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SECURITIES MARKETS

Decimal Pricing Has Contributed to Lower Trading Costs and a More Challenging Trading Environment



G A O

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Highlights of [GAO-05-535](#), a report to congressional requesters

SECURITIES MARKETS

Decimal Pricing Has Contributed to Lower Trading Costs and a More Challenging Trading Environment

Why GAO Did This Study

In early 2001, U.S. stock and option markets began quoting prices in decimal increments rather than fractions of a dollar. At the same time, the minimum price increment, or tick size, was reduced to a penny on the stock markets and to 10 cents and 5 cents on the option markets. Although many believe that decimal pricing has benefited small individual (retail) investors, concerns have been raised that the smaller tick sizes have made trading more challenging and costly for large institutional investors, including mutual funds and pension plans. In addition, there is concern that the financial livelihood of market intermediaries, such as the broker-dealers that trade on floor-based and electronic markets, has been negatively affected by the lower ticks, potentially altering the roles these firms play in the U.S. capital market. GAO assessed the effect of decimal pricing on retail and institutional investors and on market intermediaries.

What GAO Recommends

GAO observes that the goals for implementing decimal pricing have been met and that investors have adapted to the new environment and continue to trade large numbers of shares at lower cost.

www.gao.gov/cgi-bin/getrpt?GAO-05-535.

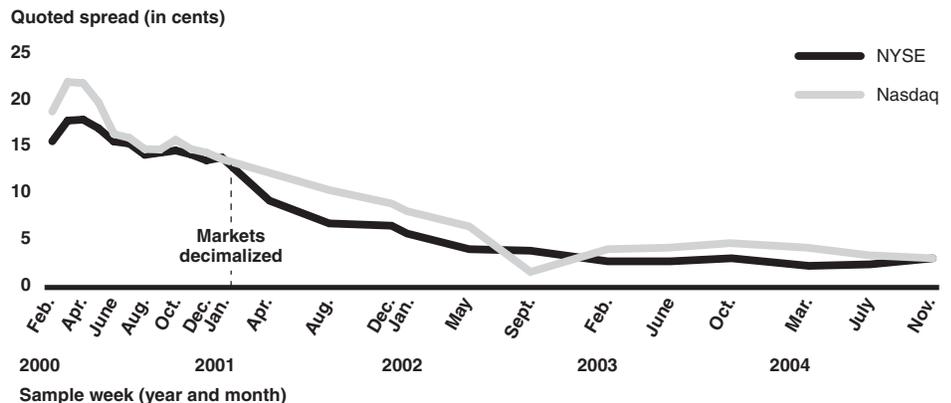
To view the full product, including the scope and methodology, click on the link above. For more information, contact Richard J. Hillman at (202) 512-8678 or hillmanr@gao.gov.

What GAO Found

Trading costs, a key measure of market quality, have declined significantly for retail and institutional investors since the implementation of decimal pricing in 2001. Retail investors now pay less when they buy and receive more when they sell stock because of the substantially reduced spreads—the difference between the best quoted prices to buy or sell. GAO’s analysis of data from firms that analyze institutional investor trades indicated that trading costs for large investors have also declined, falling between 30 to 53 percent. Further, 87 percent of the 23 institutional investor firms we contacted reported that their trading costs had either declined or remained the same since decimal pricing began. Although trading is less costly, the move to the 1-cent tick has reduced market transparency. Fewer shares are now generally displayed as available for purchase or sale in U.S. markets. However, large investors have adapted by breaking up large orders into smaller lots and increasing their use of electronic trading technologies and alternative trading venues.

Although conditions in the securities industry overall have improved recently, market intermediaries, particularly exchange specialists and NASDAQ market makers, have faced more challenging operating conditions since 2001. From 2000 to 2004, the revenues of the broker-dealers acting as New York Stock Exchange specialists declined over 50 percent, revenues for firms making markets on NASDAQ fell over 70 percent, and the number of firms conducting such activities shrank from almost 500 to about 260. However, factors other than decimal pricing have also contributed to these conditions, including the sharp decline in overall stock prices since 2000, increased electronic trading, and heightened competition from trading venues.

Average Quoted Spreads Before and After Decimal Pricing Implemented in Cents per Share, February 2000 through November 2004



Source: GAO.

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Abbreviations

Amex	American Stock Exchange
ATS	alternative trading system
BOX	Boston Options Exchange
bps	basis points
CBOE	Chicago Board Options Exchange
CQ	Consolidated Quotes
CMS	composite match score
ECN	electronic communication network
FOCUS	Financial and Operational Combined Uniform Single
GAO	Government Accountability Office
IBM	International Business Machines
IPO	initial public offering
ISE	International Securities Exchange
MMID	market maker identification
mps	messages per second
NASD	National Association of Securities Dealers
NASDAQ	National Association of Securities Dealers Automated Quotations
NBB	national best bid
NBO	national best offer
NBBO	national best bid and offer
NMS	National Market System
NYSE	New York Stock Exchange
OPRA	Options Price Reporting Authority
OTC	over-the-counter
OTCBB	over-the-counter bulletin board
PCX	Pacific Exchange
Phlx	Philadelphia Stock Exchange
SEC	Securities and Exchange Commission
SIA	Securities Industry Association
TAQ	Trade and Quote
VWAP	volume weighted average price

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United States Government Accountability Office
Washington, D.C. 20548

May 31, 2005

The Honorable Michael Enzi
United States Senate

The Honorable Rick Santorum
United States Senate

With encouragement from Congress, in 2000 the Securities and Exchange Commission (SEC) ordered U.S. stock and option markets to begin quoting prices in decimal increments rather than fractions of a dollar.¹ As U.S. markets implemented decimal pricing in early 2001, they also reduced the minimum price increment, or tick size, at which prices could be quoted. The minimum tick on the stock markets generally fell from 1/16 of a dollar to a penny and on the option markets from 1/8 and 1/16 of a dollar to 10 cents and 5 cents, respectively.² The United States had been one of the last countries to use fractions on its markets, and decimal pricing was expected to simplify securities pricing for investors, help lower investors' trading costs and align U.S. pricing standards with those of other markets.

Many market participants and others who have observed the markets believe that decimal pricing has benefited small retail investors seeking to buy or sell a few hundred shares of stock.³ But concerns have been raised that the smaller tick size has made trading more challenging and costly for large institutional investors, including mutual funds and pension plans, that trade large blocks of shares.⁴ In addition, concerns exist over whether trading in 1-cent ticks has negatively affected the financial livelihood of market intermediaries, such as the broker-dealers that trade on floor-based

¹A stock is a security that signifies an ownership position in a company. An option contract provides the purchaser the right to buy (call) or sell (put) a fixed amount of a given security at a specified price within a limited period of time.

²For option contracts priced \$3 and above, the tick size was reduced from 1/8 of a dollar (12.5 cents) to 10 cents, and the tick size for contracts priced below \$3 was reduced from 1/16 of a dollar (6.25 cents) to 5 cents.

³As used in this report, retail investors are individuals who buy or sell securities for their own accounts.

⁴Institutional investors are entities, such as mutual funds, insurance companies, pension plans, or charitable organizations, that invest on behalf of themselves or others. Such investors typically have large pools of assets and buy and sell securities in large quantities or blocks. The stock markets classify block trades as those involving 10,000 shares or more.

and electronic markets, potentially altering the roles these firms play in the U.S. capital market.

This report responds to your February 12, 2004, request that we study the impact of decimal pricing on the trading of U.S. stocks and options. As agreed with your staffs, our objectives were to study the impact of decimal pricing on (1) retail and institutional investors, (2) market intermediaries, and (3) options market investors and intermediaries.

To determine the effect of decimalization on retail and institutional investors in securities, we analyzed a comprehensive database of all trades conducted on U.S. stock markets from February 2000 to November 2004 to identify changes to key characteristics of stock markets, such as spreads, liquidity, trading volumes, and price volatility.⁵ We also analyzed data on institutional investors' trading costs that were provided by three trade analytics firms in order to identify trends in these costs before and after decimalization. In addition, we reviewed relevant academic, industry, and regulatory studies that address the effects of decimal pricing on the stock markets. Finally, we interviewed almost 70 market participants, including securities traders, broker-dealers, and institutional investors such as pension and mutual fund investment managers, as well as representatives of regulatory agencies, stock markets, electronic trading systems, and industry associations. To determine decimalization's effect on intermediaries in U.S. stock markets, we reviewed studies and data on market participants' revenue and profitability and interviewed a variety of intermediaries, including broker-dealers, market makers, regional and national exchange specialists, and traders. We sought the perspectives of other market participants, including representatives from regulatory agencies, stock markets, industry associations, and institutional investors. To determine the effect of decimal pricing and the tick size reductions on investors and intermediaries in the options market, we reviewed studies by options exchanges; interviewed representatives of all six U.S. options markets, as well as broker-dealers and hedge funds that trade options; and reviewed comment letters that SEC received on potential changes in options market regulations. Appendixes I and II contain a full description of our scope and methodology. We conducted our work in Baltimore, Boston, Chicago, Los Angeles, New York, Philadelphia, San Francisco, and

⁵This analysis used the Trade and Quotes (TAQ) database maintained by the New York Stock Exchange. The TAQ contains records of all trades and price quotes from all U.S. exchanges and the NASDAQ Stock Market.

Washington, D.C., between May 2004 and May 2005 in accordance with generally accepted government auditing standards.

Background

In implementing decimal pricing, regulators hoped to improve the quality of U.S. stock and option markets. The quality of a market can be assessed using various characteristics, but the trading costs that investors incur when they execute orders are a key aspect of market quality. Trading costs are generally measured differently for retail and institutional investors. In addition to the commission charges to paid broker-dealers that execute trades, the other primary trading cost for retail investors, who typically trade no more than a few hundred shares at a time, is measured by the spread, which is the difference between the best quoted “bid” and “ask” prices that prevail at the time the order is executed. The bid price is the best price at which market participants are willing to buy shares, and the ask price is the best price at which market participants are willing to sell shares.⁶ The spread represents the cost of trading for small orders because if an investor buys shares at the ask price and then immediately sells them at the bid price, the resulting loss or cost is represented by the size of the spread.

Because institutional orders are generally much larger than retail orders and completing one order can require multiple trades executed at varying prices, spreads are not generally used to measure institutional investors’ trading costs. Instead, the components of trading costs for large institutional investors, who often seek to buy or sell large blocks of shares such as 50,000 or 1 million shares, include the order’s market impact, broker commissions paid, and exchange fees incurred, among other things. An order’s market impact is the extent to which the security changes in price after the investor begins trading. For example, if the price of a stock begins to rise in reaction to the increased demand after an investor begins executing trades to complete a large order, the average price at which the investor’s total order is executed will be higher than the stock’s price would have been without the order.

⁶In general, for a given stock transaction the best bid (ask) price represents the highest (lowest) price available from all U.S. market venues providing quotes to sellers (buyers) of the stock. This is known as the national best bid and offer, or NBBO.

In addition to trading costs, decimal pricing may have affected several other aspects of market quality, including liquidity, transparency, and price volatility.

Liquidity. Liquid markets have many buyers and sellers willing to trade and have sufficient shares to execute trades quickly without markedly affecting share prices. Generally, the more liquid the overall market or markets for particular stocks are, the lower the market impact of any individual orders. Small orders for very liquid stocks will have minimal market impact and lower trading costs. However, larger orders, particularly for less liquid stocks, can affect prices more and thus have greater market impact and higher trading costs.

Transparency. When markets are transparent, the number and prices of available shares are readily disclosed to all market participants, and prices and volumes of executed trades are promptly disseminated. A key factor that can affect market participants' perceptions of market transparency is the volume of shares publicly displayed as available at the best quoted bid and ask prices, as well as at points around these prices—known as market depth. Markets with small numbers of shares displayed in comparison to the size of investors' typical orders seem less transparent to investors because they have less information that can help them specify the price and size of their own orders so as to execute trades with minimal trading costs.

Price volatility. Price volatility is a measure of the frequency of price changes as well as a measure of the amount by which prices change over a period of time. Highly volatile markets typically disadvantage investors that execute trades with less certainty of the prices they will receive. Conversely, market intermediaries, such as broker-dealers, can benefit from highly volatile markets because they may be able to earn more revenue from trading more frequently as prices rise and fall.

The trading that occurs on U.S. securities markets is facilitated by broker-dealers that act as market intermediaries. These intermediaries perform different functions depending on the type of trading that occurs in each market. On markets that use centrally located trading floors to conduct trading, such as the New York Stock Exchange (NYSE), trading occurs primarily through certain broker-dealer firms that have been designated as specialists for particular stocks. These specialists are obligated to maintain fair and orderly markets by buying shares from or selling shares to the other broker-dealers who present orders from customers on the trading floor or through the electronic order routing systems used by the exchange.

Interacting with the specialists on the trading floor are employees from large broker-dealer firms that receive orders routed from these firms' offices around the country. In addition, specialists receive orders from staff from small, independent broker-dealer firms who work only on the floor.

In contrast, trading of the stocks listed on the NASDAQ Stock Market (NASDAQ), which does not have a central physical trading location, is conducted through electronic systems operated by broker-dealers acting as market makers or by alternative trading venues. For particular stocks, market makers enter quotes indicating the prices at which these firms are simultaneously willing to buy from or sell shares to other broker-dealers into NASDAQ's electronic system. The NASDAQ system displays these quotes to all other broker-dealers that are registered to trade on that market. Much of the trading in NASDAQ stocks now also takes place in alternative trading venues, including electronic communication networks (ECN), which are registered as broker-dealers and electronically match the orders they receive from their customers, much like an exchange.

At the same time that decimal pricing was being implemented, other changes were also occurring in the marketplace. For example, in 1997, SEC enacted new rules regarding how market makers and specialists must handle the orders they received from their customers, including requiring firms to display these orders to the market when their prices are better than those currently offered by that broker.⁷ These rules facilitated the growth of additional trading venues such as the ECNs, which compete with the established markets, such as NYSE and NASDAQ, for trading volumes. The increased use of computerized trading has also provided alternative mechanisms for trading and reduced the role of specialists, market makers, and other intermediaries in the trading process. In addition, after rising significantly during the late 1990s, U.S. stock prices experienced several years of declines, affecting trading costs and market intermediary profits. Facing lower investment returns, institutional investors and professional traders have focused more on reducing trading costs to improve those returns. Regulators also began placing greater emphasis on institutional

⁷Securities Exchange Act Release No. 37619A (Sept. 6, 1996), 61 FR 48290 (Sept. 12, 1996).

investors' duty to obtain the best execution for their trades, further increasing the pressure on these firms to better manage their trading costs.⁸

Results in Brief

Trading costs, a key measure of market quality, have declined significantly for retail and institutional investors since the implementation of decimal pricing in 2001. Retail investors are now able to trade small orders that execute in one trade more cheaply as a result of the substantially reduced spreads that prevail in the stock markets. Data from firms that analyze institutional investors' trading costs and academic studies also showed that trading costs for large investors have also declined. Further, 20 of the 23 institutional investor firms we contacted (representing about 31 percent of assets managed by the top 300 U.S. money management firms) reported that their trading costs had either declined or remained the same since decimal pricing began. The extent to which decimal pricing is responsible for these improvements is not clear because other factors, including the multiyear downturn in stock prices that began in 2000, may have also contributed to the reduced trading costs. Although trading is less costly, the move to the 1-cent tick appears to have reduced market transparency as the number of shares that are generally displayed as available for purchase or sale in U.S. stock markets shrank. In part, institutional investors became less willing to display large orders to the markets because the 1-cent tick lowered the financial risks for other traders seeking to "step ahead" of these larger orders by entering orders priced just a penny better. Institutional investors told us that they had adapted to these new conditions by breaking up large orders into smaller lots and using electronic trading technologies to execute these smaller orders in the markets. In addition, they reported increasing their use of alternative trading venues, such as ECNs and crossing networks that anonymously match large institutional investor orders. Through these adaptations, institutional investors have been able to continue executing large orders at reduced costs.

⁸For example, the Chartered Financial Analyst Institute, which sets standards for investment professionals, issued guidelines on trade management that emphasize the need for investment managers to seek to achieve best execution for their clients. In addition, a top SEC examination official noted in a speech in 2002 that firms should increase their efforts to better ensure that the broker-dealers they use are achieving the best executions for their trades.

Although investors appear to have benefited since decimal pricing began, some market intermediaries have faced more challenging operating conditions. Despite overall improving conditions in the securities industry since 2001, broker-dealers acting as exchange specialists and NASDAQ market makers have seen their profits fall, forcing some to merge with other firms or to leave the industry. Between 2000 and 2004, the exchange specialist broker-dealers that match investor orders and buy and sell shares on the trading floors of various exchanges experienced reduced revenues and profits. For example, in 2004 NYSE exchange specialists reported aggregate revenues of \$902 million, down by more than 50 percent from the \$2.1 billion such firms earned in 2000. Broker-dealers that make markets in NASDAQ and other non-exchange listed stocks appear to have been affected even more by the lower spreads and reductions in displayed liquidity that have accompanied decimal pricing. According to data from the Securities Industry Association, aggregate revenues for these firms declined more than 70 percent between 2000 and 2004, falling from \$9 billion to \$2.5 billion. Since 2001, market intermediaries conducting certain activities have consolidated. For example, the number of NYSE specialist firms fell from 25 in 1999 to 7 in 2004, and the number of NASDAQ market makers declined from almost 500 in 2000 to about 260 in 2004. However, factors other than decimal pricing have also contributed to these conditions, including the sharp decline in overall stock prices since 2000, reduced revenues from customers' increasing use of electronic trading strategies, and heightened competition from ECNs and other electronic trading venues. Market participants noted that these trends had been in place before decimalization. We found that market intermediaries had attempted to adapt to the new conditions by changing their business practices. For example, NASDAQ market makers had begun charging commissions on trades, broker-dealers had invested heavily in technological trading devices and data management systems, and other firms had reduced the sizes of their trading staffs. These conditions and the perceived decline in displayed liquidity in U.S. stock markets has caused a proposal to be made to conduct a pilot study of the use of higher minimum ticks for stock trading. Such a pilot was favored by most of the market intermediaries we contacted but by only about half of the institutional investors interviewed, and some of those that were open to testing larger tick sizes for trading saw them as being useful primarily for less liquid stocks rather than for all stocks.

The effect of decimal pricing for options trading has been less significant. In part, options markets were less affected because the tick sizes that accompanied decimal pricing did not represent large changes from those

previously in use. Nevertheless, the quality of U.S. options markets, as measured by their trading costs, liquidity, and increased trading volumes, has improved since 2001. However, options markets participants attributed these improvements primarily to other changes, including the increased competition arising from multilisting (the trading of options on the same securities on multiple exchanges), which began in 1999, and the establishment of new electronic exchanges and trading systems. Decimal pricing's effect on options market intermediaries such as market makers and specialists has been mixed, with market participants indicating that floor-based firms have experienced declining revenues and profitability and electronic-based firms are seeing increased trading revenues and profitability. A 2004 SEC release sought industry comments on a range of issues pertaining to options markets, including whether these markets should use 1-cent ticks. However, officials of options exchanges and firms we contacted and virtually all of those providing comments to SEC were strongly opposed to lowering minimum price increments to one penny for options. Many were concerned that penny ticks would generate large numbers of price quote messages that would overwhelm the transmission and processing capacity of the existing market and data vendor systems. They also feared that lower intermediary revenues and more price points would reduce liquidity in the options markets.

In their comments on a draft of this report, staff from SEC's Division of Market Regulation and Office of Economic Analysis said that, overall, the report accurately depicted conditions in the markets after the implementation of decimal pricing.

Investors' Trading Costs Have Declined Since Decimalization, but Reduced Market Transparency Has Caused Firms to Adopt New Trading Strategies

Trading costs for both retail and institutional investors fell after the implementation of decimal pricing and the corresponding reduction in tick size. While decimalization appears to have helped to lower these costs, other factors—such as the multiyear downturn in stock prices—also likely contributed to these cost reductions. Although trading costs and other market quality measures improved after decimal pricing's implementation, another measure—the transparency of U.S. stock markets—declined following the reduction in tick size in 2001 because fewer shares were displayed as available for trading. However, most market participants we interviewed reported they have been able to continue to execute large orders by using electronic trading tools to submit a larger volume of smaller orders and making greater use of alternative trading venues.

Decimal Pricing Reduced Trading Costs for Retail Investors

In ordering U.S. markets to convert to decimal pricing, SEC had several goals.⁹ These included making securities pricing easier for investors to understand and aligning U.S. markets' pricing conventions with those of foreign securities markets. Decimalization appears to have succeeded in meeting these goals. In addition, SEC hoped that decimal pricing would result in lower investor trading costs, as lower tick sizes would spur competition that would lead to reduced spreads. Narrower spreads benefit retail investors because retail size orders generally execute in one trade at one price. Prior to being ordered to implement decimal pricing, U.S. stock markets had voluntarily reduced their minimum ticks from 1/8 to 1/16 of a dollar, and studies of these actions found that spreads declined as a result.

Following decimalization and the implementation of the 1-cent tick in 2001, retail investor trading costs declined further as spreads were narrowed even more substantially.¹⁰ To analyze the effects of decimal pricing, we selected a sample of 300 pairs of NYSE-listed and NASDAQ stocks with similar characteristics (like share price and trading activity).¹¹ We examined several weeks before and after the implementation of decimal pricing and found that spreads declined after decimal prices were implemented and remained low through 2004. Our study considered 12 weeklong sample periods from February 2000 to January 2001 (our predecimalization period) and 12 weeklong sample periods from April 2001 through November 2004 (our postdecimalization period). As shown in figure 1, quoted spreads continued a steady decline on both NYSE and

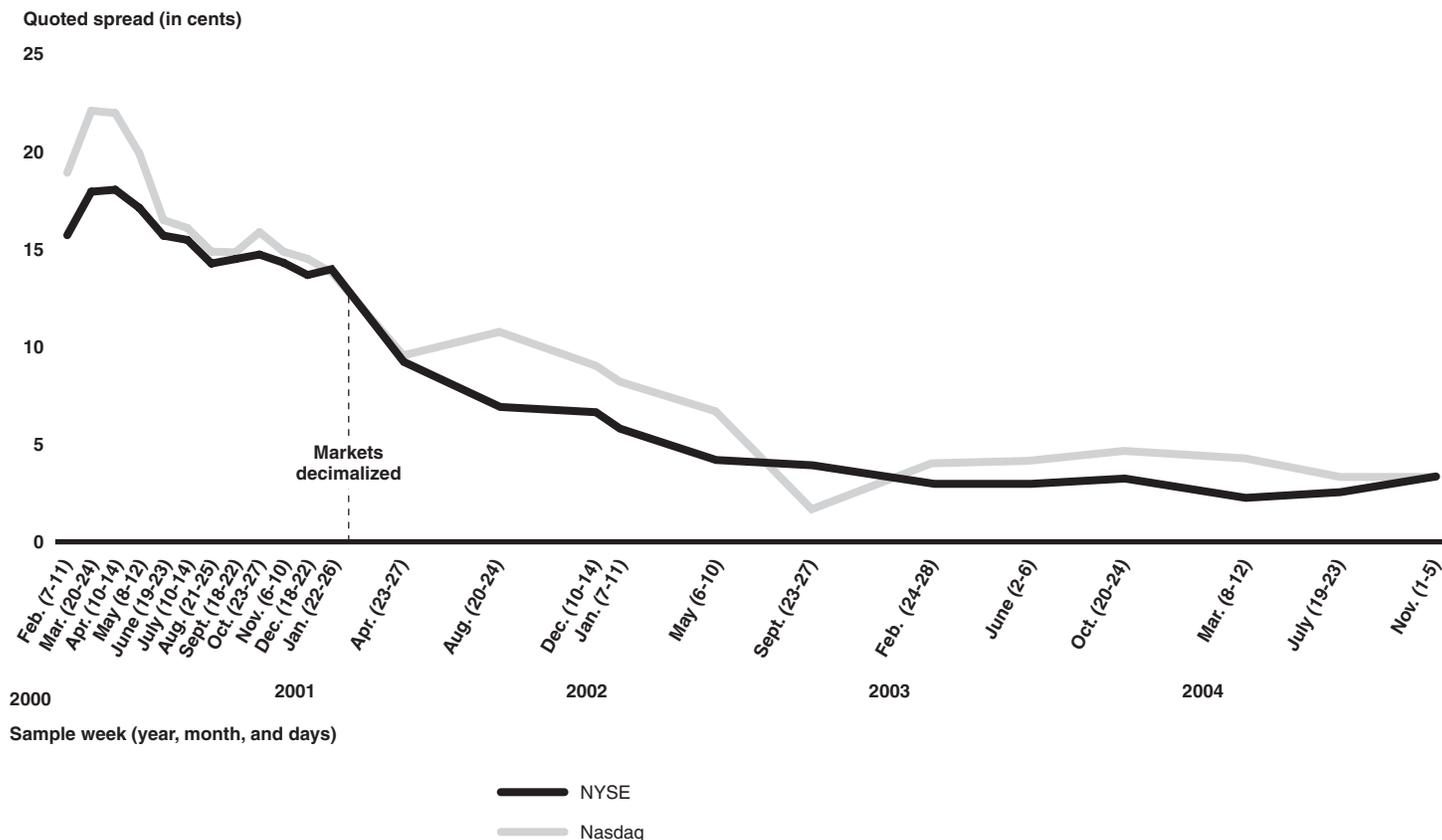
⁹SEC, Division of Market Regulation: Order Directing the Exchanges and NASD to Submit a Decimalization Implementation Plan, Exchange Act Release No. 42360 (January 28, 2000), 65 Fed. Reg. 5003 (2000).

¹⁰Another component of small investors' trading costs is the commission they pay to broker-dealers for executing their trades. The move to decimal pricing was not expected to change retail commissions and thus have not been included in our analysis of retail investor costs.

¹¹For this analysis, we selected pairs of NYSE and NASDAQ stocks by matching stocks with similar trading and stock characteristics. By generating these pairs, we attempted to prevent our results from being influenced by the differences between stocks' characteristics so as to better isolate the impact of decimal pricing alone. By selecting pairs of NYSE and NASDAQ stocks, our sample may be biased because the smallest NASDAQ stocks are not generally comparable in characteristics to NYSE stocks; this bias may tend to overstate the benefits of decimalization such as reductions in spreads and thus caution should be used in generalizing our results. However, our matched pairs also tended to underrepresent stocks with higher daily trading volume, which likely would bias our results toward understating spread reductions.

NASDAQ following the implementation of decimal pricing, falling to levels well below those that existed before the conversion to decimal pricing.

Figure 1: Average Quoted Spreads Before and After Decimalization (cents per share)



Source: GAO.

Note: The figure presents the average spread for the stocks in our sample from a 5-day period (a trading week) in each of the above listed months. Our sample weeks exclude any from February and March 2001 because not all stocks were trading using decimal prices during the transition period. The change in spread for each stock in this analysis was weighted by its trading volume relative to the total trading volume. See appendix II for a detailed explanation of the methodology for this analysis.

Our analysis of the TAQ data also found that quoted spreads declined for stocks with varying levels of trading volume. As shown in table 1, quoted spreads declined significantly after decimal pricing began for the most actively traded stocks, those with medium levels of trading volume, and also for those with the lowest amount of daily trading activity, with the

average quoted spread falling 73 percent for NYSE stocks and 68 percent for NASDAQ stocks.

Table 1: Average Quoted Spreads Before and After Decimalization, 2000–2004 (cents per share)

Stocks by average daily volume of shares traded	NYSE quoted spread			NASDAQ quoted spread		
	Average spread in cents before decimals	Average spread in cents after decimals	Percent change	Average spread in cents before decimals	Average spread in cents after decimals	Percent change
High	14.93	2.77	-81%	12.95	2.74	-79%
Medium	14.94	3.78	-75	15.58	4.47	-71
Low	16.25	5.26	-68	18.97	7.69	-59
All stocks	15.39	4.18	-73	16.96	5.39	-68

Source: GAO analysis of TAQ data.

Note: Quoted spreads in the table represent the volume-weighted average quoted spread (i.e., stocks and weeks with more total trading volume have greater weight) over 12 sample weeks during the predecimals period (February 2000–January 2001) and 12 sample weeks during the postdecimals period (April 2001–November 2004) for our sample of stocks. Stocks were segregated by volume according to the following categories:

- High volume stocks were those in our sample of stocks with average daily trading volumes exceeding 500,000 shares.
- Medium volume stocks were those in our sample of stocks with average daily trading volumes between 100,000 and 499,999 shares.
- Low volume stocks were those in our sample of stocks with average daily trading volumes of less than 100,000 shares.

Quoted spreads are time-weighted across quotes (quotes in effect longer have greater weights) and volume-weighted across stocks (stocks with more shares traded have greater weight).

While the quoted spread measure is useful for illustrative purposes, a better measure of the cost associated with the bid-ask spread is the effective spread, which is twice the difference between the price at which an investor's trade is executed and the midpoint between the quoted bid and ask prices that prevailed at the time the order was executed.¹² Thus, the effective spread measures the actual costs of trades occurring rather than just the difference between the best quoted prices at the time of the trade. As shown in table 2, effective spreads declined by 62 percent for our NYSE

¹²For example, the effective spread for a trade executed for an investor at a price of \$10.03 for stock that was purchased when the bid-ask prices were \$10.01 (bid) and \$10.03 (ask) would be 2 cents per share.

sample stocks and 59 percent for our NASDAQ sample stocks between the periods after decimal pricing was implemented.

Table 2: Average Effective Spreads Before and After Decimalization, 2000–2004 (cents per share)

Stocks by average daily volume of shares traded	NYSE effective spreads			NASDAQ effective spreads		
	Average spread in cents before decimals	Average spread in cents after decimals	Percent change	Average spread in cents before decimals	Average spread in cents after decimals	Percent change
High	14.85	4.71	-68%	15.85	4.86	-69%
Medium	13.17	4.95	-62	15.14	6.15	-59
Low	12.86	6.37	-50	16.00	8.27	-48
All stocks	13.36	5.05	-62	15.66	6.48	-59

Source: GAO analysis of TAQ data.

