	-0.1254 -3.00	0.0942 1.15	-0.0374 -0.62	-0.4617 -7.74
Size	-0.0178 -0.96	-0.0493 -0.47	-0.1716 -1.87	-0.0062 -0.24
Price	0.0514 1.04	0.1028 1.06	0.0803 0.96	0.0406 0.62
Volatility	0.0363 0.38	-0.0903 -0.54	0.1821 1.14	0.0786 0.48
Turnover	-0.03923 -1.16	0.0401 0.87	-0.0904 -1.68	-0.1329 -1.97
Change in Intra-period Volatility	5.2349 2.25	16.1061 2.72	4.98 1.31	5.84 2.24
Change in Quote Frequency	0.1107 3.42	0.0624 1.28	0.1645 3.61	0.0664 1.06
Adjusted R-Squared N	6.69% 718	7.33% 230	11.69% 242	30.04% 246

Table 5b

Regression Analysis of Change in Spreads from calm to stress periods, Mar 22, 2001

Panel A: Univariate Regression

	Log Ratio of Relative Spreads (stress to calm)	Log Ratio of Relative Spreads (stress to calm)	Log Ratio of Relative Spreads (stress to calm)	Log Ratio of Relative Spreads (stress to calm)
	All Firms	Smallest Tercile	Middle Tercile	Largest Tercile
Intercept	0.11438 (9.12)	0.13586 (1.35)	0.15309 (2.84)	0.05545 (1.08)
Nasdaq Dummy	-0.21818 (-2.61)	-0.28768 (1.12)	-0.21919 (-3.33)	-0.14795 (-2.34)
Adjusted R-Squared N	4.18% 728	6.69% 242	3.91% 238	17.14% 248

Panel B: Multivariate Regression

	Log Ratio of Relative Spreads (stress to calm)	Log Ratio of Relative Spreads (stress to calm)	Log Ratio of Relative Spreads (stress to calm)	Log Ratio of Relative Spreads (stress to calm)
	All Firms	Smallest Tercile	Middle Tercile	Largest Tercile
Intercept	0.23113 (0.69)	0.6662 (1.99)	-0.000045 (1.99)	0.15222 (0.28)
Nasdaq Dummy	-0.2325 (-4.62)	-0.29377 (-5.84)	-0.255 (-5.84)	-0.10463 (-1.23)
Size	0.00488 (0.26)	0.00261 (0.14)	0.00205 (0.14)	-0.01626 (-0.58)
Price	-0.08166 (-1.42)	-0.13913 (-2.42)	-0.04267 (-2.42)	-0.11635 (-1.08)
Volatility	-0.0104 (-0.10)	0.03704 (0.37)	0.039 (0.37)	-0.22798 (-1.31)
Turnover	0.00905 (0.24)	0.02171 (0.59)	-0.05868 (0.59)	0.06465 (0.97)
Change in Intra-period Volatility	36.5537 (9.54)	33.5603 (8.76)	34.75127 (8.76)	40.69055 (5.76)
Change in Quote Frequency	-0.04565 (-1.22)	-0.03916 (-1.04)	-0.07018 (-1.04)	-0.02707 (-0.45)
Adjusted R-Squared N	15.91% 728	16.41% 242	13.41% 240	13.49% 248

Table 5c

Regression Analysis of Change in Spreads from calm to stress periods, Jan 2, 2003

Panel A: Univariate Regressions

	Log Ratio of Relative Spreads (stress to calm)	Log Ratio of Relative Spreads (stress to calm)	Log Ratio of Relative Spreads (stress to calm)	Log Ratio of Relative Spreads (stress to calm)
	All Firms	Smallest Tercile	Middle Tercile	Largest Tercile
Intercept	0.3708 (18.71)	0.3132 8.05	0.4044 10.86	0.3918 13.54
Nasdaq Dummy	-0.0770 (-2.61)	-0.0078 -0.13	-0.1059 -1.97	-0.2234 -2.96
Adjusted R-Squared N	0.77% 754	-0.41% 242	1.10% 254	2.91% 258

