The Declining Trend in Idiosyncratic Volatility: Post Decimalization Evidence

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Abstract

Extant research has documented the major effects of decimalization on market microstructure variables of U.S. markets such as lower spreads, and lower quoted depths. We concentrate our research attention on idiosyncratic volatility given the recent surge in research regarding idiosyncratic volatility. We provide empirical evidence of lower idiosyncratic volatility post-decimalization on both NYSE and Nasdaq using a procedure of matched samples. Furthermore, we find that the observed reduction in idiosyncratic volatility is related to the dramatic post-decimalization decline in bid-ask spreads documented in earlier research. Other notable findings include our discovery that Nasdaq firms show a greater decline in idiosyncratic volatility ceteris paribus. Also, the impact on idiosyncratic volatility on a given change in spread is higher on the NYSE as compared to Nasdaq. High volume and low price stocks benefit more from the decimalization as compared to other firms. These findings are particularly significant given new evidence of a dramatic drop in idiosyncratic volatility during the first few years of the twenty-first century as documented by Brandt, Brav, and Graham (2005). Our findings are likely to be useful to researchers especially those involved in event studies and option pricing.

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1.0 **Introduction**

In 2001, major U.S. markets such as the NYSE and Nasdaq switched to a decimal system of prices the stocks. This landmark change triggered a number of studies such as Chakravarty, Wood, and Van Ness (2004), and Bacidore, Battalio, and Jennings (2003). These studies find that both quoted and effective spreads decrease significantly along with a corresponding reduction in bid and ask depths. Chakravarty, Van Ness and Van Ness (2005) find that NYSE stocks experience a significant reduction in dollar adverse selection costs although adverse selection costs as a percentage of spread increases substantially.

We explore the linkage between decimalization and changes in volatility in this paper. In particular, we focus on changes in idiosyncratic volatility of stocks traded on NYSE and Nasdaq. Our motivation for examining idiosyncratic volatility is influenced by four major considerations. First, we feel that volatility changes after decimalization is not adequately researched. Second, microstructure theory as expounded by the work of Amihud and Mendelson (1987) posits that observed firm-specific volatility can be decomposed into true volatility and noise volatility. One of the proxies for noise volatility is the bid-ask spread. Since earlier research has unequivocally demonstrated that spreads reduce after decimalization, we expect to see a reduction in observed firm-specific volatility. Third, recent work by Goyal and Santa-Clara (2003) find that idiosyncratic risk is useful in predicting stock market return. Thus in contrast to the traditional view point of CAPM, idiosyncratic risk is now considered as a priced risk factor. Our fourth consideration for studying idiosyncratic volatility is elucidated by

Karolyi (2001). According to him, investors typically perceive idiosyncratic volatility as a measure of excess volatility. The existence of excessive volatility or noise undermines the usefulness of stock price as a signal of the intrinsic value of the firm. Thus a reduction in idiosyncratic volatility can ostensibly improve the efficient functioning of the market.

We enumerate our contribution to the literature as follows. First, extant research has not comprehensively documented the impact of decimalization on stock return volatility. We remedy this major lacuna in this study. Second, we provide empirical evidence of lower idiosyncratic volatility post-decimalization on both NYSE and Nasdaq using a procedure of matched samples. Third, we find that the observed reduction in idiosyncratic volatility is related to the dramatic post-decimalization decline in bid-ask spreads documented in earlier research. Fourth, we find that Nasdaq firms show a greater decline in idiosyncratic volatility ceteris paribus. Fifth, high volume and low price benefit more from the decimalization as compared to other firms.

These findings are particularly significant given new evidence of a dramatic drop in idiosyncratic volatility during the first few years of the twenty-first century as documented by Brandt, Brav, and Graham (2005). We are able to explain their "puzzle" by explicitly studying the impact of decimalization.

We organize the rest of the paper as follows. Section 2 outlines the theoretical and empirical effects of decimalization on stock return volatility. In section 3, we describe the matching procedure used for constructing samples to compare the relative impacts of decimalization on the NYSE and Nasdaq. Section 4 contains our multivariate regression results. The final section concludes.

2.0 Decimalization and Change in Volatility

Stock return volatility is a function of the stochastic nature of stock returns. A seminal paper by Amihud and Mendelson (1987) posits that the stochastic behavior of stock returns is affected by the following three major factors: a) the arrival of new information, b) the noise in the trading process and c) institutional rules of conduct such as the price stabilization efforts of NYSE specialists.

