

Are “Teenies” Better?

Low-priced shares are the greatest beneficiary.

Nicolas P.B. Bollen and Robert E. Whaley

On June 5, 1997, the New York Stock Exchange voted to adopt a system of decimal price trading, changing its longstanding practice of using eighths. While the decimal system does not go into place until the turn of the century, the NYSE began trading stocks in sixteenths, so-called teenies, as an intermediate step on June 24, 1997. The move to reduce the tick size was prompted by competition from Nasdaq, the American Stock Exchange, and the regional exchanges, and by a threat of congressional action to force the issue.

The NYSE's move to a smaller tick size offers a rare opportunity to evaluate empirically competing arguments regarding an “optimal tick size.” The arguments in favor of a larger, “significant,” tick are threefold.

First, significant ticks may encourage market liquidity. The larger the tick size, the greater the minimum quoted bid/ask spread.¹ If the tick size is binding, then a larger tick size will generate more market maker revenue, thereby increasing the number of individuals willing to engage in market-making and providing the market with enhanced liquidity.

The strength of this argument depends on the extent to which the tick size is a binding constraint on the bid/ask spread. Just because spreads can be reduced to as little as the tick size does not mean they have to be. The London Stock Exchange, for example, has no minimum tick size, and quoted bid/ask spreads are typically five pence or greater.

Second, significant ticks reduce bargaining costs.

NICOLAS P.B. BOLLEN is assistant professor of finance at the Eccles School of Business at the University of Utah in Salt Lake City (UT 84112).

ROBERT E. WHALEY is T. Austin Finch Foundation professor of business administration at the Fuqua School of Business at Duke University in Durham (NC 27708).

A larger tick size reduces the number of possible prices at which to trade, thereby reducing bargaining costs and increasing operational efficiency.²

Third, significant ticks provide stronger priority rules in the order book. If a tick is too low, some investors may offer marginally better prices, thereby gaining priority and discouraging other investors from placing limit orders.³

The primary argument in favor of a smaller tick size is that smaller ticks may encourage market liquidity. Presumably investors are interested in after-transaction cost returns. If the current tick size is binding, a lower tick size will mean lower trading costs, thereby encouraging existing investors to trade more frequently or encouraging new investors to begin trading.

The debate over whether there is an optimal tick size clearly has important implications for exchanges. Holding other factors constant, exchanges earn revenue in direct proportion to trading volume. Since the arguments for and against a significant tick size suggest a relation between tick size and trading volume, they also suggest a relation between tick size and exchange revenue.

The ideal time to test theories concerning a market's optimal tick size is when the tick size is changed. Changes to tick size are made infrequently, so direct tests are sparse. Bacidore [1997] examines the effect of the change to decimal pricing for stocks traded on the Toronto Stock Exchange. He reports that, for stocks over \$5 (Canadian), effective spreads dropped by 26% for stocks cross-listed on other exchanges and 20% for non-cross-listed stocks.

For the U.S. stock markets, the only direct evidence has appeared in the popular press. *The Wall Street Journal* reports that quoted bid/ask spreads on the NYSE fell by more than 10 cents a share from the day before to the day after the change to sixteenths for some large market capitalization stocks (June 25, 1997). Spreads also dropped by more than 5 cents a share for some low- and mid-capitalization stocks. The same article reports that Nasdaq spreads dropped 10% during the first five days after the switch to sixteenths on June 2, 1997, compared to the nineteen days beforehand, and that AMEX spreads dropped 7.6% after a switch to sixteenths on May 7, 1997.

Indirect evidence has also been reported. Angel [1997] argues that there is an optimal stock price level for a given tick size that balances the positive and negative impact of tick size on spreads, depth, and liquidity. He argues that the remarkably stable average price of

NYSE stocks this century is the result of the constant tick size. Firms can use stock split decisions in order to maintain the optimal tick-to-price ratio. Harris [1994] uses data prior to the NYSE's switch to sixteenths, and runs a series of regressions to predict how spreads, depth, and trading volume would change if the NYSE lowered the tick size from an eighth to a sixteenth.

The purpose of this study is to measure changes in the trading environment and investor welfare resulting from the NYSE's switch to sixteenths on June 24, 1997. We analyze the effects of the switch to sixteenths at an aggregate market level as well as stratify the stocks in the sample by price per share and dollar trade size to determine whether stocks were affected differentially by the switch.

DATA AND VARIABLE MEASUREMENT

We examine all 2,852 common stocks that traded on the NYSE during June 1997. Trade and quote data for these stocks were collected for the twenty trading days before the change in tick size (i.e., May 27, 1997, through June 23, 1997) and the twenty trading days including the change and after (i.e., June 24, 1997, through July 22, 1997). These data were obtained from the NYSE's TAQ data base.

The TAQ trade and quote data are separate files. In merging the two data sets, we proceeded as follows. For each trade of each stock each day, we obtained the most recent bid/ask price quotes and market depth figures and appended them to the trade record. The trade record itself includes the time of trade, the trade price, and the volume of shares traded. Since the first trade of the day is usually determined through a call auction market, it does not have supporting bid/ask price quotes. We drop these opening trades because we are interested only in determining the effects of the change in tick size on the bid/ask spread and other aspects of "open" market microstructure. Consequently, if a stock traded only at the open on a particular day, it is not included in the analysis on that day.

