THE EFFECT OF STOCK SPLITS ON SMALL, MEDIUM, AND LARGE-SIZED FIRMS BEFORE AND AFTER DECIMALIZATION

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This study examines the impact of reducing tick size and, in particular decimalization on stock splits. Based on previous studies, this study examines hypotheses in the following three areas: first, market reaction around stock split announcement and ex-dates, second, the effect of tick size on liquidity after stock split ex-dates, and third, the effect of tick size on return volatility after stock split ex-dates.

The impact of tick size on market reaction around split announcement and ex-dates is measured by abnormal returns and buy and hold abnormal returns (BHARs). Also, this study investigates the long term impact of decimalization on market reaction for small, medium, and large firms for the three different tick size periods. The effect of tick size on liquidity after stock split ex-dates is measured by turnover, relative bid ask spread, and market maker count. The effect of tick size on return volatility around stock split announcement and ex-dates is measured by return standard deviation. Also, this study investigates the long term impact of decimalization on volatility after split ex-dates for small, medium, and large firms for three different tick size periods.

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CHAPTER 1

INTRODUCTION

Stock splits should not change the value of firms, but split announcements are associated with positive abnormal returns. A large number of studies have examined the effects of stock splits and there is extensive empirical evidence supporting competing hypotheses relative to stock splits. Among the split hypotheses, the two major explanations for stock splits are, first, the market reacts to stock splits as managers provide favorable inside information that conveys signals about the future prospects of a firm and, second, stock splits are used to adjust share prices to increase liquidity.

Stock splits may convey favorable private information about the firm and the market reacts to stock splits that signal the future prospects of a firm. The existence of positive abnormal returns around split announcements is consistent with the signaling hypothesis [Fama, Fisher, Jensen, and Roll (FFJR) (1969), Grinblatt, Masulis, and Titman (1984), Lamoureux and Poon (1987), Brennan and Copeland (1988), Asquith, Healy, and Palepu (1989), Brennan and Hughes (1991), and Boehme and Danielsen (2007)]. FFJR (1969) document that signaling explanations are consistent with abnormal increases in returns and/or dividends around the stock split announcements. They show that when the information effects of stock splits are taken into account, the apparent price effect of the stock splits vanishes following the stock split announcements. The FFJR (1969) monthly study results also indicate that the market's judgment concerning the information implications of splits is fully reflected in the price of a share at least by the end of the split announcement month. Byun and Rozeff (2003)

also find significant negative abnormal returns following the splits providing evidence against market efficiency by examining long-run performance of stocks after stock splits.

The liquidity hypothesis suggests that stock splits move stock prices to a lower preferred trading range to improve liquidity [Copeland (1979), Lamoureux and Poon (1987), Lakonishok and Lev (1987), Baker and Phillips (1994), and Dhar, Shepherd, and Zhu (2004)]. Baker and Phillips (1994) document that managers often justify stock splits on the basis that splits improve liquidity and marketability. Dhar, Shepherd, and Zhu (2004) also find that stock splits help attract new investors and improve stock liquidity. However, empirical tests that stock splits improve liquidity and marketability are mixed. Among the evidence, Lamoureux and Poon (1987) report that stock splits increase the number of trades and shareholders, but could not find an increase in split adjusted trading volume. Also, Copeland (1979) finds that stock splits increase bid-ask spreads and stock return volatility. Ohlson and Penman (1985) also report that subsequent to the split ex-date, stock volatilities increase by an average of thirty-five percent. These empirical results imply that stock splits decrease liquidity. However, Lakonishok and Lev (1987) point out flaws in the findings of reduced liquidity following splits. They find no significant change in trading volume when comparing longer windows before and after stock splits, and conclude that stock splits are to restore stock prices to a normal range rather than signaling.

On the other hand, previous empirical evidence on stock splits show that the liquidity and signaling hypotheses are not mutually exclusive but closely related [Muscarella and Vetsuypens (1996) and Ikenberry et al. (1996)]. Managers split their stocks to move the stock price to their preferred trading range to improve liquidity.

However, investors interpret the split decision as a signal of managers' optimism about the future of the firm.

However, most of these stock split empirical studies about market efficiency, signaling, liquidity, and volatility were documented and confirmed by studies before stock prices became decimalized[1]. The results of studies investigating decimalization effects on abnormal returns, liquidity, and volatilities experienced through the splitting of a firm's stock are mixed and different from the studies before the decimalization period. Decimalization requires stocks to move in penny increments. Before that, stocks had traded in increments of one-sixteenth (one-eighth) of a dollar, or 6.25 (12.5) cents[2]. Financial market decimalization had the expected result of smaller spreads lowering transaction costs on trades, benefiting investors by making market makers more competitive, and making prices easier to understand. However, since U.S. financial markets became decimalized in early 2001, some studies on stock decimalization argue that due to the reduction in the bid-ask spread after decimalization, markets have become less volatile but less liquid [Bessembinder (2003), Kadapakkam, Krishnamurthy, and Tse (2005), Chou, Lee, Chen (2005), Lipson and Mortal (2006), and Griffin (2010)]. These empirical studies on the stock market after decimalization find that the reduced bid-ask spreads have reduced market maker compensation, and consequently reduced the incentives for brokers to promote a stock after a split.

1 The decimalization on NYSE listed stocks began in January 29, 2001, while Nasdaq listed stocks started in April 9, 2001.

2 NYSE listed stocks had traded in increments of one-eighth (one-sixteenth) until June 23, 1997 (January 28, 2001), and Nasdaq listed stocks had traded one-eighth (one-sixteenth) until October 1997 (April 8, 2001). However, NYSE listed stocks before June 24, 1997, if stocks between $0.50 and $1.00, had traded 1/16th while stocks below $0.50 had traded 1/32th. For Nasdaq listed stocks, from October 1997 to April 8, 2001, stocks below $10 had traded 1/32th.

Kadapakkam, Krishnamurthy, and Tse (2005), Chou, Lee, Chen (2005), Lipson and Mortal (2006), and Griffin (2010) observe significant positive abnormal returns and improved liquidity around splits during the $1/8^{th}$ and $1/16^{th}$ pricing periods, but not in the decimal pricing period. Empirical studies also report that trading costs are up during post-decimalization compared to before the decimalization, especially for small firms, because narrower spreads mean less profit for market makers as their compensation reduced[3] [Bessembinder (2003), Kadapakkam, Krishnamurthy, and Tse (2005), and Chou, Lee, Chen (2005)].

The Securities and Exchange Commission (SEC) report to Congress on decimalization in July 2012 reveals that the narrower bid-ask spreads have reduced market maker compensation since the spread might be as tight as one penny, whereas before there was a minimum spread increment of 6.25 cents. After decimalization, the reduction in spreads may have reduced broker incentives to promote stocks but there has been no apparent reduction in market maker profitability. Tighter market maker compensation may have resulted in less liquidity for small-cap stocks, since broker-dealers may not find the reduced compensation enticing enough to invest in making a market in small-cap stocks which typically have lower volumes and therefore less trading flow [Bessembinder (2003)]. Also, the Securities and Exchange Commission (SEC) report to Congress documents that decimalization increased volatility in the short-run but decreased volatility in the long-run. These findings suggest that the initial

3 In 2007, the General Accountability Office (GAO) did a study and found that trading costs actually increased since the inception of decimalization.

effect of decimalization was improved market quality[4], most notably for large capitalization securities.

At the SEC Roundtable on Decimalization on Feb. 5, 2013, regulators, researchers, and other interested groups tried to evaluate the impact of tick size on the securities market, especially on small and mid-sized companies[5]. Decimalization was thought to bring about more precise trading and capture the true value of a stock, since the stock could tick up or down one cent. Also, with narrower spreads, a specialist on the New York Stock Exchange (NYSE) requires less capital to bridge the gap between buyers and sellers. However, the SEC Roundtable discussion was inconclusive because there are not many studies to show clear results about the impact of decimalization on the stock market, especially for small and medium size stocks and the long run effect after decimalization. The roundtable discussion concluded that more time to observe real data and side effects or unintended consequences over various market cycles and platforms was needed.