Decimalization is expected to impact stock return volatility through its impact on noise. According to Amihud and Mendelson (1987) the bid-ask spread is a major source of the noise that gets reflected in stock return volatility. They derive the following equation that makes the role of spread explicit:

$$\mathrm{Var}(R_t) = [g/(2-g)]\, v^2 + [2/(2-g)]\, s^2 \qquad \ldots (1),$$

where, Var (R_t) is the observed return variance, v^2 is the unobserved "true" variance, g an adjustment coefficient, and s is the bid-ask spread. Decimalization should result in a lower bid-ask spread and this decline should reduce the noise component whereby total observed variance is reduced.

However, it should be noted that a smaller tick size does not automatically guarantee higher market quality. Harris (1994, 1999) has argued that a smaller tick size can hamper incentives to provide liquidity, with potentially detrimental effects on market quality. Hence it is possible that stock return volatility would be adversely affected by the deterioration in liquidity caused by a reduction in tick size.

Institutional factors are another dimension which is worthwhile of further examination. Recent studies such as Huang and Stoll (1996), Bessembinder (1999),

Stoll (2000), and Weston (2000) have compared trading costs across NYSE's specialist market and Nasdaq's dealer market structure. The overwhelming evidence of these studies is that the Nasdaq market is characterized by higher trading costs as compared to NYSE, although the cross-market differential has steadily narrowed over time. Our study provides further insights and empirical evidence to bear on this crucial issue.

We examine the change in total volatility of U.S. stocks before and after decimalization and portray the results in Table 1. The pre-decimalization window is (-90, -60) while the post-decimalization window is (+60, +90). Our choice of windows to examine the impact of decimalization is designed to eliminate transitory effects of the event. Our results show that median standard deviation of returns reduced substantially for the stocks belonging to the Dow Jones Index of 30 industrial stocks. The drop is statistically significant at conventional levels. Similar results are found for the stocks belonging to the S&P 500 index and Nasdaq 100 index.

Additionally, we examine the changing pattern in total volatility for two matched samples - one listed on the NYSE and the other listed on the Nasdaq. Both samples show significant declines in total volatility which is statistically significant. Interestingly, the median decline in volatility of Nasdaq stocks is higher at 42.7% versus a 22.8% drop of the NYSE match. These results are robust to alternate specification of pre- and post-decimalization windows.

In table 2, we show results regarding the change in idiosyncratic volatility before and after decimalization for the same groups of stocks as in table 1. Idiosyncratic volatility is measured by the standard deviation of the residuals estimated from the Fama and French 3-factor model. We use the same window as before for denoting pre- and post-

decimalization. Our results show that median idiosyncratic volatility of returns declined substantially for all groups of stocks. As before, the drop is statistically significant at conventional levels. Furthermore, both the NYSE and Nasdaq matched samples show statistically significant declines in idiosyncratic volatility. Once again, the median decline in volatility of Nasdaq stocks is higher at 35.5% versus a 23.7% drop of the NYSE match. These results are unaltered when we use alternate specification of pre- and post-decimalization windows. Figure 2 portrays these dramatic results graphically.

3.0 Matching Procedure and Descriptive Statistics

Since a salient component of our study relies on making reliable comparisons of the impact of decimalization on volatility on the NYSE as compared to Nasdaq, we form comparable matched samples. We describe the matching procedure below and provide descriptive statistics of the two samples both before and after decimalization.

We first eliminate all stocks belonging to NYSE whose market capitalization exceeded those of the Nasdaq firm with the largest market capitalization. We also remove small Nasdaq firms whose market capitalization fell below the lowest value of a listed NYSE firm. Market capitalization is computed as of January 26, 2001 – one trading day before the onset of decimal pricing on the NYSE. For each NYSE firm we choose the Nasdaq firm which is closest in terms of market capitalization using ±10% as the maximum tolerance for deviation. We eliminated all firms for which we could not a match. The resulting sample is composed of 618 and 704 firms each from the NYSE and Nasdaq respectively.