Note: Effective quoted spreads (the difference between the price at which a trade is executed and the midpoint between the prevailing quoted bid and ask prices) in the table represent the volume-weighted average effective spread (i.e., stocks and weeks with more total trading volume have greater weight) over 12 sample weeks during the predecimals period (February 2000–January 2001) and 12 sample weeks during the postdecimals period (April 2001–November 2004) for our sample of stocks. Stocks were segregated by volume according to the following categories:

- High volume stocks were those in our sample of stocks with average daily trading volumes exceeding 500,000 shares.
- Medium volume stocks were those in our sample of stocks with average daily trading volumes between 100,000 and 499,999 shares.
- Low volume stocks were those in our sample of stocks with average daily trading volumes of less than 100,000 shares.

In addition, several academic and industry studies found similar results. For example, one academic study examined differences in trade execution cost and market quality measures in 300 NYSE stocks and 300 NASDAQ stocks (matched on market capitalization) for several weeks before decimal pricing was fully implemented on NYSE stocks and after both markets converted to decimal pricing. As shown in table 3, the study found that average effective spreads declined by 41 percent for the NYSE stocks and by 54 percent for the NASDAQ stocks from the predecimalization sample period (January 8–26, 2001) to the postdecimalization sample period (April 9–August 31, 2001).¹³ As the table also shows, the study found that spreads declined the most for NYSE stocks with the largest market capitalizations and for NASDAQ stocks with the smallest market capitalizations.¹⁴

Table 3: Volume-weighted Average Effective Spreads Before and After Decimalization for Selected NYSE and NASDAQ Stocks, by Market Capitalization (cents per share)

Stocks by market capitalization	NYSE effective spreads			NASDAQ effective spreads		
	Before decimals (cents)	After decimals (cents)	Percent change	Before decimals (cents)	After decimals (cents)	Percent change
Large	12.51	6.93	-45%	12.55	5.61	-55%
Medium	11.78	9.76	-17	14.76	8.97	-39
Small	17.05	12.50	-27	18.89	7.56	-60
All stocks	12.67	7.45	-41	12.66	5.78	-54

Source: Hendrik Bessembinder.

¹³Hendrik Bessembinder, “Trade Execution Costs and Market Quality after Decimalization,” *Journal of Financial and Quantitative Analysis*, vol. 38, no. 4, 760.

¹⁴Market capitalization is a company’s share price multiplied by the number of shares outstanding.

Similar declines in spreads were also reported in studies that SEC required the various markets to conduct as part of its order directing them to implement decimal pricing. For example, in its impact study, NYSE reported that share-weighted average effective spreads declined 43 percent for all 2,466 NYSE-listed securities trading in the pre- and postdecimalization sample periods the exchange selected.¹⁵ NASDAQ's study found that effective spreads declined between its sample periods by an average of 46 percent for the 4,766 NASDAQ securities that converted to penny increments on April 9, 2001.¹⁶ In addition, an official at a major U.S. stock market told us that all the research studies that he reviewed on the impact of decimal pricing concluded that spreads narrowed overall in response to the reduction in tick size.

Many market participants we interviewed also indicated that retail investors benefited from the narrower spreads that followed decimalization and the adoption of 1-cent ticks. For example, a representative of a firm that analyzes trading activities of large investors told us that investors trading 100 shares are better off following decimalization because small trades can be executed at the now lower best quoted prices. Representatives from two broker-dealers stated that the narrower spreads that prevailed following decimalization meant that more money stayed with the buyers and sellers of stock rather than going to market intermediaries such as brokers-dealers and market makers. Furthermore, the chief financial officer of a small broker-dealer told us that retail investors had benefited from the adoption of the 1-cent tick because their orders can generally be executed with one transaction at a single price unlike those of institutional investors, which are typically larger than the number of shares displayed as available at the best prices.

¹⁵New York Stock Exchange, Inc., *Decimalization of Trading on the New York Stock Exchange: A Report to the Securities and Exchange Commission*, September 7, 2001. For the predecimalization sample period, the NYSE used the 19 trading days from August 1, 2000, through August 25, 2000. The postdecimalization sample period is composed of the 21 trading days in June 2001.

¹⁶The NASDAQ Stock Market, Inc., *The Impact of Decimalization on the NASDAQ Stock Market: Final Report to the SEC*, June 11, 2001. The predecimalization sample period NASDAQ used included the 2 weeks before and the 2 weeks after the final date all NASDAQ securities had converted to penny increments on April 9, 2001.

Institutional Investors' Trading Costs Have Also Declined Since Decimalization

Analysis of the multiple sources of data that we collected generally indicated that institutional investors' trading costs had declined since decimal prices were implemented. We obtained data from three leading firms that collect and analyze information about institutional investors' trading costs. These trade analytics firms (Abel/Noser, Elkins/McSherry, and Plexus Group) obtain trade data directly from institutional investors and brokerage firms and then calculate trading costs, including market impact costs, typically for the purpose of helping investors and traders limit costs of trading.¹⁷ These firms also aggregate client data in order to approximate total average trading costs for all their institutional investor clients. Generally, the client base represented in these firms' aggregate trade cost data is broad enough to be sufficiently representative of all institutional investors. For example, officials at one firm told us that its data captured 80 to 90 percent of all institutional investors and covers trading for every stock listed on the major U.S. stock markets.¹⁸ An official of a major U.S. stock market told us that these firms are well regarded and that their information is particularly informative because these firms measure costs from the point the customer makes the decision to trade by using the price at which stocks are trading at that time, which is data that exchanges and markets generally do not have.

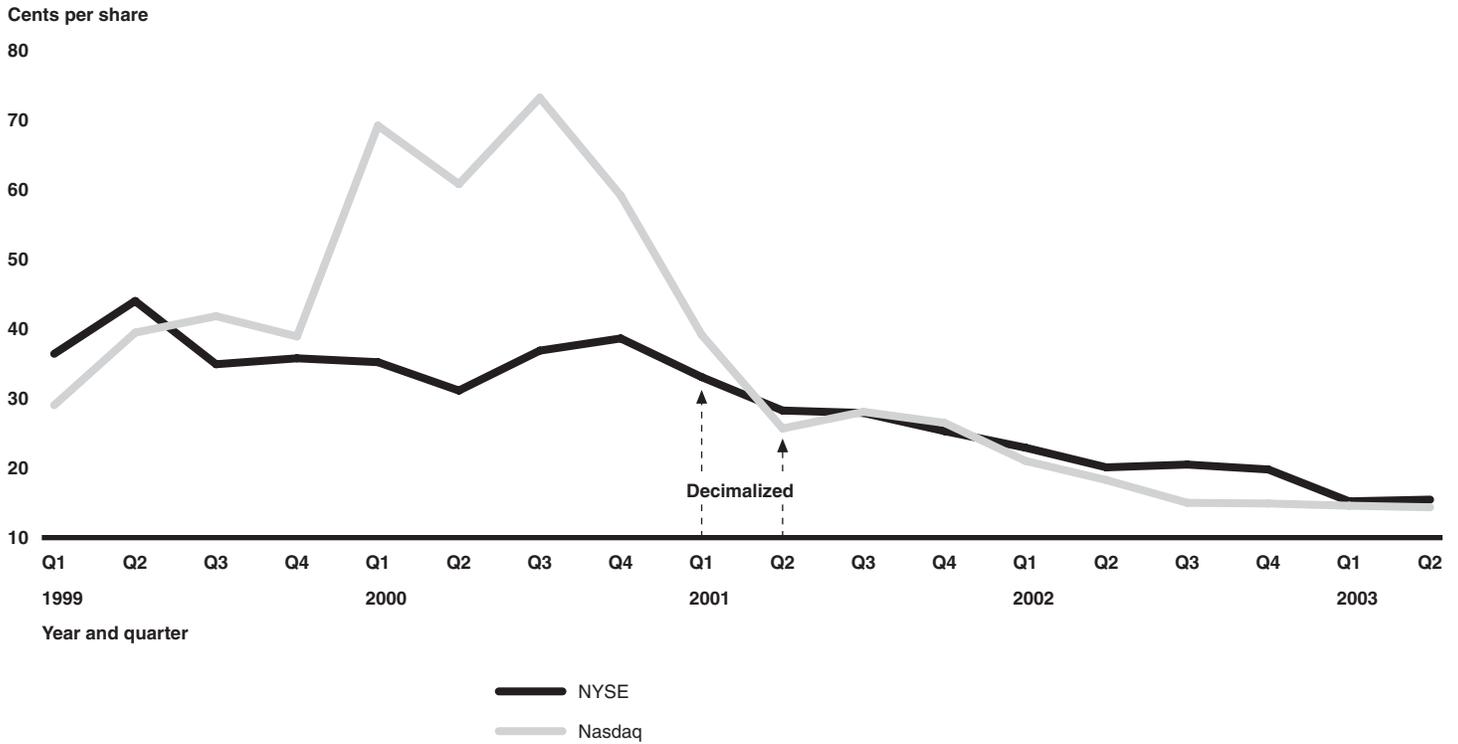
¹⁷ITG, another trade analytics firm, did not begin to measure institutional investors' trading costs until January 2003, after the implementation of decimal pricing and 1-cent ticks.

¹⁸Specifically, Abel/Noser captures data from about 50 large investment management firms that in some years represent over 500 institutional investors and well over 1,000 unique portfolio managers. In addition, Abel/Noser claims its data represent nearly \$3 trillion in principal traded each year. Elkins/McSherry captures trade data from about 1,400 investment managers and 2,000 brokers worldwide, capturing about 20 percent of all dollars traded on NYSE and NASDAQ. The Plexus Group collects data from money managers representing as many as 100 institutional investors.

Although these firms use different methodologies, their data uniformly showed that costs had declined since decimal pricing was implemented. Our analysis of data from the Plexus Group showed that costs declined on both NYSE and NASDAQ in the 2 years after these markets converted to decimal pricing. Plexus Group analyzes various components of institutional investor trading costs, including the market impact of investors' trading.¹⁹ Total trading costs declined by about 53 percent for NYSE stocks, falling from about 33 cents per share in early 2001 to about 15.5 cents (fig. 2). For NASDAQ stocks, the decline was about 44 percent, from about 25.7 cents to about 14.4 cents. The decline in trading costs, shown in figure 2, began before both markets implemented decimal pricing, indicating that causes other than decimal pricing were also affecting institutional investors' trading during this period. An official from a trade analytics firm told us that the spike in costs that preceded the decimalization of NASDAQ stocks correlated to the pricing bubble that technology sector stocks experienced in the late 1990s and early 2000s. An official from another trade analytics firm explained that trading costs increased during this time because when some stocks' prices would begin to rise, other investors—called momentum investors—would also begin making purchases and drive prices for these stocks up even faster. As a result, other investors faced greater than usual market impact costs when also trading these stocks. In general, trading during periods when stock prices are either rapidly rising or falling can make trading very costly.

¹⁹To measure market impact costs, the Plexus Group compares a proprietary benchmark stock price to the average price an investor receives. The Plexus Group benchmark attempts to show the price at which the order for a particular stock should be executed. The firm calculates this expected price using trade data of its clients for the two quarters preceding the date of the trade under study and takes into account variables such as trade size, liquidity, and the direction of stock price movement.

Figure 2: Total Trading Costs from a Trade Analytics Firm for NYSE and NASDAQ Stocks, 1999–2003 (cents per share)



Source: GAO analysis of Plexus Group data.

Note: Data are reported quarterly. After a phase-in period, all NYSE stocks were trading with decimal prices by January 29, 2001, and all NASDAQ stocks were converted by April 9, 2001.

Cents Per Share Versus Basis Points

Institutional investors' trading costs are commonly measured in two units: cents per share and basis points. Cents per share is an absolute measure of cost based on executing a single share. Basis points—measured in hundredths of a percentage point—show the absolute costs relative to the stock's average share price. Costs reported in terms of basis points can show changes resulting solely from changes in the level of stock prices.

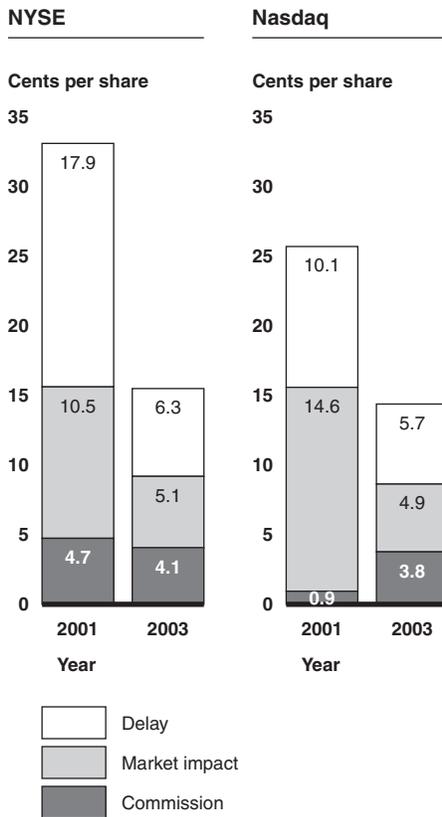
In this section, we present our analysis of trade analytics firms' data on institutional investor trading costs in cents per share because the period surrounding the U.S. markets' implementation of decimal pricing coincided with a large decline in the overall prices of stocks. Therefore, we chose to present data on trading costs in cents per share units as a way to better isolate decimalization's impact. However, we also calculated these same costs in basis points and present this analysis in appendix III.

Source: GAO.

According to our analysis of the Plexus Group data, market impact and delays in submitting orders accounted for the majority of the decline in trading costs for NYSE stocks and NASDAQ stocks.²⁰ Together, the reduction in these two cost components accounted for nearly 17 cents per share (or about 96 percent) out of a total decline of about 17.6 cents per share on NYSE. Delay costs declined about 11.2 cents per share in the 2 years following the implementation of decimal pricing and 1-cent ticks on NYSE and market impact costs declining by about 5.8 cents (fig. 3). An SEC economist noted that declines in delay costs may reflect increased efficiency on the part of institutional investors in trading rather than changes in the markets themselves.

²⁰Delay costs are market impact costs that occur between the time institutional investors' portfolio managers direct their traders to buy or sell stock and the moment these orders are released to brokers. The amount that the stock's price changes during this period is the cost of delaying the order. An order may be delayed for a number of reasons—for instance, because it could affect prices in the market too much. See Plexus Group, *The Official Icebergs of Transaction Costs, Commentary #54*, January 1998.

Figure 3: Trading Cost Components from a Trade Analytics Firm for NYSE and NASDAQ Stocks, 2001 and 2003 (cents per share)



Source: GAO analysis of Plexus Group data.

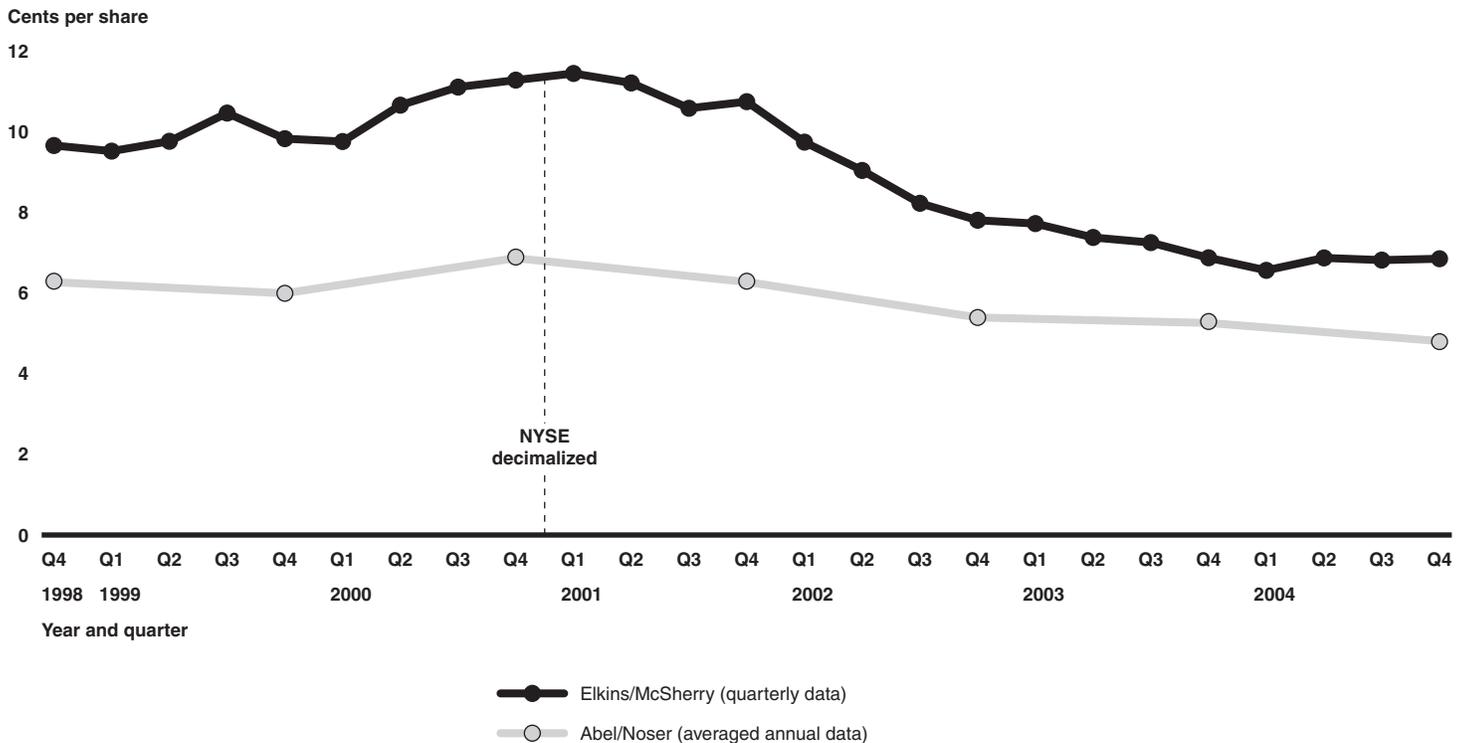
Note: Data are from first quarter 2001 to second quarter 2003 for NYSE and second quarter 2001 to second quarter 2003 for NASDAQ.

Figure 3 also shows that market impact and delay costs accounted for all declines to total NASDAQ trading costs. For example, market impact and delay costs declined about 14.1 cents per share between the second quarter of 2001 and the second quarter of 2003. However, at the same time that these cost components were improving, commission charges for NASDAQ stocks were rising. As shown in figure 3, commissions that market intermediaries charged for trading NASDAQ stocks increased about 2.8 cents per share from second quarter of 2001 to second quarter of 2003. Industry representatives told us these increases were the result of the broker-dealers that made markets in NASDAQ stocks transitioning from trading as a principal, in which a portion of the trade's final price included some compensation for the market maker, to trading as an agent for the customer and charging an explicit commission.²¹

Analysis of data from the other two trade analytics firms from whom we obtained data, Elkins/McSherry and Abel/Noser, also indicated that institutional investor trading costs declined following the decimalization of U.S. stock markets in 2001. Because these two firms' methodologies do not include measures of delay, which the Plexus Group data shows can be significant, analysis of data from these two firms results in trading cost declines of a lower magnitude than those indicated by the Plexus Group data analysis. Nevertheless, the data we analyzed from Elkins/McSherry showed total costs for NYSE stocks declined about 40 percent between the first quarter of 2001 and year-end 2004 from about 11.5 cents per share to about 6.9 cents per share. Analysis of Abel/Noser data indicated that total trading costs for NYSE stocks declined about 30 percent, from 6.9 cents per share to 4.8 cents per share between year-end 2000 and 2004 (fig. 4).

²¹As principals, NASDAQ market makers had earned revenue from spreads by buying shares at the bid price from investors and selling those same shares to other investors at the higher ask price.

Figure 4: Total Trading Costs from Two Trade Analytics Firms for NYSE, 1998–2004 (cents per share)

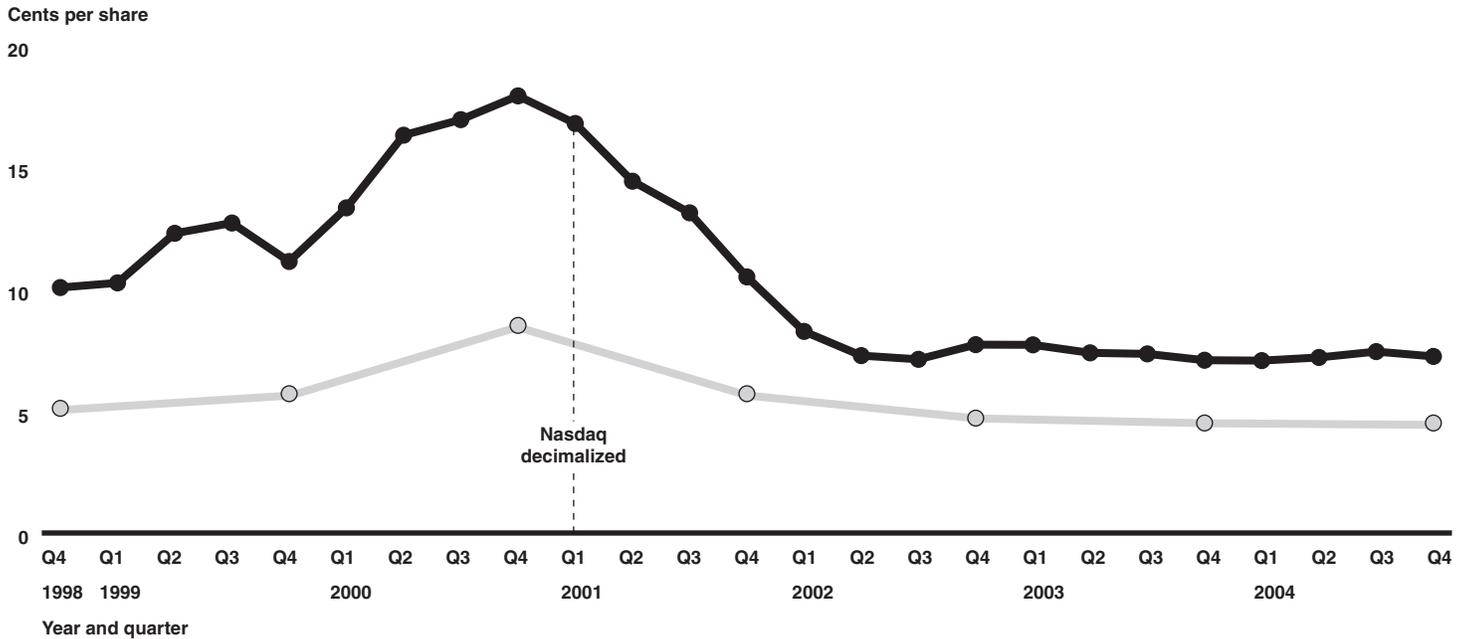


Source: GAO analysis of Elkins/McSherry and Abel/Noser data.

Note: Elkins/McSherry data are quarterly from fourth quarter of 1998 and the fourth quarter of 2004; Abel/Noser data are year-end totals for 1998–2004.

Our analysis of these firms’ data also indicated that total trading costs declined for NASDAQ stocks, which appeared to have declined even more significantly than they did for NYSE stocks. For example, our analysis of the Elkins/McSherry data showed that total trading costs for NASDAQ stocks dropped by nearly 50 percent, from about 14.6 cents per share to about 7.4 cents per share, between the second quarter of 2001 when that market decimalized and the end of 2004. Analysis of the Abel/Noser data indicated that total trading costs declined about 46 percent for NASDAQ stocks between the end of 2000 and 2004, falling from 8.7 cents per share to 4.7 cents per share (fig. 5).

Figure 5: Total Trading Costs from Two Trade Analytics Firms for NASDAQ Stocks, 1998–2004 (cents per share)



● Elkins/McSherry (quarterly data)
○ Abel/Noser (averaged annual data)

Source: GAO analysis of Elkins/McSherry and Abel/Noser data.

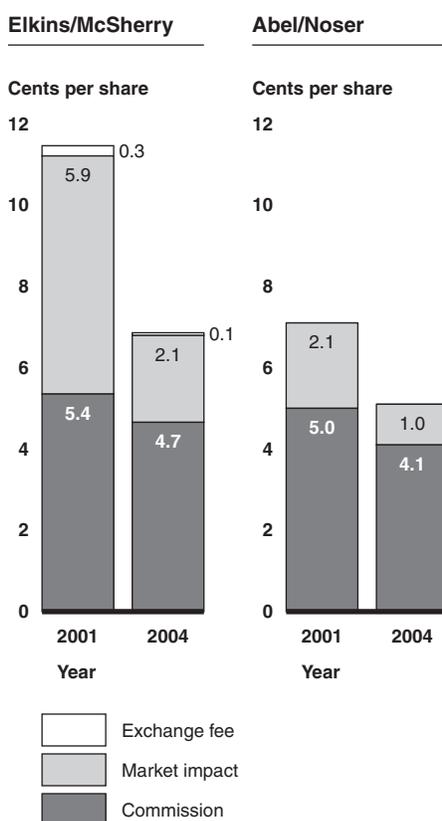
Note: Elkins/McSherry data are quarterly from fourth quarter of 1998 and the fourth quarter of 2004; Abel/Noser data are year-end totals for 1998–2004.

As our analysis of the Plexus Group data showed, the Elkins/McSherry and Abel/Noser data also indicated that reductions to market impact costs accounted for a vast proportion of overall reductions for NYSE stocks (fig. 6).²² Analysis of the Elkins/McSherry data indicated that these costs declined by 3.7 cents per share, accounting for about 80 percent of the total fall in trading costs during this period. The 1.1 cent per share reduction in

²²These two firms analyze market impact costs by comparing their clients' trades to the volume-weighted average price (VWAP) of the particular stocks traded. The VWAP represents the average price at which a particular stock traded on a specific trading day and is calculated by adding up the dollars traded for every transaction (price times shares traded) and then dividing by the total number of shares traded for the day. The closer an investor's average price is to the VWAP, the lower the calculated market impact costs.

market impact costs identified in the Abel/Noser data represented over half of the total trading cost reductions of 2.1 cents per share for NYSE stocks.

Figure 6: Trading Cost Components from Two Trade Analytics Firms for NYSE Stocks, 2001 and 2004 (cents per share)



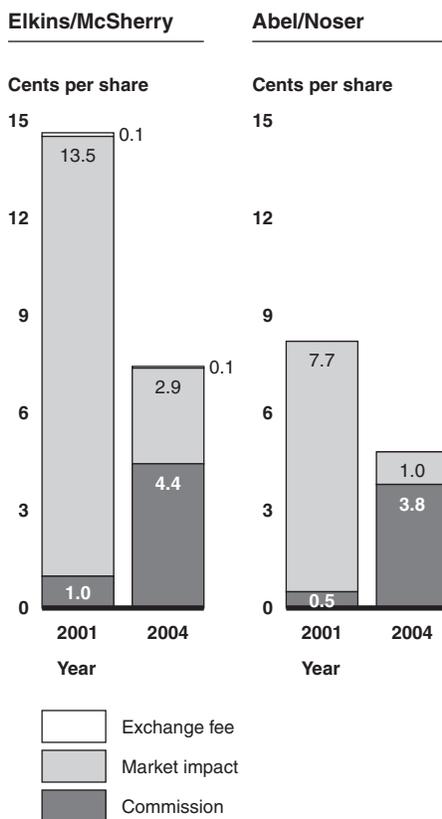
Source: GAO analysis of Elkins/McSherry and Abel/Noser data.

Note: Abel/Noser does not account for exchange fees as a component of trading cost. For Elkins/McSherry, we obtained first quarter 2001 data and fourth quarter 2004. For Abel/Noser, we obtained data from the end of 2000 and 2004.

Reductions to market impact costs explained the entire decline to total trading costs captured by the Elkins/McSherry and Abel/Noser data for NASDAQ stocks, and the total declines would have been even larger had commissions for these stocks not increased after 2001. Market impact costs declined about 10.6 cents per share (about 78 percent) according to our analysis of the Elkins/McSherry data, and 6.7 cents per share (about 87

percent) according to our analysis of the Abel/Noser data (fig. 7). However, during this period, commissions charged on NASDAQ stock trades included in these firms' data increased by more than 3 cents per share, representing a more than threefold increase in commissions as measured by Elkins/McSherry and a more than sixfold rise according to Abel/Noser.

Figure 7: Trading Cost Components from Two Trade Analytics Firms for NASDAQ Stocks, 2001 and 2004 (cents per share)



Source: GAO analysis of Elkins/McSherry and Abel/Noser data.

Note: Abel/Noser does not account for exchange fees as a component of trading cost. For Elkins/McSherry, we obtained first quarter 2001 data and fourth quarter 2004. For Abel/Noser, we obtained data from the end of 2000 and 2004.

Academic Studies Generally Showed Declining Costs for Institutional Investors

Data from a fourth firm, ITG, which recently began measuring institutional trading costs, also indicates that such costs have declined. This firm began collecting data from its institutional clients in January 2003. Like the other trade analytics firms, its data is similarly broad based, representing about 100 large institutional investors and about \$2 trillion worth of U.S. stock trades. ITG's measure of institutional investor trading cost is solely composed of market impact costs and does not include explicit costs, such as commissions and fees, in its calculations. Although changes in ITG's client base for its trade cost analysis service prevented direct period to period comparisons, an ITG official told us that its institutional investor clients' trading costs have been trending lower since 2003.²³

In attempting to identify all relevant research relating to the impact of decimal pricing on institutional investors, we found 15 academic studies that discussed the impact of decimalization but only 3 that specifically examined institutional investors' trading costs. As of May 2005, none of these three studies had been published in an academic journal. Two of these studies used direct measures of trading costs, and the other used an indirect measure.²⁴ Those that relied on more direct measures of these costs found that these costs had declined since the implementation of decimal pricing and 1-cent ticks. The first of these studies analyzed more than 80,000 orders in over 1,600 NYSE-listed stocks that were traded by 32 institutional investors.²⁵ To measure the change in trading costs after decimal pricing was implemented, this study used data from one of the leading trade analytics firms and computed trading costs over the period from November 28, 2000, to January 26, 2001 (before the change to decimal pricing), and the period from January 30 to March 31, 2001 (after decimal pricing). The study found that institutional trading costs appeared to have

²³We do not present the specific analysis of ITG's data because the firm's client base for its trade cost analysis grew significantly after it first began offering this service, including the addition of some larger clients with sophisticated trading operations that contributed to the overall decline measured by the firm.