Four exclusionary criteria are applied to the stocks in the sample. First, the shares of Berkshire Hathaway (A and B) are excluded because their share prices are so high (and spreads so wide) that they are meaningless with respect to the issue at hand. Second, any stock with a stock split during the interval is excluded. Due to the discreteness of prices, the effects of stock splits on the bid/ask spread are not well under-

stood.⁴ This eliminates eighty-one additional stocks. Third, any stock trading in ticks below one-eighth prior to June 24, 1997, is eliminated. There are twenty-seven such occurrences. Finally, any stock with no recorded trading volume in the twenty days before or the twenty trading days after the change in price reporting is eliminated. This restriction removes thirty-three stocks. The total number of stocks in our final sample is therefore 2,709.

From the data in the combined trade and quote file, we compute a number of measures of market activity and bid/ask spreads for each stock each day. Two measures of the quoted spread require definition:

Percentage quoted spread: The average of the ratio of the quoted bid/ask spread to the bid/ask price midpoint.

Volume-weighted average quoted spread: The average of the quoted bid/ask spreads during the day weighted by the proportion of daily trading volume executed while each pair of quotes was in effect.

We measure the percentage quoted spread to illustrate that spreads differ by the level of share price.⁵ Trading costs for low-price per share stocks are higher. The volume-weighted quoted spread weights the prevailing quotes by the number of shares traded (as a proportion of total daily trading volume) while the quotes were in effect. Consequently, this measure of quoted spread is more accurate a priori since transactions at the prevailing quotes indicate that prices were "firm."

Our measures of market depth and market quality also merit comment. We attempt to measure market quality with an index that is designed to capture the trade-off between quoted bid/ask spread and market depth. The market quality index (MQI) is the ratio of the average share depth at the prevailing bid and ask price quotes to the percentage quoted spread; that is:

$$MQI = \frac{(\text{Depth at bid} + \text{Depth at ask})/2}{\text{Percent spread}} \quad (1)$$

where depth at bid and depth at ask are measured in thousands of shares, and percent spread is the quoted bid/ask spread divided by the bid/ask price midpoint.

To illustrate how this market quality index works, suppose that before the change to price quotes

in sixteenths the bid and ask price quotes are 49.875 and 50.125, respectively, with a depth of 1,000 shares on each side of the market. The prechange MQI is

$$MQI = \frac{(1+1)/2}{\left[100 \left(\frac{0.25}{(49.875 + 50.125)/2} \right) \right]} = 2.0 \quad (2)$$

Now, suppose that after the change to sixteenths, the spread narrows from a quarter to an eighth, but the market depth falls to 500 on each side of the market. The postchange MQI is

$$MQI = \frac{(0.5+0.5)/2}{\left[100 \left(\frac{0.125}{(49.9375 + 50.0625)/2} \right) \right]} = 2.0 \quad (3)$$

reflecting no change in the quality of the market.

In other words, although the quoted spread has been reduced, the market depth has been reduced commensurately with no change in market quality. On the other hand, if the market depth remained at 1,000 shares on each side of the market, the MQI would double.

A large portion of trading volume takes place within the quoted bid/ask spread.⁶ We document this behavior by measuring the proportion of daily trades (and the proportion of daily dollar volume) executed within the prevailing bid/ask price quotes. To account for the fact that trades take place within the prevailing quotes, we measure the "effective" spread as twice the absolute difference between the trade price and the midpoint of the quoted bid/ask spread; that is:

$$\text{Effective spread}_t = 2 \left| \frac{\text{Trade price}_t - (\text{Bid price}_t + \text{Ask price}_t)/2}{2} \right| \quad (4)$$

Note that the effective spread measured in this way will always be less than or equal to the quoted spread. We also measure the volume-weighted effective spread for the same reason as we measure the volume-weighted quoted spread.

EMPIRICAL EVIDENCE IN AGGREGATE

The basic framework of our analysis is to com-

pare measures of trading volume, bid/ask spreads, market depth, and market quality in the twenty trading days prior to the switch to sixteenths with those same measures in the twenty trading days after the switch. Each daily measurement for each stock is then averaged across the twenty days prior to the switch and after the switch. The averages are then aggregated across stocks to estimate marketwide changes in the microstructure measures. The change in the cross-sectional averages is tested using a t-test for a difference in means.⁷

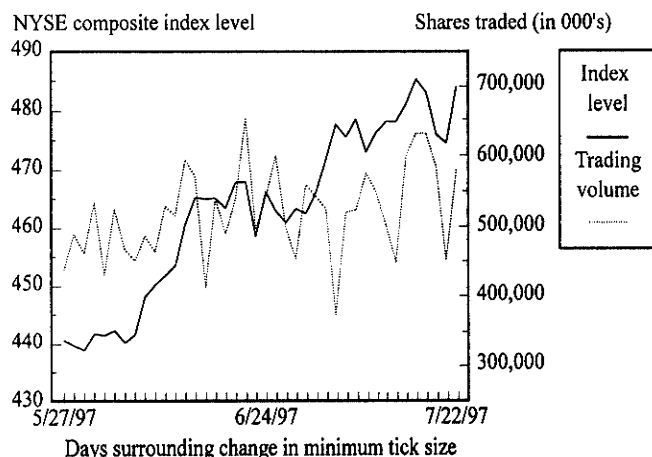
Exhibit 1 shows that the level of the NYSE composite index increased from a level of about 440 to 485 from the beginning of the preimplementation period to the end of the post-period. This marketwide increase in price will affect some of our microstructure measures; percentage spread, for example, will fall if prices rise and spreads are constant. So we need to interpret some of our results with caution.