There are several empirical studies on decimalization effects around stock splits [Chou, Lee, and Chen (2005), Kadapakkam, Krishnamurthy, and Tse (2005), Lipson and Mortal (2006), Griffin (2010)]. These studies investigate whether or not the change in pricing regime, from fractional to decimalized, has had an effect on the abnormal returns, liquidity, and volatilities experienced through the splitting of a company's stock. Their findings are mixed and the results are different from one another. These stock split studies on decimalization did not focus on different effects related to firm size, especially long-term effects of small and medium sized firms. Many of these empirical

4 Market quality is measured by spread size, liquidity, and volatility.

5 SEC concerns about the adverse impact of decimalization on firms with market capitalization below $1 billion.

study findings on stock splits are presented for an average firm rather than a firm of a specific firm size. Moreover, these studies examine only the days surrounding the implementation of decimalization and do not examine its longer term effects. As the SEC report to Congress on decimalization inn July 2012 pointed out, market structure has changed significantly since the advent of decimalization. Therefore, the empirical study findings of the previous literature on stock splits may not be as applicable today given the current and continuously evolving nature of equity markets.

Therefore, the objective of this study is to examine the impact of stock splits in tick size regimes of $1/8^{th}$, $1/16^{th}$, and $1/100^{th}$ on small, medium, and large-sized firms. Specifically, the impact of tick size is measured by market reaction, liquidity, and volatility around stock splits before and after decimalization for small, medium, and large-sized firms listed on the NYSE and Nasdaq. I expect the impact of decimalization on different market cap stocks to be different because previous studies report that small cap stocks, on average, have lower share prices, wider spread, and higher volatility than large cap stocks. Since large cap stocks are more heavily traded than small cap stocks, I anticipate that stock split impact on market reaction, liquidity, and return volatilities for large cap stocks is different from small cap stocks after decimalization.

The remainder of the dissertation is organized as follows: Chapter 2 reviews previous studies of stock splits and decimalization relative to market reaction, liquidity effects, and return volatility. Chapter 3 develops hypotheses to be tested. Chapter 4 discusses the sample and data. Chapter 5 describes the general research methods employed. Chapter 6 presents the results about market reaction, the liquidity effect, and

the return volatility effect. Chapter 7 summarizes the evidence as to whether decimalization has improved market quality and the trading environment, and concludes.

CHAPTER 2

LITERATURE REVIEW

There are numerous empirical studies documenting competing hypotheses relative to stock splits. Among the stock split hypotheses, this study examines the signaling hypothesis, liquidity hypothesis, tick-size hypothesis, market microstructure hypothesis, and broker promotion hypothesis. The objective of the study is to examine the short and long term impact of stock splits and tick size for small, medium, and large-sized firms. The impact of splits is measured by market reaction, liquidity effect, and volatility.

2.1 Signaling Hypothesis

The signaling hypothesis states that stock splits convey favorable private information about the firm and that the market reacts to stock splits that signal about the future prospects of a firm. Empirical studies show that stock prices typically increase when stock splits are announced. It is widely held that stock split announcements may reduce investor uncertainty about future performance. These signaling-based studies argue that firms may split their stocks to convey good information about their managers' confidence regarding continued earnings, pushing the stock price upward [Fama, Fisher, Jensen and Roll (FFJR) (1969), Grinblatt, Masulis, and Titman (1984), Lamoureux and Poon (1987), Brennan and Copeland (1988), Asquith, Healy, and Palepu (1989), and Michayluk and Zhao (2010)].

Empirical studies document that signaling explanations are also consistent with abnormal increases in earnings and/or dividends around the stock split announcements

(FFJR 1969). Empirical evidence on stock splits provide that when the information effects of stock splits are taken into account, the apparent price effects of the stock splits vanishes following the stock split announcements [FFJR (1969) and Fama (1998)]. Byun and Rozeff (2003) also find significant negative abnormal returns following the splits providing evidence against market efficiency by examining long-run performance of stocks after stock splits. Other studies document that splitting firms typically experience a price run-up before the announcement of the split. Ikenbery and Ramnath (2002) report splitting firms show high momentum.

Grinblatt et al. (1984) used 1,380 stock splits during 1967-1976 and find consistent results with the previous literature. FFJR (1969) find an average increase in shareholders wealth of about 3.9% in the two days around the split announcement. These results indicate that split announcements convey information to the market. Grinblatt et al. (1984) also find that smaller firms' stock split announcements contain greater information. They conclude that firms signal information about their future earnings or equity values through their split decision. Asquith, Healy, and Palepu (1989) study a sample of 122 firms that announced stock splits during 1970 – 1980. They empirically confirm the signaling hypothesis by showing that splits signal that the recent earnings increases are permanent and not temporary.

Brennan and Copeland (1988) develop a signaling model in which undervalued firms signal their higher quality by splitting the stock. They show that stock splits are a costly but effective signal of a firm's future prospects. Their empirical evidence confirms the signaling hypothesis that split announcements convey information to the market. Brennan and Hughes (1991) develop a signaling model in which they predict that the

flow of information about firms is an increasing function of firm size and a decreasing function of share price. Their attention-getting model argues that managers with favorable inside information use stock splits to attract attention from institutional investors and financial analysts to trigger a revaluation of future cash flows. Brennan and Hughes (1991) argue that firms split their stocks to increase brokerage commissions, and thus create incentives for brokerage firms to promote a stock. By examining a sample of stock splits during 1976 – 1977, Brennan and Hughes (1991) find evidence supporting their model that the number of analysts following firms is positively related to firm size and negatively related to stock price. They find that security analyst coverage increases after splits. This argument may help to explain stock splits by smaller and less well-known firms.

2.2 Liquidity Hypothesis

Liquidity-based stock split studies argue that firms prefer to keep their stock price within a target price range to attract a specific clientele and increase their stocks liquidity [Copeland (1979), Lamoureux and Poon (1987), Lakonishok and Lev (1987), Conroy, Harris, and Benet (1990), Baker and Phillips (1994), and Stovall (1995)]. While some studies report improvements in post-split liquidity [Lamoureux and Poon (1987), Maloney and Mulherin (1992), Baker and Phillips (1994), Kryzanowski and Zhang (1996)], others show a reduction, or at best no change, in post-split liquidity [Copeland (1979), Lakonishok and Lev (1987), Conroy, Harris, and Benet (1990)].

Lamourex and Poon (1987) used 215 NYSE and AMEX firms during 1963-1982 and find an increase in the number of shareholders following stock splits but a decline in

split-adjusted trading volume following stock splits. Their empirical results support the survey by Baker and Gallagher (1980) that corporate managers use stock splits to expand the firms' shareholder base. An increased number of shareholders is desirable because more shareholders translate into greater overall liquidity as measured by variables such as trading volume and bid-ask spread.

Maloney and Mulherin (1992) used 446 stock splits of NASDAQ firms during 1984-1990, measuring liquidity effects associated with stock splits such as trading volume and bid-ask quotes. They document that stock splits lead to a greater number of shareholders, higher dollar volume, a greater number of trades, and narrower absolute bid-ask spreads while returning share price and average trade size to a target range. Maloney and Mulherin (1992) also report an increase in the number of institutional shareholders and the percentage institutional ownership for the sample firms subsequent to the split. They find positive returns on the split execution day itself and the split announcement date. Splitting firms experience a substantial price run-up in the two years prior to the split.

Copeland (1979) finds that stock splits increase bid-ask spreads and stock return volatility. This implies that stock splits decrease liquidity. Copeland (1979) used 25 NYSE splits during 1963-1974 and finds a significant widening in the relative bid-ask spread following stock splits and a reduction in the liquidity of a stock after splitting. However, Lakonishok and Lev (1987) point out flaws in the findings of reduced liquidity following splits. They note that the above average equity performance that firms experience prior to splits induces abnormal trading activity in the year preceding execution. They find that the pre-split volume was exceptionally high, and that stock

splits seem to have no permanent impact on trading volume. They argue that comparing post-split volume to this heavy trading volume associated with factors that arguably induce the split in the first place unduly biases the results toward a finding of reduced liquidity following the split. They find no significant change in trading volume when comparing longer windows before and after stock splits. They conclude that stock splits are to restore stock prices to a normal range rather than signaling. Conroy, Harris, and Benet (1990) measure liquidity in terms of bid-ask spreads by comparing 147 NYSE stocks that split with a random sample of 143 non-splitting NYSE stocks during 1981 – 1983 period. They find that shareholder's liquidity, measured by the percentage bid-ask spread, is actually worse after stock splits. The bid-ask spread as a percentage of closing stock price increases after the ex-date, and splits result in decreased liquidity, suggesting the existence of liquidity costs.