²⁴According to an academic recognized as an expert in financial markets' use of information technology, studies based on direct measurements of institutional trading costs, such as data compiled by trade analytics firms and exchanges, lead to more reliable calculations of trading costs than do studies that rely on indirect determinants.

²⁵Sugato Chakravarty, Venkatesh Panchapagesan, and Robert A. Wood. "Has Decimalization Hurt Institutional Investors? An Investigation into Trading Costs and Order Routing Practices of Buy-Side Institutions" (Unpublished study: May 28, 2003).

declined by about 5 cents per share (or about 11 percent), falling from 44 cents per share to 39 cents per share after NYSE switched to 1-cent ticks.

The other study that used direct measures of institutional trading costs examined the trading of over 1,400 NASDAQ stocks.²⁶ The author of this study obtained data on over 120,000 orders for NASDAQ stocks submitted by institutional investors, which allowed her to calculate the costs of trading orders of more than 9,999 shares before and after NASDAQ's adoption of 1-cent ticks. Given the potentially large volume of order data, the author studied three sample periods, each consisting of 5 trading days: February 1 through 8, 2001 (before decimalization), and June 18 through 22 and November 26 through 30, 2001 (after decimalization). Trading costs in this study are measured as the difference between an order's volume-weighted average execution price and a pre-execution benchmark price, the opening midquote (the midpoint between the quoted bid and ask prices). Using the opening midquote benchmark, the author found that average trading costs for orders of 10,000 shares and above fell about 19 cents per share (or about 49 percent), from about 39 cents per share to about 20 cents per share during the 9 months or so after NASDAQ's adoption of 1-cent ticks.

²⁶Ingrid M. Werner, "Execution Quality for Institutional Orders Routed to NASDAQ Dealers Before and After Decimals, Study Prepared for the Fisher College of Business, The Ohio State University" (October 20, 2003).

Unlike the other two studies we identified, the third study reported that costs for institutional investors had increased. However, this study relied on an indirect measure of these costs for its analysis.²⁷ To assess the change in trading costs, the authors of this study examined a sample of 265 mutual funds chosen from a database of mutual funds compiled by Morningstar, an independent investment research firm. These firms were selected using two criteria—investing predominantly in U.S. stocks and having at least 90 percent of assets invested in stocks. However, the study did not obtain these mutual funds’ actual trading data but instead attempted to identify costs by comparing the funds’ daily returns (gain or loss from the prior day’s closing price) to the daily returns of a synthetic benchmark for the periods before and after decimalization, from April 17 through August 25, 2000, and from April 16 through August 24, 2001.²⁸ After finding that the returns of actively managed mutual funds were generally lower than the returns of the benchmark in the period after decimals were introduced, the authors attributed the lower returns to increases in the trading costs for these funds.

Although this is a plausible explanation for these funds’ lower returns, some of the market participants that we spoke with indicated that other factors could also account for the results. For example, officials from a large mutual fund company that had reviewed the study told us that the lower returns may have resulted from the 3-year decline in stock prices in the market. As the value of their assets decline, funds can report higher expenses because their fixed operating costs correspondingly represent a larger portion of a mutual fund’s total costs, which would reduce reported returns. In addition, an academic regarded as an expert in applying technology to the financial markets noted that the lower returns could be the result of many of the funds in the study’s sample having similar holdings that all performed more poorly than those in the benchmark portfolio in the months following decimalization.

²⁷Nicolas P.B. Bollen and Jeffrey A. Busse, “Tick Size, Trading Costs, and Mutual Fund Performance” (Unpublished study: 2004).

²⁸The authors constructed a synthetic benchmark that mimics the stock holdings and expense ratios of the actual mutual funds they studied. Because the benchmark portfolio has zero trading costs by construction, the difference between the return on the benchmark and the actual funds was the authors’ measure of trading cost.

Institutional Investors Reported Reduced or Level Trading Costs after Decimalization

In addition to analyzing data from trade analytics firms and academic studies, we interviewed 23 institutional investors that represented nearly one-third of assets managed by a ranking of the 300 largest money managers.²⁹ Representatives for 20 of these firms said that their trading costs had fallen or stayed about the same since decimals were implemented (table 4).

Table 4: Institutional Investor Positions on Changes to Trading Costs After Decimalization

Trading cost change	Institutional investors	
	Number	Percent
Declined	15	65%
Increased	3	13
Stayed about the same	5	22
Total	23	100%

Source: GAO.

Note: Percentages rounded to the nearest full number.

As shown in table 4, fifteen of these firms said that their trading costs had declined since decimals were introduced. These firms included large mutual fund companies, pension fund administrators, a hedge fund, and smaller asset management firms, indicating that cost declines in our sample were not limited solely to just larger firms with greater trading resources. For example, a representative of a small money management firm not ranked as one of the 300 largest noted that trading costs had decreased since decimalization. In addition, the president of a hedge fund that was ranked in the lower half of the rankings told us that his firm's trading costs had declined significantly since 2001. As shown in the table above, 5 of the 23 firms we interviewed said that their costs had remained about the same since decimal pricing was implemented. For example, representatives of one large mutual fund firm that measures its trading costs internally as well as through a trade analytics firm told us that their

²⁹This ranking was published in *Institutional Investor*, vol. 38, no. 7 (July 2004). The firms we interviewed represented a broad cross section of the institutional investor community, including representatives of the four largest money managers in the United States in 2003, four large public pension plan administrators, two large hedge funds, and other large, mid-size, and small money managers with assets under management ranging from about \$2 billion to \$500 billion.

firm's transaction costs had not increased since decimal pricing was introduced, but had trended down to flat. Three institutional investors reported higher trading costs. One of these firms, a large mutual fund manager, attributed the increases to heightened levels of volatility following the reduction in tick size. For example, in his view, stock prices tended to trade in a wider daily range since decimals were implemented than they had before. The other two firms included a mutual fund firm and a mid-size asset management firm, with officials from the mutual fund noting that trading had become more involved and that completing trades of similarly sized orders takes longer since the conversion to decimal pricing.

In discussing institutional investors' views on their trading costs since decimal pricing began, we found that the precision with which these firms measured their trading costs varied. Many firms told us that they used outside trade analytics firms, such as Abel/Noser, Elkins/McSherry, ITG, and Plexus Group, to measure their transaction costs. Representatives of some firms and a state pension plan administrator noted that their firms used trade cost analysis tools from more than one trade analytics firm. The head of trading for one firm said that his firm had been using a trade analytics firm to measure their trading costs for 10 years. Some firms said that they had developed in-house capabilities to measure their own transaction costs. These systems appeared to vary in their levels of sophistication. For example, representatives of a large money management firm told us that they had developed a sophisticated cost measurement system that shows them what a trade should cost before it is executed. The system takes into account factors such as the executing broker and the market venue where the trade executes. A managing partner of another firm noted that it measures costs of completed trades in-house, including the bid-ask spreads and the execution prices, and compares them to the volume-weighted average price for trades it executes. Some money managers told us that their firms did not measure their costs for trading. For example, officials from one firm said that while not formally measuring costs on their own, they sometimes were provided with data on the costs of their trades from their own clients who use trade analytics firms to evaluate the costs of using various money managers. Also, another state pension plan administrator told us that while his organization does not currently measure its trading costs, it plans to do so within the next 2 years.

Volatility Has Also Improved since Decimal Pricing Began

In addition to lower spreads and reduced market impact costs, some market participants noted that another measure of market quality—price volatility—had also improved since decimal pricing was implemented. According to some market participants, the smaller 1-cent ticks generally slowed price movement in the markets and narrowed the range of prices at which stocks trade over the course of time, such as a day. For example, a noted expert on market microstructure told us that price volatility has declined since the reduction in tick size because price changes occur in smaller increments.³⁰ Our own study of NYSE and NASDAQ stocks using TAQ data showed that price volatility has declined since decimal pricing was implemented. To assess the change in volatility for the stocks in our sample, we calculated the percentage change in price for each one hour increment (between 10 a.m. and 4 p.m.) each trading day. We also calculated the percentage change in price for each stock that occurred between 10 a.m. and 4 p.m. For each stock, we also calculated the standard deviation of these percentage changes, which measures how widely the individual price changes are dispersed around the average change, and reported the median (that is the middle) standard deviation. As shown in table 5, the volatility of the price changes in the stocks in our sample decreased for both the hourly percentage change between 10 a.m. and 4 p.m. each trading day and the percentage change from 10 a.m. to 4 p.m. each trading day after decimal prices were implemented. These findings were in agreement with a recently published academic study.³¹

³⁰Market microstructure is the study of the process of how the trading of securities affects prices, volumes and trader behavior.

³¹See Hendrik Bessembinder, “Trade Execution Costs.”

Table 5: Price Change Volatility for NYSE and NASDAQ Stocks Before and After Decimalization

Price change period	Median standard deviation of price changes			
	NYSE stocks		NASDAQ stocks	
	Before decimals	After decimals	Before decimals	After decimals
Hourly	1.00%	0.79%	0.97%	0.75%
From 10 a.m. to 4 p.m.	2.48	1.99	2.37	1.87

Source: GAO analysis of TAQ data.

Note: The median standard deviation in this table is based on the continuously compounded percentage change in the quote midpoint for each stock.

However, not all participants attributed the reduced price volatility to decimal pricing. For example, a representative of a trade analytics firm noted that with the Internet boom, investors increased their positions in technology-sector stocks in a hurry and when the prices of these stocks fell—which was coincident with the change to decimal pricing—investors quickly reversed their positions. By selling quickly, these investors incurred greater market impact costs. With the subsiding of this type of trading activity in ensuing years, markets have become calmer, which has made trading less costly.

Despite Reduced Market Transparency for Large Orders, Institutional Investors Have Been Able to Complete Trades

Although some major elements of market quality—trading costs and volatility—have improved since decimal pricing began, another market quality element—transparency—appears to have been negatively affected. The transparency of a market can depend on whether large numbers of shares are publicly quoted as available to buy or sell. The various sources of data we collected and analyzed indicated that after decimal pricing and the 1-cent tick were implemented in 2001, the volume of shares shown as available for sale—or displayed depth—on U.S. stock markets declined significantly. For example, studies required by SEC on the impact of decimal pricing on trading, among other things, on U.S. markets showed that the average number of shares displayed for trading on NYSE and NASDAQ at the best quoted prices declined by about two-thirds between a

sample period before the markets converted to decimal pricing and a period soon after the conversion took place (table 6).³²

Table 6: Average Number of Shares Displayed at the Best Quoted Prices Reported by NYSE and NASDAQ in Studies of Their Markets Before and After Decimalization

Market	Average shares displayed before	Average shares displayed after	Percent change
NYSE ^a	7,930	2,657	-67%
NASDAQ ^b	13,974	4,539	-68

Source: GAO analysis of NYSE and NASDAQ data.

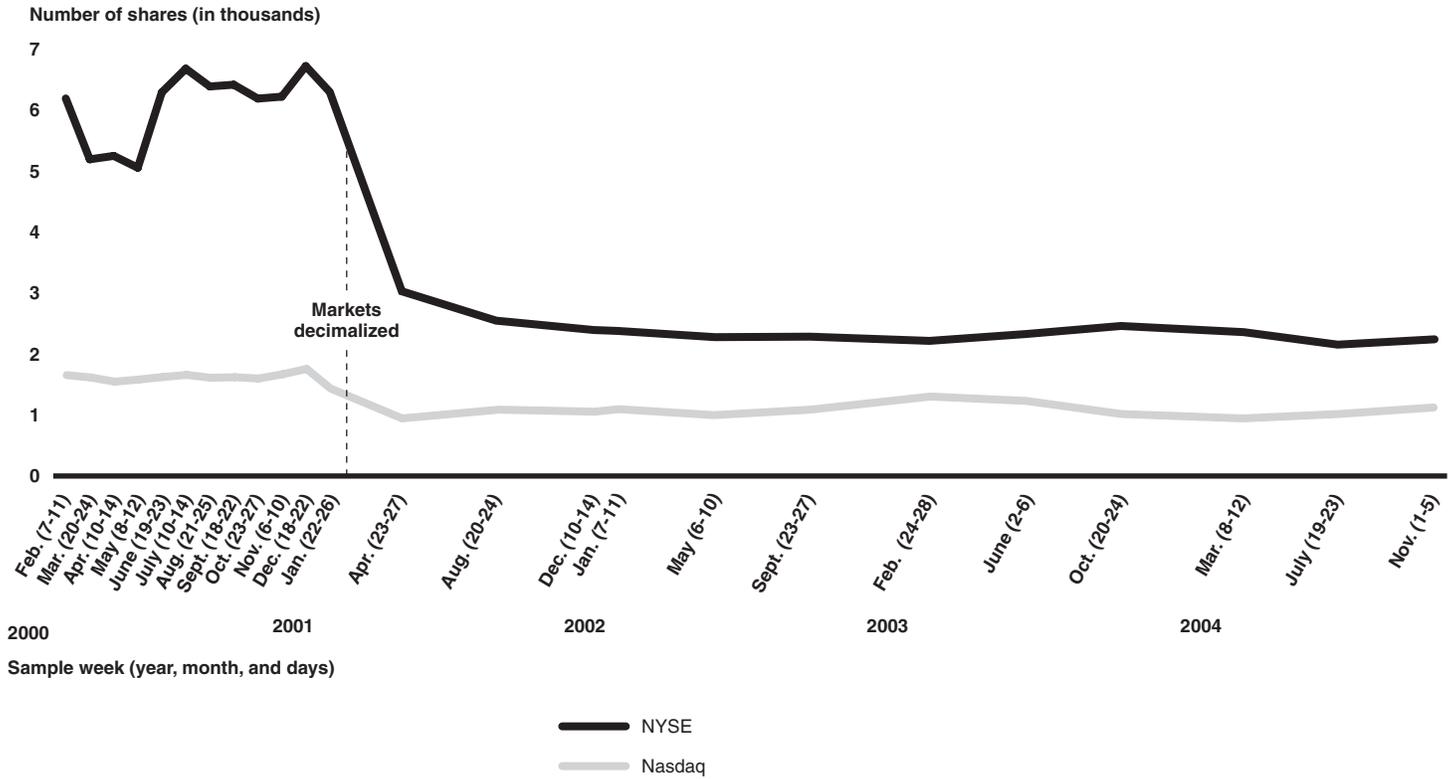
^aAverages on NYSE are trade weighted. Averages are for all 2,466 NYSE-listed securities trading in both sample periods. NYSE's presample period is August 1-25, 2000; its postsample period is June 2001.

^bAverages are for 4,766 NASDAQ-listed securities that converted to decimal pricing on April 9, 2001. Another 211 securities converted to decimal pricing earlier. NASDAQ's pre sample period is the 2 weeks prior and 2 weeks after the conversion date.

In addition, our own study of 300 matched pairs of NYSE and NASDAQ stocks found that the liquidity at the best quoted prices declined significantly. According to our analysis, the average number of shares displayed at the best quoted prices fell by 60 percent on NYSE and 34 percent on NASDAQ over the nearly 5-year period between February 2000 and November 2004 (fig. 8). The greatest declines occurred around the time that the markets converted to decimal pricing and 1-cent ticks. In its impact study, NASDAQ attributed declines in the volume of shares displayed at the best prices to the conversion to decimal pricing.

³²New York Stock Exchange, Inc., *Decimalization of Trading on the New York Stock Exchange, A Report to the Securities and Exchange Commission*, 9. Also see NASDAQ Stock Market, Inc., *The Impact of Decimalization on The NASDAQ Stock Market: Final Report to the SEC*, 33.

Figure 8: Volume-weighted Average Number of Shares Displayed at the Best Quoted Prices on the NYSE and NASDAQ Before and After Decimalization, Sample Weeks from February 2000–November 2004



Source: GAO.

The amount of shares displayed as available for trading also declined at prices away from the best quoted prices. For example, the SEC-mandated NYSE impact study shows that the amount of shares displayed for trading within about a dollar of the midpoint between the best quoted prices generally declined to well under half of what it was when the tick size was 1/16 of a dollar. NASDAQ's own impact study reported that the cumulative amount of shares displayed for trading declined by about 37 percent within a fixed distance equal to twice the size of the average quoted spread from the midpoint between the best quoted prices.³³ This decline in the volume of shares displayed across all prices—called market depth—is particularly significant for institutional investors because they are often executing large orders over multiple price points that are sometimes inferior to the best quoted prices.

Various reasons can explain the reduced number of shares displayed at the best prices. First, the amount of shares displayed for trading at the best price likely declined because the decrease in the minimum tick size created more prices at which orders could be displayed. The reduction in tick size increased the number of price points per dollar at which shares could be quoted from 16, under the previous minimum tick size of 1/16 of a dollar, to 100. With more price points available to enter orders, some traders that may have previously priced their orders in multiples of 1/16 to match the best quoted price may now instead be sending orders priced 1, 2, or 3 cents away from the best price, depending on their own trading strategy. As a result, the volume of shares displayed as available at the best price is lower as more shares are now distributed over nearby prices.

In addition to fewer shares displayed at the best price, displayed market depth may also have declined because the reduction in tick size reduced incentives to large-order investors to display their trading interest. Since the implementation of penny ticks, market participants said that displaying large orders is less advantageous than before because other traders could now submit orders priced one penny better and execute these orders ahead of the larger orders. This trading strategy, called “penny jumping” or “stepping ahead,” harms institutional investors that display large orders

³³NASDAQ used the average quoted spread from January 2001, before the market converted to decimal pricing, to study the cumulative number of shares that were displayed before and after decimalization.

and can increase their trading costs.³⁴ For example, an investor wants to purchase a large quantity of shares of a stock (e.g., 15,000 shares) and submits an order to buy at a price of \$10.00 (a limit order).³⁵ Another trader, seeing this large trading interest, submits a smaller limit order (e.g., 100 shares) to buy the same stock at \$10.01. This smaller order will be executed against the first market order (which are orders executed at the best price currently prevailing at the time they are presented for execution) that arrives. As a result, the investor's larger order will go unexecuted until that investor cancels its existing order at \$10.00 and resubmits it at a higher price. In this case, the investor's trading costs increase due to price movements that occur in the process of completing a large order (i.e., market impact).

The potential for stepping ahead has increased because in a 1-cent tick environment the financial risk to traders stepping ahead of larger displayed orders has been greatly reduced. For example, assume a trader who steps ahead of a larger order offering to buy shares at \$10.00 by entering a limit order to buy 100 shares at a price of \$10.01 is executed against an incoming market order. However, if the price of the stock appears to be ready to decline, such as when additional orders to sell are entered with prices lower than \$10.00, the trader who previously stepped ahead can quickly enter an order to sell the 100 shares back to the large investor whose order is displayed at \$10.00. In such situations, the trader's loss is only one penny per share, whereas in the past, traders stepping ahead would have risked at least 1/16 of a dollar per share. Many market participants we spoke to acknowledged that institutional investors are reluctant to display large orders in the markets following the switch to 1-cent ticks for fear that competing traders would improve the best quoted prices by one penny and drive up prices to execute large orders.

³⁴In a related matter, on April 6, 2005, the SEC Commission adopted Regulation NMS (National Market System), which included a ban on quotations in increments of less than one penny (known as subpenny pricing) for stocks priced \$1 and above. In prior GAO work, we found that quoting in subpenny increments resulted in more instances of traders "stepping ahead" of large limit orders. For additional information on subpenny pricing, see GAO's testimony *Securities Markets: Preliminary Observations on the Use of Subpenny Pricing*, GAO-04-968T (Washington, D.C.: July 22, 2004).

³⁵An order that specifies a particular price at which it can be executed is called a limit order. Limit orders are required to be executed at the specified price or better. Limit orders provide liquidity to markets.

The potential that the reduced tick size would increase the prevalence of stepping ahead was acknowledged prior to decimal pricing's implementation. For example, in 1997 a prominent academic researcher predicted that problems with stepping ahead would increase following decimalization because smaller price increments would make it easier (i.e., cheaper) for professional traders to step in front of displayed orders and that this would result in fewer shares being quoted and less transparency in the markets.³⁶ However, some market participants we interviewed acknowledged that stepping ahead had been a problem before decimal pricing was implemented. For example, representatives of a hedge fund told us they were worried about getting stepped ahead of if they revealed their interest to trade large amounts of a stock by entering limit orders with large numbers of shares even when ticks were 1/8 and 1/16. An SEC staff person told us that instances of orders being stepped ahead of has increased since the penny tick was implemented, but he did not think that it negated the benefits of decimal pricing overall.

Institutional Investors Have Adjusted Their Trading Methods to Continue Executing Large Orders

Although markets became less transparent following decimalization, institutional investors and traders appear to be able to execute large orders at a lower cost by adapting their trading strategies and technologies. For example, the academic study that studied around 120,000 large orders submitted for NASDAQ stocks found that the average proportion of total order size that was executed (filled) increased slightly from 78 percent before the change to decimal pricing to about 81 percent about 6 months following the change. Similarly, the study found the length of time required to fill orders—measured from the time the order arrived at a NASDAQ dealer to the time of the last completed trade—decreased from about 81 minutes before decimal pricing to about 78 minutes 6 months after.³⁷ Eight of the institutional investment firms we contacted for this report also provided information about their experiences in completing trades. Of these, officials from seven of the eight told us that their fill rates had either stayed about the same or had increased. An official at one firm noted that the proportion of orders that were completely executed had risen by as much as 10 percent in the period following decimal pricing's introduction.

³⁶Lawrence Harris, *Decimalization: A Review of the Arguments and Evidence*, USC Working Paper (Los Angeles, Calif.: Apr. 3, 1997), i.

³⁷Ingrid M. Werner, 17 and 26.

One of the ways that institutional investors have adapted their trading strategies to continue trading large orders is to break up these orders into a number of smaller lots. These smaller orders can more easily be executed against the smaller number of shares displayed at the best prices. In addition, not displaying their larger orders all at once prevents other traders from stepping ahead. Evidence of this change in investors' trading strategy is illustrated by the decline in the average executed trade size on NYSE and NASDAQ. As table 7 shows, the average size of trades executed on these markets has declined about 67 percent since 1999 on NYSE and by about 41 percent on NASDAQ.

Table 7: Average Trade Size for NYSE and NASDAQ, 1999–2004 (in shares)

Market	1999	2000	2001	2002	2003	2004	Percent change 1999– 2004
NYSE	1,205	1,187	907	666	488	393	-67%
NASDAQ	808	693	782	735	580	477	-41

Source: GAO analysis of NYSE and NASDAQ data.

With average trade size down, some market participants noted that at least 4 to 5 times as many trades are required to fill some large orders since decimalization. For example, a representative of a large mutual fund company said that his traders have always broken their funds' large orders up into smaller lots so that they could trade without revealing their activity to others in the marketplace. Before decimalization, completing an order may have required 10 trades, but following the change to decimal pricing a similar order might require as many as 200 smaller trades. Referring to the increased difficulty of locating large blocks of shares available for trading, one representative of a money management firm stated that "decimalization changed the trading game from hunting elephants to catching mice." In fact, the number of trades that NYSE reported being executed on its market increased more than fourfold between 1999 and 2004, rising from about 169 million trades to about 933 million trades.³⁸

Institutional Investors Increasingly Use Electronic Trading and Alternative Trading Venues

To facilitate the trading of large orders while minimizing market impact costs, many market participants said that they had increased their use of electronic trading techniques. Many of these techniques involve algorithmic execution strategies, which are computer-driven models that segment larger orders into smaller ones and transmit these over specified periods of time and trading venues. The simplest algorithms may just break a large order into smaller pieces and route these to whichever exchange or alternative trading system offers the best price. Institutional investors often obtain these algorithms as part of systems offered by broker-dealers and third-party vendors. They may also develop them using their own staff and integrate them into the desktop order management systems they use to help conduct their trading.

One of the primary purposes of using these algorithmic trading systems is to conduct trading in a way that prevents other traders from learning that a large buyer or seller is active in the market. Institutional investors want tools that allow them to trade more anonymously to reduce the extent to

³⁸Data on the volume of trades executed on NASDAQ for this period was not comparable to that from NYSE because trades in NASDAQ stocks were increasingly being executed outside this market. The declining trading volumes being reported by NASDAQ were the result of alternative trading venues, such as ECNs, executing increasing portions of volume in NASDAQ shares but reporting these trades outside the NASDAQ trade reporting system. For example, trades executed by the Island ECN were previously reported to NASDAQ and were included in NASDAQ's total trading volume statistics. However, in 2002 Island began reporting its trades instead through the Cincinnati Stock Exchange (now called the National Stock Exchange), which caused a reduction of over 20 percent in trades that NASDAQ reported as being executed within its market.

which others can profit at their expense, such as when other traders, realizing that a large buyer is active, also buy shares, which quickly causes prices to rise, in hopes of selling these now more expensive shares to this large buyer. Several market participants told us that the anonymity that algorithms provide reduces the potential for other traders to learn that a large buyer or seller is active in the market (known as information leakage), thus reducing the likely market impact of executing the entire order.

The use of these tools is growing. A 2004 survey conducted by The Tabb Group, a financial markets' consulting firm, of more than 50 head and senior traders at institutional investor firms reported that over 60 percent of these firms were using algorithmic trading vehicles.³⁹ The report noted that this widespread adoption rate was higher than anticipated. Many of the market participants we contacted also told us they were actively using algorithms in their trading activities and those that were not currently using algorithms generally indicated that they planned to begin using them in their trading strategies in the near future. In its report, The Tabb Group predicted that algorithmic trading will grow by almost 150 percent over the next 2 years.

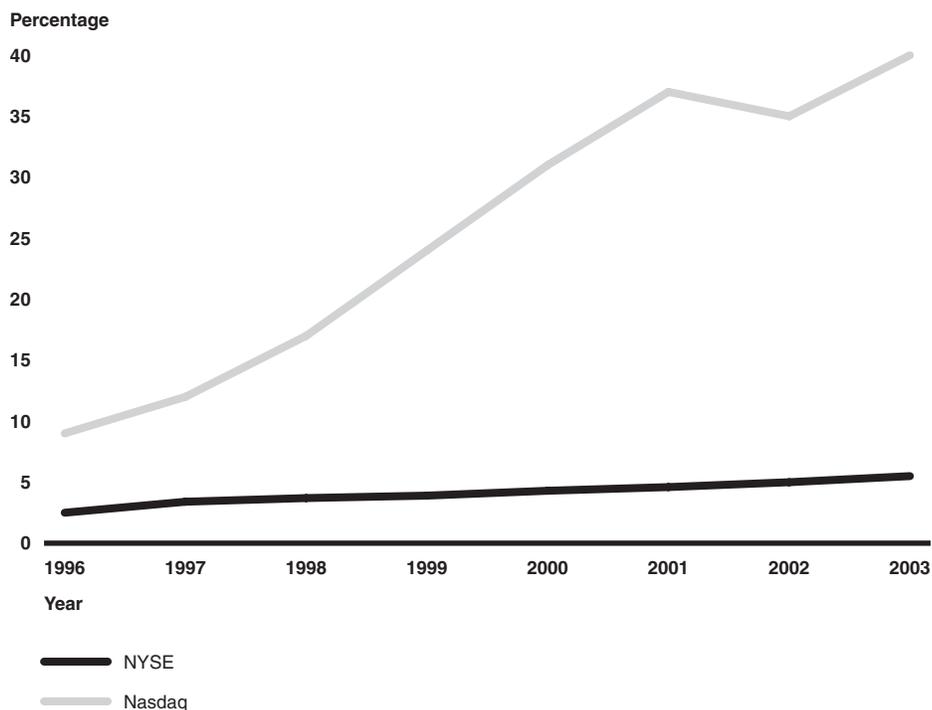
To locate the additional shares available for trading that are otherwise not displayed, institutional investors are also increasingly using alternative trading venues outside the primary markets, such as NYSE and NASDAQ, to execute their large orders at lower cost. For example, institutional investors are conducting increasing portions of their trading on ECNs. Originally, ECNs were broker-dealers that operated as real-time electronic trading markets by allowing their customers to enter orders for stocks and obtain executions automatically when the prices of the orders entered matched those of orders entered by other customers. Recently, ECNs have entered into formal associations with existing stock exchanges.⁴⁰

³⁹See The Tabb Group, *Institutional Equity Trading in America: A Buy-Side Perspective*. (Westborough, Mass.: April 2004), 32.

⁴⁰For example, in 2001 SEC approved the establishment of the Archipelago Exchange as the stock trading facility of the Pacific Exchange. See SEC, PCX Rulemaking: Order Approving Proposed Rule Change by the Pacific Exchange, Inc., as Amended, and Notice of Filing and Order Granting Accelerated Approval to Amendment Nos. 4 and 5 Concerning the Establishment of the Archipelago Exchange as the Equities Trading Facility of PCX Equities, Inc., Exchange Act Release No. 44983 (October 25, 2001), 66 Fed. Reg. 55225 (2001).

Use of ECNS has been a growing trend. According to The Tabb Group, 88 percent of the institutional investor firms it surveyed responded that they traded using ECNs. Furthermore, a 2004 survey by *Institutional Investor* magazine asked the trading staff of institutional investor firms to identify their preferred venues for executing stock trades. The survey reported that three of the top five trading venues for institutional stock trade execution were ECNs.⁴¹ According to data we obtained from a financial markets consulting firm, the share of ECN trading in NASDAQ and NYSE stocks has increased between 1996 and 2003. For example, ECN trading volume increased from about 9 percent of all NASDAQ trading in 1996 to about 40 percent of total NASDAQ trading volume in 2003 (fig. 9).