Daily trading volume in shares varied from day to day and also showed a modest increase on average. This marketwide increase in trading volume will also affect some of our measures. We might expect market makers to increase their quoted depth in a more liquid trading environment, for example.

Microstructure Measures

Panel A of Exhibit 2 reports average trading activity. The number of trades per day increased from an average of 65.47 trades per day before the switch to

EXHIBIT 1
NYSE COMPOSITE INDEX LEVEL AND
NYSE TRADING VOLUME



75.74 trades afterward — an increase of 15.69%.⁸ Similarly, the average number of shares traded each day increased by 5.86%, while the average dollar trading volume increased by 11.97%. The difference between the percentage increases in share volume versus dollar volume indicates that volume increased more for high-priced stocks than low-priced stocks — an issue that we return to later.

Interestingly, average trade size decreased after the change to sixteenths. The average trade size fell by 9.33% when measured in number of shares and by 7.00% when measured in dollar volume. On the one hand, this change could be a result of smaller investors entering the market. On the other, large traders may be choosing to use a greater number of smaller orders so as not to compromise market depth at the prevailing bid/ask quotes.

Panel B of Exhibit 2 reports measures of the quoted bid/ask spread. All measures decreased after the reduction in tick size. The average and median dollar quoted spreads, for example, fell by 14.51% and 14.54%. Of a total of 2,709 stocks, 2,325 experienced a drop in the average dollar quoted spread (85.82%). The average percentage spread fell by 21.26%, considerably more than the average dollar spread. This implies that the quoted bid/ask spread as a proportion of share price fell more for low-priced shares than high-priced shares.

The volume-weighted average quoted spread fell by 13.32%, slightly less than the decrease in the average dollar spread. This means that higher-volume stocks did not experience as much of a reduction as lower-volume stocks.

Exhibit 3 illustrates the empirical distribution of average volume-weighted quoted spread before and after the reduction in tick size. The graph shows that a significant portion of the quoted spreads of NYSE stocks dropped below an eighth after the switch to sixteenths. Apparently, the one-eighth tick size had been a binding constraint on many of the quoted spreads.

Panel C of Exhibit 2 reports measures of market depth and market quality at the prevailing bid/ask quotes. The average number of shares at the bid was 11,703 prior to the NYSE's reduction in tick size and 7,429 afterward. In other words, the market depth in number of shares at the bid was reduced by 36.52%. The reduction in the market depth at the ask was slightly larger, at 39.43%.

The significance of the reduction in bid (ask) market depth is reflected by the fact that 2,146 (2,130)

EXHIBIT 2
AVERAGE DAILY MARKET MEASURES FOR SAMPLE OF 2,709 NYSE COMMON STOCKS

PANEL A. TRADING ACTIVITY

	No. of Trades	Trading Volume		Trade Size		Share Price
		Shares	Dollars	Shares	Dollars	
Pre	65.47	161,681	6,649,559	1,979.95	51,985.52	28.14
Post	75.74	171,159	7,445,273	1,795.19	48,344.03	29.31
Difference	10.27	9,478	795,715	-184.76	-3,641.49	1.16
% Difference	15.69%	5.86%	11.97%	-9.33%	-7.00%	4.14%
No. of Negatives	767	1,197	1,103	1,613	1,489	587
p-value (t-test)	0.000	0.001	0.000	0.000	0.000	0.000

PANEL B. QUOTED BID/ASK SPREADS

	Average	Median	Percentage	Volume-Weighted Average
Pre	0.190	0.177	1.08%	0.193
Post	0.162	0.151	0.85%	0.168
Difference	-0.028	-0.026	-0.23%	-0.026
% Difference	-14.51%	-14.54%	-21.26%	-13.32%
No. of Negatives	2,325	2,234	2,426	2,265
p-value (t-test)	0.000	0.000	0.000	0.000

PANEL C. MARKET DEPTH AND MARKET QUALITY

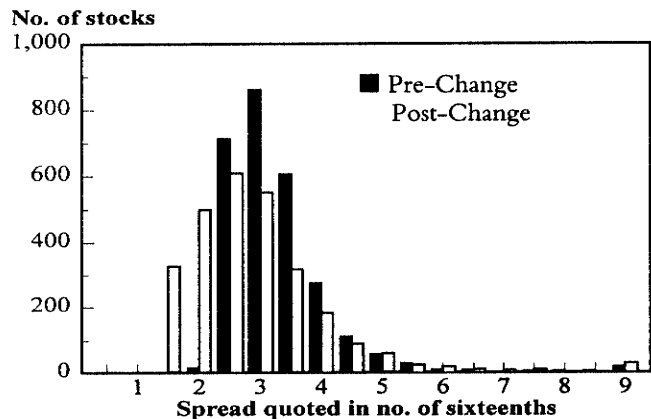
	No. of Shares		Dollar Value		Market Quality Index
	at Bid	at Ask	at Bid	at Ask	
Pre	11,703	11,951	209,471	227,109	152.15
Post	7,429	7,240	138,680	144,912	154.34
Difference	-4,274	-4,712	-70,791	-82,196	2.19
% Difference	-36.52%	-39.43%	-33.80%	-36.19%	1.44%
No. of Negatives	2,146	2,130	2,074	2,069	1,285
p-value (t-test)	0.000	0.000	0.000	0.000	0.353

PANEL D. EFFECTIVE SPREADS

	Percentage of Trades Within Spread	Effective Spread Dollar Value Within Spread		Volume-Weighted Average
		Average	Average	
Pre	23.08%	21.42%	0.129	0.140
Post	29.08%	24.34%	0.112	0.127
Difference	6.01%	2.92%	-0.017	-0.012
% Difference	26.03%	13.64%	-13.13%	-8.77%
No. of Negatives	476	886	2,131	1,911
p-value (t-test)	0.000	0.000	0.000	0.000

Note: "Pre" represents twenty trading days before, and "post" twenty trading days including and after June 24, 1997.