A natural question arising from our matching procedure is whether the key results of the study would hold if we used criteria other than market capitalization. We take shelter

in the findings of Chung, Van Ness and Van Ness (2000) and LaPlante and Muscarella (1997) who use different matching criteria and find that results are not sensitive to the use of alternate matching techniques.

We provide descriptive statistics of the NYSE and Nasdaq matching firms in table 3 below. Panel A contains the statistics as of the pre-decimalization period. Panel B contains the post-decimalization values of the variables. In panel C, we compare the differences (post-pre) for all the relevant variables and provide the t-statistics and Wilcoxon signed Z-ranks. The means and medians are computed based on the 30-day period during the (-90, -60) and (+60, +90) windows in pre- and post-decimalization, respectively. The dates of decimalization for NYSE and NASDAQ were January 29, 2001 and April 9, 2001, respectively.

We use the daily closing price of the stock for computing the mean and median prices. Market Value is defined as price multiplied by the number of shares outstanding. Trading Volume is the total traded volume. Shares Outstanding is the total number of shares outstanding. Dollar Spread is found as ask price minus the bid price. Percentage Spread is computed as absolute spread divided by the average of bid and ask prices. Depth is the total of bid and ask depths. The absolute spread, percentage spread, and depth are computed based on -75 and +75 day in pre- and post-decimalization, respectively.

We show the efficacy of our matching procedure in panel A which contains the pre-decimalization values. Our procedure has produced samples that match adequately with respect to Price, market value, shares outstanding, and dollar spread. We find that the mean price level of NYSE sample was $23.51 as compared to $20.32 of Nasdaq firms. The mean market value of the NYSE match was $1,252 million versus $1,068 million of

Nasdaq firms. Shares outstanding were also roughly similar – 50.37 million on NYSE versus 45.50 million on Nasdaq. Mean dollar spread was $0.1710 on NYSE versus $0.1974 on Nasdaq. However, the matching procedure did not work well with respect to trading volume and depth.

We find three noteworthy results when we compare values during the post-decimalization period with the pre-decimalization period (see Panels B and C). The mean dollar spread declined steeply from $0.1710 to $0.0917 on the NYSE, the decline being statistically significant. Similarly, on the Nasdaq dollar spreads declined from $0.1974 to $0.1291. Percentage spreads and depth also dropped significantly on both markets, the decline in depth of NYSE stocks being particularly dramatic.

4.0 Determinants of Change in Idiosyncratic Volatility

Table 1 shows preliminary evidence regarding the reduction in total volatility during the post-decimalization period of our NYSE and Nasdaq matched samples. It is customary to decompose total volatility into two components – systematic and unsystematic. Thus our evidence regarding total volatility reduction could either be due to a reduction in systematic risk or unsystematic risk. Since our focus in this paper is on unsystematic risk, also known as idiosyncratic risk, we extract this component and use it in our empirical tests. We extract residuals using the Fama and French 3-factor model and compute its variance. We denote this as the idiosyncratic risk.[1]

Table 2 and Figure 2 show compelling evidence regarding the reduction in idiosyncratic risk on both NYSE and Nasdaq during the post-decimalization period. We notice that even after decimalization idiosyncratic risk is higher for the Nasdaq match.

[1] Our results are unaltered by alternate measures of idiosyncratic risk using models such as the CAPM. We do not report those results in order to conserve space.

As discussed in section 2, it is possible that the reduction in idiosyncratic risk is due to the reduction in spreads. Graphical evidence on the decline in spreads in the post-decimalization period is presented in Figure 3.

In order to explore the effects of spread directly we invoke a special case of Amihud and Mendelson (1987) model as outlined in Conroy, Benet and Harris (1990). We use the model as described in their equation 2 given below:

$$\Delta OV = \Delta TV + \tfrac{1}{2}\Delta S^2, \qquad \ldots(2)$$

Where OV = observed variance of return,

TV = "true" variance of return,

S = the percentage bid-ask spread.

We compute the square of the spread post-decimalization and subtract pre-decimalization spread to obtain ΔS^2. Similarly, ΔOV is the post-decimalization observed variance minus the pre-decimalization observed variance.

In an analogous manner, we use the model given below for our tests of idiosyncratic risk:

$$\Delta IV = \Delta TV + \tfrac{1}{2}\Delta S^2, \qquad \ldots(3)$$

Where IV = Estimated idiosyncratic variance computed using the Fama-French 3-factor model,

TV = "true" idiosyncratic variance of return,

S = the percentage bid-ask spread.