On the other hand, some previous empirical evidence on stock splits show that the liquidity and signaling hypotheses are not mutually exclusive, but closely related [Muscarella and Vetsuypens (1996) and Ikenberry et al. (1996)]. Managers split their stocks to move the stock price to their preferred trading range to improve liquidity. However, investors interpret the split decision as a signal of managers' optimism about the future of the firm. Ikenberry et al. (1996) propose a "self-selection" hypothesis as a synthesis of the trading range and signaling theories. They do not treat the signaling and the trading range hypothesis as mutually exclusive, instead they contend that managers use splits to move share price into a more favorable trading range. The result show that splits realign prices to a lower trading range, but managers self-select by conditioning their decision to split on expected future performance. They find a 3.38%

five-day announcement return, which confirms prior research that splits convey favorable information.

Muscarella and Vetsuypens (1996) investigate the signaling and liquidity hypotheses by studying splits of American depositary receipts (ADRs) that are not associated with splits in their home-country stock, and which represent unique illustrations of the effect of liquidity. They argue that ADR solo-splits cannot be motivated by any explicit managerial desire to signal favorable inside information. If that were the case, the company would likely split in its primary domestic market. Besides, for unsponsored ADRs, the split is initiated not by the company, but by the depositary bank, thus ruling out any implicit signaling interpretation of the split decision. They find evidence that liquidity improves with significant positive returns between 1% and 2% around the ADR solo-split announcement. They observe these returns in the ADR market as well as in the stock's home market. They interpret these excess returns as the market's reflection of the expected benefits from greater post-split liquidity.

2.3 Market Anomaly

Stock splits should not change the value of splitting firms. However, empirical evidence confirms that the announcement of stock splits is associated with positive abnormal returns. The positive abnormal return around a split announcement is said to represent a consistent signal of future prospect of splitting firms. Grinblatt et al. (1984) examine the signaling hypothesis and also examine evidence relating to several efficient market anomalies that have been documented in other studies. In an efficient market, traders are unable to earn abnormal profits by trading on the public

announcement of a stock dividend or split. However, prior literature documents that traders could have earned an excess return by purchasing shares at the end of the announcement date of a stock split and holding them for three to five years [Grinblatt et al. (1984), Maloney and Mulherin (1992), Ikenberry et al. (1996), Ikenberry and Ramnath (2002), Chou, Lee, and Chen (2005), and Kadapakkam, Krishnamurthy, Tse (2005)]. Grinblatt et al. (1984) find abnormal returns in the months subsequent to a stock split announcement and on stock distribution ex-dates. Their analysis find that post announcement returns, particularly around the ex-dates, are often abnormally large, especially for stock dividends and for securities that trade on the American Stock Exchange. However, they were not able to provide resolution of this anomaly.

2.4 Market Microstructure

Maloney and Mulherin (1994) support such conjectures by relating the anomalous ex-day return for stock splits to market microstructure phenomena. They trace the source of the microstructure bias in the execution day returns to conventional explanations as to why stock splits are implemented in the first place. They find that in the eleven trading days following the ex-split date, trades of splitting stocks tend to congregate at ask prices and the ex-day return is dominated by an asymmetric increase in the ask price compared to the bid. This causes an apparent abnormal return using observed prices that is not available to the average trader.

Easley, O'Hara, and Saar (2001) evaluate alternative hypotheses about stock splits by examining their implications for trading in the stocks using a microstructure model. They show that uninformed trading increases following splits, and that there is a

slightly increased tendency of uninformed buyers to execute trades using market orders. These effects are consistent with the entry of a new clientele and, thus, are supportive of the trading range hypothesis. However, they do not find any significant increase in liquidity, partly, because they find that informed traders intensify their activity as well. Their trading model shows that the increase in relative spreads documented in the literature is not due to increased adverse selection, but rather to an increase in the underlying volatility of the stocks. Their finding that the overall trading costs of the uninformed traders increase after splits seems inconsistent with the enhanced liquidity. They also find that while limit order trading does increase, this increase is not sufficient to compensate the uninformed traders for the increase in the bid-ask spread and the more intense usage of market buy orders by uninformed traders. Therefore, they are able to show that a rise in the trading costs of uninformed traders can be consistent with both increased uninformed trading and increased limit order activity.

2.5 Tick Size and Broker Promotion Hypothesis

Angel (1997) presents a tick-size hypothesis which argues that firms split to increase the tick-to-price ratio and, hence, market maker profits. A large relative tick size provides an incentive for dealers to make markets and for investors to provide liquidity by placing limit orders, despite its placing a high floor on the quoted bid-ask spread. Supposedly, in return for the higher profit potential, market makers reward the firms with better liquidity and exert more effort at marketing the firm's stock. The costs of splitting are substantial, therefore Angel (1997) argues that companies would not split unless there were some perceived benefits.

Goldstein and Kavajecz (2000), Bessembinder (2003) and other empirical studies document that a smaller tick size can adversely affect incentives to provide liquidity, potentially damaging market quality. These studies report that a smaller tick size decreases bid-ask spreads and also decreases liquidity provision. Harris (1994) using data during the 1/8th era, fits a regression model and estimates that reducing the minimum tick size to 1/16th would be accompanied by both lower bid-ask spreads and lower quoted depth. His results are consistent with the idea that the optimal tick size is related to the size of a trade. Harris (1994) predicts that as quote sizes reduce, decreased liquidity could also be manifest in the form of more volatile prices. Harris (1997) reports previous tick size reductions on the Toronto Stock Exchange from 12.5 cents to 5 cents for most stocks and on the U.S. equity markets from 12.5 cents to 6.25 cents. Harris (1999) made predictions about the impact of reducing the tick size to a penny such as reductions in bid-ask spreads for heavily traded stocks, reductions in quotation sizes, and an increase in price improvement rates for stocks traded in specialist auction markets. The reduction is expected to be greater for heavily traded stocks since their equilibrium spreads are likely to be smaller and the one cent constraint is more likely to be binding.

Goldstein and Kavajecz (2000) investigate the impact of reducing the minimum tick size from 1/8th to 1/16th on the liquidity of the market by using limit order data provided by the NYSE. While both spreads and depths, quoted and on the limit order book, declined after the NYSE's change from 1/8th to 1/16th, depth declined throughout the entire limit order book as well. The combined effect of smaller spreads and reduced cumulative limit order book depth has made liquidity demanders trading small orders

better off, however, traders who submitted larger orders in lower volume stocks did not benefit, especially if those stocks were low priced.

Bessembinder (2003) assesses trade execution costs and market quality for NYSE and Nasdaq stocks before and after the 2001 change to decimal pricing. He finds quoted bid-ask spreads declined substantially in each market with reduced tick size, and for stocks in all market capitalization groups. The largest declines were for heavily traded stocks (large capitalization Nasdaq stocks). Spreads of large capitalization Nasdaq stocks decreased on a volume-weighted basis to 1.6 cents per share, or 0.096% of share price. Spreads on large capitalization NYSE listed stocks also declined significantly to 5.2 cents or 0.182% of share price. He also documents that the volume-weighted average effective bid ask spread for sample Nasdaq stocks after decimalization is statistically indistinguishable from the corresponding pre decimalization Nasdaq measure, or from the corresponding post-decimalization sample NYSE measure. This result reflects in part the declining relevance of quotations after decimalization. The data supports the overall conclusion that trade execution costs are quite similar across NYSE and Nasdaq stocks of matched capitalization in the decimalization period. In general, Bessembinder (2003) argues that reducing tick size resulted in narrower average quoted, effective, and realized bid-ask spreads in both markets, lower volatility in both markets, and the absence of systematic reversals of quote changes on either market, indicating that market quality has indeed been improved.