EXHIBIT 3
NUMBER OF NYSE COMMON STOCKS
IN EACH AVERAGE VOLUME-WEIGHTED
QUOTED SPREAD CATEGORY



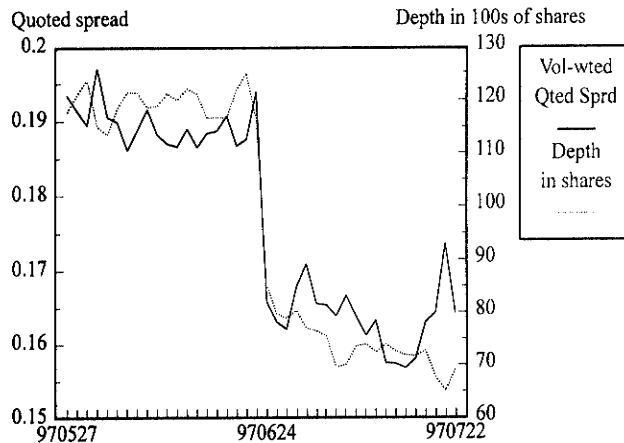
of 2,709 stocks, or about 79%, experienced a reduction. The percentage reductions in dollar depth were slightly smaller than share depth. Again, this is evidence that the change in tick size has had a differential effect on low-priced shares and high-priced shares.

The results in Exhibit 2 provide strong evidence that both quoted bid/ask spreads and quoted market depth decreased significantly following the switch from quoting stock prices in eighths to sixteenths.⁹ Exhibit 4 illustrates this sharp decline by plotting the daily average percentage spread and average share depth for the NYSE sample for the twenty trading days prior to the switch and the twenty trading days after and including June 24, 1997.

A critical question is whether investors' apparent savings from the reduction in bid/ask spreads have been offset by a lack of ability to execute trades "in size." We attempt to answer this question using a "market quality index" (MQI). Panel C of Exhibit 2 shows that, after the NYSE's change in tick size, the market quality index rose only slightly, by an average of 1.44%. The number of stocks for which the market quality index increased totaled 1,424 or about 53% of the sample, not significantly different from what we would expect under the null hypothesis of no change. As measured by the MQI, the change to sixteenths appears to have had little overall effect. A problem with this measurement, of course, is that it presumes all trades occur at the prevailing bid/ask price quotes.

Panel D of Exhibit 2 shows that a considerable

EXHIBIT 4
AVERAGE QUOTED BID/ASK SPREAD AND
AVERAGE DEPTH IN SHARES



percentage of daily trades are consummated within the prevailing bid/ask quotes — 23.08% prior to the change in tick size. Since the change, the frequency has increased to 29.08%. Apparently, the move to a smaller price gradation has created more opportunities to negotiate trade prices within the spread.

The effective bid/ask spread measure in the last column of Panel D accounts for trades within the quoted levels. The effective bid/ask spread has been reduced by 13.13% on average, and 8.77% when weighted by volume. The volume-weighted average is probably more important in the sense that it measures the actual cost incurred by investors. The difference between the two measures reflects the fact that the reduction in spread has been larger for less-active stocks than more-active stocks.

Robustness Tests

The evidence reported in Exhibit 2 shows that the introduction of sixteenths coincides with changes in the nature of trading and in trading costs. In particular, trading costs have decreased significantly, and trading volumes have increased. Since changes in the bid/ask spread are the focus of much of the debate surrounding a change in the tick size, we need to determine whether the reduction in the spread is attributable to the change in the tick size and not to changes in trading volume, volatility, or market competition.

To control for these other factors, we perform a set of time series regressions for each stock in the sam-

ple. Theoretical models of the quoted bid/ask spread predict that spreads are determined by, among other factors, trading volume and price volatility (see Stoll [1978]). The higher the daily trading volume, the lower the margin that market makers need to cover the fixed costs of operation. Spreads should also vary with price risk. The greater the price variability of a stock, the greater the likelihood that an adverse price move will occur while the stock is in the market maker's inventory. The higher the price risk, therefore, the higher the spread.

The regression model also includes a measure of the intermarket competition for the stocks. This is simply the number of exchanges that make a market in the stock. Ideally, intramarket competition should also be included, but there is no good way to measure the number of market makers standing ready to trade at each specialist's post. Finally, the regression includes an indicator variable to measure the shift in dependent variable over time after controlling for changes in the other independent variables.