Figure 9: Proportion of Total Share Trading Volume NASDAQ and NYSE Stocks by ECNs, 1996–2003



Source: GAO analysis of Celent Communications data.

⁴¹Justin Shack, “The Orders of Battle,” *Institutional Investor*, vol. 38, no. 11, November 2004, 82.

The percent of trading volume for NYSE stocks conducted through ECNs has also increased, though to a much lesser degree than has these organizations' trading in NASDAQ stocks. According to some market participants, ECNs have been less successful in gaining greater market share in NYSE stocks because of rules that result in most orders being sent to that exchange. For example, one regulation—the trade through rule—requires that broker-dealers send orders to the venue offering the best price, and in most cases NYSE has the best quoted price for its listed stocks. However, in a report issued by a financial market consulting firm, ECN officials called the trade through rule anticompetitive because the rule fails to acknowledge that some investors value the certainty and speed of execution more than they do price. They noted that under current rules, the NYSE specialists have as long as 30 seconds to decide whether to execute an order sent to them or take other actions. During this time, market participants told us that the price of the stock can change and their order may not be executed or will be executed at an undesirable price. On April 6, 2005, SEC approved Regulation NMS (National Market System) which, among other things, limits the applicability of trade through requirements to quotes that are immediately accessible.⁴²

⁴²Regulation NMS was originally proposed for public comment in February 2004. Exchange Act Release No. 49325 (Feb. 26, 2004), 69 Fed. Reg. 11126 (2004). The SEC extended the period for comment and issued a supplemental release regarding Regulation NMS in May 2004. Exchange Act Release No. 49749 (May 20, 2004), 69 Fed. Reg. 30142 (2004). SEC repropoed a revised Regulation NMS in December 2004. Exchange Act Release No. 50870 (Dec. 16, 2004), 69 Fed. Reg. 77424 (2004). Changes to the trade through rule (now known as the Order Protection Rule) are to be implemented for a limited number of stocks beginning April 10, 2006, and for all National Market System stocks by June 12, 2006.

Institutional investors we spoke with highlighted anonymity, speed, and the quality of the prices they receive as reasons for their increased use of ECNs. The respondents to The Tabb Group survey indicated that their firms used ECNs to reduce market impact costs and to take advantage of lower fee structures. Many market participants we interviewed and studies we reviewed also indicated that trading using ECNs lowered institutional trading costs. According to market participants we interviewed, decimalization accelerated technology innovation, which they believe has been significant in reducing trading costs primarily by providing a means for investors to directly access the markets and reducing the need for intermediation. However, many acknowledged that increasing use of ECNs has been a growing trend since 1997, when SEC implemented rule changes that allowed ECNs to better compete against NASDAQ market makers.⁴³

Other alternative trading venues that institutional investors are increasingly using to execute their large orders are block trading platforms operated by broker-dealers called crossing networks. These networks are operated by brokers such as ITG, Liquidnet, and Pipeline Trading Systems. Crossing networks generally provide an anonymous venue for institutional investors to trade large blocks of stock (including orders involving tens or hundreds of thousands of shares) directly with other institutional investors. For example, one crossing network integrates its software with the investor's desktop order management system so that all of the investor's orders are automatically submitted to this crossing network in an effort to identify a match with another institutional investor. Once a match is identified, the potential buyer and seller are notified, at which time they negotiate the number of shares and price at which a trade would occur. The heads of stock trading for two large money management firms told us an advantage of using crossing networks is that they minimize market impact costs by allowing investors to trade in large blocks without disclosing their trading interests to others in the markets. Also, the chief executive officer of a crossing network noted that the absence of market intermediaries in the negotiation of trades on crossing networks provides the customers' traders with the ability to control the price and quantity of their executions. However, we were told that crossing networks may not be the preferred

⁴³These rules include the Limit Order Display Rule (SEC Rule 11Ac1-4) and the Quote Rule (SEC Rule 11Ac1-1). Rule 11Ac1-4 mandated that public limit orders for all NASDAQ securities should be reflected in the best bid and offer disseminated by that market. Rule 11Ac1-1, states that market makers may not post one quote on NASDAQ and a different quote on an alternative quote dissemination system (i.e., ECN). These rules are known as the Order Handling Rules.

strategy for all kinds of institutional orders because orders remain unexecuted if a natural match cannot be found.

Crossing networks are gaining in prominence among institutional investors as a destination of choice for trading large quantities of stock. According to The Tabb Group's survey of head and senior traders, 70 percent of all firms reported using crossing networks.⁴⁴ In *Institutional Investor's* 2004 survey, Liquidnet, a crossing network established in 2002, ranked second on the list of institutional investors' favorite venues for trade executions.⁴⁵

Despite advances in electronic trading technologies that give institutional investors increased access to markets, some institutional investors continue to use full-service brokers to locate natural sources of liquidity as they did before decimal pricing began. According to institutional investor officials we interviewed, with fewer shares displayed as available for trading and reductions in average trade size, they are more patient about the time required to completely execute (fill) large orders using brokers in this way. In addition, some noted they increasingly use NYSE floor brokers to facilitate the trading of large orders in less-liquid stocks, explaining that floor brokers have information advantages in the current market structure that help to minimize adverse price changes.

Market Conditions May Also Have Helped Lower Institutional Investors' Trading Costs

In addition to increased use of electronic trading, overall market conditions also likely helped lower trading costs for institutional investors. For example, prices on U.S. stock markets began a multiyear downturn around 2000. As stock prices declined, asset managers faced increased pressure to manage costs and boost investment returns. Representatives of all four leading firms we interviewed that analyze institutional investors' trading activity noted that the declining market that persisted after the implementation of decimal pricing also had led to reduced costs. Representatives of two of these trade analytics firms noted specifically that institutional buyers and sellers appeared more cost sensitive as a result of the 3-year declining stock market, which caused investment returns to decline substantially. This increased the incentive for institutional investors to take actions to lower their trading costs as a way to offset some of the reduced market returns.

⁴⁴The Tabb Group, *Institutional Equity Trading*, 29.

⁴⁵Shack, "Orders of Battle," 82.

Some Stock Intermediaries Have Experienced Lower Profits since Decimalization, but Other Factors Have Contributed to the Declines

Although overall securities industry profits have returned to levels similar to those in the past, some market intermediaries, particularly those broker-dealers acting as exchange specialists and NASDAQ market makers, have been significantly affected by the implementation of decimal pricing. Between 2000 and 2004, exchange specialists and NASDAQ market makers generally saw their revenues and profits from stock trading fall, forcing some smaller market intermediaries out of the market. Decimal pricing was not the only force behind these declines, however. Sharp declines in the overall level of prices in the stock market, the growing use of trading strategies that bypass active intermediary involvement, and heightened competition from ECNs and other electronic trading venues have affected revenues and profits. We found that intermediaries were adapting to the new conditions by changing their business practices—for example, by investing in electronic trading devices and data management systems, reducing the size of their trading staffs, or changing how they priced their services. In response to the negative conditions that some believe exist in U.S. stock markets, a proposal has been made to conduct a pilot test of the use of a higher minimum tick for trading. Many of the market intermediaries but fewer than half of the institutional investors we contacted favored this move.

Conditions in the Overall Securities Industry Appear to Be Improving

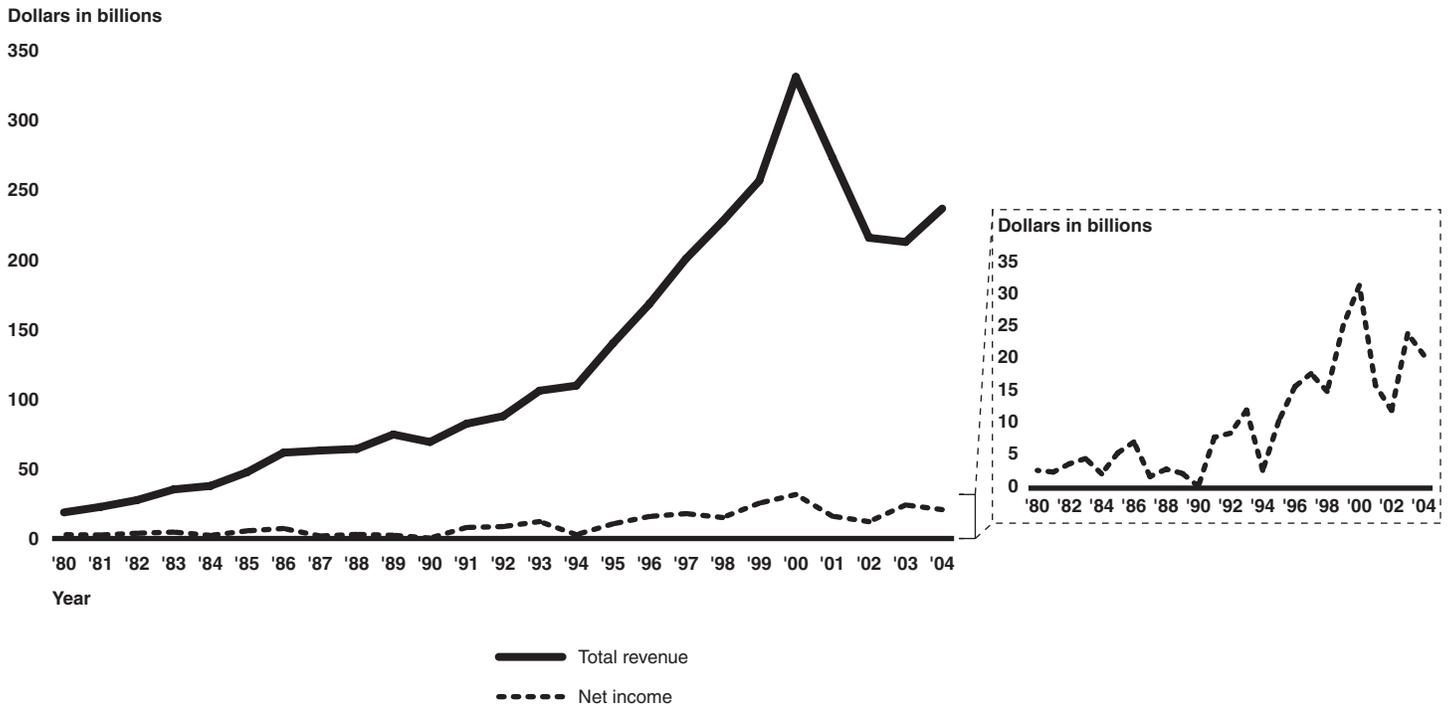
The business environment for the securities industry as a whole, which saw reduced revenues after 2000, appears to be improving. The Securities Industry Association (SIA), which represents the broker-dealers holding the majority of assets in the securities industry, has compiled data on all of its member broker-dealers that have conducted business with public customers in the United States over the last 25 years.⁴⁶ As shown in figure 10, the data SIA compiles are derived from filings broker-dealers are required to make with the SEC and detail, among other things, revenues and expenses for market activities such as trading in stocks, debt securities, and options and managing assets.⁴⁷ SIA's 2004 data show that industry revenues of \$237 billion, while down from the height of the bull market in 2000, are now similar to revenues earned before the unprecedented gains of 2000.⁴⁸ In addition, the industry's total pretax net income of \$24.0 billion in 2003 and \$20.7 billion in 2004 represent some of the highest levels of pretax industry profits of the past 25 years.

⁴⁶SIA has approximately 600 members. SIA members include most of the largest U.S. broker-dealers.

⁴⁷These filings are the Financial and Operational Combined Uniform Single (FOCUS) reports.

⁴⁸A bull market is a market in which stock prices rise over a sustained period of time.

Figure 10: Securities Industry Total Revenues and Net Income, 1994–2004



Source: Securities Industry Association.

Further, our review indicated these improved industry conditions are not only the result of improved performance among the largest firms. By examining the trend in this data after excluding the results for the 25 largest broker-dealers, the revenue and net-income trend for the remaining firms revealed the same pattern of improvement.

Decimalization Has Negatively Affected Exchange Specialists

Despite these improvements, some market intermediaries, such as stock exchange specialists, have been negatively affected by the shift to decimal pricing. Stock exchange specialists buy or sell shares from their own accounts when insufficient demand exists to match orders from public customers directly. The lower spreads that have prevailed since decimal pricing have reduced the income that exchange specialists can earn from this activity. In addition, the number of shares displayed as being available for purchase or sale has declined, leaving specialist firms with less information about market trends and thus less ability to trade profitably.⁴⁹ According to NYSE data, between 2000 and 2004 aggregate NYSE specialist revenues declined by more than 50 percent, falling from \$2.1 billion to \$902 million (table 8).

Table 8: NYSE Specialist Firm Revenues and Profits, 1999–2004 (in millions of dollars)

Category	1999	2000	2001	2002	2003	2004
Revenues	\$1,566	\$2,136	\$1,776	\$1,645	\$987	\$902
After-tax profits	\$476	\$708	\$414	\$397	\$3 ^a	\$(38) ^b

Source: GAO analysis of NYSE data.

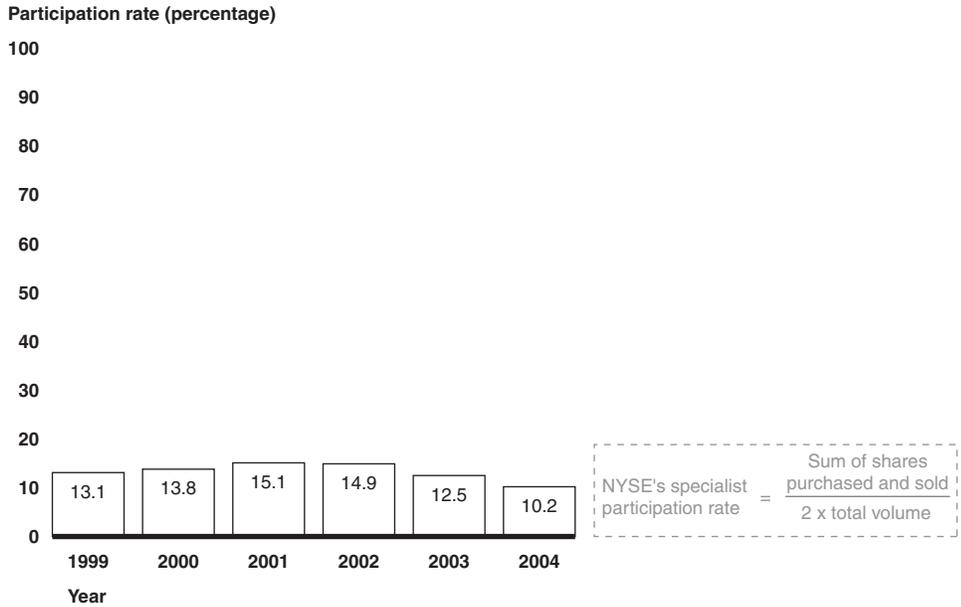
^aResult reflects the booking of approximately \$147 million in fines that NYSE specialist firms paid to settle charges with SEC and NYSE for trading violations.

^bResult reflects the booking of approximately \$109 million in fines that NYSE specialist firms paid to settle charges with SEC and NYSE for trading violations.

Further, since decimal pricing began, the extent to which specialist firms participate in trades on their own exchanges has been low, falling below predecimalization levels. The participation rate shows the percentage of the total shares traded represented by trades conducted by specialists as part of their obligation to purchase shares when insufficient demand exists or sell shares when insufficient numbers of shares are being offered. After climbing during the first year decimal pricing was implemented, the percentage of trades on NYSE in which NYSE specialists participated declined from 15.1 percent in 2001 to 10.2 percent in 2004 (fig. 11).

⁴⁹Lawrence Harris and Venkatesh Panchapagesan, "The Information Content of the Limit Order Book: Evidence from NYSE Specialist Trading Decisions," *Journal of Financial Markets*, Vol. 8 (2005).

Figure 11: NYSE Specialist Participation Rates, 1999-2004, in Percent of Trades



Source: NYSE Fact Book.

Note: These percentages are calculated by dividing the total number of shares that specialists traded by twice the total volume of the trading on the exchange to reflect that specialists are usually only either buying shares or selling shares as part of a trade with other customers.

The trend toward smaller order sizes and more trade executions that have accelerated since the introduction of decimal pricing (as discussed earlier in this report) has also impacted the operating expenses of exchange specialists. The average trade execution size on the NYSE dropped from 1,205 shares per execution in 1999 to 393 shares per execution in 2004, so that specialists now generally process more trades to execute orders than they did before decimal pricing began. This trend toward greater numbers of executions, which many market participants indicated was exacerbated by decimal pricing, has required exchange specialists to absorb additional processing costs and make related investments in more robust data management and financial reporting tools. For example, each trade that is submitted for clearance and settlement carries a fee, paid to the National

Securities Clearing Corporation, of between \$0.0075 to \$0.15 per trade.⁵⁰ Several smaller regional exchange specialist firms we spoke with highlighted these kinds of increased operating costs as significant to their ability to continue profitable operations. Additionally, a floor brokerage firm we spoke with said that other charges had contributed to its declining operating performance. These charges included those from clearing firms, which typically charge in the range of \$0.20 cents per 100 shares to process trades, and execution fees from exchange specialists related to the processing of more trades and typically paid by floor brokers.

As shown in table 9 below, average trade size has declined over the past 6 years as the number of executions on NYSE has risen. As the table shows, volumes have remained relatively consistent since 2002, even though exchange specialists and floor brokers have seen their revenue and profits decline during this period.

Table 9: NYSE Reported Trades, Average Daily Volume, and Average Trade Size, 1999–2004

Category	1999	2000	2001	2002	2003	2004
Total reported trades (in millions of shares)	169	221	339	546	723	933
Average daily share volume (in millions of shares)	809	1,042	1,240	1,441	1,398	1,457
Average trade size (number of shares)	1,205	1,187	907	666	488	393

Source: NYSE Fact Book.

⁵⁰This fee is one charged for trade recording and is assessed at \$0.0025 per share in the trade with a minimum charge of \$0.0075 and the maximum of \$0.15. For example, a trade executed for 10,000 shares would be charged the maximum of \$0.15. However, if this trade is broken into two executions of 5,000 shares each, each trade would be charged \$0.125, or a total of \$0.25, illustrating how more trades could lead to higher clearing costs.

Broker-dealers Revenues from NASDAQ Activities Have Also Fallen since Decimal Pricing Began

Decimal pricing has also generally negatively affected the profitability of firms that make markets in NASDAQ stocks. Traditionally, these firms earned revenue by profitably managing their inventories of shares and earning the spread between the prices at which they bought and sold shares. With the reduced bid-ask spreads and declines in displayed liquidity that have accompanied decimal pricing, the ability of broker-dealers to profitably make markets in NASDAQ stocks has been significantly adversely affected. For example, an official from one firm said that penny spreads had severely curtailed the amount of revenues that market makers could earn from their traditional principal trading. Table 10 presents SIA data on all NYSE members, which SIA indicates is often used as a proxy for the entire industry. As the table shows, these firms' revenues from NASDAQ market making activities, after rising between 1999 and 2000, declined about 73 percent between 2000 and 2004, falling from nearly \$9 billion to about \$2.5 billion.

Table 10: NYSE Member Broker-Dealer Revenues from NASDAQ Market Making Activities, 1999–2004 (in millions of dollars)

Category	1999	2000	2001	2002	2003	2004
Revenues	\$6,786	\$8,994	\$4,648	\$2,742	\$2,385	\$2,462

Source: SIA Databank.

Firms acting as NASDAQ market makers have also seen their operating expenses rise since decimal pricing began. Officials at one broker-dealer said that because the average trade size is smaller, market makers now generally process more trades to execute the same volume. This increase in the number of executions has required NASDAQ market makers to absorb additional processing and clearing costs. Additionally, the increased number of executions associated with decimal pricing has required some NASDAQ market makers to increase their investments in information technology systems. Table 11 shows the reduced average order size on the NASDAQ market over the past 6 years.

Declining Intermediary Profits Have Accelerated Industry Consolidation

Table 11: NASDAQ Average Trade Size, and Average Daily Volume, 1999–2004

Category	1999	2000	2001	2002	2003	2004
Average trade size (number of shares)	808	693	782	735	580	477
Average daily volume (in millions of shares)	1,071	1,752	1,923	1,754	1,702	1,808

Source: NASDAQ.

Declining revenues and increased operating expenses since the implementation of decimal pricing have encouraged some firms to merge with other entities and forced other smaller market intermediaries out of the market, accelerating a trend toward consolidation among stock exchange specialists and NASDAQ market makers. Generally, to date, two developments have contributed to the decline in the number of specialists: acquisitions of smaller firms by larger entities and, on the regional exchanges, smaller specialist firms and proprietorships leaving the business. As shown in table 12, the number of specialist firms operating on various floor-based stock exchanges has declined significantly in recent years.

Table 12: Number of Specialist Firms Operating on Selected Stock Markets, 1999–2004

Market	Number of specialist firms	
	1999	2004
Boston Stock Exchange	16	7
NYSE	25	7
Philadelphia Stock Exchange	20	3

Sources: Boston Stock Exchange, NYSE, and Philadelphia Stock Exchange.

The number of firms that make markets on NASDAQ has similarly declined. Between 2000, when 491 firms were acting as NASDAQ market makers, and 2004, the number of firms making markets in NASDAQ stocks declined to 258—a drop of more than 47 percent. According to an industry association official, NASDAQ market-making activity is increasingly not a stand-alone profitable business activity with firms but instead is conducted

to support other lines of business. For example, an official of a broker-dealer that makes markets in NASDAQ stocks told us that his firm has made no profits on its market-making operations in the last 3 years but continues the activity in order to present itself as a full-service firm to customers.

Although fewer firms are now acting as market makers, the overall NASDAQ market has not necessarily been affected. Since 2000, the number of stocks traded on NASDAQ has declined from 4,831 to 3,295, potentially reducing the need for market makers. In addition, some firms that continue to make markets have expanded the number of stocks in which they are active. For example, one large broker-dealer expanded its market-making activities from 500 stocks to more than 1,500. A NASDAQ official told us that with reduced numbers of stocks being traded, the average number of market makers per stock has increased since decimal pricing began. As shown in table 13, our analysis of data from NASDAQ indicated that although the number of NASDAQ market makers has declined, the number of firms making markets in the top 100 most active NASDAQ stocks actually grew between 1999 and 2004.

Table 13: Consolidation among NASDAQ Market Makers, 1999–2004

	1999	2000	2001	2002	2003	2004
Number of NASDAQ market makers	528	491	459	384	316	258
Market makers per top 100 NASDAQ stocks	23	25	28	32	29	63

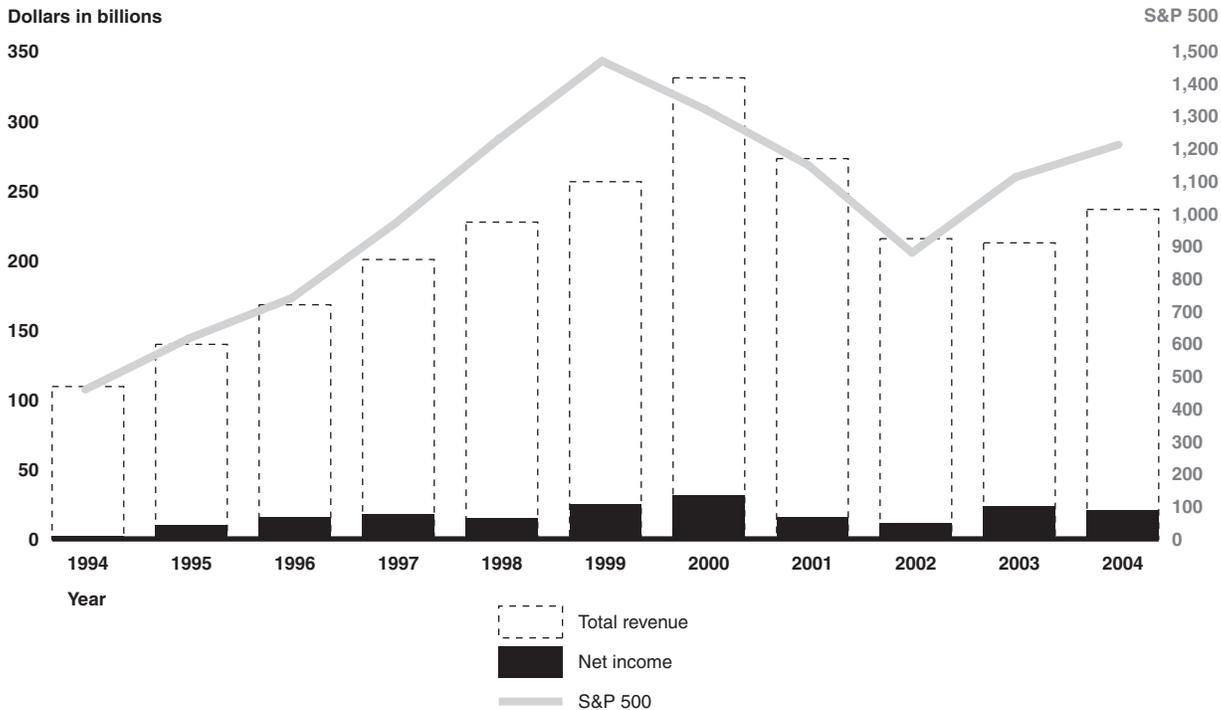
Source: NASDAQ.

Improved technology has likely helped market makers increase their ability to make markets in more stocks. An official at one market maker we spoke with explained that his firm had invested in systems that automatically update the firm's price quotes across multiple stocks when overall market prices change, allowing the firm to manage the trading of more stocks with the same or fewer staff. The use of such technology helps explain why the number of market makers per stock has not fallen as the overall number of market-making firms has declined.

Other Factors Have Contributed to Declining Intermediary Revenues and Profits

Although decimal pricing affected market intermediaries' operations, the changes in these firms' revenues, profits, and viability are not exclusively related to the reduction in the minimum tick size. One major impact on firms' revenues since 2000 has been the sharp multiyear decline in overall stock market prices. Securities industry revenues have historically been correlated with the performance of U.S. stock markets (fig. 12). After 5 consecutive years of returns exceeding 10 percent, prices on U.S. stock markets began declining in March 2000, and these losses continued until January 2003. The performance record for U.S. stocks during this period represents some of the poorest investment returns for U.S. stocks over the last 75 years. Because intermediary revenues tend to be correlated with broader stock market returns, as measured by the Standard & Poor's 500 (S&P 500) Stock Index, many market observers we spoke with told us that the 3-year down market, which coincided with the transition to decimal pricing, contributed to reduced intermediary revenues and profits.

Figure 12: Securities Industry Revenues and Net Income as Compared to the Performance of the S&P 500 Stock Index, 1994–2004



Source: Securities Industry Association.

The widespread emergence of technology-driven trading techniques, such as algorithmic trading models, has also reportedly affected market intermediaries negatively. These new techniques allow institutional investors, which account for the bulk of stock trading volume, to execute trades with less active intermediary involvement. Although only broker-dealers can legally submit trades for execution on U.S. stock markets, broker-dealers are reportedly only charging around 1 cent per share to transmit orders sent electronically as part of algorithmic trading models, an amount that represents much less revenue than the standard commission of around 5 cents per share for orders broker-dealers execute using their own trading systems and staff. Market intermediaries' revenues are also reduced by institutional investors increasing use of alternative execution venues such as crossing networks to execute trades. The commissions these venues charge are less than those of traditional broker-dealers, specialists, and market makers. Several market observers said that because

crossing networks and algorithmic trading solutions divert order flow from and create price competition for traditional broker-dealers, their increased use is a probable factor in the reduced profitability of exchange specialists, floor brokers, and NASDAQ market makers.

The increasing use of ECNs also has also likely reduced the revenues earned by market intermediaries. Several market participants we spoke with told us that the increased number of executions on ECNs, such as Bloomberg Tradebook, Brut, and INET, has reduced the profits of exchange specialists, floor brokers, and NASDAQ market makers. ECN executions are done on an agency/commission basis, typically in the range of 1 to 3 cents per share, compared with traditional broker-dealer execution fees of approximately 5 cents per share. As a result, the activities that lower investors trading costs can result in lower revenues for market intermediaries. However, market participants noted that institutional investors' use of electronic trading technologies and ECNs had been increasing even before decimal pricing was implemented.

Brokerage Firms Have Made Adjustments to Business Activities and Personnel Levels

We found that in response to the changes brought about by decimal pricing and particularly to changes in institutional investors' trading behavior, many stock market intermediaries had adapted their business operations by making investments in technology to improve trading tools and data management systems, reducing the size of their trading staffs, and changing the pricing and mix of services they offer. Most exchange specialists, floor brokers, NASDAQ market makers, and the broker-dealer staff that trade stocks listed on the exchanges we spoke with had made investments in new technology since the implementation of decimal pricing. For example, some NASDAQ market makers and listed traders were increasingly using aggregation software to locate pools of liquidity instead of relying on telephone contacts with other broker-dealers as they had in the past. Several intermediaries were also using algorithmic trading solutions more frequently to execute routine customer orders, allowing more time for their staff to work on more complex transactions or the trading of less liquid stocks.

Other intermediary firms have responded to the more challenging business environment since 2000 by reducing the size of their trading staffs. Most stock broker-dealer firms we spoke with employed fewer human traders in 2004 than they had before 2001. Senior traders at the firms we spoke with cited reduced profits and the increased number of electronic and automated executions as the primary reasons for the reductions in the

number of traders they employed. Consequently, although trades executed by broker-dealers using computer-generated algorithms typically generated lower revenues from commissions than traditional executions, the reduced salary and overhead costs associated with employing fewer traders, we were told, had made it easier for some broker-dealers to maintain viable stock trading operations.