The SEC report to Congress on July 2012 documents that narrower bid-ask spreads have reduced market maker compensation since the spread might be as tight

as one penny, whereas before there was a minimum bid and ask spread increment 6.25 cents. After decimalization, the reduction in spreads may have reduced broker incentives to promote stocks but there was no apparent reduction in market maker profitability. Tighter market maker compensation may have resulted in less liquidity for small-cap stocks, since most broker-dealers will not find the reduced compensation attractive enough to invest in making a market in small-cap stocks which typically have lower volumes and therefore less trading flow [Bessembinder (2003)].

2.6 Volatility Change around Stock Splits

There is large number of empirical studies about stock return variance changing around stock splits. Ohlson and Penman (1985), Dubofsky (1991), and Easley, Kiefer, O'hara, and Paperman (1996) provide evidence that stock return variances increase subsequent to stock splits. Ohlson and Penman (1985) provide evidence that NYSE stock return variances increase subsequent to ex stock distribution days for splits of 100% or greater. They report that the increase in volatility is independent of the size of the split and the post-split price. They suggest that the greater post-split volatility may be due to the activity of relatively ignorant noise traders who prefer trading low-priced stocks, and institutional factors, a rather broad category that incorporates measurement problems created by the "1/8 effect" and bid-ask spreads, as possible hypotheses for the post-split volatility increase.

Dubofsky (1991) reports there are post-split increases in the variance of both NYSE and AMEX daily returns. However, the increase in post-split daily volatility is less for AMEX stocks than for NYSE stocks after controlling for price and split size. He

argues the exchange trading location is a significant factor in explaining the volatility shift even after stock price and firm size are considered. Dubofsky (1991) suggests that measurement errors created by bid-ask spreads and the 1/8 effect, and also one or more of the elements that make the NYSE different from the AMEX, such as market making mechanisms, and owner characteristics, explain why the estimated volatility of daily stock returns increases after the ex-split date. Shares of low priced and small sized firms are characterized by wider bid-ask spreads [Roll (1984)], and wider spreads can create more "noise-induced variance" [Amihud and Mendelson (1986)].

Easley, Kiefer, O'hara, and Paperman (1996) examine whether differences in information-based trading can explain observed differences in spreads for active and infrequently traded stocks. They estimate the risk of information-based trading for a sample of NYSE listed stocks. Using regressions, they provide evidence of the economic importance of information-based trading on spreads. They argue that despite the large volumes traded on organized exchanges, many (if not most) listed stocks trade infrequently. One characteristic of such infrequently-traded stocks is their large bid-ask spreads. They provide three explanations for the large spreads, inventory or liquidity effects, market power, and information effects. First, if a stock trades infrequently, the specialist handling the stock may have to maintain an inventory imbalance for a long period. This lack of liquidity may induce a risk averse specialist to set higher spreads to compensate for the exposure. Second, for many inactive stocks, only a single market maker provides liquidity, with few limit order traders willing to post competing orders. This monopoly position may allow the market maker to set larger spreads than would not arise in a competitive environment. Third, infrequently-traded

stocks tend to have greater variability in order flow, with active days interspersed with slow days. When shares do trade, it is because of traders acting on private information, then the market maker would face large losses. The large spreads arise, therefore, as the natural consequence of the greater risk of informed trading in illiquid stocks.

Chakravarty, Wood, and Van Ness (2004) use a constructed matched sample of control (non-decimal) stocks and isolate the effects of decimalization for a sample of NYSE listed common stocks trading in decimals. They find that stock return volatilities display an initial increase but a decline over the longer term, which the authors attribute to trader learning, or traders becoming accustomed to the new market structure.

2.7 Other Stock Split Literature

Other literature documents that splitting firms typically experience a price run-up before the announcement of the split. Ikenberry and Ramnath (2002) report the presence of abnormal returns in ex-split dates due to a momentum factor. They report a drift of 9% in the year following a split announcement. They consider fundamental operating performance as a source of the underreaction and find that splitting firms have an unusually low propensity to experience a contraction in future earnings. Further, analysts' earnings forecasts are comparatively low at the time of the split announcement and revise sluggishly over time. They conclude that the results are consistent with the notion of market underreaction to the information in corporate news events.

2.8 Literature on Decimalization

There is an impressive body of empirical evidence regarding the impact of stock split announcements on the value of a firm. Most of the hypotheses such as market efficiency, signaling, liquidity, tick size, and broker promotion hypotheses were documented and confirmed by studies before the stock market became decimalized. But not many studies show the impact of stock splits after decimalization for different firm sizes and their long term effects. Decimalization requires stocks to move in penny increments. Before that, stocks traded in increments of $1/16^{th}$ ($1/8^{th}$) of a dollar, or 6.25 (12.5) cents. Studies on stock decimalization argue that stock market decimalization had the expected result of smaller spreads on trades, benefiting investors by lowering trading costs, making market makers more competitive, and making prices easier to understand. However, some studies of the stock market before and after decimalization find that there was more liquidity when the price increment was larger. Also studies document that other trading costs rose and market volatility increased during the post-decimalization period because narrower spreads mean less profit for market makers [Bessembinder (2003), Chou, Lee, and Chen (2005), Kadapakkam, Krishnamurthy, and Tse (2005), Lipson and Mortal (2006), Griffin (2010), and SEC Report to Congress on Decimalization (2012)].

Bessembinder (2003) finds that quoted spreads decreased substantially after decimalization on both NYSE and Nasdaq markets and for stocks in all market capitalization groups. The most striking reduction in average quoted spreads is for large capitalization stocks on both NYSE and Nasdaq that decreased significantly on a volume-weighted basis. Also, quote sizes were reduced substantially on each market.

Nasdaq (2001a) and Chung, Van Ness, and Van Ness (2001) compare trading costs across Nasdaq and the NYSE after decimalization. Nasdaq (2001a) reports lower quoted and effective spreads on the Nasdaq market, while Chung, Van Ness, and Van Ness (2001) find that execution costs on Nasdaq are still larger than on the NYSE after decimalization.

Bessembinder (2003) shows that volume weighted quoted spreads decreased substantially after decimalization on both NYSE and Nasdaq markets and for stocks in all market capitalization groups. He also reports that the percentage of shares receiving price improvement increased significantly on the NYSE, but was almost unchanged on the Nasdaq market and that the magnitude of price improvement declined. Quoted and effective spreads for the majority of medium and small capitalization stocks remained narrower on the NYSE.

Chung, Van Ness, and Van Ness (2001) include smaller stocks and use equal weights for each stock and find results biased toward higher trading costs on the Nasdaq market. But spreads for large heavily traded stocks are narrower on Nasdaq after decimalization. On the other hand, results from volume-weighted averaging across stocks as in Nasdaq (2001a) will be more likely to find lower trading costs on Nasdaq.

Bessembinder (2003) also finds that trade execution costs decreased on both markets after decimalization and that a smaller tick size can inhibit liquidity supply. According to Bessembinder (2003), possible adverse effects of the smaller tick size include 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. Bessembinder (2003) finds that the volume-

weighted average effective bid-ask spread for sample Nasdaq stocks after decimalization is statistically indistinguishable from the corresponding before decimalization Nasdaq measure, or from the corresponding after decimalization sample NYSE measure. This empirical result supports the overall conclusion that trade execution costs are similar across NYSE and Nasdaq stocks of matched capitalization after decimalization.

Decimalization was thought to bring about more precise trading and capture the true value of a stock since the stock could tick up or down one cent. Also, with narrower spreads, a specialist on the NYSE required less capital to bridge the gap between buyers and sellers. However, Chakravarty, Wood, and Van Ness (2004) find that the quoted depth as well as the quoted and effective bid-ask spreads declined significantly following decimalization. Additionally, both the number of trades and trading volume declined significantly.

Chou, Lee, and Chen (2005) documented the stock price behavior around the ex-split dates both before and after the decimalization on the NYSE. They find the abnormal ex-split day returns decrease as the tick size and hence the bid-ask spread decrease. The mean abnormal returns in the $1/8^{th}$ era and in the $1/16^{th}$ era, respectively, are significant. However, the abnormal return in the decimal era is smaller and insignificant. The abnormal trading volume increases in the $1/16^{th}$ and decimal pricing eras, relative to the $1/8^{th}$ pricing era. The volume results imply that higher bid-ask spreads do impair the ex-split short-term trading in the $1/8^{th}$ era, because in both the $1/16^{th}$ and the decimal eras, the short-term abnormal volume increases.