The form of the regression is

$$X_{i,t} = a_0 + a_1 I_t + a_2 \text{Volume}_{i,t} + a_3 \text{Volatility}_{i,t} + a_4 \text{MktComp}_{it} + \varepsilon_t \quad (5)$$

where

- $X_{i,t}$ = dependent variable measured for stock i on day t (volume-weighted quoted spread, average market depth, market quality index, and volume-weighted effective spread);
- I_t = an indicator variable that equals zero prior to June 24, 1997, and one thereafter;
- $\text{Volume}_{i,t}$ = trading volume of stock i on day t measured in thousands of shares;
- $\text{Volatility}_{i,t}$ = price change volatility measured as the difference between the high and low price midpoints of stock i on day t ; and
- $\text{MktComp}_{i,t}$ = number of exchanges making a market in stock i on day t .

The market competition variable is omitted if the number of exchanges does not change for a particular stock over the event window. The regression is

performed for each stock. The results are summarized in Exhibit 5 by the significance of the coefficient estimates. The coefficient, a_1 , is key to the analysis in that it measures the effect of the NYSE's change in tick size after controlling for the effects of other factors.

Overall, the results in Exhibit 5 indicate that the effects reported in Exhibit 2 are largely driven by the change in the tick size. Panel A of Exhibit 5, for example, shows that, when the volume-weighted quoted spread is used as the dependent variable, 2,318 of the 2,703 coefficient estimates of a_1 are negative. This exceeds the 2,265 reductions reported in Panel B of Exhibit 2. In other words, after controlling for other effects on the quoted spread, the reduction in spread as a result of the change in tick size is more prevalent than it was before.

Of the quoted spread's determinants, the strongest appears to be price volatility. The volatility coefficient a_3 is significantly positive for 718 stocks in the sample of 2,702.

When average market depth in shares is used as the dependent variable, the regression results are qualitatively similar to those of the quoted spread. The frequency of depth reductions, 2,201 of 2,703, is higher than it was in Exhibit 2. Market depth is reduced significantly for 1,291 of the stocks in the sample.

The risk variable again enters significantly for a large number of stocks, but here the effect is negative, as expected. The greater the price variability, the fewer the number of shares that the market maker is willing to trade at the prevailing quotes.

The market quality regression results reported in Panel C, like the results reported in Exhibit 2, indicate that the change to sixteenths had little effect. 70% of the coefficient estimates are insignificantly different from zero, with the remaining 30% about evenly balanced between significant increases and significant decreases. The only economic variable with a notable impact on market quality appears to be price risk. The greater the price variability, the lower the market quality.

Finally, the volume-weighted effective spread regression results reported in Panel D indicate that spreads have decreased for 1,926 of the 2,703 stocks in the regression. This number is higher than it was in Exhibit 2, indicating that once the effects of other factors are eliminated, the impact of the change to sixteenths is greater. The volume-weighted effective spread appears to be positively associated with price risk.

In summary, the robustness tests indicate that the

EXHIBIT 5
SUMMARY OF COEFFICIENT ESTIMATE SIGNIFICANCE IN DAILY TIME SERIES REGRESSIONS

$$X_{i,t} = a_0 + a_1 I_t + a_2 \text{Volume}_{i,t} + a_3 \text{Volatility}_{i,t} + a_4 \text{MktComp}_{i,t} + \varepsilon_t$$

Coefficient	Total	Number of Estimates			Significantly Positive	Average
		Negative	Significantly Negative	Insignificant		
PANEL A. VOLUME-WEIGHTED QUOTED SPREAD (VWQS)						
Adjusted R ²						0.3277
a ₀	2,703	6	0	150	2,553	
a ₁	2,703	2,318	1,560	1,101	42	
a ₂	2,703	1,043	75	2,367	261	
a ₃	2,702	403	8	1,976	718	
a ₄	2,580	1,656	166	2,388	26	
PANEL B. AVERAGE MARKET DEPTH IN SHARES (AMD)						
Adjusted R ²						0.2116
a ₀	2,703	128	2	991	1,710	
a ₁	2,703	2,201	1,291	1,332	80	
a ₂	2,703	1,163	66	2,444	193	
a ₃	2,702	2,083	378	2,309	15	
a ₄	2,580	1,060	60	2,402	118	
PANEL C. MARKET QUALITY INDEX (MQI)						
Adjusted R ²						0.1260
a ₀	2,703	252	5	1,399	1,299	
a ₁	2,703	1,222	349	1,931	423	
a ₂	2,703	1,415	125	2,413	165	
a ₃	2,702	2,132	400	2,280	22	
a ₄	2,580	958	39	2,394	147	
PANEL D. VOLUME-WEIGHTED EFFECTIVE SPREAD (VWES)						
Adjusted R ²						0.2292
a ₀	2,703	59	2	592	2,109	
a ₁	2,703	1,926	914	1,713	76	
a ₂	2,703	1,845	245	2,405	53	
a ₃	2,702	431	27	1,892	783	
a ₄	2,580	1,385	96	2,428	56	

sharp changes documented in trading behaviors in Exhibit 2 are attributable not to fundamental economic factors but rather to the change in tick size on the NYSE. The switch to sixteenths has reduced trading costs for investors. In the short run, at least, investors are better off.¹⁰

STRATIFIED RESULTS

To examine how the move to sixteenths has

impacted stocks differentially, we stratify the stocks in the sample by the average closing share price midpoint and average trade size in the twenty trading days leading up to June 24, 1997. We then compute summary statistics for the key market measures by quintile.