We also found that market intermediaries were adapting to the new business environment by modifying the pricing and mix of the services they offered. For example, instead of trading as principals, using their own capital to purchase or sell shares for customers, many NASDAQ market makers have begun acting as agents that match such orders to other orders in the market. Like ECNs, these market makers charge commissions to match buy and sell orders. The agency/commission model provides the benefit of reduced risk for NASDAQ market makers because they were using less of their own capital to conduct trading activity. However, market participants told us that this activity may not generally be as profitable for market makers as traditional principal/dealer trading operations. Other firms had attempted to diversify or broaden their service offerings. For example, a NYSE floor brokerage firm we spoke with was attempting to make up for lost revenues by developing a NASDAQ market-making function.

Some firms were also expanding into other product lines. For example, one large NASDAQ market maker we spoke with was attempting to make up for declining stock trading revenue by becoming a more active market maker in other over-the-counter stocks outside those traded on NASDAQ's National Market System, including those sold on the Over-the-Counter Bulletin Board (OTCBB) market, which trades stocks of companies whose market valuations, earnings, or revenues are not large enough to qualify them for listing on a national securities market like NYSE or NASDAQ.⁵¹ These stocks often trade with higher spreads on a percentage basis than do the stocks listed on the national exchanges. Finally, other firms had moved staff and other resources formerly used to trade stocks to support the trading of other instruments, such as corporate bonds, credit derivatives, or energy futures.

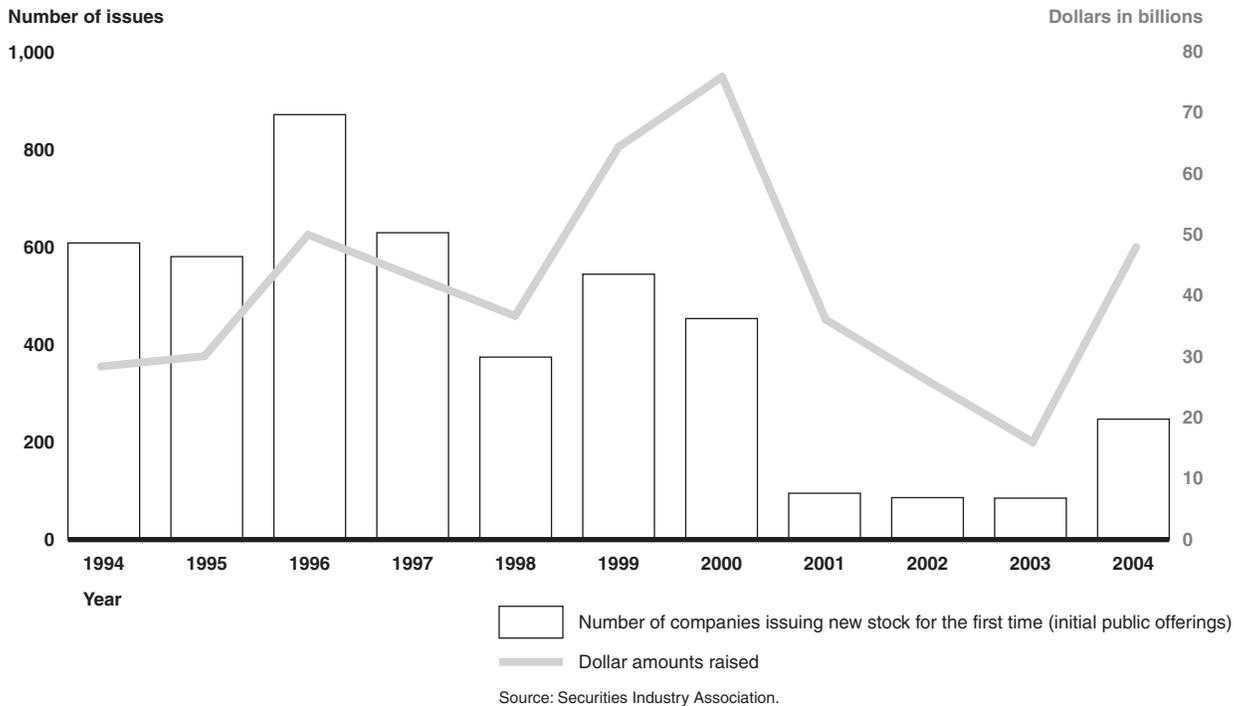
⁵¹Over-the-counter stocks are those not listed on exchanges. NASDAQ's National Market System includes the largest, most actively traded stocks.

Decimal Pricing Did Not Appear to Affect Businesses' Ability to Raise Capital

The willingness and ability of broker-dealers to assist companies with raising capital in U.S. markets also does not appear to have diminished as a result of decimal pricing. Broker-dealers, acting as investment banks, help American businesses raise funds for operations through sales of stock and bonds and other securities to investors. After the initial public offering (IPO), such securities can be traded among investors in the secondary markets on the stock exchanges and other trading venues.⁵² Several market observers had voiced concerns that the reduced displayed liquidity and declining ability of market makers to profit from trading could reduce the liquidity for newly issued and less active stocks. In turn, this loss of liquidity could make it more difficult for firms to raise capital. We found that in 2002 and 2003, U.S. stock underwriting activity was down significantly from recent years (fig. 13). However, as figure 13 shows, although stock IPOs are down from record levels of the bull market of the late 1990s, 247 companies offered stock to the public for the first time in 2004—up from the 2002 and 2003 levels of 86 and 85 companies, respectively. Additionally, stock underwriting activity measured in dollars rose to \$47.9 billion in 2004, a level consistent with activity in the late 1990s.

⁵²An IPO is the first sale of stock by a private company to the general public. This process is often called “going public” and represents the primary market. The secondary market for stocks is the market where securities are traded after they are initially offered in the primary market.

Figure 13: Number of IPOs and Dollars Raised, 1994–2004



Of the market participants that we spoke with, most did not believe that decimal pricing had affected companies’ ability to raise capital in U.S markets, noting that underwriting activity is primarily related to investors’ overall demand for stocks. More IPOs generally occur during periods with strong economic growth and good stock market performance. Institutional investors we spoke with noted that the poor growth of the U.S. economy after 2000 and the associated uncertainty about future business conditions had contributed more than decimal pricing to the reduced level of new stock issues in 2002 and 2003. Others cited the new Sarbanes-Oxley Act corporate governance and disclosure requirements, which can increase the costs of being a public company, as a factor that may be discouraging some firms that otherwise would have sought to raise capital from filing an IPO. However, one broker-dealer official said that his firm was less willing to help small companies raise capital because of its reduced ability since decimal pricing began to profitably make a market in the new firm’s stock after its IPO.

Proposed Pilot for Higher Minimum Tick Size Receives Mixed Responses

In response to the drop in displayed liquidity and other negative conditions that some believe to exist in the U.S. stock markets, a proposal has been made to conduct a pilot that would test the use of a higher minimum tick for trading, but opinions among the various market participants we spoke with were mixed. The proposal, which was put forth by a senior official at one NYSE specialist firm, calls on SEC to oversee a pilot program that would test a 5-cent tick on 200 to 300 NYSE stocks across all markets. The purpose of the pilot program would be to provide SEC with information it could use to decide whether larger-sized ticks improve market quality in U.S. stock markets.

Proponents believe that larger ticks would address some of the perceived negative conditions such as the reduction in displayed liquidity brought about with the change to penny ticks. For example, some proponents anticipate that investors would be more willing to display large orders because larger tick sizes would increase the financial risk of stepping ahead for other traders. Some also expected that market intermediaries would be more willing to trade in less liquid stocks because of the increased potential to profit from larger spreads. Some proponents of a pilot program believed 5-cent ticks would also increase the cost efficiency, speed, and simplicity of execution for large-order investors, especially in less liquid stocks. Most of the market intermediaries we spoke with supported the proposed 5-cent pilot for stocks. Opinions from the representatives of the markets we spoke with were more mixed, with officials from floor-based exchanges supporting the pilot, while officials from two of the electronic markets we spoke with did not support a change and officials from two others supporting the pilot under the belief that larger ticks would benefit less liquid stocks.

Of the 23 institutional investors we talked with, 10 indicated support for a proposed 5-cent pilot, 9 did not see a need for such a pilot, and 4 were indifferent or had no opinion. Of those institutional investors who did not see the need to conduct a pilot, most indicated that 5-cent ticks would not increase liquidity in the markets because the negative conditions that are attributed to decimal pricing are more the result of the inefficiencies they believed existed in markets that rely on executing trades manually rather than using technology to execute them automatically. In addition, officials at several firms noted that such a pilot is unnecessary because institutional investors have already adjusted to penny ticks. For example, an official of a very large institutional investment firm noted that the challenges of locating sufficient numbers of shares for trading large orders had already been solved with advances in electronic trading and crossing networks.

Some of these investors were also concerned that conducting such a pilot could have negative consequences. For example, one firm noted that having different ticks for different stocks could potentially confuse investors. Also, a trade association official noted that mandating that some stocks trade only in 5-cent ticks could be viewed as a form of price fixing, particularly for highly liquid stocks that were already trading efficiently using a 1-cent tick. An official from a financial markets consulting and research firm noted that if a pilot program were to occur, NASDAQ stocks should be included; this would better isolate the effects of a larger tick size on market quality factors since NYSE appears to be undergoing changes towards a more electronic marketplace, potentially making it more difficult to interpret the study's results.

In addition, some of the 10 institutional investors that supported a pilot of nickel-sized ticks indicated that they saw such ticks as being useful primarily for less-liquid stocks that generally have fewer shares displayed for trading, including smaller capitalized stocks. These proponents told us that 5-cent ticks might increase displayed liquidity for such stocks. In addition, they stated that 5-cent ticks could provide financial incentive for intermediaries to increase their participation in the trading of such stocks, including providing greater compensation for market makers and specialists to commit more capital to facilitate large-order trades. Many also anticipated a reduction in stepping ahead since it would become more costly to do so. SEC staff that we asked about the pilot told us that conducting such a test did not appear to be warranted because, to date, the benefits of penny pricing—most notably the reduction in trading costs through narrower spreads—seem clearly to justify the costs. They also noted that penny pricing does not, and is not designed to, establish the optimal spread in a particular security, which will be driven by market forces.

Decimal Pricing Has Had a Limited Impact on the Options Markets, but Other Factors Have Helped Improve Market Quality

Decimal pricing in U.S. options markets has generally had a more limited impact on the options market than it has on the stock market. Although various measures of market quality, including trading costs and liquidity, have improved in U.S. options markets, factors other than decimal pricing are believed to be the primary contributors. First, the tick size reductions adopted for options trading were less dramatic than those adopted in the stock markets. Second, other factors, including increased competition among exchanges to list the same options, the growing use of electronic trading, and a new system that electronically links the various markets, were seen as being more responsible for improvement in U.S. options

markets. Options market intermediaries such as market makers and specialists have had mixed experiences since decimal pricing began, with floor-based firms facing declining revenues and profitability and electronic-based firms seeing increased trading revenues and profitability. As part of a concept release on a range of issues pertaining to the options markets, SEC has sought views on reducing tick sizes further in the options markets by lowering them from the current 5 and 10 cents to one penny. Options market participants were generally strongly opposed to such a move for a variety of reasons, including the possibility that the number of quotes could increase dramatically, overwhelming information systems, and the potential for reduced displayed liquidity.

The Shift to Decimal Pricing Did Not Reduce Tick Sizes for Options as Much as for Stocks

One reason that decimal pricing's impact on options markets was not seen as significant was that the tick size reductions for options market were not as large as those adopted for the stock markets. Options markets had previously used a minimum tick size of 1/8 of a dollar (12.5 cents) for options contracts priced at \$3 and more and a tick size of 1/16 of a dollar (6.25 cents) for options priced at less than \$3. After decimal pricing came into effect, these tick sizes fell to 10 cents and 5 cents, respectively—a decrease of 20 percent. This decline was far less than the 84 percent reduction in tick size in the stock market, where the bid-ask spread dropped from 1/16 of a dollar to 1 cent.

Studies done by four options exchanges in 2001 to assess the impact of decimal prices on, among other factors, options contract bid-ask spreads did not find that decimal pricing had any significant effect on the spreads for options.⁵³ Most market participants shared this view. For example, an official of a large market-making firm stated that decimalization in the options market was “a small ripple in a huge pond.”

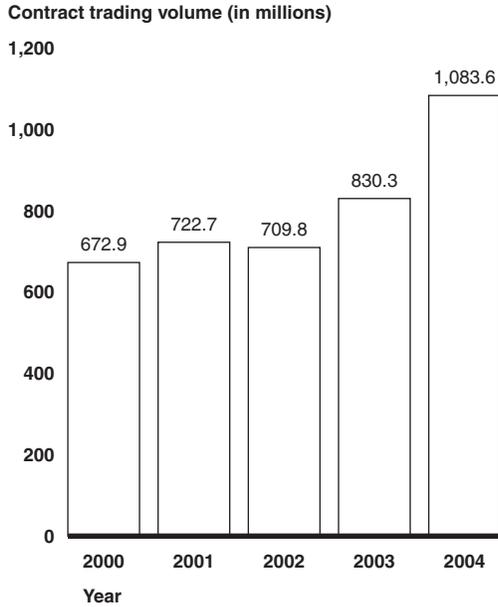
Although Decimal Pricing Not Significant, Key Measures of Options Markets’ Quality Have Improved

Although decimal pricing’s impact was not seen as significant, various measures used to assess market quality have shown improvements in U.S. options markets in recent years. Unlike for stocks, data on trading costs in options markets was not generally available. For example, we could not identify any trade analytics or other firms that collected and analyzed data for options trading. However, some market participants we interviewed indicated that bid-ask spreads, which represent a measure of cost of trading in options markets, have narrowed since the 1990s. In addition, the studies done by SEC and others also indicated that spreads have declined for options markets.

In addition to lower trading costs, liquidity, which is another measure that could be used to assess the quality of the options market, has improved since decimal pricing was implemented. According to industry participants we interviewed, liquidity in the options market has increased since 2001. They noted that trading volumes (which can be an indicator of liquidity) had reached historic levels and that many new liquidity providers, such as hedge funds and major securities firms, had entered the market. As shown in figure 14, options trading volumes have grown significantly (61 percent) since 2000, rising from about 673 million contracts to an all-time high of 1.08 billion contracts in 2004.

⁵³The four option exchanges whose studies we obtained include the American Stock Exchange, Chicago Board Options Exchange, Pacific Exchange, and Philadelphia Stock Exchange.

Figure 14: Total Contract Trading Volumes for Stock Options, 2000–2004 (Volume in millions)



Source: GAO analysis of Options Clearing Corporation data.

However, some market participants noted that the implementation of decimal pricing in the stock markets had negatively affected options traders. According to these participants, the reduced number of shares displayed in the underlying stock markets and quote flickering in stock prices had made buying and selling shares in the stock markets and determining an accurate price for the underlying stocks more difficult.⁵⁴ As a result, options traders' and market makers' attempts to hedge the risks of their options positions by trading in the stock markets had become more challenging and costly.

⁵⁴Quotes "flicker" on trading information screens when the prices of underlying stocks are changing too rapidly.

Factors Other Than Decimal Pricing Have Been Credited with Improving the Quality of Options Markets

Market participants attributed the improvements in market quality for U.S. options markets not to decimal pricing but to other developments, including the practice of listing options contracts on more than one exchange (multilisting), the growing use of electronic exchanges, and the development of electronic linkages among markets. These developments have increased competition in these markets. Multilisting, one of the most significant changes, created intense competition among U.S. options markets.⁵⁵ Although SEC had permitted multilistings since the early 1990s, the options exchanges had generally tended not to list options already being actively traded on another exchange, but began doing so more frequently in August 1999.⁵⁶ According to an SEC study, in August 1999, 32 percent of stock options were traded on more than one exchange, and that percentage rose steadily to 45 percent in September 2000. The study also showed that the percentage of total options volume traded on only one exchange fell from 61 percent to 15 percent during the same period. Almost all actively traded stock options are now listed on more than one U.S. options exchange.

⁵⁵The first multiple listing of an options contract occurred in February 1976 when the Chicago Board Options Exchange multilisted options on the stock of the Boise Cascade Corporation, which had previously been listed only by the Philadelphia Stock Exchange.

⁵⁶In September 2000, both the Department of Justice and SEC reached a settlement with the American Stock Exchange, Chicago Board Options Exchange, Pacific Exchange, and Philadelphia Stock Exchange with respect to alleged anticompetitive activities and the failure to adequately enforce compliance with their own rules.

Multilisting has been credited with increasing price competition among exchanges and market participants. The SEC study examined, among other things, how multiple listings impacted pricing and spreads in the options market and found that the heightened competition had produced significant economic benefits to investors in the form of lower quoted and effective spreads.⁵⁷ The study looked at 1-week periods, beginning with August 9 through 13, 1999 (a benchmark period prior to widespread multilisting of actively traded options), and ending with October 23 through 27, 2000 (a benchmark period during which the actively traded options in the study were listed on more than one exchange). During this period, the average quoted spreads for the most actively traded stock options declined 8 percent. Quoted spreads across all options exchanges over this same period showed a much more dramatic change, declining approximately 38 percent. The actual transaction costs that investors paid for their options executions, as measured by effective spreads, also declined, falling 19 percent for options priced below \$20 and 35 percent for retail orders of 50 contracts or less. Several academic studies also showed results consistent with SEC's findings that bid-ask spreads had declined since the widespread multiple listing of the most active options.⁵⁸

The introduction of the first all-electronic options exchange in 2000 also increased competition in the options markets. Traditionally, trading on U.S. options markets had occurred on the floors of the various exchanges. On the new International Securities Exchange (ISE), which began operations in May 2000, multiple (i.e., competing) market makers and specialists can submit separate quotes on a single options contract electronically. The quotes are then displayed on the screens of other market makers and at the facilities of broker-dealers with customers interested in trading options, enhancing competition for customer orders. ISE also introduced the practice of including with its quotes the number of contracts available at

⁵⁷SEC, Office of Compliance Inspections and Examinations and Office of Economic Analysis, *Special Study: Payment for Order Flow and Internalization in the Options Markets*, December 2000. The quoted spread is the difference between the displayed bid and ask prices and generally measures retail trading costs, since retail investors typically conduct transactions at these prices. The effective spread measures the trading cost relative to the midpoint of the quoted spread at the time the trade occurred. The lower the effective spread, the lower the cost to investors.

⁵⁸See Patrick De Fontnouvelle, Raymond P.H. Fishe, and Jeffrey H. Harris, "The Behavior of Bid-Ask Spreads and Volume in Options Markets During the Competition for Listings in 1999," *The Journal of Finance*, vol. 58, no. 6, (December 2003); Battalio, Robert, Brian Hatch and Robert Jennings, "Toward a National Market System for U.S. Exchange-Listed Stock Options," *The Journal of Finance*, vol. 59, no. 2, (April 2004).

the quoted price. According to market participants, the additional information benefited retail and institutional investors by providing them with better information on the depth of the market and the price at which an order was likely to be executed. Finally, ISE allowed customers to execute trades in complete anonymity and attracted additional sources of liquidity by allowing market makers to access its market remotely.

In response, the four floor-based options exchanges—the American Stock Exchange, Chicago Board Options Exchange (CBOE), the Pacific Exchange (PCX), and the Philadelphia Stock Exchange—also began including the number of available contracts with their quotations and offering electronic trading systems in addition to their existing floor-based trading model.⁵⁹ Another new entrant, the Boston Options Exchange (BOX) (an affiliate of the Boston Stock Exchange) also began all-electronic operations in 2004. The result has been increased quote competition among markets and their participants that has helped to further narrow spreads and has opened markets to a wide range of new liquidity providers, including broker-dealers, institutional firms, and hedge funds.

Electronic linkages were first introduced to U.S. options markets in 2003, offering the previously unavailable opportunity to route orders among all the registered options exchanges. In January 2003, SEC announced that the options markets had implemented the intermarket linkage plan, so that U.S. options exchanges could electronically route orders and messages to one another. The new linkages further increased competition in the options industry and made the markets more efficient, largely by giving brokers, dealers, and investors' better access to displayed market information. According to SEC and others, as a result of this development investors can now receive the best available prices across all options exchanges, regardless of the exchange to which an order was initially sent. Intermarket linkages are as essential to the effective functioning of the options markets as they are to the functioning of the stock markets and will further assist in establishing a national options market system.

⁵⁹These systems include the American Stock Exchange's ANTE, the CBOE's Hybrid Trading System, the Pacific Exchange's PCX Plus, and the Philadelphia Stock Exchange's XL. The two electronic-based option exchanges are BOX and ISE.

The Impact on Options Market Intermediaries Varied since Decimal Pricing Began

Decimal pricing and other changes in options markets appear to have affected the various types of market intermediaries differently. Representatives of firms that trade primarily on floor-based exchanges told us that their revenues and profits from market making had fallen while their expenses had increased. For example, one options specialist said that his firm's profitability had declined on a per-option basis and was now back to pre-1995 levels. However, he noted that the cost of technology to operate in today's market had increased substantially and that adverse market conditions and increased competition were more responsible for his firm's financial conditions than were decimal prices.

The increasingly competitive and challenging environment has also led to continued consolidation among firms that trade on the various options exchange floors. According to data from one floor-based options exchange, the number of market intermediaries active on its market declined approximately 22 percent between 2000 and 2004. Market intermediaries and exchange officials we spoke with noted in particular that the smaller broker-dealer firms that trade options and sometimes have just one or two employees had been the most affected, with many either merging with other firms or going out of business because of their inability to compete in the new trading environment.

In contrast, the introduction of electronic exchanges and expanded opportunities for electronic trading at other exchanges has been beneficial for some market intermediaries. Officials of some broker-dealers that trade options electronically told us that their firms' operations had benefited from the increased trading volume and the efficiency of electronic trading. The officials added that other firms, such as large financial institutions, had increased their participation in the options marketplace. They also noted that the availability of electronic trading systems and the inherent economies of scale associated with operating such systems had attracted new marketplace entrants, including some hedge funds and major securities firms. For example, representatives of ISE and several broker-dealers told us that the ability to trade electronically had encouraged several large broker-dealers that were not previously active in options markets to begin acting as market makers on that exchange. These firms, they explained, were able to enter into the options markets because making markets electronically is less expensive than investing in the infrastructure and staff needed to support such operations on a trading floor. According to market participants we spoke with, these new entrants appeared to have provided increased competition and positively affected spreads, product innovation, and liquidity in the options industry.

Options Market Participants Oppose Lower Minimum Ticks for the Options Industry

In 2004, SEC issued a concept release that sought public comments on options-related issues that have emerged since the multiple listing of options began in 1999, including whether the markets should reduce the minimum tick sizes for options from 5 and 10 cents to 1-cent increments.⁶⁰ According to the release, SEC staff believed that penny pricing in the options market would improve the efficiency and competitiveness of options trading, as it has in the markets for stocks, primarily by tightening spreads. If lower ticks did lead to narrower spreads for options prices, investors trading costs would likely similarly decline. As of May 2004, SEC has received and reviewed comments on the concept release but has taken no further action.

All of the options exchanges and virtually all of the options firms we spoke with, as well as 15 of the 16 organizations and individuals that submitted public comments on SEC's 1-cent tick size proposal, were opposed to quoting options prices in increments lower than those currently in use (10 and 5 cents, depending on the price of an options contract). One of the primary reasons for this opposition was that trading options contracts in 1-cent increments would significantly increase quotation message traffic, potentially overwhelming the capacity of the existing systems that process options quotes and disrupting the dissemination of market data. For any given stock, hundreds of different individual options contracts can be simultaneously trading, with each having a different strike price (the specified price at which the holder can buy or sell underlying stock) and different expiration date.⁶¹ Because options are contracts that provide their holders with the right to either buy or sell a particular stock at the specified strike price, an option's value and therefore its price also changes as the

⁶⁰Competitive Developments in the Options Markets, Exchange Act Release No. 49175 (Feb. 3, 2004), 69 *Fed. Reg.* 6124 (2004). In this release, SEC also sought comments on a variety of issues, including payment for order flow, internalization, and specialist participation guarantees. Payment for order flow is an arrangement under which a broker is paid to route its customer orders to a particular market for execution. Internalization occurs when a brokerage firm fills a customer's order from the broker's own inventory of securities without exposing the order to the market. Specialist participation guarantees offer these intermediaries a percentage of the order flow from a particular options exchange for providing liquidity, depth, and continuity in that market.

⁶¹An actively-traded stock like International Business Machines (IBM) may have thousands of options available for trading. For example, if IBM's stock price is around \$100, options granting the right to buy or sell the stock are likely trading with strike prices of \$90, \$95, \$100, \$105, \$110, etc., and each of these prices will have separate options expiration dates (months). Simultaneously, trading will also be occurring in both call options and put options using the same strike prices and expiration months.

underlying stock's price changes. If options were priced in pennies, market participants said that thousands of new option price quotes could be generated because prices would need to adjust more rapidly to remain accurate than they do using nickel or dime increments.

Markets and market participants also expressed concerns that penny pricing would exacerbate an already existing problem for the industry—ensuring that the information systems used to process and transmit price quotations to market participants have adequate capacity. The quotes generated by market makers on the various markets are transmitted by the systems overseen by the Options Price Reporting Authority (OPRA). The OPRA system has been experiencing message capacity issues for several years. In terms of the number of messages per second (mps) that can be processed, the OPRA system had a maximum mps of 3,000 in January 2000. Since then, the processing and transmission capacity of the system has had to be expanded significantly to accommodate the growth in options' quoting volumes, and as of April 2005, the OPRA system was capable of processing approximately 160,000 mps. Prior to the implementation of decimal pricing in 2001, similar concerns about the impact on message traffic volumes were also raised for stocks, but the magnitude of the anticipated increases were much larger for options.

To address the capacity constraints in the options market systems thus far, the administrators of the OPRA system have tried to reduce quotation traffic by having the options exchanges engage in quote mitigation. Quote mitigation requires the exchanges to agree to prioritize their own quotes and trade report message volumes so that the amount of traffic submitted does not exceed a specified percentage of the system's total capacity. As of April 2005, the OPRA administrators were limiting the volume of messages that exchanges were able to transmit to just 88,000 mps based on requests from the six options exchanges.

Two market participants that commented on SEC's proposal noted that with options market data continuing to grow at a phenomenal rate each year, OPRA would have to continue increasing its current message capacity to meet ongoing demand. If penny quoting were to create even faster growth in the total number of price quotes generated, market participants indicated that options exchanges, market data vendors, and broker-dealers would need to spend substantial sums of money on operational and technological improvements to their capacity and communication systems in order to handle the increased amounts of market data. These costs, they said, would likely be passed on to investors.

Another reason that market participants objected to lowering tick sizes for options trading was that doing so would likely reduce market intermediaries' participation in the markets. Because these intermediaries make their money from the spreads between the bid and offer prices, narrower spreads that would likely accompany penny ticks would also reduce these intermediaries' revenues and profits. This, in turn, would reduce these firms' ability and willingness to provide liquidity, especially for options that are traded less frequently. According to the commenters on the proposal and the participants we contacted, intermediaries would likely become reluctant to provide continuous two-sided markets (e.g., offering both to buy and sell options simultaneously) to facilitate trading, since profit potential would be limited by the 80 percent or more reduction in tick size. And because the 1-cent tick could increase the chance of other traders stepping ahead of an order, such intermediaries could become reluctant to display large orders. With the options markets having hundreds of options for one underlying stock, market intermediaries would likely quote fewer numbers of contracts, which would further reduce displayed liquidity, and market transparency.

Market participants also raised other concerns about trading in penny ticks for options. For example, they worried that option prices quoted in 1-cent increments would change in price too rapidly, resulting in more quote "flickering." They also noted that the options market could experience some of the other negative effects that have occurred in the stock markets, including increasing instances of stepping ahead by other traders.

SEC staff responsible for options markets oversight told us that they would like to see tick sizes reduced in the options markets as a means of lowering costs to investors. They acknowledged that the benefits of such tick size reductions would have to be balanced with the likely accompanying negative impacts. SEC staff responsible for options markets oversight told us that they would like to see tick sizes reduced in the options markets as a means of lowering costs to investors. They acknowledged that the benefits of such tick size reductions would have to be balanced with the likely accompanying negative impacts. They noted that recent innovations permit a small amount of trading in pennies and that continued innovation and technological advances may lead to approaches more favorable to investors without substantial negative effects.

Observations

In advocating decimal pricing, Congress and SEC expected to make stock and options pricing easier for the average investor to understand and reduce trading costs, particularly for retail investors, from narrower bid-ask spreads. These goals appear to have been met. Securities priced in dollars and cents are clearly more understandable, and the narrower spreads that have accompanied this change have made trading less costly for retail investors. Although the resulting trading environment has become more challenging for institutional investors, they too appear to have benefited from generally lower trading costs since decimal pricing was implemented. In response to the reduced displayed market depth, institutional investors are splitting larger orders into smaller lots to reduce the market impact of their trading and accelerating their adoption of electronic trading technologies and alternative trading venues. As a result of these adaptations, institutional investors have been able to continue to trade large numbers of shares and at even less total cost than before.

However, since decimal pricing was introduced, the activities performed by some market intermediaries have become less profitable. Decimal prices have adversely affected broker-dealers' ability to earn revenues and profits from their stock trading activities. But one of the goals of decimal pricing was to lower the artificially established tick size, and thus the loss of revenue for market intermediaries that had benefited from this price constraint was a natural outcome. Various other factors, including institutional investors' adoption of electronic technologies that reduce the need for direct intermediation, can also explain some of market intermediaries' reduced revenues. Nevertheless, the depressed financial condition of some intermediaries would be of more concern if conditions were also similarly negative for investors, which we found was not the case.

In response to the changes since decimal pricing began, a proposal has been made to conduct a pilot program to test higher tick sizes. This program would provide regulators with data on the impacts, both positive and negative, of such trading. However, given that many investors and market intermediaries have made considerable efforts to adapt their trading strategies and invest in technologies that allow them to be successful in the penny tick trading environment, the need for increased tick sizes appears questionable.