Furthermore, institutional factors also seem to play a role since we always find that Nasdaq stocks tend to have higher idiosyncratic (and total) volatility as compared to NYSE stocks. A further factor to consider is the changes in other liquidity measures

(besides spread) in the post-decimalization period. Figure 4 shows that trading volume increased significantly in the post-decimalization period for the NYSE stocks but reduced substantially over the Nasdaq. Thus it is useful to assess the relative impacts of spread changes, liquidity effects and institutional factors on idiosyncratic volatility. We conduct multivariate regression tests using idiosyncratic volatility changes and total volatility changes as dependent variables and report the results in tables 4 and 5 respectively.

Our idiosyncratic volatility regressions show that ΔS^2 has a positive and significant coefficient. This finding confirms that firms experiencing the most reduction in S^2 suffer the most reduction in volatility. We introduce the exchange dummy (NYSE=1) to control for institutional factors. The exchange dummy is positive and significant indicating that NYSE stocks have higher idiosyncratic volatility other things being equal. The cross-term, Exchange x ΔS^2 is negative and statistically significant signifying that NYSE stocks that suffer the most declines in spreads in the post-decimalization period also experience the greatest decrease in idiosyncratic volatility.

We also include control variables such as Price, Trading Volume, and Market Value to control for predictable variations in idiosyncratic volatility. The coefficient on Price is positive and significant denoting that low price stocks benefit more from decimalization than comparable high price stocks ceteris paribus. The negative coefficient on Trading Volume indicates that high volume stocks experience steeper declines in idiosyncratic volatility as compared to low volume stocks. Market capitalization has no significant impact on changes in idiosyncratic volatility.

For comparison purposes, we conduct regressions using changes in total volatility and portray the results in table 5. Our results are similar to those shown in table 4. Taken together, the results of tables 4 and 5 show that the observed reduction in total volatility in the post-decimalization period is mostly due to the lower idiosyncratic risk which are driven by lower bid-ask spreads.

5.0 Conclusion

Extant research has documented the major effects of decimalization on market microstructure variables of U.S. markets. In particular, researchers have documented lower spreads, but lower quoted depths. The impact of decimalization on stock return volatility has not been comprehensively studied until now. We remedy this major lacuna in this study.

We concentrate our research attention on idiosyncratic volatility given the recent surge in research regarding idiosyncratic volatility. We provide empirical evidence of lower idiosyncratic volatility post-decimalization on both NYSE and Nasdaq using a procedure of matched samples. Furthermore, we find that the observed reduction in idiosyncratic volatility is related to the dramatic post-decimalization decline in bid-ask spreads documented in earlier research. Other notable findings include our discovery that Nasdaq firms show a greater decline in idiosyncratic volatility ceteris paribus. High volume and low price benefit more from the decimalization as compared to other firms.

These findings are of significance to financial economists. Given the recent empirical finding that idiosyncratic volatility is a priced risk factor implies that required returns should be lower in the post-decimalization period as compared to the prior period. Our findings are particularly noteworthy given new evidence of a dramatic drop in

idiosyncratic volatility during the first few years of the twenty-first century as documented by Brandt, Brav, and Graham (2005). Furthermore, event study results which use residual variance to detect statistical significance are likely to encounter less noise. Another possible area where our findings will find application is option pricing. Future research on these aspects is likely to be beneficial.

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Figure 1: Total and Idiosyncratic Volatility During Pre- and Post-Decimalization

The figure below presents the median total and idiosyncratic volatility of NYSE and NASDAQ during pre- and post-decimalization periods. Total volatility is the variance of the daily returns. Idiosyncratic volatility is the variance of the residuals from the Fama and French 3-factor model. The estimation windows for pre- and post-decimalization are (-90,-60) and (+60,+90) days respectively.