Share Price Quintiles

Exhibit 6 provides the results from the lowest-price shares to the highest-price shares. The low-price quintile has an average price of \$8.10, while the high-

**EXHIBIT 6
AVERAGE DAILY MARKET MEASURES BY
STOCK PRICE QUINTILE**

PANEL A. AVERAGE PRICE

Quintile	Lowest	2	3	4	Highest
No. of Observations	542	542	542	542	541
Average Price	8.10	15.51	22.72	33.02	61.42

**PANEL B. VOLUME-WEIGHTED
QUOTED SPREAD**

Quintile	Lowest	2	3	4	Highest
Pre	0.155	0.173	0.200	0.201	0.237
Post	0.119	0.150	0.176	0.176	0.216
Difference	-0.036	-0.024	-0.024	-0.025	-0.020
% Difference	-23.35	-13.60	-12.02	-12.29	-8.51
No. of Negatives	487	431	447	451	449
p-value (t-test)	0.000	0.000	0.000	0.000	0.000

**PANEL C. AVERAGE MARKET DEPTH
IN SHARES**

Quintile	Lowest	2	3	4	Highest
Pre	26,457	14,032	6,930	6,393	5,311
Post	16,707	8,031	4,371	4,165	3,390
Difference	-9,750	-6,002	-2,559	-2,228	-1,920
% Difference	-36.85	-42.77	-36.93	-34.85	-36.16
No. of Negatives	453	448	407	414	447
p-value (t-test)	0.000	0.000	0.000	0.000	0.000

price quintile has an average price of \$61.42.

Panel B shows the quoted bid/ask spread for each share price quintile. While the quoted bid/ask spread fell considerably in all share price quintiles, the largest reduction is for the low-priced share quintile, which experienced a 23.35% reduction. At the same time, there is a large reduction in market depth. Panel C shows that all share price quintiles experienced reductions in market depth measured in shares of at least 34%. The reductions are fairly uniform across quintiles, with the exception of Quintile 2.

The market quality index attempts to capture the trade-off between the reduced quoted bid/ask spread and the reduced market depth. Panel D reveals that the MQI increased significantly for *only* low-priced shares. The improvement was 10.89%. The second-lowest

**EXHIBIT 6
CONTINUED**

PANEL D. MARKET QUALITY INDEX

Quintile	Lowest	2	3	4	Highest
Pre	162.57	153.88	107.84	142.66	193.87
Post	180.27	143.07	107.80	145.59	195.04
Difference	17.70	-10.81	-0.04	2.93	1.17
% Difference	10.89	-7.03	-0.04	2.05	0.60
No. of Negatives	261	319	232	236	237
p-value (t-test)	0.000	0.124	0.993	0.535	0.814

**PANEL E. PERCENTAGE OF DOLLAR VALUE
WITHIN QUOTED SPREAD**

Quintile	Lowest	2	3	4	Highest
Pre	13.50	18.21	23.68	24.73	26.98
Post	17.79	22.30	26.64	26.70	28.28
Difference	4.29	4.09	2.96	1.97	1.30
% Difference	31.74	22.45	12.51	7.96	4.83
No. of Negatives	150	169	191	183	193
p-value (t-test)	0.000	0.000	0.000	0.000	0.000

**PANEL F. VOLUME-WEIGHTED
EFFECTIVE SPREAD**

Quintile	Lowest	2	3	4	Highest
Pre	0.122	0.129	0.142	0.142	0.162
Post	0.092	0.114	0.132	0.133	0.166
Difference	-0.030	-0.015	-0.010	-0.009	0.003
% Difference	-24.70	-11.83	-6.90	-6.36	1.91
No. of Negatives	463	387	358	370	333
p-value (t-test)	0.000	0.000	0.000	0.000	0.431

price quintile appears to have a large reduction in market quality, albeit insignificant in a statistical sense. The other quintiles' results are all small and statistically insignificant. The improvement in market quality for high-priced shares, for example, is less than 1%.

Interestingly, the reduction in tick size has not only reduced the size of the quoted bid/ask spread for low-priced shares but also increased the frequency with which trades occur within the prevailing spread. Panel E of Exhibit 6 shows that the percentage of the dollar value of all trades during the day occurring at prices within the prevailing quotes has increased 31.74% for low-priced shares. These increases occur across the board for all share price quintiles, decreasing monotonically as share price increases.

So, low-priced shares appear to have been dou-

bly blessed. First, the minimum price change of an eighth prior to the change appears to have been binding on the quoted spread, so the quoted spread has now been reduced. Second, the refined price gradation has increased the frequency with which low-priced shares are traded at prices within the prevailing quotes.

Both these effects are incorporated within the volume-weighted effective spread, as was described in greater detail earlier. So, the results in Panel F should not be surprising. The volume-weighted effective spread fell by 24.70% for the low-priced share quintile, well in excess of all other quintiles. The effective spread reduction is 11.83% for the second-lowest price quintile, 6.90% for the third quintile, and 6.36% for the fourth. The high-priced quintile experiences an increase in the volume-weighted effective spread, albeit insignificant in a statistical sense. These results are illustrated graphically in Exhibit 7.

Trade Size Quintiles

To examine how the move to sixteenths has impacted investors differentially, we also stratify the stocks in the sample by the average dollar trade size in the twenty trading days leading up to June 24, 1997, and compute the same summary statistics as in Exhibit 6. Panel A of Exhibit 8 indicates that the average trade size in the smallest trade size quintile was \$12,399, and the average trade size in the largest trade size quintile was \$110,598.