Although decimal pricing has been a less significant development in U.S. options markets, other factors, such as new entrants and the increased use

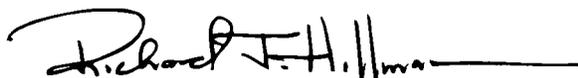
of electronic trading and linkages, have served to improve the quality of these markets. SEC's proposal to further reduce tick sizes in the options markets has been met with widespread opposition from industry participants, and many of the concerns market participants raised, including the potential for significant increases in quote traffic and less displayed liquidity, appear to have merit. The magnitude of these potential impacts appears larger than those that accompanied the implementation of penny ticks for stocks. As a result, it is not clear that additional benefits of the narrower spreads that could accompany mandated tick size reductions would be greater than the potentially negative impacts and increased costs arising from greatly increased quote processing traffic.

Agency Comments

We provided a draft of this report to SEC for comments and we received oral comments from staff in SEC's Division of Market Regulation and Office of Economic Analysis. Overall, these staff said that our report accurately depicted conditions in the markets after the implementation of decimal pricing. They also provided various technical comments that we incorporated where appropriate.

As agreed with your offices, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days after the date of this report. At that time, we will send copies of this report to the Chairman and Ranking Minority Member, Subcommittee on Securities and Investments, Senate Committee on Banking, Housing, and Urban Affairs. We will also send copies of this report to the Chairman, SEC. We will make copies available to others upon request. This report will also be available at no charge on GAO's Web site at <http://www.gao.gov>.

Please contact me at (202) 512-8678 if you or your staff have any questions concerning this report. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. Key contributors to this report are listed in appendix V.

A handwritten signature in black ink that reads "Richard J. Hillman" followed by a horizontal line.

Richard J. Hillman
Director, Financial Markets and
Community Investment

Scope and Methodology

To determine the impact of decimal pricing on retail investors, we analyzed data from a database of trades and quotes from U.S. stock markets between February 2000 and November 2004. Appendix II contains a detailed methodology of this analysis. Using this data, we selected a sample of stocks traded on the New York Stock Exchange (NYSE) and the NASDAQ Stock Market (NASDAQ) and calculated how the trading in these stocks had changed between a 1-year period before and an almost 4-year period after decimal pricing began. As part of this analysis, we examined the changes in spreads on these stocks (the relevant measure of trading costs for retail investors). We also undertook steps to assess the reliability of the data in the TAQ database by performing a variety of error checks on the data and using widely accepted methods for removing potential errors from data to ensure its reliability. Based on these discussions, we determined that these data were sufficiently reliable for our purposes. We also reviewed market and academic studies of decimal pricing's impact on spreads. In addition, we interviewed officials from over 30 broker-dealers, the Securities and Exchange Commission (SEC), NASD, two academics, and five alternative trading venues, eight stock markets, four trade analytics firms, a financial markets consulting and research firm, and four industry trade groups.

Methodology for Assessing Impact on Institutional Investors

To analyze the impact of decimal pricing on institutional investors, we obtained and analyzed institutional trading cost data from three leading trade analytics firms—Plexus Group, Elkins/McSherry, and Abel/Noser—spanning from the first quarter of 1999 through second quarter of 2003 from the Plexus Group and from the fourth quarter of 1998 to the end of 2004 from Elkins/McSherry and Abel/Noser—to determine how trading costs for institutional investors responded to decimalization. These firms' data do not include costs for trades that do not fully execute. To address this issue, we interviewed institutional investors on their experiences in filling large orders. We also undertook steps to assess the reliability of the trade analytics firms' data by interviewing their staffs about the steps the firms follow to ensure the accuracy of their data. Based on these discussions, we determined that these data were sufficiently reliable for our purposes.

To identify all relevant research that had been conducted on the impact of decimal pricing on institutional investors' trading costs, we searched public and private academic and general Internet databases and spoke with academics, regulators, and market participants. We identified 15 academic studies that met our criteria for scope and methodological considerations.

Of these, 3 addressed trading costs for institutional investors and 12 addressed trading costs for retail investors.

To determine the impact of pricing on investors' ability to trade, we interviewed roughly 70 judgmentally selected agencies and firms, including representatives of 23 institutional investors with assets under management ranging from \$2 billion to more than \$1 trillion. The assets being managed by these 23 firms represented 31 percent of the assets under management by the largest 300 money managers in 2003. In addition, we also discussed the impact on intuitional investors during our interviews with broker-dealers, securities regulators, academics, and alternative trading venues, stock exchanges, trade analytics firms, a financial market consulting and research firm, and industry trade groups.

Methodology for Assessing Impact on Market Intermediaries

To assess the impact of decimal pricing on stock market intermediaries, we obtained data on the revenues of the overall securities industry from the Securities Industry Association (SIA). SIA's revenue data come from the reports that each broker-dealer conducting business with public customers is required to file with SEC—the Financial and Operational Combined Uniform Single (FOCUS) reports. We used these data to analyze the trend in revenues for the industry as a whole as well as to identify the revenues associated with making markets in NASDAQ stocks. In addition, we obtained data on the specialist broker-dealer revenues and participation rates and on executed trade sizes from NYSE. For the number of specialist firms participating on U.S. markets, we sought data from NYSE and the other exchanges, including the American Stock Exchange (Amex), the Boston Stock Exchange, the Chicago Stock Exchange, the Pacific Exchange (PCX), and the Philadelphia Stock Exchange (Phlx). We obtained data on the number of market makers and the trend in executed trade size from NASDAQ. We discussed how these organizations ensure the reliability of their data with officials from the organizations where relevant and determined that their data were sufficiently reliable for our purposes. We also discussed the impact of decimals on market intermediaries during our interviews with officials from broker-dealers, securities regulators, alternative trading venues, stock exchanges, trade analytics firms, a financial market consulting and research firm, and industry trade groups, as well as experts from academia.

Methodology for Assessing Impact on Options Markets

To determine the impact of decimal pricing on the options markets, both investors and intermediaries, we reviewed studies that four U.S. options exchanges, including Amex, Chicago Board Options Exchange (CBOE), PCX, and Phlx, submitted to SEC in 2001 on the impact of decimalization on their markets. We also performed literature searches on the Internet for academic and other studies that examined the impact of decimal pricing on options markets. In addition, we also attempted to identify any sources or organizations that collected and analyzed options trading costs.

To determine the impact on intermediaries, we interviewed officials of all six U.S. options exchanges, including Amex, Boston Options Exchange, CBOE, International Securities Exchange, PCX, and Phlx, and various market participants (an independent market maker, designated primary market makers, specialists, a floor broker, hedge funds and a retail investor firm) to ascertain their perspectives on the impact of the conversion to decimalization on them, investors, and the markets.

To determine the potential impact of reducing the minimum price tick in the options markets to a penny, we interviewed officials from the option exchanges and market participants. We also reviewed all comment letters that SEC had received on its concept release discussing potential changes in options market regulation, including lowering the minimum tick size in the options markets to a penny. We reviewed those letters posted on SEC's Web site as of May 4, 2005. Sixteen of these letters specifically commented on the penny-pricing proposal.

Methodology for GAO Analysis of Trade and Quotes Data

To assess the impact of decimal pricing, one of the activities we performed was to analyze data from the New York Stock Exchange (NYSE) Trade and Quote (TAQ) database spanning the 5-year period between February 2000 (before the conversion to decimal pricing) and November 2004 (after the adoption of decimal pricing) to determine how trading costs for retail investors changed and how various market statistics changed, such as the average number of shares displayed at the best prices before and after decimalization. Although maintained by NYSE, this database includes all trades and quotes that occurred on the various exchanges and the NASDAQ Stock Market (NASDAQ). Using this database, we performed an event-type study analyzing the behavior of trading cost and market quality variables for NYSE and NASDAQ stocks in pre- and postdecimalization environments.¹ For each of our sample stocks, we used information on each recorded trade and quote (that is, intraday trade and quote data) for each trading day in our sample period. We generally followed the methods found in two recently published academic studies that examined the impact of decimalization on market quality and trade execution costs.² In particular, we analyzed the pre- and postdecimalization behavior of several trading cost and market quality variables, including various bid-ask spread measures and price volatility, and we also analyzed quote and trade execution price clustering across NYSE and NASDAQ environments. We generally presented our results on an average basis for sample stocks in a given market in the pre- and postdecimalization periods; in some cases we separated sample stocks into groups based on their average daily trading

¹Throughout, “decimalization” reflects the transition from fractional pricing (that is, pricing generally in sixteenths of a dollar) to decimal pricing (that is, pricing in round cents) and, more significantly, the 84 percent reduction in the minimum price increment, or tick, from one-sixteenth of a dollar to 1 cent. Decimalization was fully implemented on the NYSE on January 29, 2001, but not until April 9, 2001, on NASDAQ. An event study is the analytical framework used to measure the economic effect of an event, such as the transition from fractional to decimal pricing.

²Hendrik Bessimbinder, 2003, “Trade Execution Costs and Market Quality after Decimalization,” *Journal of Financial and Quantitative Analysis* 38(4), 747-777; and K. Chung, B. Van Ness, and R. Van Ness, 2004, “Trading Costs and Quote Clustering on the NYSE and NASDAQ after Decimalization,” *Journal of Financial Research* 27(3), 309-328. Bessimbinder (2003) performed an event study analysis of the impact of decimalization on several trade execution cost and market quality measures using a sample of NYSE-listed and NASDAQ stocks in a predecimalization period and a postdecimalization period. While not an event study, Chung et al. (2004) focused on the differences in several trade execution cost and market quality measures between a sample of NYSE-listed and NASDAQ stocks in the month after decimalization; they also analyzed quote clustering, which is the tendency for quotes to “cluster” at certain price points, such as nickels and dimes.

volume and reported our results so that any differences across stock characteristics could be observed.³

Our analysis was based on intraday trade and quote data from the TAQ database, which includes all trade and quote data (but not order information) for all NYSE-listed and NASDAQ stocks, among others. TAQ data allowed us to study variables that are based on trades and quotes but did not allow us to study any specific effects on or make any inferences regarding orders or institutional trading costs.⁴

Our data consisted of trade and quote activity for all stocks listed on NYSE, NASDAQ, and the American Stock Exchange (Amex) from February 1, 2000, through November 30, 2004, excluding the month of September 2001. We focused on NYSE-listed and NASDAQ issues, as is typical in the literature, since the potential sample size from eligible Amex stocks tends to be much smaller. Our analysis compared 300 matched NYSE and NASDAQ stock pairs over the 12 months prior to decimalization and 12 months selected from the period spanning April 2001 through November

³Stocks were grouped by volume according to the following categories:

- High volume stocks were those in our sample of stocks with average daily trading volumes exceeding 500,000 shares (the maximum was less than 1.6 million shares).
- Medium volume stocks were those in our sample of stocks with average daily trading volumes between 100,000 and 499,999 shares.
- Low volume stocks were those in our sample of stocks with average daily trading volumes of less than 100,000 shares.

⁴For example, since an order can often be filled through a number of trade executions, and use of TAQ data implicitly assumes that each trade record reflects a unique order that is filled, our analysis failed to address any impact of a change in how orders are filled and the costs associated with this.

2004.⁵ In constructing our sample period, we omitted the months of February and March 2001 from consideration, because not all stocks were trading using decimal prices during the transition period.

Because there were a host of concurrent factors impacting the equities markets around the time of and since the transition to decimal pricing, it is unlikely that any of our results can be attributed solely to decimalization. Any determination of statistically significant differences in pre- and postdecimalization trading cost and market quality variables was likely due to the confluence of decimalization and these other factors.

Determining the Sample Period for Our Analysis

Determining the best sample period presented a challenge because decimalization was implemented at different times on NYSE and NASDAQ. The transition to decimal pricing was completed on NYSE on January 29, 2001, while on NASDAQ it was completed on April 9, 2001. In addition, there were selected decimalization pilots on NYSE and NASDAQ prior to full decimalization on each. Researchers who have analyzed the transition to decimal pricing have generally divided up the pre- and postdecimalization sample periods differently depending on the particular focus of their research.⁶ Relatively short sample periods too close to the transition might suffer from unnatural transitory effects related to the learning process in a new trading environment, while sample periods farther from the implementation date or longer in scope might suffer from the influence of confounding factors. Analyses comparing different months before and after decimalization (e.g., December 2000 versus May 2001)

⁵Since there are important structural differences between the NYSE and NASDAQ markets and the stocks listed on each, a general analysis of the effect of an event on both markets could yield biased results if the stock samples are not chosen carefully. For this reason, researchers analyzing the impact of decimalization on the NYSE and NASDAQ usually employ a matched-pairs analysis. For our analysis, a matched pair consisted of one NYSE-listed stock and one NASDAQ stock (among all NASDAQ stocks) that provided the closest match to it in terms of characteristics related to trading activity, such as share price and average daily trading volume, which are generally thought to explain variation in bid-ask spreads, among other things. By matching the stocks on these characteristics, a matched-pairs analysis attempts to isolate the effect of an event on the different markets by considering how it affects groups of analogous stocks.

⁶Bessimbinder (2003) separated the pre and postdecimalization periods as the 3 weeks before January 29, 2001, and from April 9, 2001 through August 31, 2001. Chung et al. (2004) considered only May 2001, as their focus was not on a pre- versus postdecimalization comparison. Other studies, both from researchers and exchanges, examining decimalization often selected a 1-month or shorter period sometime shortly before decimalization and an analogous period sometime after decimalization for comparison.

might suffer from seasonal influences. We extended the current body of research, which includes studies by academic and industry researchers, exchanges and markets, and regulators, by including more recent time periods in our analysis, providing an expanded view of the trend in trade execution cost and market quality variables since 2000. However, to the extent that the influence of other factors introduced by expanding the sample window outweighed any influence of decimalization on trade cost and market quality measures, our results should be interpreted with caution.

Our sample period spanned February 2000 through November 2004 (table 14). The predecimalization period included February 1, 2000, through January 19, 2001, and the postdecimalization period included April 23, 2001, through November 5, 2004, excluding September 2001 (due to the effects of the September 11 terrorist attacks). We selected one week from each month, allowing for monthly five-trading day comparisons that avoided holidays and options expiration days as well controlling for seasonality issues.⁷ Our predecimalization period consisted of a 1-week sample from each of the 12 months and our postdecimalization period consisted of twelve 1-week sample periods excerpted from April 2001 through November 2004, excluding the month of September 2001.

⁷Despite the two “event dates” for the NYSE and NASDAQ, our analysis incorporated calendar-period comparisons rather than event-time comparisons (for example, 1 month following decimalization on the NYSE compared with 1 month following decimalization on NASDAQ). We believed that it was reasonable to assume that the lag time between full decimalization on the NYSE and NASDAQ would not lead to any sizeable learning discrepancies between the markets since NASDAQ market participants were able to observe NYSE activity over this period.

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Table 14: Pre- and Postdecimalization Sample Weeks

Period	Year	Month	Day of the week				
			Monday	Tuesday	Wednesday	Thursday	Friday
Predecimals	2000	February	7	8	9	10	11
	2000	March	20	21	22	23	24
	2000	April	10	11	12	13	14
	2000	May	8	9	10	11	12
	2000	June	19	20	21	22	23
	2000	July	10	11	12	13	14
	2000	August	21	22	23	24	25
	2000	September	18	19	20	21	22
	2000	October	23	24	25	26	27
	2000	November	6	7	8	9	10
	2000	December	18	19	20	21	22
		2001	January	22	23	24	25
Postdecimals	2001	April	23	24	25	26	27
	2001	August	20	21	22	23	24
	2001	December	10	11	12	13	14
	2002	January	7	8	9	10	11
	2002	May	6	7	8	9	10
	2002	September	23	24	25	26	27
	2003	February	24	25	26	27	28
	2003	June	2	3	4	5	6
	2003	October	20	21	22	23	24
	2004	March	8	9	10	11	12
2004	July	19	20	21	22	23	
2004	November	1	2	3	4	5	

Source: GAO.

Note: The sample weeks selected avoided holidays and partial trading days either before or after holidays, as well as other noted trading stoppages, options expiration days (the third Friday of each month), and end of quarter days, all of which may lead to unusual trading activity.

**Generating the Sample of Stocks
for Our Analysis**

Generally following the methods used by other researchers, we generated our list by including only common shares of domestic companies that were active over our period of interest and that were not part of decimalization pilot programs in effect before January 29, 2001. Specifically, we excluded preferred stocks, warrants, lower class common shares (for example, Class B and Class C shares), as well as NASDAQ stocks with five-letter symbols not representing Class A shares.⁸ We then eliminated from consideration stocks with average share prices that were below \$5 or above \$150 over the February 2000 through December 2000 period. We also eliminated stocks for which there were no recorded trades on 10 percent or more of the trading days, to ensure sufficient data, leaving us with 981 NYSE-listed and 1,361 NASDAQ stocks in the potential sample universe. Our stock samples for the analysis ultimately consisted of 300 matched pairs of NYSE-listed and NASDAQ stocks.

⁸NASDAQ stock symbols are four to five letters in length. A fifth letter in a NASDAQ stock symbol indicates, among other things, share class or unusual circumstances such as bankruptcy or delayed SEC filing.

Generating the Matched Pairs

The NYSE-listed and NASDAQ stocks were matched on variables that are generally thought to help explain interstock differences in spreads. To the extent that our matching samples of NYSE-listed and NASDAQ stocks had similar attributes, any differences in spreads between the groups should have been due to reasons other than these attributes. The attributes we considered were (1) share price, (2) share price volatility, (3) number of trades, and (4) trade size.⁹ For the matching procedure, daily data from February 2000 through December 2000 were used and averages were taken over this sample period. Share price was measured by the mean value of the daily closing price and volatility by the average of the logarithm of the high-low intraday price range. The number of trades was measured by the average daily number of trades, and average trade size was measured as the average daily trading volume.¹⁰ These factors have different measurement units, implying that they could not be directly converted into a single measure of similarity. To develop a combined measure of similarity we first had to standardize the measures of all factors so that their average values and differences in their averages were measured on comparable scales. Once standardized measures of averages and differences were developed, we were able to sum the four measurements into a total measure of similarity and identify matched pairs of stocks. Comparability was assured because all averages and differences were divided by the standard deviation of the measure of each factor on the NYSE.

Our matching algorithm was similar to those described in Chung et al. (2004) and Van Ness et al. (2001). To obtain a matching sample of NYSE and NASDAQ stocks, we first calculated the following combined measure of similarity—the composite match score (CMS)—for each NYSE stock using our entire sample of NASDAQ stocks. The CMS is defined as

⁹While Bessimbinder (2003) used only market capitalization as the matching criterion, Chung et al. (2004) used five stock attributes—share price, number of trades, trade size, return volatility, and market capitalization. In the absence of market capitalization data, we followed Van Ness et al. (2001) and used four variables. Researchers have generally found that overall results are similar regardless of the matching variables used.

¹⁰The reported number of trades on NYSE is not directly comparable to that reported on NASDAQ due to interdealer trading on NASDAQ. NASDAQ volume has been estimated to be exaggerated by 30 percent to 50 percent relative to NYSE volume. As with Chung et al. (2004), we counterbalance the discrepancy by including trades in NYSE-listed stocks that occur outside of the NYSE, reflecting activity at regional exchanges and elsewhere, rather than incorporating an “inflation factor.”

$$CMS_{ij} = \sum_{v=1}^4 \left\{ \left[\frac{Y_{v_i}^N - Y_{v_j}^T}{\sigma_{Y_v^N}} \right] / \left[\frac{Y_{v_i}^N + Y_{v_j}^T}{2 \cdot \sigma_{Y_v^N}} \right] \right\}^2,$$

in which the superscripts *N* and *T* refer to NYSE and NASDAQ, respectively, and $Y_{v_i}^N$ and $Y_{v_j}^T$ represent one of the four stock attributes for each—in which *i* denotes the NYSE stock and *j* denotes the NASDAQ stock being matched. In the matching algorithm, each of the attributes *v* was weighted equally. Unlike the matching algorithms in the two aforementioned papers, we divided each stock attribute difference by the sample standard deviation of that attribute for the entire NYSE sample—denoted as $\sigma_{Y_v^N}$ —in order to create unit less measures that were normalized relative to the overall NYSE attributes.

Ultimately, for each NYSE stock we selected the NASDAQ stock with the smallest CMS. Chung et al. (2004) used a sequential matching algorithm as is common in the literature. To start, they considered an NYSE stock and computed its CMS with all NASDAQ stocks; they matched that NYSE stock to the NASDAQ stock with the lowest CMS. Then they considered the next NYSE stock, but the NASDAQ stock that matched the prior NYSE stock was no longer considered among the possible universe of matches for this or any subsequent NYSE stock. The outcome of this type of algorithm is path dependent—the order in which the NYSE stocks are taken influences the ultimate list of unique matches. We employed another method that avoided this path dependence—ensuring an optimal match for each stock—but also allowed for the possibility of duplicate, nonunique NASDAQ matches. For the 981 NYSE-listed stocks, there were 293

NASDAQ stocks that provided the best matches.¹¹ We chose the 300 best CMS matched pairs, which consisted of 300 NYSE and 186 unique NASDAQ stocks.¹² Of these 186 NASDAQ stocks, 114 were best matches for one NYSE-listed stock, 45 were best matches for two NYSE-listed stocks, 19 were best matches for three NYSE-listed stocks, 5 were best matches for four NYSE-listed stocks, 1 was a best match for five NYSE-listed stocks, and 2 were best matches for seven NYSE-listed stocks. In the subsequent analysis, each NASDAQ stock was weighted according to the number of best matches it yielded. For example, if a NASDAQ stock provided the best match for two NYSE-listed stocks, it was counted twice in the overall averages for NASDAQ.

Characteristics of Our Sample Stocks

The pairings resulting from the CMS minimization algorithm were well matched. The average share price for the 300 NYSE-listed (NASDAQ matching) stocks was \$19.66 (\$19.56), the average daily volume was 132,404 (127,107), the average number of trades per day was 121 (125), and the measure of daily volatility was 0.018 (0.018). In terms of average share price, the 300 matching-pair stocks were fairly representative of the full sample of matching stocks, as well as of the potential sample universe of stocks, as illustrated in table 15 and figure 15. However, the resulting matched-pairs sample tended to have more lower-priced stocks.

¹¹Of the 293 NASDAQ matches, 127 were best matches for one NYSE-listed stock, 64 were best matches for two NYSE-listed stocks, 28 were best matches for three, 13 were best matches for four, 16 were best matches for five, 7 were best matches for six, 11 were best matches for seven, 1 was a best match for eight, 6 were best matches for nine, 3 were best matches for ten, and 17 were best matches for 11 to 26 NYSE stocks.

¹²Relative to the marginal cost in terms of computing resources and analysis time, the marginal benefit of increasing the number of matched pairs was limited, as the top 400 (500) matched pairs consisted of 400 (500) NYSE stocks and 215 (235) NASDAQ matching stocks.

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Table 15: Price Characteristics of NYSE-Listed and NASDAQ Stocks

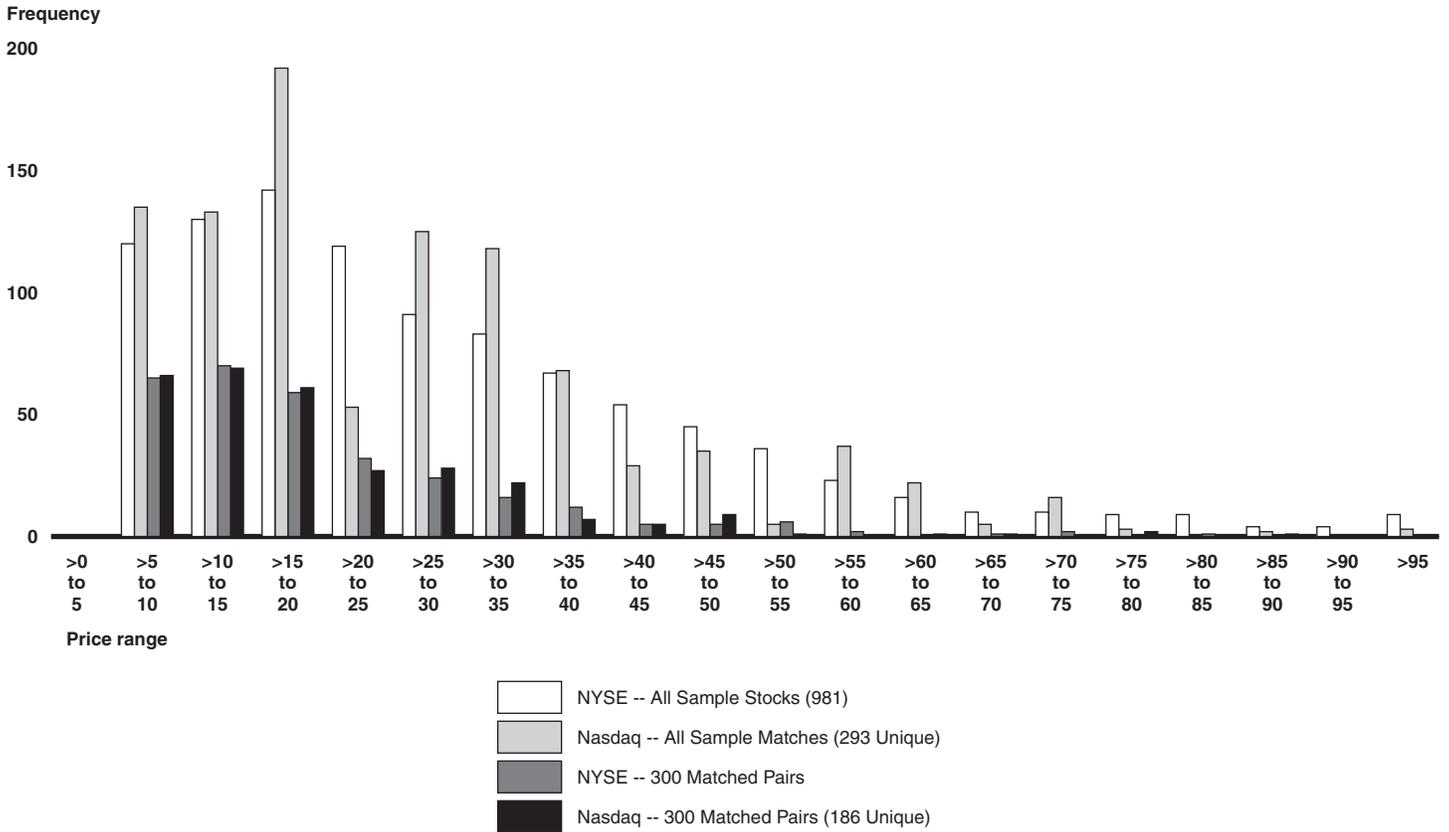
	NYSE	NASDAQ
Potential universe of stocks		
Number	981	1,361
Average (median) share price	\$29.20 (24.07)	\$25.27 (17.54)
Percent priced below \$25	52%	65%
Percent priced below \$50	87%	89%
Full sample of matching stocks		
Number	981	263
Average (median) share price	\$29.20 (24.07)	\$26.60 (22.27)
Percent priced below \$25	52%	52%
Percent priced below \$50	87%	91%
300 matched-pair sample of stocks		
Number	300	186 unique
Average (median) share price	\$19.66 (16.55)	\$19.56 (15.94)
Percent priced below \$25	75%	74%
Percent priced below \$50	96%	98%

Source: GAO analysis of TAQ data.

Note: Share price was measured as the average daily closing price from February 2000 through December 2000. Of the 186 NASDAQ stocks, 114 were best matches for one NYSE-listed stock and the remainder were best matches for multiple NYSE-listed stocks. In the analysis, each NASDAQ stock was weighted according to the number of best matches it yielded.

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Figure 15: Distribution of Average Daily Closing Prices for Full Sample of Matching Stocks and 300 Matched-Pairs Sample



Source: GAO analysis of TAQ data.

Note: Share price was measured as the average daily closing price from February 2000 through December 2000. There were 981 NYSE-listed stocks and 293 matching NASDAQ stocks in the all matching stocks sample. There were 300 NYSE-listed and 300 (186 unique) matching NASDAQ stocks in the matched pairs sample. Each NASDAQ stock was weighted according to the number of best matches it yielded.

In terms of average daily trading volume, the matched-pairs sample underrepresented higher-volume stocks, which likely biased our results toward reporting larger spreads (see table 16 and fig. 16).