Kadapakkam, Krishnamurthy, and Tse (2005) examine the broker promotion explanation for stock splits by examining whether decimalization alters investor trading patterns around ex-split dates for both NYSE and Nasdaq. They find that decimalization reduces the tick size and results in narrower bid-ask spreads for both NYSE and Nasdaq stocks. They document that decimalization has decreased bid-ask spreads and reduced the incentives for brokers to promote a stock after it is split. On the other hand, during the 1/8th pricing period, they show that after the ex-date, the relative spread increases significantly. They also observe significant positive abnormal returns around the ex-date during the 1/8th pricing period, but not in the decimal pricing period. However, this study covers only one year of splits for each tick size for NYSE and Nasdaq. Therefore, the results may not represent the long term effects of decimalization.

Lipson and Mortal (2006) find little evidence that firms adjusted prices to maintain similarly binding tick sizes as the NYSE reduced tick sizes. Also they find little evidence supporting theories, such as spread-induced sponsorship, that rely on binding tick sizes to link splits and clientele.

Griffin (2010) documented that under the decimalized system, abnormal returns tend closer to zero throughout the period, while under the fractional system (1/8th era) as a whole, abnormal returns tended to be more positive in the period around the split announcements. According to the broker promotion hypothesis, brokers actively promote splitting stocks to the average investor due to the increase in bid-ask spread after splitting. However, Griffin (2010) finds that under the fractional system (1/8th era), the transaction costs after a stock split became greater as a percentage of the stock price, while under the decimalization system, the bid-ask spread adjusts in exact

proportion to the reduction in stock price. Therefore, the decimalization system eliminates any undue transaction costs as well as any undue incentives for the broker to recommend the stock to clients. Despite a reduction in transaction costs under the new system, this study finds that there are no long-term benefits of splitting.

These post decimalization studies did not focus on different effects related to market capitalization especially long-term decimalization effects of small and medium sized firms. Many of these study findings are presented for an average firm rather than a firm of a specific size. Moreover, these studies examine only the few days surrounding the implementation of decimalization and do not examine its longer term effects.

There are not many studies showing clear ideas about the impact of decimalization on stock markets after splitting, especially for small and medium stocks, and the long term split effects after decimalization. As stated in the SEC report to Congress on Decimalization (2012), market structure has changed significantly since the advent of decimalization. The findings of the previous literature on stock splits may not be as applicable today given the current and continuously evolving nature of equity markets.

CHAPTER 3

HYPOTHESES DEVELOPMENT

This study examines the impact of decimalization on stock splits for small, medium, and large firms listed on NYSE and Nasdaq. This study utilizes stock split data before and after decimalization for small, medium, and large capitalization firms. Following previous studies about stock splits, this study examines hypotheses in the following three areas: First, market reactions around stock split announcement and ex-dates before and after decimalization for small, medium, and large capitalization firms. Second, the effect of decimalization on liquidity after ex-dates for small, medium, and large capitalization firms. Third, the effect of decimalization on return volatility after split ex-dates for small, medium, and large capitalization firms.

To investigate the impact of decimalization on stock splits for small, medium, and large firms, the stock splits for three different tick size periods are examined. Also, small, medium, and large firms listed on NYSE and Nasdaq are analyzed separately before and after decimalization. The impact of market reaction around stock split announcement and ex-split dates after decimalization is measured by abnormal returns and buy and hold abnormal returns. The effect of decimalization on liquidity change after ex-split dates is measured by turnover ratio, relative bid-ask spread, and market maker count. The effect of decimalization on return volatility after split ex-dates is measured by return standard deviation. Also, this study investigates the long term impact of decimalization for small, medium, and large capitalization firms.

The hypotheses of this study are based on the existing literature concerning market reaction, liquidity, and volatility. They are stated as follows.

3.1 Market Reaction

Hypothesis 1: There is no short-term market reaction around the stock split announcement date among the three different tick size periods and three firm size groups.

Hypothesis 2: There is no long-term market reaction after the stock split announcement date among the three different tick size periods and three firm size groups.

Hypothesis 3: There is no short-term market reaction around the stock split ex-date among the three different tick size periods and three firm size groups.

Hypothesis 4: There is no long-term market reaction after the stock split announcement date among the three different tick size periods and three firm size groups.

3.2 Liquidity Effect

Hypothesis 5: Tick size and firm size have no effect on the change in a firm's liquidity following a stock split.

3.3 Effect of Return Volatility

Hypothesis 6: Tick size and firm size have no effect on the change in a firm's return volatility following a stock split.

CHAPTER 4

SAMPLE AND DATA

4.1 Sample Selection

This study includes splits of ordinary common shares with split factors of 25% or greater. Stock splits with pre-split share price less than $10 are excluded because these stocks had different tick sizes before decimalization. Also, certificates[6], American Depository Receipts (ADRs)[7], Shares of Beneficial Interest (SBIs)[8], Units[9], Closed-end funds, and REITs are excluded. There are 3,593 stock splits (distribution code 5523, and share code 10 and 11) available from the Center for Research in Security Prices (CRSP) from January 1, 1991 to December 31, 2011 for stocks listed on the NYSE and Nasdaq. From the initial 3,593 stock splits, 2,098 stock splits with dividends and earnings within five days before and after split announcement dates or split ex-dates are excluded to remove any contamination effect. Also, splits with announcement dates and ex-split dates not within the same tick period are removed. Finally, splits occurring more than once a year and splits with buy and hold abnormal returns (BHARs) higher (lower) than 75% (-75%) stocks are removed. So, 1,344 stock split announcement dates and split ex-dates are the sample of this study.

6 The actual piece of paper that is evidence of ownership of stock in a corporation. Watermarked paper is finely engraved with delicate etchings to discourage forgery.

7 A share of stock of an investment in shares of a non-US corporation. A receipt that is issued by a U.S. depositary bank which represents shares of a foreign corporation held by the bank. Because ADRs are quoted in U.S. dollars and trade just like any other stock, they make it simple for investors to diversify their holdings internationally.

8 The ownership of shares through a right to legal title rather than through actual possession.

9 A combination of multiple securities, such as common stock and warrants, sold together as a single product such as Depository Units, Units of Beneficial Interest, Units of Limited Partnership Interest, Depository Receipts, etc.

Table 1

Stock Splits for NYSE and Nasdaq

Tick Size	Stock Splits				Total	%
	NYSE		Nasdaq			
	Period	Splits	Period	Splits		
1/8th	Jan. 1, 1991 - May 31, 1996	226	Jan 1, 1991 – May 31, 1996	417	643	47.8
1/16th	June 24, 1998 - Jan. 28, 2000	64	Oct. 1, 1998 - March 31, 2000	181	245	18.2
1/100th	May 1, 2002 - Dec. 31, 2011	151	May 1, 2002 - Dec. 31, 2011	305	456	33.9
Total		441		903	1,344	100.0

4.2 Data

Of the 1,344 stock splits, 441 (32.8%) stock splits are listed on NYSE and 903 (62.2%) stock splits are listed on Nasdaq. The stock splits are divided into three different periods based on tick size, the 1/8th period, the 1/16th period, and the 1/100th period for both NYSE and Nasdaq.

Table 1 shows the number of stock splits in three different tick size periods for both NYSE and Nasdaq. Of the 1,344 stock splits, 643 (47.8%) splits are from the 1/8th tick period, 245 (18.2%) splits are from the 1/16th tick period, and 456 (33.9%) splits are from the 1/100th tick period.

This study examines the impact of decimalization for small, medium and large firms. Therefore, the stock splits are also divided into three different firm sizes, small,

medium and large, according to Standard and Poor's market capitalization categories[10]. Market capitalization in this study is calculated as the share price just before the split date multiplied by the total number of shares outstanding just before the split date. Table 2 presents the total number of stock split announcements and split ex-dates under different tick size periods and market capitalizations combined for both NYSE and Nasdaq. Of the 1,344 splits, 830 (61.8%) splits are made by small firms, 336 (25%) splits are by medium firms, and 178 (13.2%) splits are by large firms.