Panel B shows that the quoted bid/ask spread fell

considerably for all trade sizes. The small trade quintile, for example, has a 13.23% decrease, and the large trade quintile has a 14.61% decrease. Similarly, market depth has also fallen. Panel C shows a 34.67% reduction for the small trade quintile and a 43.08% reduction for the large trade quintile.

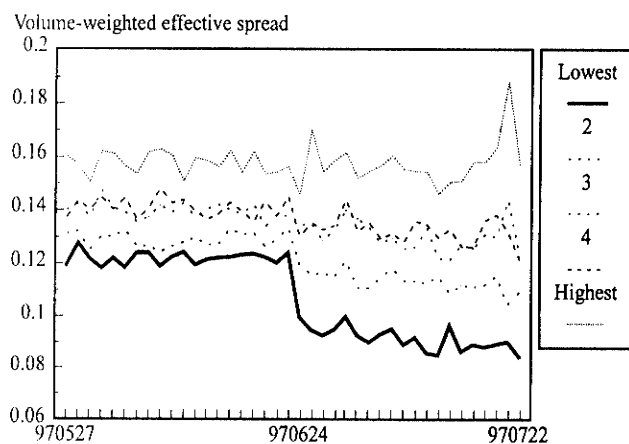
Combining the two effects, the market quality results reported in Panel D show that the greatest beneficiaries are investors with small trades. The market quality index rose by 7.80% for small trades, and by about 5% for all other trade size quintiles, except the largest. The large trade size quintile experienced a 5.29% decline in market quality.

The proportion of the dollar value of trades within the quoted spread has its greatest increase for the small trade quintile, as is reported in Panel E of Exhibit 8. Apparently, the market maker's increased flexibility in negotiating price has benefited investors making small trades.

The positive benefits associated with small trades are also reflected in the volume-weighted effective spread figures reported in Panel F. The small trade quintile experienced an 11.54% drop, followed closely by an 11.49% drop for the second-smallest quintile. For larger trades, the drop is not quite as large, although it is significant in a statistical sense.

There are at least two interpretations of these results. The first is that small investors, whose trades are small due to limited capital, have increased trading or begun trading because of the reduction in trading costs. The second is that large investors are strategically decreasing their average trade size.

EXHIBIT 7
AVERAGE VOLUME-WEIGHTED EFFECTIVE SPREAD BY SHARE PRICE QUINTILE



NYSE MARKET SHARE

The NYSE's decision to reduce tick size must have been predicated, at least in part, on the reduction of tick size on other exchanges. An interesting question in its own right, therefore, is whether the NYSE gained market share as a result of its actions. Recall that Panel A of Exhibit 2 shows that trading volume did indeed increase on the NYSE after the switch to sixteenths. The number of trades was up 16%; the number of shares traded was up 6%; and the market value of shares traded was up by 12%, all highly significant.

Exhibit 9 seeks to examine to what extent the switch to sixteenths has attracted trading volume away from the other domestic stock exchanges. The results indicate that the NYSE's decision to reduce

**EXHIBIT 8
AVERAGE DAILY MARKET MEASURES
BY DOLLAR TRADING VOLUME QUINTILE**

PANEL A. AVERAGE PRICE

Quintile	Lowest	2	3	4	Highest
No. of Observations	542	542	542	542	541
Average Price	12,399	22,536	35,792	60,509	110,598

**PANEL B. VOLUME-WEIGHTED
QUOTED SPREAD**

Quintile	Lowest	2	3	4	Highest
Pre	0.192	0.187	0.194	0.201	0.192
Post	0.167	0.162	0.168	0.177	0.164
Difference	-0.025	-0.026	-0.025	-0.024	-0.028
% Difference	-13.23	-13.81	-13.11	-11.92	-14.61
No. of Negatives	423	443	455	463	481
p-value (t-test)	0.000	0.000	0.000	0.000	0.000

**PANEL C. AVERAGE MARKET DEPTH
IN SHARES**

Quintile	Lowest	2	3	4	Highest
Pre	11,436	17,443	11,802	7,413	11,040
Post	7,472	10,852	7,306	4,756	6,284
Difference	-3,965	-6,591	-4,496	-2,657	-4,756
% Difference	-34.67	-37.78	-38.10	-35.84	-43.08
No. of Negatives	389	422	411	445	502
p-value (t-test)	0.000	0.000	0.000	0.000	0.000

**EXHIBIT 8
CONTINUED**

PANEL D. MARKET QUALITY INDEX

Quintile	Lowest	2	3	4	Highest
Pre	62.09	147.64	131.53	126.15	293.60
Post	66.93	154.86	139.41	132.64	278.08
Difference	4.84	7.22	7.88	6.48	-15.52
% Difference	7.80	4.89	5.99	5.14	-5.29
No. of Negatives	255	261	239	225	305
p-value (t-test)	0.053	0.225	0.238	0.083	0.012

**PANEL E. PERCENTAGE OF DOLLAR VALUE
WITHIN QUOTED SPREAD**

Quintile	Lowest	2	3	4	Highest
Pre	19.48	17.81	21.56	23.70	24.55
Post	24.08	21.54	23.87	25.65	26.58
Difference	4.60	3.73	2.30	1.95	2.03
% Difference	23.61	20.96	10.68	8.23	8.25
No. of Negatives	167	160	192	201	166
p-value (t-test)	0.000	0.000	0.000	0.000	0.000