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Table 16: Volume Characteristics of NYSE-Listed and NASDAQ Stocks

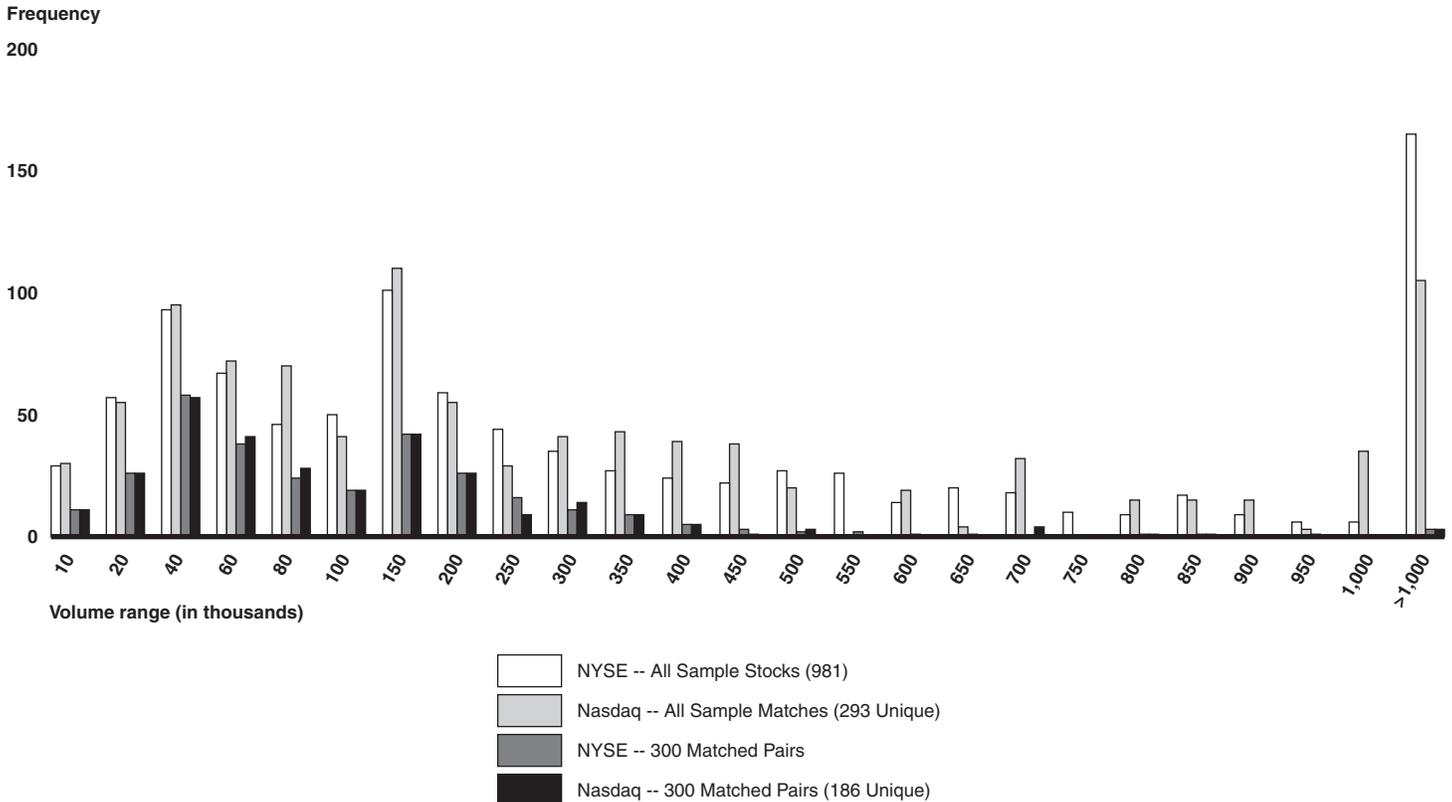
	NYSE	NASDAQ
Potential universe of stocks		
Number	981	1,361
Average (median) daily volume	689,811 (190,070)	607,687 (125,627)
Percent below 150,000 shares	45%	54%
Percent below 500,000 shares	69%	82%
Full sample of matching stocks		
Number	981	263
Average (median) daily volume	689,811 (190,070)	511,980 (185,787)
Percent below 150,000 shares	45%	48%
Percent below 500,000 shares	69%	75%
300 matched-pair sample of stocks		
Number	300	186
Average (median) daily volume	132,404 (74,188)	127,107 (73,204)
Percent below 150,000 shares	73%	75%
Percent below 500,000 shares	97%	97%

Source: GAO analysis of TAQ data.

Note: Volume was measured as the average daily trading volume from February 2000 through December 2000. Of the 186 NASDAQ stocks, 114 were best matches for one NYSE-listed stock and the remainder were best matches for multiple NYSE-listed stocks. In the analysis, each NASDAQ stock was weighted according to the number of best matches it yielded.

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Figure 16: Distribution of Average Daily Trading Volume for Full Sample of Matching Stocks and 300 Matched-Pairs Sample



Source: GAO analysis of TAQ data.

Note: Volume was measured as the average daily trading volume from February 2000 through December 2000. There were 981 NYSE-listed stocks and 293 matching NASDAQ stocks in the all matching stocks sample. There were 300 NYSE-listed and 300 (186 unique) matching NASDAQ stocks in the matched pairs sample. Each NASDAQ stock was weighted according to the number of best matches it yielded.

Filtering and Manipulation of Trade and Quote Data

Once we had defined our stock sample, to undertake the subsequent analysis we first had to filter the trades and quotes data for each sample stock, which involved discarding records with TAQ-labeled errors (such as canceled trade records and quote records identified with trading halts), identifying and removing other potentially erroneous quotation and trade records (such as stale quotes or trade or quote prices that appeared aberrant), as well as simply confining the data to records between 9:30 a.m. and 4 p.m. We also had to determine the national best bid and offer quotes in effect at any given moment from all quoting market venues—the NBBO quotation. In general, for a given stock the best bid (offer) represents the

highest (lowest) price available from all market venues providing quotes to sellers (buyers) of the stock.

The NBBO quotes data for a given stock were used to compute quoted bid-ask spreads, quote sizes, and share prices, as well as intraday price volatility for that stock on a daily basis. They were also used independently to document any quote clustering activity in that stock. The trades' data for a particular stock were used to analyze daily price ranges and trade execution price clustering. For each stock, the trades and NBBO quotes data were used to compute effective bid-ask spreads, which rely on both quotes and trades data.

The TAQ Consolidated Quotes (CQ) file covers most activity in major U.S. market centers but does not include foreign market centers. A record in the CQ file represents a quote update originating in one of the included market centers: Amex, the Boston Stock Exchange, the Chicago Stock Exchange, electronic communication networks (ECN) and alternative trading systems (ATS), NASDAQ, the National Stock Exchange, NYSE, the Pacific Stock Exchange, and the Philadelphia Stock Exchange.¹³ It does not per se establish a comprehensive marketwide NBBO quote, however. A quote update consists of a bid price and the number of shares for which that price is valid and an offer price and the number of shares for which that price is valid. In general, a quote update reflects quote additions or cancellations. The record generally establishes the best bid and offer prevailing in a given market center. Normally, a quote from a market center is regarded as firm and valid until it is superseded by a new quote from that center—that is, a quote update from a market center supersedes that market center's previous quotes and establishes its latest, binding quotes.

Specifying the NBBO involved determining the best bid and offer quotes available—at a particular instant, the most recent valid bids and offers posted by all market centers were compared and the highest bid and the

¹³In the TAQ CQ file, NASDAQ dealers and ECNs are collectively classified under "T" as the source market for quotations for NYSE-listed issues. The market maker identification (MMID) data field provides an additional classification layer among NASDAQ dealers and ECNs. For example, "TRIM" denotes "Trimark," a NASDAQ dealer, while "BRUT" denotes the BRUT ECN. "CAES" is the acronym for "Computer Assisted Execution System," which is a NASDAQ system that allows its members to quote NYSE-listed stocks. The National Securities Clearing Corporation provides a listing of NASDAQ market makers and their MMIDs in the Member Directory at www.nsccl.com. The Boston Stock Exchange, the Chicago Stock Exchange, the National Stock Exchange, the Pacific Stock Exchange, and the Philadelphia Stock Exchange are regional exchanges.

lowest offer were selected as the NBBO quotes. The national best bid (NBB) and national best offer (NBO) are not necessarily from the same market center or posted concurrently, and the bid and offer sizes can be different. Bessimbinder (2003) outlined a general method for determining the NBBO. First, the best bid and offer in effect for NYSE-listed stocks among individual NASDAQ dealers (as indicated by the MMID data field) was assessed and designated as the NASDAQ bid and offer. Then, the best bid and offer in effect across the NYSE, the five regional exchanges, and NASDAQ were determined and designated as the NBBO quotations for NYSE-listed stocks. For NASDAQ stocks, quote records from NASDAQ market makers reflect the best bid and offer across these participants (collectively classified as “T” in the TAQ data). Competing quotes are issued from other markets (e.g., the Pacific Stock Exchange) as well as NASDAQ’s SuperMontage Automated Display Facility, which reflects the quotes from most ECNs. We required additional details in constructing the NBBO, since quote records from competing market makers and market centers can have concurrent time stamps and there can be multiple quotes from the same market center recorded with the same time stamp. Moreover, identical bid or offer prices can be quoted by multiple market makers. To address these complications, we relied on language offered in SEC’s Regulation NMS proposal, which defined the NBBO by ranking all such identical bids or offers first by size (giving the highest ranking to the bid or offer associated with the largest size) and then by time (giving the highest ranking to the bid or offer received first in time). In our algorithm, the NBB (NBO) is located by comparing the existing bids (offers) from all venues. The NBBO is updated with each instance of a change in the NBB or NBO.

General Analysis Techniques

Each NBBO quotation was weighted by its duration (i.e., the time for which it was effective) and used to compute a sample week time-weighted average NBBO quotation for the relevant market, which was reported on a volume-weighted (relative to total sample market trading volume) basis. Ultimately, these averages were compared across markets and across pre and postdecimalization periods. The same general techniques were used in computing effective spreads, which were determined by comparing trade executions with NBBO quotations. For analysis of trades data (e.g., in computing price ranges), a simple average over all stocks in a given market was computed. In analyzing volatility, intraday returns were measured for each stock based on continuously compounded percentage changes in quotation midpoints, which were recorded between 10 a.m. and 4 p.m. The standard deviation of the intraday returns was then computed for each stock, and the cross-sectional median across all stocks was taken. In

assessing clustering, the frequencies of trades and quotes at pennies, nickels, dimes, and quarters were determined for each market on an aggregate basis.

In reporting any differences between the pre- and postdecimalization sample periods in the trade execution cost and market quality measures that we analyzed, statistical significance was assessed based on cross-sectional variation in the stock-specific means. With the exception of volatility measures, statistical significance was assessed using a standard t-test for equality of means. Since average volatility measures do not conform well to the t-distribution, median volatility was reported for each market and the Wilcoxon rank sum test used to assess equality.

Measuring Trade Execution Costs and Other Market Quality Components with TAQ Data

TAQ data allowed us to study variables that are based on trades and quotes but did not allow us to study any specific effects on or make any inferences regarding orders or institutional trading costs. This is an important limitation because the transition to decimal pricing may have impacted retail traders, whose generally smaller orders tend to be executed in a single trade, differently than institutional traders. Use of TAQ data implicitly assumes that each trade record reflects a unique order that is filled, so our analysis failed to address any impact of a change in how orders are filled and the costs associated with this. We reported the pre- and postdecimalization behavior of quoted bid-ask spreads and effective spreads. Beyond measures of trade execution cost, market quality is multidimensional. Possible adverse effects of decimalization on market quality included increased trade execution costs for large traders, increased commissions to offset smaller bid-ask spreads, slower order handling and trade executions, decreased market depth, and increased price volatility. The TAQ data allowed measurement of quotation sizes and price volatility, which we reported. We also analyzed quote clustering, which reflects any unusual frequency with which prices tend to bunch at multiples of nickels, for example. We generally presented our results on an average basis for a given market in the pre- and postdecimalization periods; we also reported the results for sample stocks grouped by average daily trading volume.

Calculating Quoted Bid-Ask Spreads as a Simple Measure of Trading Costs

Average pre- and postdecimalization bid-ask spreads were calculated in cents per share and basis points (that is, the spread in cents relative to the NBBO midpoint) using the NBBO quote prices. The average spread was obtained in the following way. First, each NBBO quote for a given stock was weighted by the elapsed time before it was updated—its duration—on a given day of a sample week relative to the total duration of all NBBO

quotes for that stock in that sample week. Next, the duration-weighted average over the five trading days in that sample period for that stock was used to compute the average across all stocks in a given market for that week; ultimately, a volume-weighted average was computed. For the twelve-sample week period, a volume-weighted average was also computed.

Calculating Effective Bid-Ask Spreads as a Better Measure of Trading Costs

The effective bid-ask spread—how close the execution price of a trade is relative to the quote midpoint—is generally considered to be the most relevant measure of trade execution cost, as it allows measurement of trades that execute at prices not equal to the bid or ask. In keeping with standard practice, we measured the effective spread for a trade as twice the absolute difference between the price at which a trade was executed and the midpoint of the contemporaneous NBBO quote. Suppose for example that the NBB is \$20.00 and the NBO is \$20.10, so that the NBBO midpoint is \$20.05. If a trade executes at a price of \$20.05 then the effective spread is zero because the trade executed at the midpoint of the spread—the buyer of the stock paid \$0.05 per share less than the ask price, while the seller received \$0.05 per share more than the bid price. If a trade executes at \$20.02 with the same NBBO prices, the effective spread is \$0.06—the buyer of the stock paid \$0.08 per share less than the ask price, while the seller received \$0.02 per share more than the bid price. Effective spreads were computed in cents per share and in basis points.

Measuring Quotation Sizes

Smaller quote sizes could reflect a decrease in liquidity supply, which in turn could be associated with increased volatility. The size of each NBBO quote was weighted by its duration and used to compute a volume-weighted average over each sample week as well as across all sample weeks.

Measuring Intraday Return Volatility

A reduction in the tick size could lead to a decline in liquidity supply, which in turn could create more volatile prices. Intraday returns were measured for each stock based on continuously compounded percentage changes in quotation midpoints, which were recorded on an hourly basis between 10 a.m. and 4 p.m. The continuously compounded return over 6 hours, from 10 a.m. to 4 p.m., was also computed. The standard deviation (a measure of dispersion around the average) of the intraday returns was then computed for each stock, and the cross-sectional median (the middle of the distribution) was taken over all stocks in a given market.

Measuring Daily Price Range

As another measure of price volatility, we also considered how a stock's daily price range (i.e., the highest and lowest prices at which trades were executed) may have changed following the implementation of decimal pricing, as the claim has been made that prices have been moving to a greater degree during the day after decimalization. We computed the equal-weighted average of each stock's daily price range and then computed the average over all stocks in a given market. To account for potentially varying price levels across the pre and postdecimalization sample periods, we computed the price range in both cents per share as well as relative to the midpoint of the first NBBO quote for each day.

Measuring Trade and Quote Clustering

Decimalization provides a natural experiment to test whether market participants prefer to trade or quote at certain prices when their choices are unconstrained by regulation. Theory suggests that if price discovery is uniform, realized trades should not cluster at particular prices. The existence of price clustering following decimalization could suggest a fundamental psychological bias by investors for round numbers and that there may be only minor differences between the transactions prices that would prevail under a tick size of 5 cents relative to those observed under decimal pricing.¹⁴ For quotes, according to competing hypotheses in the literature, clustering may be due to dealer collusion, or it may simply be a natural phenomenon—as protection against informed traders, as compensation for holding inventory, or to minimize negotiation costs.¹⁵ For our analysis, we computed the frequency of trade executions and quotes across the range of price points, but we did not attempt to determine the causes of any clustering.

Efforts to Assess Reliability of TAQ Data

Consistent with generally accepted government auditing standards, we assessed the reliability of computer-processed data that support our findings. To assess the reliability of TAQ data, we performed a variety of error checks on data from a random sample of stocks and dates. This involved comparing aggregated intraday data with summary daily data, scanning for outliers and missing data. In addition, since the TAQ database is in widespread use by researchers and has been for several years, we were able to employ additional methods for discarding potentially erroneous data records following widely accepted methods (e.g., we

¹⁴This was explored in a working paper, D. Ikenberry and J. Weston, 2003, "Clustering in U.S. Stock Prices after Decimalization."

¹⁵This was explored in Chung et al. (2004).

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discarded quotation information in which a price or size was reported as negative). We assessed the reliability of our analysis of the TAQ data by performing several executions of the programs using identical and slight modifications of the program coding. Program logs were also generated and reviewed for errors.

Measurement of Institutional Investors' Trading Costs in Basis Points Shows Decline since Decimal Pricing Implemented

As discussed in the body of this report, institutional investors' trading costs are commonly measured in cents per share and basis points (bps). Cents per share is an absolute measure of cost based on executing a single share. Basis points—measured in hundredths of a percentage point—show the absolute costs relative to the stock's average share price. For example, for a stock with a share price of \$20, a transaction cost of \$.05 would be 0.25 percent or 25 bps. Costs reported in terms of basis points can show changes resulting solely from changes in the level of stock prices—if the price of the \$20 stock falls to \$18, the \$.05 transaction cost would now be almost 0.28 percent or 28 bps. However, many organizations track costs using basis points, and in this appendix we present the results of our institutional trading cost analysis in basis points.

Analysis of the multiple sources of data that we collected generally indicated that institutional investors' trading costs had declined since decimal prices were implemented. Specifically, NYSE converted to decimal pricing on January 29, 2001, and NASDAQ completed its conversion on April 9, 2001. We obtained data from three leading firms that collect and analyze information about institutional investors' trading costs. These trade analytics firms (Abel/Noser, Elkins/McSherry, and Plexus Group) obtain trade data directly from institutional investors and brokerage firms and calculate trading costs, including market impact costs (the extent to which the security changes in price after the investor begins trading), typically for the purpose of helping investors and traders limit costs of trading.¹ These firms also aggregate client data so as to approximate total average trading costs for all institutional investors. Generally, the client base represented in aggregate trade cost data is sufficiently broad based that the firm's aggregate cost data can be used to make generalizations about the institutional investor industry.

Although utilizing different methodologies, the data from the firms that analyze institutional investor trading costs uniformly showed that costs had declined since decimal pricing was implemented. Our analysis of data from the Plexus Group showed that costs declined on both NYSE and NASDAQ during the 2 year period after these markets converted to decimal pricing. Plexus Group uses a methodology that analyzes various components of institutional investor trading costs, including the market impact of investors' trading.² Total trading costs declined by about 32

¹ITG, another trade analytics firm, did not begin to measure institutional investors' trading costs until January 2003, after the implementation of decimal pricing and 1-cent ticks.

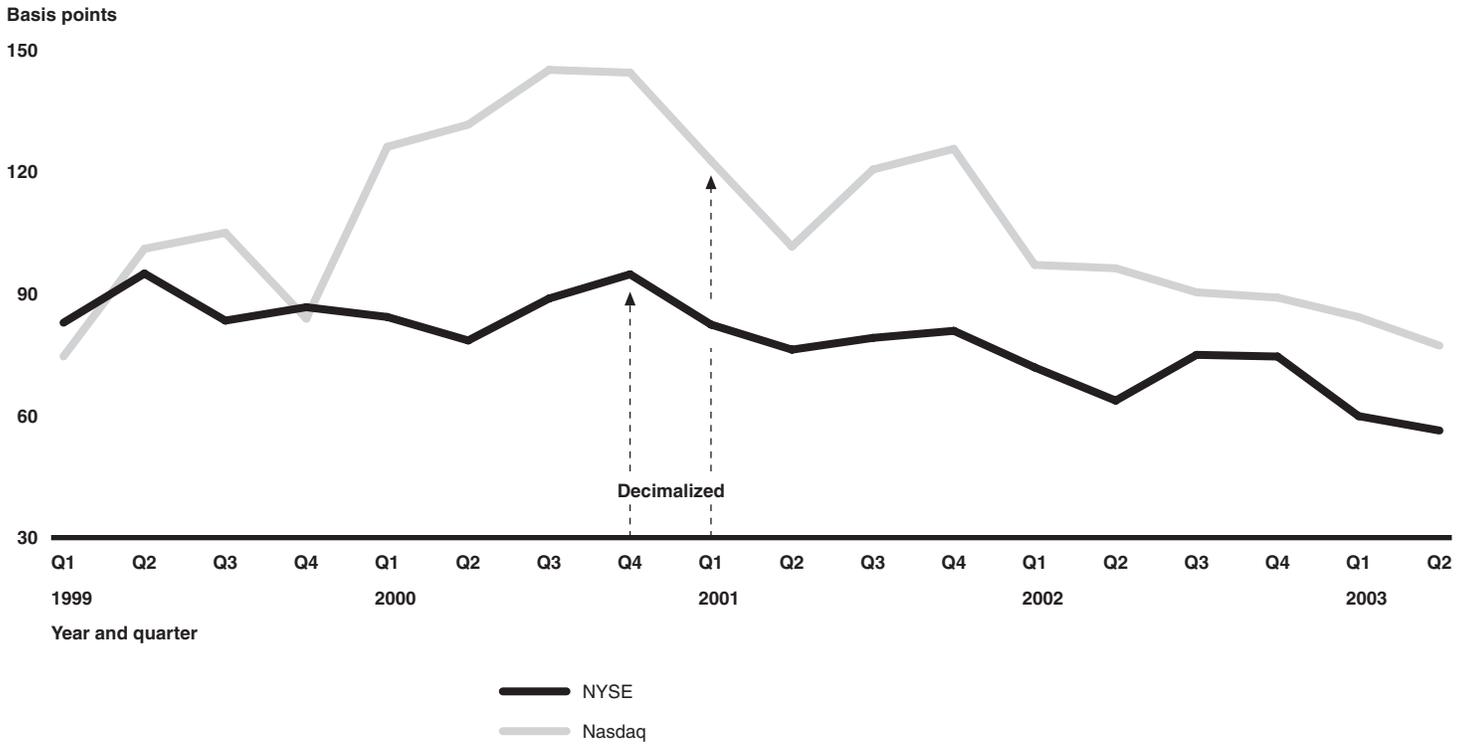
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percent for NYSE stocks, falling from about 82 bps to 56 bps (fig. 17). For NASDAQ stocks, the decline was about 25 percent, from about 102 bps to about 77 bps. As can be seen in figure 17, the decline in trading costs began before both markets implemented decimal pricing, which indicates that other causes, such as the 3-year declining stock market, in addition to decimal pricing, were also affecting institutional investors’ trading during this period. An official from a trade analytics firm told us that the spike in costs that preceded the decimalization of NASDAQ stocks correlated to the pricing bubble that technology sector stocks experienced in the late 1990s and early 2000s. An official from another trade analytics firm explained that trading costs increased during this time because when some stocks’ prices would begin to rise, other investors—called momentum investors—would begin making purchases and cause prices for these stocks to move up even faster. As a result, other investors faced greater than usual market impact costs when also trading these stocks. In general, trading during periods when stock prices are either rapidly rising or falling can make trading very costly.

²To measure market impact costs, the Plexus Group compares a proprietary benchmark stock price to the average price an investor receives. The Plexus Group benchmark attempts to show the price at which the order for a particular stock should be executed. The firm calculates this expected price using trade data of its clients for the two quarters preceding the date of the trade under study, and takes into account variables such as trade size, liquidity, and the direction of stock price movement.

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Figure 17: Total Trading Costs from a Trade Analytics Firm for NYSE and NASDAQ Stocks, 1999–2004 (basis points)



Source: GAO analysis of Plexus Group data.

Note: Data are reported quarterly. After a phase-in period, all NYSE stocks were trading with decimal prices by January 29, 2001, and all NASDAQ stocks were converted by April 9, 2001.

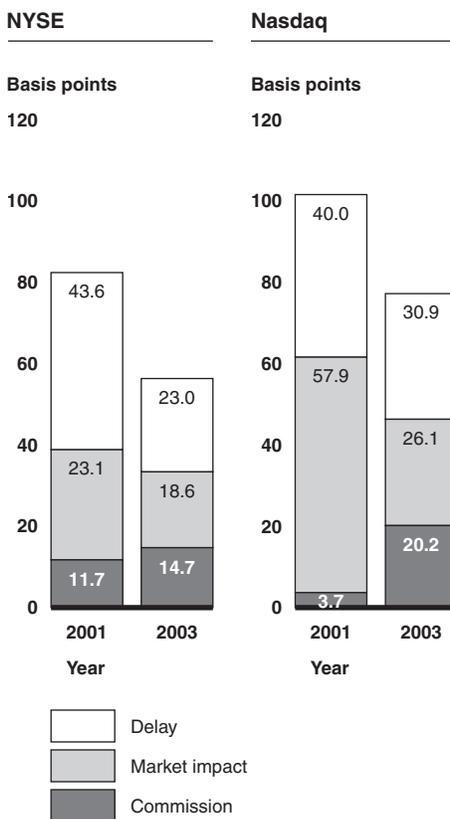
According to our analysis of the Plexus Group data, all of the decline in trading costs for NYSE stocks and NASDAQ stocks were caused by decreases in the costs resulting from market impact and delay for orders.³ Together, the reduction in these two components accounted for 29.1 bps or all of total decline, with delay costs representing 20.6 bps (or about 71 percent) in the approximately 2 years following the implementation of

³Delay costs are a type of market impact cost that occur between the time institutional investors' portfolio managers direct their traders to buy or sell stock and the moment these orders are released to brokers. The amount that the stock's price changes during this period is the cost of delaying the order. An order may be delayed for a number of reasons—for instance, because it could affect prices in the market too much. Plexus Group, *The Official Icebergs of Transaction Costs, Commentary #54*, January 1998.

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decimal pricing and 1-cent ticks on the NYSE. However, commissions increased 3 bps, which led total trading costs to decline 26.1 bps (fig. 18).

Figure 18: Trading Cost Components from One Trade Analytics Firm for NYSE and NASDAQ, 2001–2003 (basis points)



Source: GAO analysis of Plexus Group data.

Note: Data are from first quarter 2001 to second quarter 2003 for NYSE and second quarter 2001 to second quarter 2003 for NASDAQ.

Figure 18 also shows that market impact and delay costs account for all declines to total NASDAQ trading costs. For example, market impact and delay costs declined 40.9 bps between the second quarter of 2001 and the second quarter of 2003. However, overall trading costs declined by only 24.4 bps, which is 16.5 bps less than declines in market impact and delay costs. According to Plexus Group data, overall costs would have declined further if not for increases to commission costs for NASDAQ stocks, the

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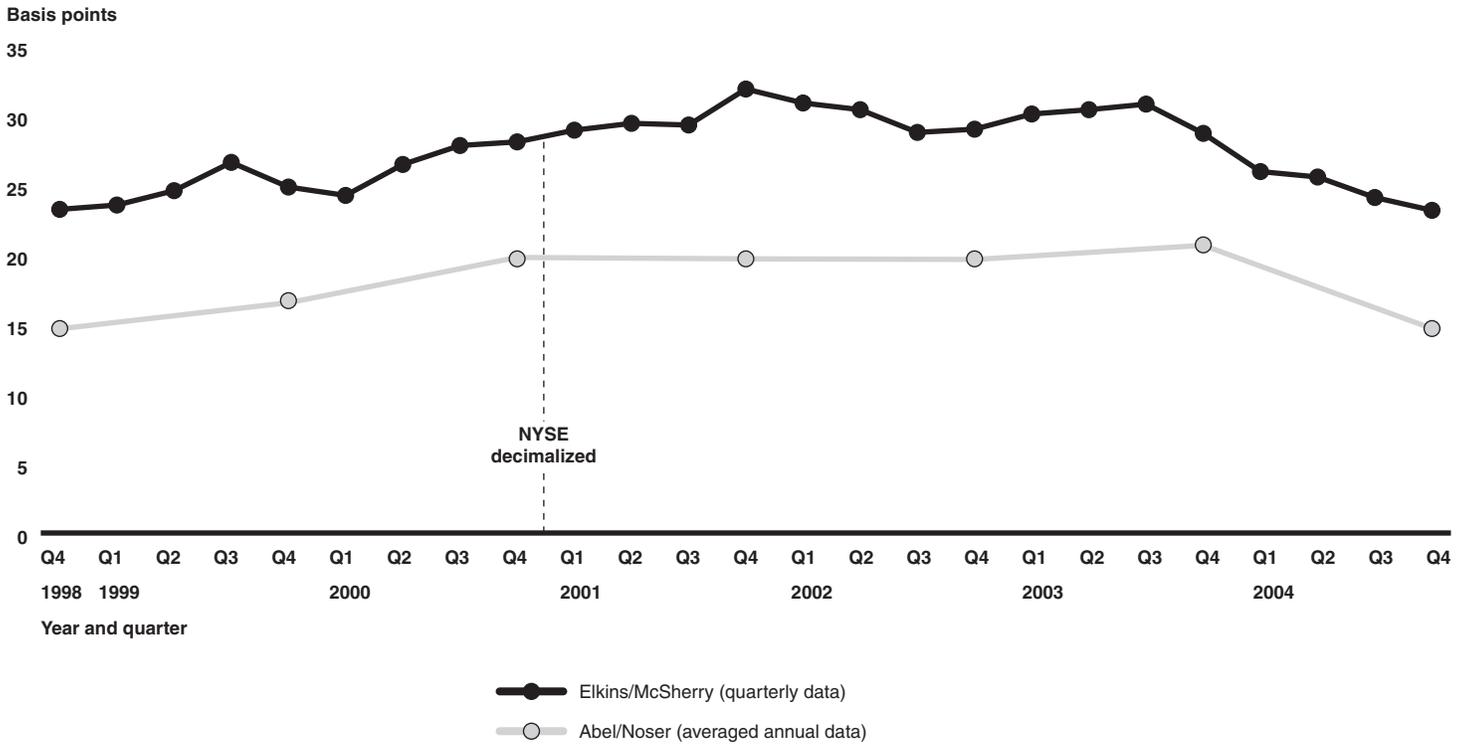
only cost component that increased after NASDAQ converted to decimal pricing and 1-cent ticks. As shown in figure 18, commissions that market intermediaries charged for trading NASDAQ stocks increased 16.5 bps from the second quarter of 2001 to the second quarter of 2003. Industry representatives told us these increases reflect the evolution of the NASDAQ brokerage industry from trading as principals, in which the compensation earned by market makers was embedded in the final trade price, to that of an agency brokerage model, in which broker-dealers charge explicit commissions to represent customer orders in the marketplace.⁴

Analysis of data from the other two trade analytics firms from which we obtained data, Elkins/McSherry and Abel/Noser, also indicated that institutional investor trading costs varied but declined following the decimalization of U.S. stock markets in 2001. Because these two firms' methodologies do not include measures of delay, which the Plexus Group data shows can be significant, analysis of data from these two firms results in trading cost declines of a lower magnitude than those indicated by the Plexus Group data analysis. Nevertheless, the data we analyzed from Elkins/McSherry showed total costs for NYSE stocks declined about 20 percent between the first quarter of 2001 and year-end 2004 from about 29 bps to about 24 bps. Analysis of Abel/Noser data indicated that total trading costs for NYSE stocks declined 25 percent from 20 bps to 15 bps between year-end 2000 and 2004 (fig. 19).