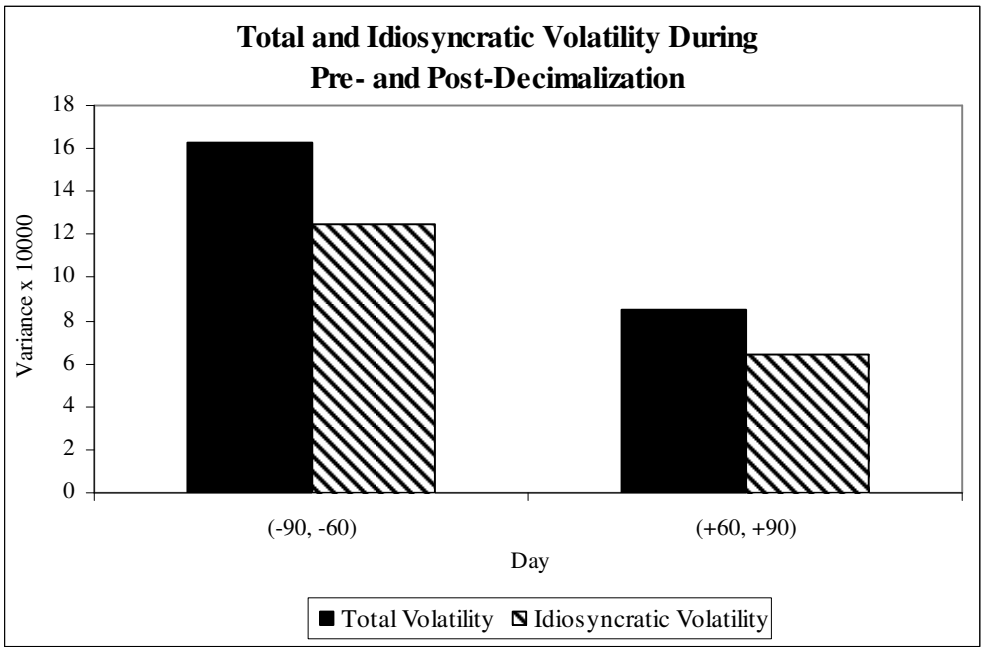

Figure 2

Idiosyncratic Volatility Pre- and Post-Decimalization on NYSE and Nasdaq

The figure below presents the median idiosyncratic volatility of NYSE and NASDAQ matches samples during pre- and post-decimalization periods. Idiosyncratic volatility is the variance of the residuals from the Fama and French 3-factor model. The estimation windows for pre- and post-decimalization are (-90,-60) and (+60,+90) days respectively.

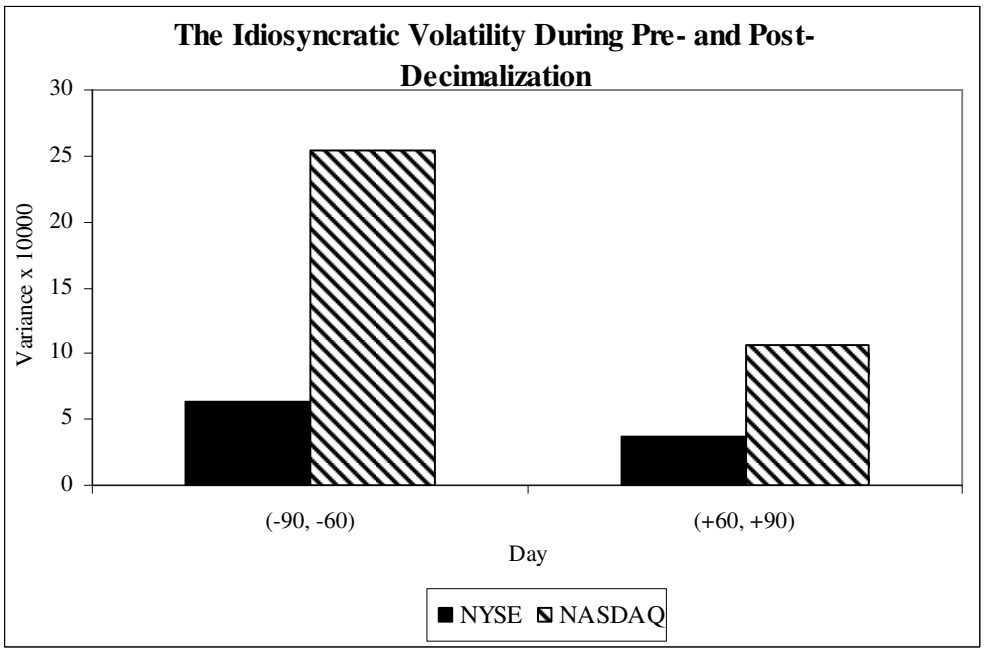

Figure 3: Percentage Spread During Pre- and Post-Decimalization

This figure presents the median percentage spreads of NYSE and NASDAQ matched samples during pre- and post-decimalization. Percentage spreads are computed based on the days -75 and +75 for the pre- and post-decimalization periods respectively.