Panel B: Multivariate Regressions

	Log Ratio of Relative Spreads (stress to calm)	Log Ratio of Relative Spreads (stress to calm)	Log Ratio of Relative Spreads (stress to calm)	Log Ratio of Relative Spreads (stress to calm)
	All Firms	Smallest Tercile	Middle Tercile	Largest Tercile
Intercept	0.5528 (2.12)	0.6533 0.62	2.1952 1.65	0.1462 0.46
Nasdaq Dummy	-0.1784 (-4.83)	-0.1390 -1.86	-0.1962 -3.14	-0.1971 -3.08
Size	-0.0313 (-2.44)	-0.0150 -0.20	-0.1280 -1.38	-0.0569 -3.61
Price	-0.00723 (-0.17)	-.0746 0.79	-0.1047 -1.41	0.0758 1.50
Volatility	-0.0051 (-0.07)	0.1681 1.06	-0.0241 -0.20	-0.1107 -0.95
Turnover	-0.0236 (-0.81)	-0.0292 -0.55	-0.0034 -0.07	-0.0594 -1.24
Change in Intra-period Volatility	43.8177 7.62	40.1363 4.11	45.8590 4.99	49.2610 4.76
Change in Quote Frequency	0.1264 3.63	0.1149 3.02	0.1949 2.62	0.0328 0.30
Adjusted R-Squared N	18.37% 754	14.89% 242	22.94% 254	19.90% 258

Table 5d

Regression Analysis of Change in Spreads from calm to stress periods, May 1, 2003

Panel A: Univariate Regression

	Log Ratio of Relative Spreads (stress to calm)	Log Ratio of Relative Spreads (stress to calm)	Log Ratio of Relative Spreads (stress to calm)	Log Ratio of Relative Spreads (stress to calm)
	All Firms	Smallest Tercile	Middle Tercile	Largest Tercile
Intercept	0.24749 (9.12)	0.07323 (1.35)	0.25527 (5.47)	0.41404 (12.59)
Nasdaq Dummy	-0.09446 (-2.61)	0.08313 (1.12)	-0.06408 (-0.99)	-0.30119 (-7.25)
Adjusted R-Squared N	0.76% 752	0.01% 252	0.4% 248	16.85% 252

Panel B: Multivariate Regression

	Log Ratio of Relative Spreads (stress to calm)	Log Ratio of Relative Spreads (stress to calm)	Log Ratio of Relative Spreads (stress to calm)	Log Ratio of Relative Spreads (stress to calm)
	All Firms	Smallest Tercile	Middle Tercile	Largest Tercile
Intercept	-0.67363 (-2.27)	-0.9188 (-0.66)	0.17779 (0.12)	-0.74645 (-2.44)
Nasdaq Dummy	-0.15761 (-3.51)	0.03878 (0.46)	-0.18697 (-2.43)	-0.28914 (-4.21)
Size	-0.01671 (-1.01)	-0.00369 (-0.04)	-0.0624 (-0.60)	-0.01528 (-0.88)
Price	0.12098 (2.29)	0.14092 (1.27)	0.14774 (1.62)	0.13013 (1.88)
Volatility	-0.25532 (-2.92)	-0.0321 (-1.86)	-0.13155 (-0.89)	-0.29125 (-2.14)
Turnover	0.05888 (1.70)	0.10861 (1.14)	0.04206 (0.72)	0.04423 (0.69)
Change in Intra-period Volatility	43.06805 (6.05)	39.99231 (4.57)	46.42961 (3.20)	47.21914 (3.98)
Change in Quote Frequency	0.17653 (4.25)	0.21462 (3.55)	0.20948 (3.08)	0.01188 (0.20)
Adjusted R-Squared N	23.12% 752	16.85% 252	23.29% 248	30.07% 252

Table 6a

Regression analysis of change in effective spreads from calm to stress periods, Jan 3, 2001

Panel A: Univariate Regression

	Log Ratio of Effective spreads (stress to calm)	Log Ratio of Effective spreads (stress to calm)	Log Ratio of Effective spreads (stress to calm)	Log Ratio of Effective spreads (stress to calm)
	All Firms	Smallest Tercile	Middle Tercile	Largest Tercile
Intercept	0.2836 10.72	0.1400 2.32	0.2973 7.20	0.3386 11.24
Nasdaq Dummy	0.1833 4.29	0.1255 1.52	0.0720 1.15	0.3489 5.00
Adjusted R-Squared N	2.46 680	0.64 204	0.13 230	8.84 246