⁴For example, NASDAQ market makers previously could earn revenue trading as principals by buying shares at the bid price from investors and selling those shares to other investors at the higher ask price, thus earning the difference or spread amount as compensation.

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Figure 19: Total Trading Costs from Two Trade Analytics Firms for NYSE Stocks, 2001–2004 (basis points)



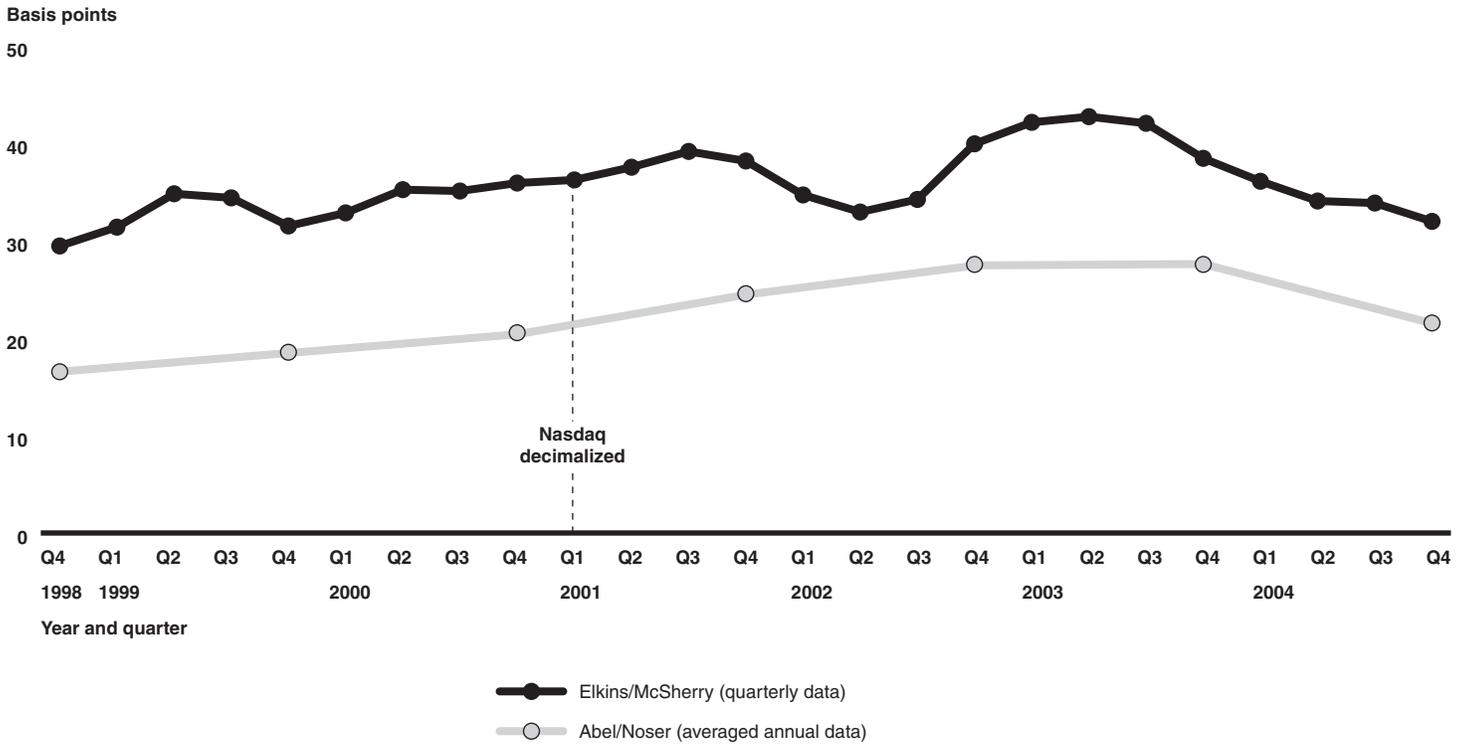
Source: GAO analysis of Elkins/McSherry and Abel/Noser data.

Note: Elkins/McSherry data are quarterly from fourth quarter of 1998 and the fourth quarter of 2004; Abel/Noser data are year-end totals for 1998–2004.

Our analysis of these firms’ data also indicated that total trading costs declined in basis points for NASDAQ stocks or were flat. For example, our analysis of the Elkins/McSherry data showed that total trading costs for NASDAQ stocks dropped by roughly 13 percent, from about 38 bps to about 32 bps between the second quarter of 2001 when that market decimalized to year-end 2004. Analysis of the Abel/Noser data indicated that total trading costs increased nearly 5 percent for NASDAQ stocks during that period, increasing from 21 bps to 22 bps (fig. 20). This increase in trading cost can possibly be explained by the approximately 50 percent decline in average share price over the period.

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Figure 20: Total Trading Costs from Two Trade Analytics Firms for NASDAQ Stocks, 2001–2004 (basis points)



Source: GAO analysis of Elkins/McSherry and Abel/Noser data.

Note: Elkins/McSherry data are quarterly from fourth quarter of 1998 and the fourth quarter of 2004; Abel/Noser data are year-end totals for 1998–2004.

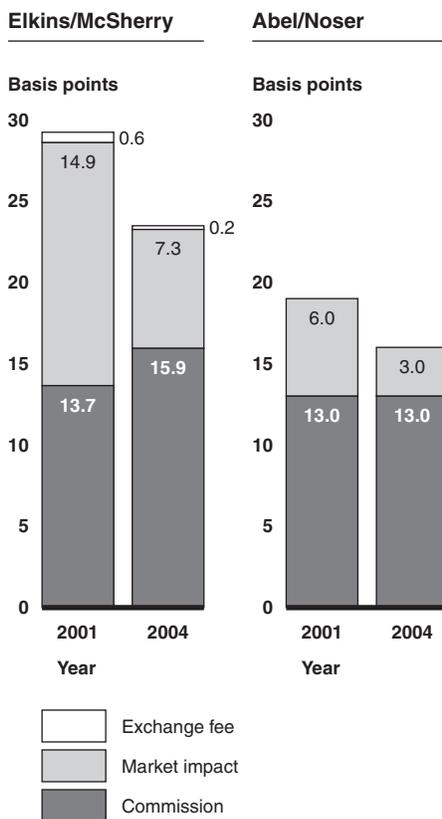
Similar to Plexus Group data analysis, our analysis of the Elkins/McSherry and Abel/Noser data also indicated that reductions to market impact costs accounted for a vast proportion of overall reductions for NYSE stocks (fig. 21).⁵ Analysis of the Elkins/McSherry data indicated that by declining 7.6 bps during this period, reduced market impact accounted for 95 percent of total cost trading declines. The 3 bps reduction in market impact costs

⁵These two firms analyze market impact costs by comparing their clients' trades to the volume-weighted average price (VWAP) of the particular stocks traded. The VWAP represents the average price at which a particular stock traded on a specific trading day and is calculated by weighting each trade's price according to the proportion of shares of a specific stock it represents on a given day. The closer an investor's average price is to the VWAP, the lower the calculated market impact costs.

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identified in the Abel/Noser data represented the entire total trading cost reductions for NYSE stocks.

Figure 21: Trading Cost Components from Two Trade Analytics Firms for NYSE Stocks, 2001 and 2004 (basis points)



Source: GAO analysis of Elkins/McSherry and Abel/Noser data.

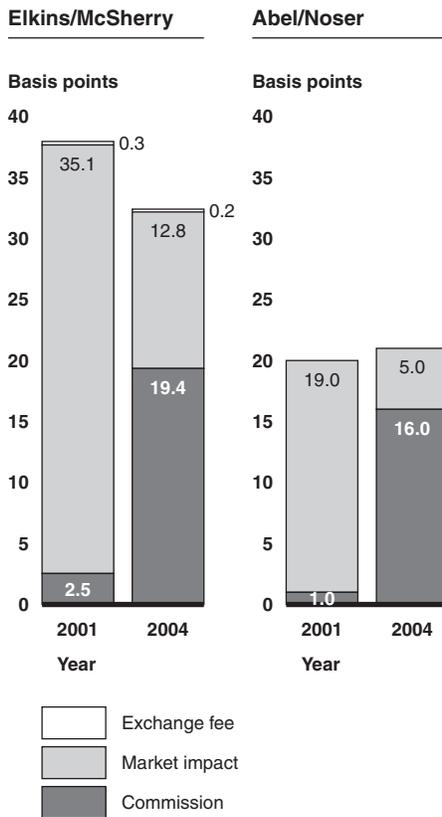
Note: Abel/Noser does not account for exchange fees as a component of trading cost. For Elkins/McSherry, we obtained first quarter 2001 data and fourth quarter 2004. For Abel/Noser, we obtained data from the end of 2000 and 2004.

Reductions to market impact costs explain virtually the entire decline to total trading costs captured by the Elkins/McSherry data for NASDAQ stocks and all of the Abel/Noser data for NASDAQ stocks. For Elkins/McSherry and Abel/Noser, such costs would have produced even larger total declines had commissions for such stocks not increased since 2001. Market impact costs declined 22.3 bps (about 64 percent) according

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to our analysis of the Elkins/McSherry data and 14 bps (about 74 percent) according to analysis of the Abel/Noser data (fig. 22). However, during this period, commissions charged on NASDAQ stock trades included in these firms' data increased by 16.9 bps, marking approximately a sixfold increase in commissions as measured by Elkins/McSherry and by 15 bps or about a fifteenfold increase according to Abel/Noser.

Figure 22: Trading Cost Components from Two Trade Analytics Firms for NASDAQ Stocks, 2001 and 2004 (basis points)



Source: GAO analysis of Elkins/McSherry and Abel/Noser data.

Note: Abel/Noser does not account for exchange fees as a component of trading cost. For Elkins/McSherry, we obtained first quarter 2001 data and fourth quarter 2004. For Abel/Noser, we obtained data from the end of 2000 and 2004.

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Data from a fourth firm, ITG, which recently began measuring institutional trading costs, also indicates that such costs have declined. This firm began collecting data from its institutional clients in January 2003. Like the other trade analytics firms, its data is similarly broad based, representing about 100 large institutional investors and about \$2 trillion worth of U.S. stock trades. ITG's measure of institutional investor trading cost is solely composed of market impact costs and does not include explicit costs, such as commissions and fees, in its calculations. Although changes in ITG's client base for its trade cost analysis service prevented direct period to period comparisons, an ITG official told us that its institutional investor clients' trading costs have been trending lower since 2003.⁶

⁶We do not present the specific analysis of ITG's data because the firm's client base for its trade cost analysis grew significantly after it first began offering this service, including the addition of some larger clients with sophisticated trading operations that contributed to the overall decline measured by the firm.

Additional Analysis Using Trade and Quotes Data

As part of our analysis of the Trade and Quotes database, we also examined how quoted and effective spreads changed as a percentage of stock prices and also examined whether the extent to which quotes clustered on particular prices changed since decimal pricing began. In addition to measuring spreads in cents per share, spreads are also frequently measured in basis points, which are 1/100 of a percent. We found that spreads generally declined when measured in basis points similar to our analysis measured in cents. Reporting spreads in basis points potentially accounts for changes in the general price level of our sample stocks, which could impact our results reported in cents per share. We found that both quoted and effective spreads generally declined when measured relative to quote midpoints as they did when measured simply in cents (see tables 17 and 18).

Table 17: Average Quoted Spreads Before and After Decimalization, 2000–2004 (basis points)

Stocks by average daily volume of shares traded	NYSE quoted spread			NASDAQ quoted spread		
	Average spread in basis points before decimals	Average spread in basis points after decimals	Percent change	Average spread in basis points before decimals	Average spread in basis points after decimals	Percent change
High	49.3	16.0	-68%	40.9	13.0	-68%
Medium	71.8	19.5	-73	72.4	22.4	-69
Low	125.7	32.6	-74	127.9	36.6	-71
All stocks	78.4	25.1	-68	82.0	27.2	-67

Source: GAO analysis of TAQ data.

Note: Quoted spreads in the table represent the volume-weighted average quoted spread (i.e., stocks and weeks with more total trading volume have greater weight) as a percentage of the midpoint of the prevailing quotes over 12 sample weeks during the predecimals period (February 2000–January 2001) and 12 sample weeks during the postdecimals period (April 2001–November 2004) for our sample of stocks. Stocks were segregated by volume according to the following categories:

- High volume stocks were those in our sample of stocks with average daily trading volumes exceeding 500,000 shares.
- Medium volume stocks were those in our sample of stocks with average daily trading volumes between 100,000 and 499,999 shares.
- Low volume stocks were those in our sample of stocks with average daily trading volumes of less than 100,000 shares.

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Table 18: Average Effective Spreads Before and After Decimalization, 2000–2004 (basis points)

Stocks by average daily volume of shares traded	NYSE effective spreads			NASDAQ effective spreads		
	Average spread in basis points before decimals	Average spread in basis points after decimals	Percent change	Average spread in basis points before decimals	Average spread in basis points after decimals	Percent change
High	47.8	29.4	-38%	51.1	25.3	-51%
Medium	61.8	26.5	-57	70.8	30.4	-57
Low	99.4	38.3	-61	112.4	39.0	-65
All stocks	65.3	29.4	-55	73.4	32.5	-56

Source: GAO analysis of TAQ data.

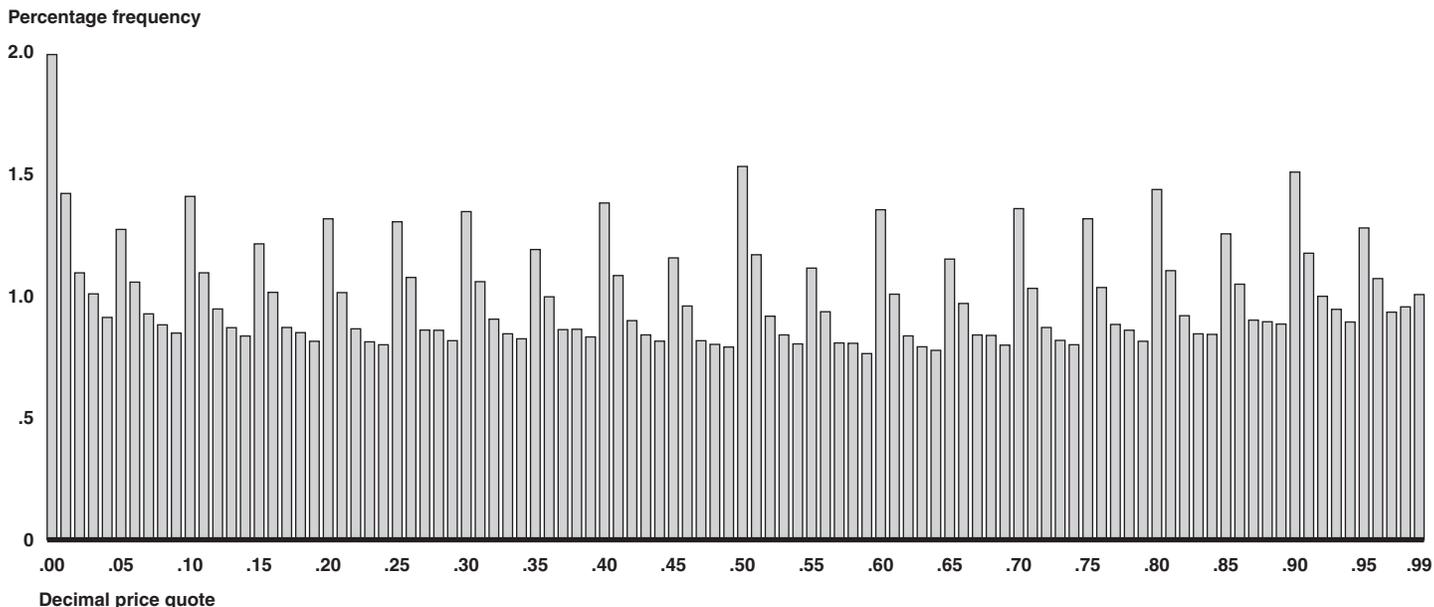
Note: Effective quoted spreads (the difference between the price at which a trade is executed and the midpoint between the prevailing quoted bid and ask prices) in the table represent the volume-weighted average effective spread (i.e., stocks and weeks with more total trading volume have greater weight) as a percentage of the midpoint of the prevailing quotes over 12 sample weeks during the predecimals period (February 2000–January 2001) and 12 sample weeks during the postdecimals period (April 2001–November 2004) for our sample of stocks. Stocks were segregated by volume according to the following categories:

- High volume stocks were those in our sample of stocks with average daily trading volumes exceeding 500,000 shares.
- Medium volume stocks were those in our sample of stocks with average daily trading volumes between 100,000 and 499,999 shares.
- Low volume stocks were those in our sample of stocks with average daily trading volumes of less than 100,000 shares.

We also analyzed the extent to which quote and trade execution prices cluster at particular price points, a phenomenon known as clustering. Clustering, particularly on multiples of nickels, dimes, and quarters, has been well documented by various researchers, and various reasons are cited to explain why all possible price points are not used with equal frequency. We extended the general body of research to include how clustering may have changed after decimalization, but we do not attempt to explain its causes. We generally found that prices tend to cluster on certain price points—especially on nickel, dime, and quarter multiples—but this tendency has been lessening over time. We provide examples of clustering in national best bid quote prices recorded for our sample of NYSE-listed stocks, but the same general features were found in national best offer quote and trade execution prices for both NYSE-listed and Nasdaq stocks. Figure 23 illustrates quote price clustering (using national best bid prices) over our entire postdecimalization sample period, which included 12

sample weeks from April 2001 through November 2004. Prices are observed generally clustering at nickel increments.

Figure 23: Quote Clustering After Decimalization, 2001-2004



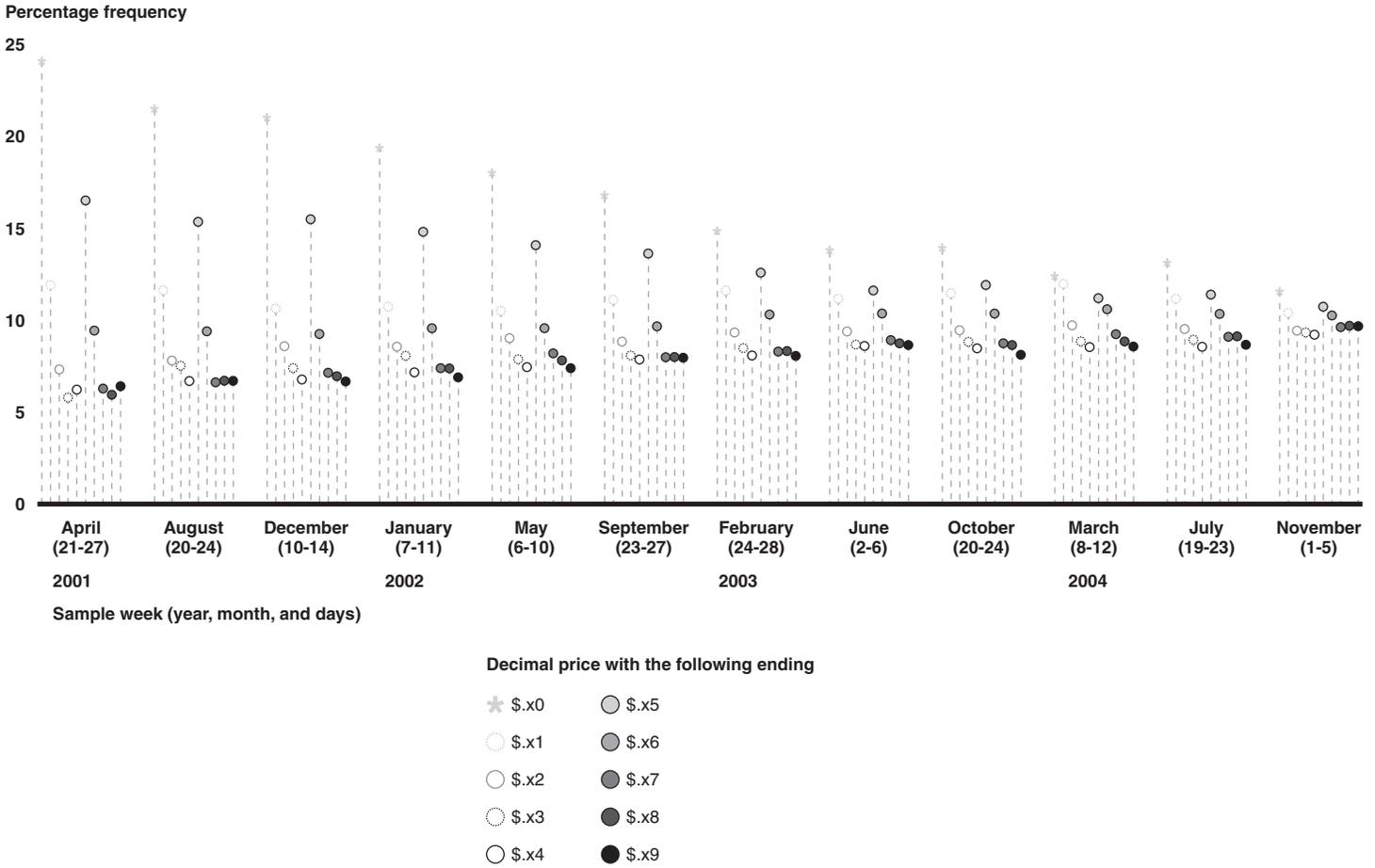
Source: GAO analysis of TAQ data.

Notes: Quote clustering in the figure represents the frequency with which each national best bid quote price point, from zero cents to 99 cents, was used by all of the NYSE-listed stocks from our matched-pairs sample over the 12 sample weeks during the postdecimals period (April 2001–November 2004). While not included in this appendix, similar results were generally obtained for both NYSE-listed and Nasdaq stocks using national best offer quote and trade execution prices.

We also analyzed how clustering may have changed over time. Using the same data as above, we separated the data by sample week. Our results, displayed in figure 24, depict a general decline in the use of price increment multiples of a nickel. This may suggest that traders have been adapting their strategies to the penny environment and are becoming increasingly comfortable with using various price points, which may be a result of the increased use of electronic trading. It may also be the case that traders are making use of the finer price grid to gain execution priority.

**Appendix IV
Additional Analysis Using Trade and Quotes
Data**

Figure 24: Quote Clustering After Decimalization, by Sample Week, 2001-2004



Source: GAO analysis of TAQ data.

Notes: Quote clustering in the figure represents the frequency with which each national best bid quote price point, from zero cents to 99 cents, was used by all of the NYSE-listed stocks from our matched-pairs sample over the 12 sample weeks during the postdecimals period (April 2001–November 2004). The notation y.x0 indicates any price for which the second decimal place is a zero (e.g., \$5.20); similarly, the notation y.x9 indicates any price for which the second decimal place is a nine (e.g., \$5.29). While not included in this appendix, similar results were generally obtained for both NYSE-listed and Nasdaq stocks using national best offer quote and trade execution prices.

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Staff Acknowledgments

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Glossary of Terms

Ask price (offer/sell price)	The lowest price at which someone is willing to sell a security at a given time.
Basis point	A basis point is equal to 1/100 of 1 percent.
Bear market	A market in which stock prices decline over a sustained period of time.
Best execution requirement	The obligation of broker-dealers to seek to obtain the best terms reasonably available under the circumstances for customer orders.
Bid-ask spread	The difference between the price at which a market maker is willing to buy a security (bid) and the price at which the firm is willing to sell it (ask). The spread narrows or widens according to the supply and demand for the security being traded. The spread is what the market maker retains as compensation (or income) for his/her effort and risk.
Bid price (buy price)	The highest price at which someone is willing to buy a security at a given time.
Block trade	Represents the purchase or sale of (1) a large quantity of stock, generally 10,000 shares or more or (2) shares valued at \$200,000 or more in total market value.
Broker	An individual or firm who acts as an intermediary (agent) between a buyer and seller and who usually charges a commission.
Bull market	A market in which stock prices rise over a sustained period of time.
Call option	A contract granting the right to buy a fixed amount of a given security at a specified price within a limited period of time.
Commission	A fee paid to a broker for executing a trade based on the number of shares traded or the dollar amount of the trade.
Dealer	An individual or firm in the business of buying and selling securities for his or her own account (principal) through a broker or otherwise.
Decimalization/decimal pricing	The quoting and trading of securities in dollars and cents (\$2.25) instead of fractions (\$8 1/8).

Delay cost	A type of market impact cost that occurs as the result of changes in the price of the stock being traded during the time institutional investors' portfolio managers direct their traders to buy and sell stock and the moment these orders are released to brokers.
Effective spread	Measures the trading costs relative to the midpoint of the quoted spread at the time the trade occurred. It is defined as twice (to reflect the implied roundtrip cost) the difference between the trade price and the midpoint of the most recent bid and ask quotes. It reflects the price actually paid or received by customers. It is considered a better measure of execution costs than quoted spreads because orders do not always execute exactly at the bid or offer price.
Electronic Communication Network (ECN)	An electronic trading system that automatically matches buy and sell orders at specified prices. It is a type of alternative trading system—an automated market in which orders are centralized, displayed, matched, and otherwise executed.
Exchange	An organized marketplace (stock exchange) in which members of the exchange, acting both as brokers and dealers, trade securities. Through exchanges, brokers and dealers meet to execute orders from individual and institutional investors and to buy and sell securities.
Floor-based (or auction) market	Is a stock exchange (like the American Stock Exchange and the New York Stock Exchange) where buyers and sellers meet through an intermediary—called a specialist. A specialist operates in a centralized location or “floor” and primarily matches incoming orders to buy and sell each stock. There is only one specialist designated for a firm or several firms who is assigned to oversee the market for those stocks.
Floor broker	A member of an exchange who is an employee of a member firm and executes orders, as agent, on the floor of the exchange for their clients.
Inside spread (inside quote)	The highest bid and lowest offer being quoted among all the market makers competing in a security.
Intermarket linkage system	An electronic trading linkage between the major exchanges (stock and option) and other trading centers. The system allows brokers to seek best execution in any market within the system.

Institutional investor	An organization whose primary purpose is to invest its own assets or those held in trust by it for others and typically buys and sells large volumes of securities. Examples of such organizations include mutual funds, pension funds, insurance companies, and charitable organizations.
Limit order	An order to buy or sell a specified number of shares of a security at or better than a customer-specified price. Limit orders supply additional liquidity to the marketplace. A limit order book is a specialist's record of unexecuted limit orders.
Liquidity	The ease with which the market can accommodate large volumes of securities trading without significant price changes.
Listed stock	The stock of a company that is listed on a securities exchange.
Market depth	The numbers of shares available for trading around the best bid and ask prices.
Market impact	The degree to which an order affects the price of a security.
Market maker	A dealer that maintains a market in a given security by buying or selling securities at quoted prices.
Market order	An order to buy or sell a stated amount of a security at the best price available when the order reaches the marketplace.
NASDAQ Stock Market (NASDAQ)	A market for securities traded "over-the-counter" through a network of computers and telephones, rather than on a stock exchange floor. NASDAQ is an electronic communications system in which certain NASD member broker-dealers act as market makers by quoting prices at which they are willing to buy or sell securities for their own accounts or for their customers. NASDAQ traditionally has been a "dealer" market in which prices are set by the interaction of dealer quotes.
National best bid and offer (NBBO)	Defined as the highest bid and lowest ask across all U.S. markets providing quotes for an individual stock.
Order Handling Rules	SEC rules that require (1) the display of customer limit orders that improve certain over-the-counter (OTC) market makers' and specialists' quotes or add to the size associated with such quotes (Rule 11Ac1-4 (Display Rule));

(2) OTC market makers and specialists who place priced orders with ECNs to reflect those orders in their published quotes (Quote Rule); and (3) OTC market makers and specialists that account for more than 1 percent of the volume in any listed security to publish their quotations for that security (Mandatory Quote Rule).

Opportunity cost	The cost from delaying execution to lessen market impact, or not be able to make the execution at all, or abandoning part of it because the market has turned against the strategy.
Price improvement	Occurs when an order is executed at better than the quoted price.
Put option	A contract granting the right to sell a fixed amount of a given stock at a specified price within a limited period of time.
Quote	The highest bid to buy and the lowest offer to sell any stock at a given time.
Quote flickering	Where a given price quote is only visible for a brief moment on the display screen.
Quoted spread	Measures the cost of executing a simultaneous buy and sell order at the quoted prices. It is the simplest measure of trade execution cost (or trading cost).
Retail investor	One who trades securities for himself/herself or who gives money to any institution, such as a mutual fund, to invest for himself/herself.
Securities and Exchange Commission	The federal regulatory agency created by the Securities Exchange Act of 1934 that is responsible for ensuring investor protection and market integrity in the U.S. securities markets.
Specialists	Members of an exchange who handle transactions on the trading floor for the stocks for which they are registered and who have the responsibility to maintain an orderly market in these stocks. They do this by buying or selling a stock on their own accounts when there is a temporary disparity between supply and demand for the stock.
Stepping ahead/penny jumping	The practice of improving the best price by a penny or less in an attempt to gain execution priority.

Stock	A financial instrument that signifies an ownership position in a company.
Tick size (or minimum price increment)	The smallest price difference by which a stock price can change (up or down).
Trade-through	The execution of a customer order in a market at a price that is inferior to a price displayed (or available) in another market.
Trading cost	The cost for executing the trade (brokerage commission, fees, market impact).
Transparency	The degree to which trade and quotation information (price and volume) is available to the public on a current basis.
Volatility	A measure of the fluctuation in the market price of a security.
Volume	The number of shares traded in a security or an entire market during a given period—generally on a daily basis. It is a measure of liquidity in a market.
Volume weighted average price (VWAP)	A trading benchmark used to evaluate the performance of institutional traders. It is the average price at which a given day's trading in a given security took place. VWAP is calculated by adding up the dollars traded for every transaction (price times shares traded) and then dividing by the total shares traded for the day. The theory is that if the price of a buy trade is lower than the VWAP, then it is a good trade. The opposite is true if the price is higher than the VWAP.

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