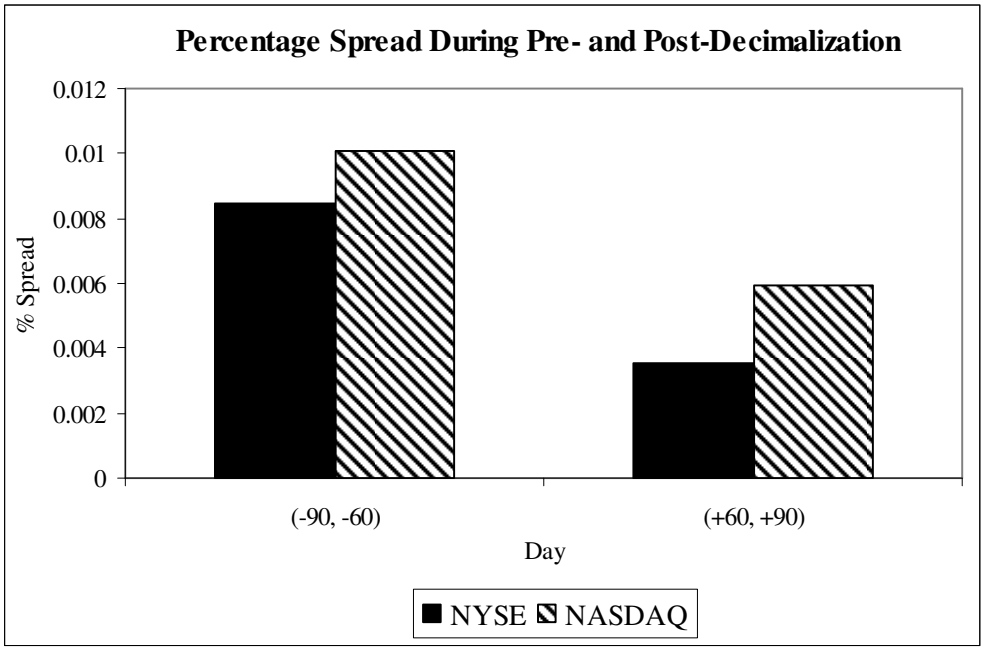

Figure 4: Trading Volume During Pre- and Post-Decimalization

The figure presents the median trading volumes of NYSE and NASDAQ matched samples during pre- and post-decimalization. Median trading volumes are computed based on the (-90,-60) and (+60, +90) windows for pre- and post-decimalization respectively.