Table 2

Stock Splits from January 1, 1991 to December 31, 2011

Tick Size	NYSE				Nasdaq				Total			
	Small cap	Mid cap	Large cap	total	Small cap	Mid cap	Large cap	total	Small Cap	Mid cap	Large cap	Total
1/8th	164	50	12	226	347	58	12	417	511	108	24	643
1/16th	33	14	17	64	72	59	50	181	105	73	67	245
1/100th	51	59	41	151	163	96	46	305	214	155	87	456
Total	248	123	70	441	582	213	108	903	830	336	178	1,344

An examination is made of the properties of daily stock returns, turnover, bid ask spread, market maker count, and return volatilities, and how the particular characteristics of the data affect the event study methodology for assessing the stock

10 Standard & Poor's (Feb. 16, 2011): Large cap (S&P 500): >$4 billion (formerly >$3 billion), Mid cap (S&P 400): $1 billion to $4.4 billion (formerly $850 million to $3.8 billion), Small cap (S&P 600): $300 million to $1.4 billion (formerly $250 million-$1.2 billion). Since the market capitalization of the mid-cap (S&P 400) is overlapping with large cap (S&P 500) and small cap (S&P 600), this study determines the large cap: > $4 billion, mid cap: $1 billion to $4 billion, and small cap < $1 billion.

price impact of split announcements or split ex-date before and after decimalization[11]. This study presents and compares the impact of decimalization on market reaction, liquidity, and return volatilities by utilizing split announcement and ex-split dates.

11 Brown and Warner (1985) argue that daily and monthly data differ in potentially important respects. They find that daily stock returns depart more from normality than do monthly returns.

CHAPTER 5

METHODOLOGY

5.1 Measuring Market Reaction

Long-term and short-term market reaction around stock split announcement dates and ex-dates before and after decimalization is measured by abnormal returns and buy and hold abnormal returns. The market adjusted model with the CRSP equally weighted index[12] is employed for measuring the abnormal returns and buy and hold abnormal returns[13].

5.1.1 Measuring Abnormal Returns

The daily abnormal return for firm i on day t (AR_{it}) is normally expressed as $AR_{it} = R_{it} – E(R_{it}|X_t)$. R_{it} = actual ex-post daily return of security i; and $E(R_{it}|X_t)$ = expected daily return without the condition that the split announcement will take place over the event window. When using the market model[14], the firm's expected return is defined as: $E(R_{it}|X_t) = \hat{\alpha}_i + \hat{\beta}_i Rm_t + \varepsilon_{it}$, where, Rm_t is the daily return on the market at time t using the CRSP equal-weighted index; $\hat{\alpha}$ and $\hat{\beta}$ are OLS parameter estimates from the estimation period; and $AR_{it} = R_{it} – \hat{\alpha}_i – \hat{\beta}_i Rm_t$ now becomes the computed daily abnormal return.

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[12] The CRSP equal-weighted market return is a simple average of the returns of all traded stocks, $R_t^{EW} = \frac{\sum r_{it}}{N_t}$.

[13] Brown and Warner (1980, 1985) find that an equally-weighted index performs better than a value weighted index.

[14] The market model assumes a stable linear relation between the market return and the firm's return.

However, in this study, the abnormal stock returns are calculated by using the market adjusted model with the CRSP equally weighted index. Previous literature shows that the period prior to the split announcement date is one of unusually high activity, possibly biasing market model parameters estimated over this period. Also, the market adjusted returns with an equally -weighted index is applied because this study employs a large sample size and I expect that the $\hat{\alpha}$ and $\hat{\beta}$ of the three different tick size sample periods, 1/8th, 1/16th, and 1/100th, and the three different market capitalization groups are not statistically different from 0 and 1, respectively. Thus, the market adjusted returns model sets $\hat{\alpha}$ = 0 and $\hat{\beta}$ = 1, therefore, computed abnormal returns by the market adjusted returns are, $AR_{it} = R_{it} - Rm_t$. The market adjusted returns model average abnormal returns on any announcement date t (AAR_{it}) are expressed as, $AAR_{it} = \frac{1}{N} \sum_{i=1}^{N} [R_{it} - Rm_t]$, where, N is total number of firms, i is an individual firm, R_{it} = actual ex-post daily return of firm i with announcement date t, and Rm_t is the daily return on the market at time t using the CRSP equal-weighted index. The standardized cross-sectional test (Boehmer, Musumeci and Poulsen, 1991) [15] is used to measure the significance of abnormal returns.

5.1.2 Methodology for Evaluating BHARs

To measure the short-term and long-term market reaction over intervals around stock splits, the average buy-and-hold abnormal return (BHAR) is measured by the market adjusted returns model. For short-term market reaction, five days before and

[15] Standardized cross-sectional test is the extension of Patell (1976) test introduced by Boehmer, Musumeci and Poulsen (1991). This test compensates for a possible variance increase on an event date by introducing a cross-sectional variance adjustment.

after stock split announcement and ex-dates is examined, and for long-term, one month[16], two month, three month, six month, and one year periods after split announcement and ex-split dates are calculated for three different tick size periods, 1/8th, 1/16th, and 1/100th. Also the short-term and long-term performance is measured for three different firm sizes, small, medium, and large, according to market capitalization. The average buy-and-hold abnormal return is calculated following Desai and Jain (1997) and Byun and Rozeff (2003).

The BHAR measures the difference between the compound actual return and the compound market return. Average compounded abnormal returns are expressed as;

$BHAR_{it,\ T1T2} = \frac{1}{N}\sum_{i=1}^{N}[\prod_{t=1}^{T}(1 + R_{it}) - \prod_{t=1}^{T}(1 + Rm_t)]$,

where, $BHAR_{it}$ = Average daily BHARs of N firms over period T_1T_2, R_{it} = Actual daily return of firm i at time t, T_1T_2 = (-5, 0), (-2, 0), (-1, 0), (-1, +1), (0, +1), (0, +2), (0, +5) for short-term periods around the stock split announcement and ex-date, T_1T_2 = (+6, +27), (+6, +48), (+6, +69), (+6, +132), and (+6, +258) trading days after the stock split announcement and ex-date for one month, two month, three month, six month, and one year holding periods, respectively, and Rmt = Daily return on the market at time t using the CRSP equal-weighted index. A T-test is used to measure the significance of buy and hold abnormal returns[17].

[16] I used trading day instead of calendar day. So, one month counts average of 21 trading days and one year for 252 trading days.

[17] T-test for BHARs (Split Announcement and Ex-dates) for short-term and long-terms are used for testing null hypothesis, Ho: $BHAR_{iT1T2} = 0$, $T_{BHAR\ T_1T_2} = \frac{\overline{BHAR}_{T1T2}}{\sigma_{BHAR_{T1T2}}/\sqrt{N-1}}$, where T_1T_2 is for short-term and long-term periods.

5.1.3 Methodology Estimating Split Announcement or Split Ex-date Effects

I use the standard event study approach to estimate market reaction on stock split announcement dates or ex-dates before and after decimalization. Define day 0 as the stock split announcement date or split ex-date for a given security. For each security, I use a maximum of 516 daily return observations for the period around its respective stock split event, starting at day -258 and ending day +258 relative to the split event. The first 252 days in this period (-258 through -6) is designated the 'estimation period', and the following 11 days (-5 through +5) is designated the event period. Firms with less than 60 days stock returns from CRSP are removed from the analysis. Figure 1 shows the estimation period and event windows for this study[18].