Panel B: Multivariate Regression

	Log Ratio of Effective spreads (stress to calm)	Log Ratio of Effective spreads (stress to calm)	Log Ratio of Effective spreads (stress to calm)	Log Ratio of Effective spreads (stress to calm)
	All Firms	Smallest Tercile	Middle Tercile	Largest Tercile
Intercept	-0.9361 -2.19	-0.0221 2.80	-1.5174 -1.06	-0.3246 -1.18
Nasdaq Dummy	0.1069 2.26	0.2697 2.92	-0.0111 -0.15	0.0506 0.59
Size	0.0772 3.00	-0.0906 -0.73	0.1590 1.50	0.1049 2.49
Price	0.0739 1.10	-0.0619 -0.50	0.0441 0.44	0.2319 2.22
Volatility	-0.0156 -0.13	-0.6576 -2.85	0.1847 1.10	0.4086 1.75
Turnover	0.0502 1.12	0.1718 2.01	-0.0044 -0.06	-0.0317 -0.36
Change in Intra-period Volatility	18.8642 5.54	36.6312 4.13	11.5464 2.29	16.9310 4.14
Change in Quote Frequency	0.0183 0.50	0.0109 0.17	0.0882 1.62	-0.1794 -2.00
Change in size	0.0186 0.71	0.0284 0.69	0.0611 1.57	-0.1015 -1.95
Adjusted R-Squared N	22.02 680	14.39 204	10.36 230	34.09 246

Table 6b
Regression analysis of change in effective spreads from calm to stress periods, Mar 22, 2001

Panel A: Univariate Regression

	Log Ratio of Effective spreads (stress to calm)	Log Ratio of Effective spreads (stress to calm)	Log Ratio of Effective spreads (stress to calm)	Log Ratio of Effective spreads (stress to calm)
	All Firms	Smallest Tercile	Middle Tercile	Largest Tercile
Intercept	0.22974 (2.53)	0.18154 (3.16)	0.18268 (3.28)	0.32 (1.27)
Nasdaq Dummy	-0.16538 (-1.27)	-0.23847 (-3.12)	-0.18119 (-2.67)	-0.081 (-0.22)
Adjusted R-Squared N	0.09% 698	3.68% 224	2.51% 234	-0.04% 240

Panel B: Multivariate Regression

	Log Ratio of Effective spreads (stress to calm)	Log Ratio of Effective spreads (stress to calm)	Log Ratio of Effective spreads (stress to calm)	Log Ratio of Effective spreads (stress to calm)
	All Firms	Smallest Tercile	Middle Tercile	Largest Tercile
Intercept	-2.23627 (-1.26)	1.16954 (0.84)	-2.12725 (-1.36)	-2.0168 (-0.69)
Nasdaq Dummy	-0.00826 (-0.02)	-0.13128 (-1.27)	-0.12978 (-1.35)	0.07259 (0.08)
Size	0.16361 (1.56)	-0.04176 (-0.43)	0.14258 (1.20)	0.12524 (1.01)
Price	-0.323 (-1.85)	-0.22602 (-1.82)	-0.18648 (-2.09)	-0.51172 (-1.00)
Volatility	-0.30164 (-0.71)	-0.13336 (-0.58)	-0.18525 (-1.26)	-0.10623 (-0.07)
Turnover	-0.00991 (-0.09)	0.0764 (1.14)	-0.04049 (-0.66)	-0.34957 (-0.78)
Change in Intra-period Volatility	44.3509 (8.65)	54.42749 (7.57)	33.0947 (4.38)	48.86286 (4.58)
Change in Quote Frequency	-0.06823 (-1.33)	-0.12135 (-1.74)	-0.01661 (-0.19)	-0.04235 (-0.37)
Change in size	0.21975 (2.00)	0.06814 (1.39)	0.03777 (0.62)	0.48444 (1.78)
Adjusted R-Squared N	2.40% 698	19.55% 224	14.50% 234	0.62% 240

Table 6c
Regression analysis of change in effective spreads from calm to stress periods, Jan 2, 2003

Panel A: Univariate Regression

	Log Ratio of Effective spreads (stress to calm)	Log Ratio of Effective spreads (stress to calm)	Log Ratio of Effective spreads (stress to calm)	Log Ratio of Effective spreads (stress to calm)
	All Firms	Smallest Tercile	Middle Tercile	Largest Tercile
Intercept	0.3629 15.04	0.3666 7.22	0.3500 8.28	0.3723 12.02
Nasdaq Dummy	-0.0305 -0.92	-0.0266 -0.36	-0.0065 -0.11	-0.0578 -1.87
Adjusted R-Squared N	-.02 754	-0.36 242	0.39 254	0.44 258