**PANEL F. VOLUME-WEIGHTED
EFFECTIVE SPREAD**

Quintile	Lowest	2	3	4	Highest
Pre	0.141	0.137	0.141	0.144	0.136
Post	0.125	0.122	0.128	0.136	0.126
Difference	-0.016	-0.016	-0.012	-0.007	-0.010
% Difference	-11.54	-11.49	-8.77	-5.06	-7.08
No. of Negatives	386	386	379	368	392
p-value (t-test)	0.000	0.000	0.000	0.001	0.000

**EXHIBIT 9
AVERAGE NYSE MARKET SHARE BY STOCK PRICE QUINTILE**

	Full Sample	Lowest	2	Price Quintile 3	4	Highest
No. of Observations	2,709	542	542	542	542	541
Pre	81.93%	71.89%	79.18%	83.56%	86.30%	88.72%
Post	83.02%	73.42%	80.33%	84.72%	87.31%	89.35%
Difference	1.09%	1.52%	1.15%	1.16%	1.02%	0.62%
% Difference	1.34	2.12	1.45	1.39	1.18	0.70
No. of Negatives	1,099	214	225	220	221	219
p-value (t-test)	0.000	0.000	0.000	0.000	0.000	0.001

the tick size garnered it market share. For the full sample of 2,709 stocks, the NYSE market share increased significantly from 81.93% to 83.02%. The price quintile results show that the gains are across the board, although the gains are again largest for the lowest-priced shares.

SUMMARY AND CONCLUSIONS

We have examined the effects of the NYSE's decision to reduce the tick size of common stock price reporting from eighths to sixteenths. Our analysis of 2,709 common stocks traded on the NYSE in the days surrounding the switch in price reporting on June 24, 1997, indicates that spreads decreased significantly. Using cross-sectional daily averages over a forty-trading day window centered on June 24, 1997, we find that the volume-weighted quoted bid/ask spread has fallen by more than 13%. Along with the reduction in the quoted spread size came a reduction in the depth of the market at the prevailing bid/ask quotes. Quoted market depth expressed in shares dropped by about 38% following the switch.

To distinguish between the two offsetting effects, we use, among other things, a measure of market quality that trades off reduced quoted spreads and reduced market depth. Over the sample period, the market quality index increases by a modest 1.44%, indicating little change. Many trades take place within the prevailing quotes, however, and these trades are ignored when quoted measures are used. Using a measure of spread that accounts for trades executed within the quoted spread (i.e., the "volume-weighted effective spread"), we find that the spreads have been reduced by nearly 9%.

Analysis of data stratified by price per share and by dollar trade size shows clearly that low-priced stocks have gained the most. Indeed, the gains realized by high-priced stocks may be regarded as marginal.

This evidence may support the notion of an optimal tick size. In the case of high-priced shares, it is unlikely that trading in eighths represented a binding constraint on the minimum size of the bid/ask spread. Consequently, when the NYSE reduced the minimum tick size to a sixteenth, spreads and trades were largely unaffected. For low-priced shares, on the other hand, quoting prices in eighths was a binding constraint, artificially holding spreads at levels higher than they would otherwise be under a competitive environment.

The results using the trade size quintiles indicate that investors with small trades have also benefited from

the change in tick size. Smaller dollar value trades experienced greater reductions in the effective bid/ask spread — in excess of 11%. These reductions appear to have had the desired effect, in the short run at least, as the NYSE market share appears to have increased.

ENDNOTES

The authors are grateful for discussions with James Cochrane, Bernard Dumas, David Henry, George Sofianos, and Hans R. Stoll.

¹The tick size is the minimum increment that a price may move. The bid/ask spread is the difference between the prices at which the market maker is willing to buy (the "bid") and sell (the "ask"); it represents the revenue per share that the market maker earns for providing the investors with immediacy in trading.

²See, for example, Grossman and Miller [1988] and Brown, Laux, and Schachter [1991].

³This argument has been advanced by Harris [1994] and Angel [1997].

⁴For an examination of the effects of stocks splits on market maker spreads, see Gray, Smith, and Whaley [1995].

⁵For a detailed investigation of the effects of transaction costs on the cross-sectional structure of stock returns, see Stoll and Whaley [1983].

⁶Trades within the quoted bid/ask spread may occur in a variety of ways. Measured by trading volume, "crossed trades" are the largest proportion. These may be trades that are negotiated away from the floor and are crossed once the trade is consummated, or trades that are negotiated directly by individuals standing at the specialist's post. System trades may also be executed within the prevailing quotes and usually represent instances when the specialist has "stopped" an order.

⁷A sign test and Wilcoxon signed rank test are also conducted for each measure to check robustness of the t-test. The results were identical, and are omitted to save space.

⁸We do not test for statistical significance here, in that we do not compare changes in the microstructure measures to their time series standard deviation, since we are simply illustrating changes in the trading environment around the switch to sixteenths. For changes in spread, depth, and market quality, we control for other factors below, using a regression framework. The regression analysis statistically tests for a significant effect resulting from the switch to sixteenths. The results confirm those noted here.

⁹This is consistent with the results of Bacidore [1997], who finds that over 91% of cross-listed stocks with a price higher than \$5 (Canadian) on the Toronto Stock Exchange experienced a drop in quoted depth following the TSE's move to share price decimalization.

¹⁰The long-run implications are less clear, for some market makers may leave the market as a result of narrower spreads.

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