[18] Stock splits and estimation periods:

- I/8th period:
  Stock splits for NYSE and Nasdaq: January 1, 1991 – May 31, 1996
  Estimation period: January 1, 1990 – December 31, 1990
  Long-term effect (for one year: 252 trading days): June 1, 1996 – May 31, 1997
- 1/16th period:
  Stock splits for NYSE: June 24, 1998 – January 28, 2000
  Estimation period: June 24, 1997 – June 23, 1998
  Long-term effect (for one year: 252 trading days): January 29, 2000 – January 28, 2001
  Stock splits for Nasdaq: October 1, 1998 – March 31, 2000
  Estimation period: October 1, 1997 – September 30, 1998
  Long-term effect (for one year: 252 trading days): April 1, 2000– March 31, 2001
- 1/100th period:
  Stock splits for NYSE and Nasdaq: May 1, 2002 –Dec. 31, 2011
  Estimation period: May 1, 2001 – April 30, 2002
  Long-term effect (for one year: 252 trading days): Jan 1, 2012 – Dec. 31, 2012

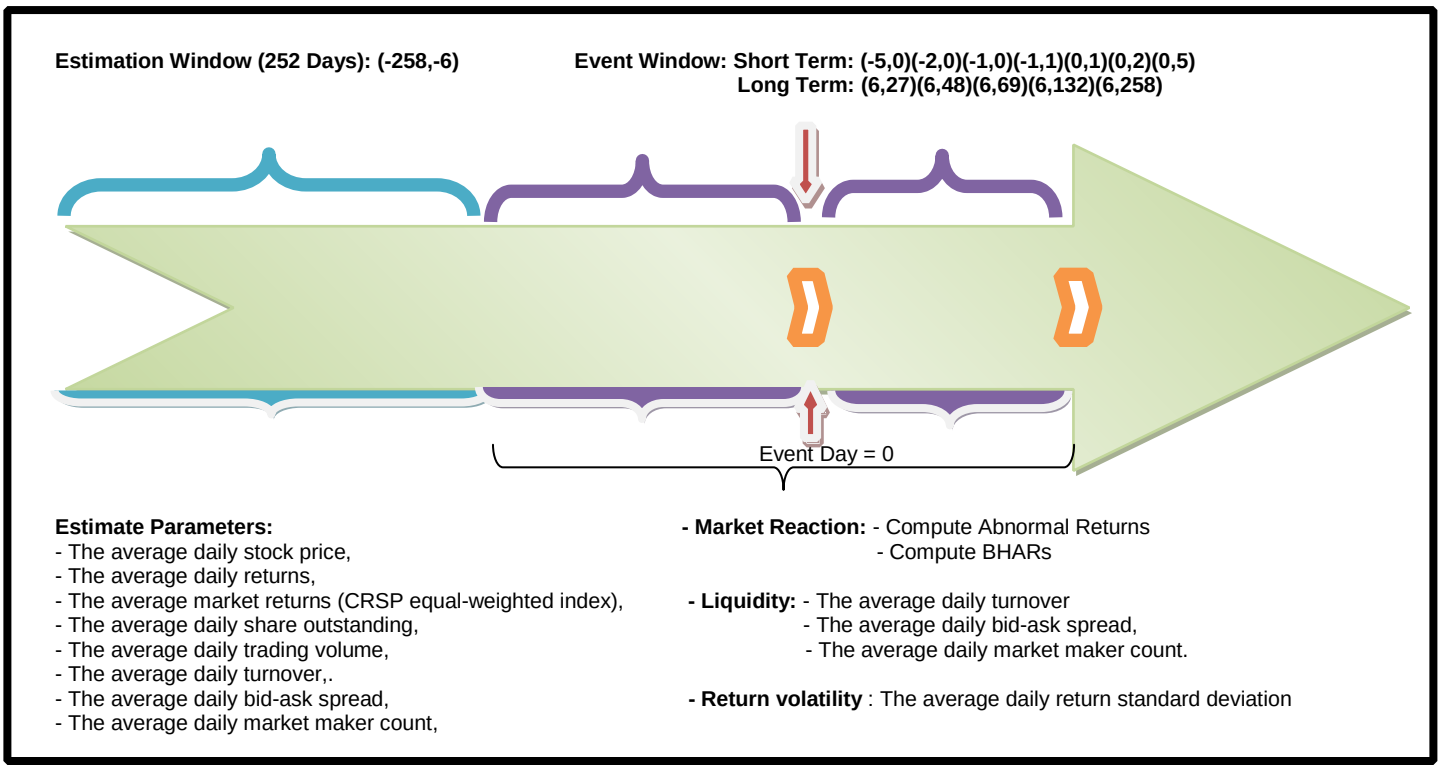

Figure 1. Estimation and event windows.

5.1.4 Evaluating Market Reaction between Groups

An analysis of variance (ANOVA) is used to evaluate more formally whether a difference exists in market reaction before and after decimalization among three different tick size periods and three different firm sized groups. An ANOVA will determine whether the differences among the sample means are too large to be attributed to the chance errors of drawing the samples from the same population. If the determination is made, then the null hypothesis is rejected and the alternate hypothesis that there is a significant difference in market reaction before and after decimalization among three different tick size periods and three different firm size groups should be accepted.

Specifically, the null hypothesis, that there is no difference in the mean buy and hold abnormal returns among the three different tick size periods and three different firm sized groups, is tested using ANOVA. The overall null hypothesis to be tested is expressed as,

Ho1: $BHAR_{T1T21S} = BHAR_{T1T21M} = BHAR_{T1T21L} = BHAR_{T1T22S} = BHAR_{T1T22M} = BHAR_{T1T22L} = BHAR_{T1T23S} = BHAR_{T1T23M} = BHAR_{T1T23L}$, where, BHAR = the average buy and hold abnormal returns; T_1T_2 = (-5,0), (-2,0), (-1,0), (-1,+1), (0,+1), (0,+2), and (0,+5) for short-term, and (+6,+27), (+6,+48), (+6,+69), (+6,+132), and (+6,+258) for long-term; 1= $1/8^{th}$, 2 = $1/16^{th}$, and 3 = $1/100^{th}$; S = Small cap., M = Medium cap., and L = Large cap. An F-test is used to measure the significance of BHAR differences.

The short-term market reaction between groups and tick size periods with the period of T_1T_2 = (-1, +1) around split announcement and ex-dates is further analyzed by size, period, and size*period. For the size, the tested null hypothesis is Ho2: $BHAR_{T1T2S} = BHAR_{T1T2M} = BHAR_{T1T2L}$, and for period, Ho3: $BHAR_{T1T21} = BHAR_{T1T22} = BHAR_{T1T23}$ by employing the Waller Duncan k-ratio test, Duncan's multiple range test, *t* tests (LSD), and Tukey's studentized range (HSD) test. For size*period, the tested null hypothesis is Ho4: $BHAR_{T1T21*S} = BHAR_{T1T21*M} = BHAR_{T1T21*L} = BHAR_{T1T22*S} = BHAR_{T1T22*M} = BHAR_{T1T22*L} = BHAR_{T1T23*S} = BHAR_{T1T23*M} = BHAR_{T1T23*L}$ by employing BonFerroni test. *t* tests (LSD), Tukey's studentized range (HSD) test, and the BonFerroni test are used with α=0.05.

5.2 Measuring Liquidity

Liquidity is measured by the mean of daily turnover ratio, relative bid-ask spread, and market maker count for 1/8th, 1/16th, and 1/100th periods, and for large, medium and small market capitalization firms. This study considers each trade in a stock is weighted equally to compute the mean for the stock, and the mean for the market is obtained as the simple average across stocks. This method gives results that pertain to an average trade in an average sample stock. The long-term liquidity effect after stock split ex-dates before and after decimalization is evaluated.

5.2.1 Turnover Ratio

Turnover is defined as daily trading volume divided by number of shares outstanding. For a given stock, the turnover ratio on day t is expressed as,

$$\text{Turnover Ratio}_t = \frac{Trading\ Volume}{Number\ of\ Shares\ Outstanding}$$

$$\text{The average daily turnover ratio} = \frac{1}{N} \sum_{i=1}^{N} \left[\frac{Daily\ Trading\ Volume}{Number\ of\ Shares\ Outstanding} \right].$$

5.2.2 Relative Bid-Ask Spread

The relative quoted bid-ask spread measure is defined as the quoted bid–ask spread divided by the midpoint of bid and ask prices. The quoted spread is defined as the differences between quoted daily ask and bid price of the transaction[19]. Specifically, for a given stock, the quoted spread on day t is defined as,

[19] If an investor buys a stock and then immediately sells it, he would pay the quoted ask price and receive the quoted bid, thereby incurring a loss, a trading cost, equal to the bid-ask spread. In

Quoted Bid-Ask Spread$_t$ = *Ask price$_t$ – Bid price$_t$*

For a given stock, the relative spread on the day t is expressed as,

Relative Bid-Ask Spread$_t$ = $\frac{\text{Ask Price}-\text{Bid Price}}{(Bid\ price + Ask\ price)/2}$

The average daily relative bid-ask spread = $\frac{1}{N}\sum_{i=1}^{N}[\frac{\text{Ask Price}-\text{Bid Price}}{(Bid\ price + Ask\ price)/2}]$.