Panel B: Multivariate Regression

	Log Ratio of Effective spreads (stress to calm)	Log Ratio of Effective spreads (stress to calm)	Log Ratio of Effective spreads (stress to calm)	Log Ratio of Effective spreads (stress to calm)
	All Firms	Smallest Tercile	Middle Tercile	Largest Tercile
Intercept	0.3296 1.15	-0.1353 -0.10	3.0478 2.25	-0.4365 -1.37
Nasdaq Dummy	-0.1239 2.84	-0.1803 -1.95	-0.1579 -2.19	-0.0026 -0.05
Size	-0.0469 -3.07	-0.0153 -0.17	-0.1842 -1.91	-0.0634 -3.84
Price	0.04915 0.94	0.1698 1.25	-0.0243 -0.30	0.0954 1.85
Volatility	-0.0118 -0.12	0.1735 0.79	0.1387 1.12	-0.3290 -3.39
Turnover	-0.0629 -1.97	-0.1300 -2.13	-0.0345 -0.68	-0.0287 -0.65
Change in Intra-period Volatility	52.1368 7.35	55.1846 4.34	45.8563 4.48	62.3278 6.55
Change in Quote Frequency	0.1012 2.38	0.1267 2.22	0.1966 2.49	-0.1554 -2.06
Change in size	0.0620 1.84	0.0888 1.52	-0.0113 -0.19	0.0579 1.48
Adjusted R-Squared N	17.72 754	18.51 242	19.55 254	24.72 258

Table 6d
Regression analysis of change in effective spreads from calm to stress periods, May 1, 2003

Panel A: Univariate Regression

	Log Ratio of Effective spreads (stress to calm)	Log Ratio of Effective spreads (stress to calm)	Log Ratio of Effective spreads (stress to calm)	Log Ratio of Effective spreads (stress to calm)
	All Firms	Smallest Tercile	Middle Tercile	Largest Tercile
Intercept	0.24647 (8.25)	0.13559 (2.03)	0.25331 (5.04)	0.34363 (10.33)
Nasdaq Dummy	-0.17342 (-1.88)	-0.26258 (-0.93)	-0.0827 (-1.19)	-0.18712 (-4.66)
Adjusted R-Squared N	0.36% 730	-0.04% 230	0.17% 246	7.52% 254

Panel B: Multivariate Regression

	Log Ratio of Effective spreads (stress to calm)	Log Ratio of Effective spreads (stress to calm)	Log Ratio of Effective spreads (stress to calm)	Log Ratio of Effective spreads (stress to calm)
	All Firms	Smallest Tercile	Middle Tercile	Largest Tercile
Intercept	-1.0697 (-2.17)	2.25781 (0.54)	0.08417 (0.05)	-1.04469 (-3.76)
Nasdaq Dummy	-0.26983 (-1.89)	-0.47879 (-1.22)	-0.12866 (-1.50)	-0.10566 (-1.52)
Size	-0.05543 (-1.75)	-0.39943 (-0.94)	-0.07583 (-0.66)	0.0021 (0.12)
Price	0.37434 (1.82)	0.86149 (1.40)	0.24608 (2.31)	0.0893 (1.40)
Volatility	-0.18347 (-1.57)	0.11525 (0.36)	-0.19121 (-1.15)	-0.48097 (-3.93)
Turnover	-0.00662 (-0.13)	-0.11109 (-0.96)	0.08437 (1.42)	0.1569 (2.93)
Change in Intra-period Volatility	37.7503 (2.39)	20.22913 (0.57)	58.45535 (3.60)	49.63397 (4.68)
Change in Quote Frequency	0.22631 (1.91)	0.43671 (1.56)	0.09447 (1.28)	0.01369 (0.23)
Change in size	0.025 (0.90)	0.01544 (0.24)	0.02451 (0.45)	0.0264 (0.81)
Adjusted R-Squared N	4.40% 730	1.45% 230	1.72% 246	26.37% 254

Table 7a

Comparison of ECN and Non-ECN quotes for NASDAQ stocks

We compute the ratio of relative spreads quoted on ECNs to relative spreads quoted by other market participants in calm and stress periods. This is done by taking the average quoted relative spread across all ECNs and dividing by the average quoted relative spread across all other market-makers for each stock. This is done separately for the calm and stress periods and the table below reports this comparison for the whole sample as well as for terciles based on firm size for both days in our sample (refer to Table 1 for details on the days and times used).