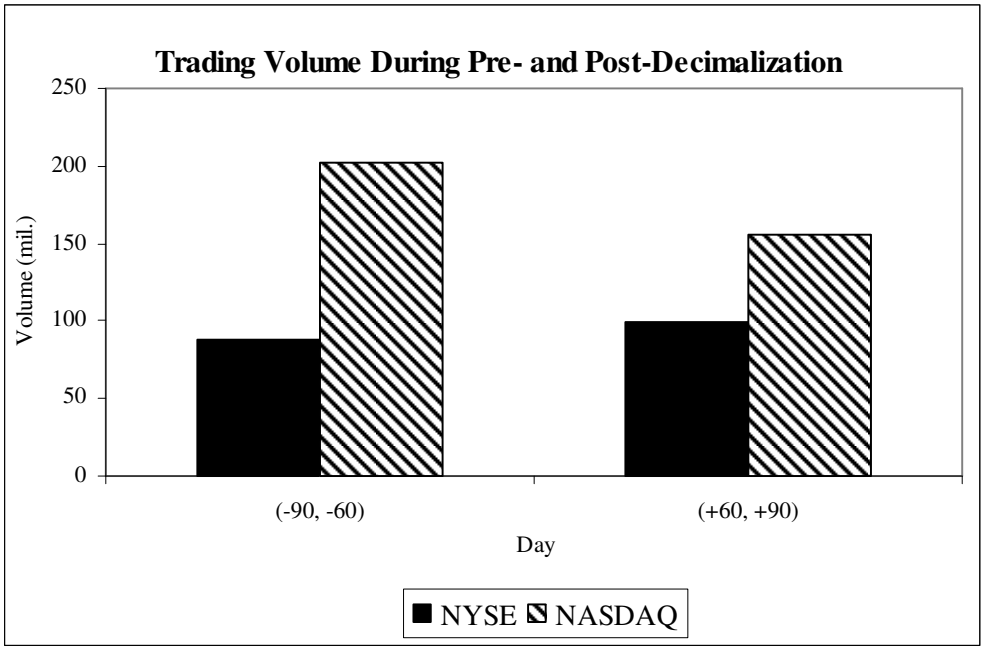

Table 1 Median Standard Deviation of Returns

This table presents the total volatility during pre- and post-decimalization periods. Total volatility is measured as the median standard deviation of raw returns. The pre- and post-decimalization windows are based on the following 30-day periods respectively: (-60, -90) and (+60, +90). z-statistics based on Wilcoxon signed rank test are provided in the last column.

	Pre-decimalization	Post-decimalizatioin	Difference (Post-Pre)	z-Statistics
Dow Jones 30	0.02832	0.01739	-0.01093	-5.23
S&P 500	0.02929	0.01827	-0.01101	-15.28
Nasdaq 100	0.07886	0.04208	-0.03678	-8.36
NYSE Match	0.02867	0.02213	-0.00654	-9.03
Nasdaq Match	0.06423	0.03681	-0.02742	-15.66

Table 2 Median Standard Deviation of Fama-French 3-Factor Model Residuals

This table presents Idiosyncratic Volatility (IV) during pre- and post-decimalization periods. Idiosyncratic Volatility is defined as the standard deviation of the residuals from Fama & French 3-factor model.The pre- and post-decimalization windows are based on the following 30-day periods respectively: (-60, -90) and (+60, +90). z-statistics based on Wilcoxon signed rank test are provided in the last column.

	Pre-decimalization	Post-decimalizatioin	Difference (Post-Pre)	z-Statistics
Dow Jones 30	0.02464	0.01407	-0.01057	-5.86
S&P 500	0.02520	0.01525	-0.00995	-16.20
Nasdaq 100	0.04866	0.02845	-0.02021	-6.95
NYSE Match	0.02535	0.01934	-0.00601	-9.20
Nasdaq Match	0.05044	0.03255	-0.01789	-13.90

Table 3 Descriptive Statistics

This table presents the mean and median values for the NYSE-match and NASDAQ-match firms. Means and medians of all variables except spread and depth are computed based on the 30-day period during the (-90, -60) and (+60, +90) windows in pre- and post-decimalization, respectively. The dates of decimalization for NYSE and NASDAQ were January 29, 2001 and April 9, 2001, respectively. Price is the closing price of the stock. Market Value is defined as price times shares outstanding. Trading Volume is the total traded volume. Shares Outstanding is the total number of shares outstanding. Absolute Spread is the ask price minus bid price. Percentage Spread is computed by dividing the absolute spread by the average of bid and ask prices. Depth is the sum of bid and ask depths. Absolute spread, percentage spread, and depth are computed based on -75 and +75 day in pre- and post-decimalization, respectively. t-statistics and Wilcoxon signed ranks z-statistics are in the parentheses. *, **, *** denote the 10%, 5%, and 1% significant level, respectively.

Panel A Pre-decimalization (-90, -60)

	NYSE match		NASDAQ match	
	mean	median	mean	median
Price	23.51	18.02	20.32	15.34
Market Value (mil)	1,251.61	486.01	1,068.41	361.03
Trading Volume (mil)	191.79	67.08	633.30	148.64
Shares Outstanding (mil)	50.37	29.01	45.50	25.45
Absolute Spread	0.1710	0.1250	0.1974	0.1250
Percentage Spread	0.0116	0.0084	0.0144	0.0101
Depth (round lots)	55.38	32.00	11.68	11.00

Panel B Post-decimalization (+60, +90)

	NYSE match		NASDAQ match	
	mean	median	mean	median
Price	26.15	19.95	18.21	15.34
Market Value (mil)	1,436.47	562.65	833.59	353.45
Trading Volume (mil)	220.52	78.48	465.18	110.87
Shares Outstanding (mil)	53.63	28.45	48.99	26.85
Absolute Spread	0.0917	0.0800	0.1291	0.0800
Percentage Spread	0.0056	0.0035	0.0107	0.0059
Depth (round lots)	17.20	12.00	9.29	7.00