Results for January 3, 2001

N = 325	Ratio of Relative Spreads (ECN to Non-ECN)		Calm vs. stress t-stat
	calm	Stress	
All Firms	0.631	0.655	-1.47 (0.14)
Smallest Tercile	0.665	0.699	-0.99 (0.32)
Middle Tercile	0.606	0.665	-.218 (0.03)
Largest Tercile	0.623	0.601	1.23 (0.22)

Results for March 22, 2001

N = 307	Ratio of Relative Spreads (ECN to Non-ECN)		Calm vs. stress t-stat
	calm	Stress	
All Firms	0.775	0.627	7.02 (0.00)
Smallest Tercile	0.785	0.620	4.10 (0.00)
Middle Tercile	0.773	0.632	4.59 (0.00)
Largest Tercile	0.769	0.629	3.60 (0.00)

Table 7b

Comparison of ECN and Non-ECN quotes for NASDAQ stocks

We compute the ratio of relative spreads quoted on ECNs to relative spreads quoted by other market participants in calm and stress periods. This is done by taking the average quoted relative spread across all ECNs and dividing by the average quoted relative spread across all other market-makers for each stock. This is done separately for the calm and stress periods and the table below reports this comparison for the whole sample as well as for terciles based on firm size for both days in our sample (refer to Table 1 for details on the days and times used).

Results for January 2, 2003

N = 360	Ratio of Relative Spreads (ECN to Non-ECN)		Calm vs. stress t-stat
	calm	Stress	
All Firms	0.545	0.586	-2.24 (0.03)
Smallest Tercile	0.598	0.687	-2.25 (0.03)
Middle Tercile	0.586	0.619	-0.95 (0.34)
Largest Tercile	0.449	0.451	-0.09 (0.92)

Results for May 1, 2003

N = 351	Ratio of Relative Spreads (ECN to Non-ECN)		Calm vs. stress t-stat
	calm	Stress	
All Firms	0.774	0.660	3.64 (0.00)
Smallest Tercile	0.794	0.706	1.51 (0.13)
Middle Tercile	0.799	0.736	1.14 (0.26)
Largest Tercile	0.729	0.535	3.96 (0.00)

Table 8

Comparison of market depth parameter (λ) for NYSE and NASDAQ stocks in year 2003 and 2001

This table presents the mean values of the market depth parameter, λ, for NYSE and Nasdaq stocks during calm and stress periods on the four days in 2001 and 2003.

	Mean (λ) on NYSE (N=65)			Mean (λ) on Nasdaq (N=65)		
	Calm (10^{-6})	Stress (10^{-6})	Diff. of Means (t-stat)	Calm (10^{-6})	Stress (10^{-6})	Diff. of Means (t-stat)
Jan. 2, 2003	3.1471	2.6750	0.70	2.9148	4.7970	-3.33
May 1, 2003	2.9080	3.1636	-0.33	2.5232	3.5241	-1.58
Jan 3, 2001	8.8207	7.7210	0.64	12.7481	15.3964	-1.65
Mar 22, 2001	8.0937	6.3413	0.75	6.5346	8.3114	-1.77

Table 9

Regression analysis of market depth parameter (λ) for NYSE and NASDAQ stocks in years 2003 and 2001

This table reports OLS regression results from a model in which the log ratio of the market depth parameter, λ, during stress versus calm periods is regressed on a number of independent variables, including a dummy variable that takes the value of 1 for Nasdaq stocks and zero for NYSE stocks. The t-statistics corresponding to the estimated coefficients are shown beneath the coefficient estimates.

	Jan 2, 2003	May 1, 2003	Jan 3, 2001	Mar 22, 2001
Intercept	-3.9681	-3.1380	-1.1898	2.7025
	-2.42	-1.68	-0.65	1.25
Nasdaq Dummy	0.3982	-0.0732	-0.4757	-0.4993
	1.44	-0.21	-1.54	-1.63
Firm Size	0.2605	0.0978	0.1891	0.0448
	2.77	0.91	1.70	0.35
Turnover	0.7198	0.3770	-0.0095	0.1703
	2.64	1.19	-0.03	0.89
Price	-0.1899	0.4878	0.5005	-0.7189
	-0.63	-1.41	1.49	-2.56
Volatility	-1.1866	-1.6300	0.9006	-0.1096
	-2.02	-2.48	1.28	-0.22
Change in trade size	-1.5083	-1.5558	-1.1708	-1.4532
	-7.49	-7.46	-5.41	-6.93
Change in quote frequency	0.1171	-0.2082	0.458	-0.1802
	0.30	-0.90	1.48	-0.54
Change in intra-priod volatility	38.9144	198.8260	1.2196	61.0833
	0.85	3.53	0.1	2.85
Adjusted R-square	33.76	32.37	17.43	33.42
	130	130	130	130