Panel C: Difference (Post-Pre)

	NYSE match		NASDAQ match	
	mean	median	mean	median
Price	2.63	1.94	-2.11	-0.01
	(1.08)	(3.00)***	(-2.58)***	(-2.19)**
Market Value (mil)	184.86	76.64	-234.82	-7.58
	(1.29)	(2.01)**	(-2.20)**	(-0.99)
Trading Volume (mil)	28.73	11.40	-168.12	-37.77
	(1.16)	(1.81)*	(-2.10)**	(-3.40)***
Shares Outstanding (mil)	3.27	-0.56	3.49	1.40
	(0.76)	(0.24)	(0.88)	(1.37)
Absolute Spread	-0.0793	-0.0450	-0.0683	-0.0450
	(-18.15)***	(-19.07)***	(-7.27)***	(-14.21)***
Percentage Spread	-0.0060	-0.0049	-0.0037	-0.0041
	(-12.55)***	(-15.82)***	(-4.62)***	(-8.63)***
Depth (round lots)	-38.18	-20.00	-2.39	-4.00
	(-9.61)***	(-18.30)***	(-3.45)***	(-9.64)***

Table 4 Idiosyncratic Volatility Regressions

The sample consists of NYSE match and NASDAQ match firms. Idiosyncratic Volatility (IV) is defined as the variance of the residuals from Fama & French 3-factor model. Dependent variable ΔIV is defined as IV in post-decimalization minus IV in pre-decimalization. S is the percentage spread changes in pre- and post-decimalization. Trading Volume is the logarithm of the total number of shares traded on the day prior to the decimalization. Price is the logarithm of the closing price prior to the decimalization. Market Value is defined as the logarithm of the closing price times the shares outstanding prior to the decimalization. Exchange is a dummy variable which takes the value of one if NYSE, otherwise zero. t-value is in the parentheses. *, **, *** denote 10%, 5%, and 1% significance levels.

	Model 1	Model 2	Model 3
Intercept	-0.00128***	-0.00212***	-0.00359***
	(-15.66)	(-20.07)	(-9.36)
ΔS^2	0.29069***	0.32305***	0.35832***
	(3.59)	(4.05)	(4.71)
Exchange		0.00179***	0.00115***
		(11.17)	(6.84)
Exchange×ΔS2		-0.14276	-0.63550**
		(-0.47)	(-2.14)
Price			0.00106***
			(7.57)
Volume			-0.00017***
			(-3.01)
Market Value			-0.00006
			(-0.53)
R^2	0.010	0.109	0.191
F-statistic	12.87***	50.85***	49.01***
N	1222	1222	1222

Table 5 Total Volatility Regressions

The sample consists of NYSE match and NASDAQ match firms. Observed variance (OV) is the variance of returns computed based on 30-day and 250-day pre- and post-decimalization. Dependent variable ΔOV is defined as OV in post-decimalization minus OV in pre-decimalization. S is the percentage spread changes in pre- and post-decimalization. Trading Volume is the logarithm of the total number of shares traded on the day prior to the decimalization. Price is the logarithm of the closing price prior to the decimalization. Market Value is defined as the logarithm of the closing price times the shares outstanding prior to the decimalization. Exchange is a dummy variable which takes the value of one if NYSE, otherwise zero. t-value is in the parentheses. *, **, *** denote 10%, 5%, and 1% significance levels.

	Model 1	Model 2	Model 3
Intercept	-0.00229***	-0.00394***	-0.00538***
	(-19.10)	(-26.62)	(-10.64)
ΔS^2	0.26856**	0.32376***	0.41237***
	(2.26)	(2.90)	(4.11)
Exchange		0.00352***	0.00237***
		(15.69)	(10.71)
Exchange×ΔS^2		-0.16062	-0.80666**
		(-0.38)	(-2.06)
Price			0.00182***
			(9.87)
Volume			-0.00053***
			(-7.26)
Market Value			-0.00010
			(-0.68)
R^2	0.003	0.183	0.343
F-statistic	5.10**	92.11***	107.36***
N	1222	1222	1222