5.2.3 Market Maker Count

The market maker count is defined as the number of registered market makers for the stock. For a given stock, the average market maker count is expressed as,

The average daily market maker count = $\frac{1}{N}\sum_{i=1}^{N}[Daily\ Market\ Maker\ Count]$.

5.2.4 Evaluating Long-Term Liquidity

To evaluate long-term liquidity after stock splits before and after decimalization, the average daily turnover ratio, relative bid-ask spread, and market maker count before and after decimalization are measured. For long-term liquidity, the average of each category for one month (+6, +27), two month (+6, +48), three month (+6, +69), six month (+6, +132), and one year (+6, +258) periods after split ex-date is calculated for three different tick size periods, 1/8th, 1/16th, and 1/100th. Also, long-term liquidity performance is measured for the three different firm sizes according to market capitalization.

Turnover Ratio$_{T1T2}$ = $\frac{1}{T}\sum_{t=1}^{T}[The\ average\ daily\ turnover\ ratio]$

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general, previous studies used the quoted spread at closing price as the variable of focus. Since trades often do not occur at the quoted prices, quoted spreads tend not to measure trading costs very well and are thus a less than perfect gauge of liquidity.

Relative Bid-Ask Spread$_{T1T2}$ = $\frac{1}{T}$

$\sum_{t=1}^{T}[\ The\ average\ daily\ relative\ bid-ask\ spread]$,

Market maker count$_{T1T2}$ = $\frac{1}{T}\ \sum_{i=1}^{T}[\ The\ average\ Daily\ market\ maker\ count\ ]$

where, T_1T_2= (+6, +27), (+6, +48), (+6, +69), (+6, +132), and (+6, +258) trading days after split ex-dates for one month, two month, three month, six month, and one year holding periods, respectively, with number of observations.

5.2.5 Evaluating Liquidity Effect between Groups

An analysis of variance (ANOVA) is used to evaluate more formally whether a difference exists in liquidity before and after decimalization among three different tick size periods and three different firm sized groups. An ANOVA will determine whether the differences among the sample means are too large to be attributed to the chance errors of drawing the samples from the same population. If the determination is made, then the null hypothesis is rejected and the alternate hypothesis that there is a difference in liquidity before and after decimalization among three different tick size periods and three different firm sized groups should be accepted.

Specifically, the null hypothesis that there is no significant difference in liquidity after stock split ex-date among the three different tick size periods and three different firm sized groups is tested by the ANOVA. The liquidity is measured by turnover ratio, relative bid and ask spreads, and market maker count. Therefore, the overall null hypotheses to be tested by ANOVA are expressed as,

Ho1: TO $_{T1T21S}$ = TO $_{T1T21M}$ = TO $_{T1T21L}$ = TO $_{T1T22S}$ = TO $_{T1T22M}$ = TO $_{T1T22L}$ = TO $_{T1T23S}$ = TO $_{T1T23M}$ = TO $_{T1T23L}$,

Ho2: $RBAS_{T1T21S} = RBAS_{T1T21M} = RBAS_{T1T21L} = RBAS_{T1T22S} = RBAS_{T1T22M} = RBAS_{T1T22L} = RBAS_{T1T23S} = RBAS_{T1T23M} = RBAS_{T1T23L}$, and

Ho3: $MMC_{T1T21S} = MMC_{T1T21M} = MMC_{T1T21L} = MMC_{T1T22S} = MMC_{T1T22M} = MMC_{T1T22L} = MMC_{T1T23S} = MMC_{T1T23M} = MMC_{T1T23L}$, where, TO = the ratio of the turnover ratio of one year before announcement date and one year after split ex-date, RBAS = the ratio of average relative bid-ask spread of one year before announcement date and one year after split ex-date, and MMC = the ratio of average market maker count of one year before announcement date and one year after split ex-date; T_1T_2 = (+6,+27) for one month, (+6,+48) for two month, (+6,+69) for three month, (+6,+132) for six month, and (+6,+258) for one year; 1 = $1/8^{th}$ period, 2 = $1/16^{th}$ period, and 3 = $1/100^{th}$ period; S = Small cap., M = Medium cap., and L = Large cap. An F-test is used to measure the significance of overall result for liquidity.

For long-term liquidity between groups, T_1T_2 = (+6,+258) for turnover, relative spread, and market maker count, for one year after stock split ex-dates is further analyzed by size, period, and size*period by comparing those of one year before announcement. For the size, the tested null hypotheses are expressed as,

Ho4: $TO_{T1T2S} = TO_{T1T2M} = TO_{T1T2L}$,

Ho5: $RBAS_{T1T2S} = RBAS_{T1T2M} = RBAS_{T1T2L}$,

Ho6: $MMC_{T1T2S} = MMC_{T1T2M} = MMC_{T1T2L}$, and for period,

Ho7: $TO_{T1T21} = TO_{T1T22} = TO_{T1T23}$,

Ho8: $RBAS_{T1T21} = RBAS_{T1T22} = RBAS_{T1T23}$,

Ho9: $MMC_{T1T21} = MMC_{T1T22} = MMC_{T1T23}$, by employing Waller Duncan k-ratio test, Duncan's multiple range test, *t* tests (LSD), and Tukey's studentized range (HSD) test. For size*period, the tested null hypothesis are expressed as,

Ho10: $TO_{T1T21*S} = TO_{T1T21*M} = TO_{T1T21*L} = TO_{T1T22*S} = TO_{T1T22*M} = TO_{T1T22*L} = TO_{T1T23*S} = TO_{T1T23*M} = TO_{T1T23*L}$,

Ho11: $RBAS_{T1T21*S} = RBAS_{T1T21*M} = RBAS_{T1T21*L} = RBAS_{T1T22*S} = RBAS_{T1T22*M} = RBAS_{T1T22*L} = RBAS_{T1T23*S} = RBAS_{T1T23*M} = RBAS_{T1T23*L}$, and

Ho12: $MMC_{T1T21*S} = MMC_{T1T21*M} = MMC_{T1T21*L} = MMC_{T1T22*S} = MMC_{T1T22*M} = MMC_{T1T22*L} = MMC_{T1T23*S} = MMC_{T1T23*M} = MMC_{T1T23*L}$ by employing the BonFerroni test. *t* tests (LSD), Tukey's studentized range (HSD) Test, and the BonFerroni test are used with $\alpha=0.05$.

5.3 Measuring Return Volatility

Harris (1994) predicts that as quote sizes reduce, decreased liquidity could also be manifest in the form of more volatile prices. This implication has been supported in several prior studies. Ohlson and Penman (1985) provide evidence that NYSE stock return variances increase subsequent to ex stock distribution days for splits. They suggest that the greater post-split volatility may be due to the activity of relatively ignorant noise traders who prefer trading low-priced stocks, and institutional factors, a rather broad category that incorporates measurement problems created by the "1/8 effect" and bid-ask spreads, as possible hypotheses for the post-split volatility increase. Dubofsky (1991) also reports that there are post-split increases in the variance of both NYSE and AMEX daily returns.

In this study, volatility is computed as cross sectional standard deviation of daily returns for each stock before and after stock splits for 1/8th, 1/16th, and 1/100th periods and for small, medium and large market capitalization firms. The standard deviation of daily returns for each stock is expressed as,

The average daily standard deviation = $\frac{1}{N}\sum_{i=1}^{N}[Daily\ Standard\ Deviation]$.

With the return volatility measures, statistical significance is assessed using a t-test for equality of variance before and after stock split. Statistical significance is assessed based on cross-sectional variation in the stock-specific means. I expect that the return volatility will decrease after decimalization.

5.3.1 Evaluating Long-Term Return Volatility

The average variance of returns is measured to evaluate the long-term volatility after stock splits before and after decimalization for three different tick size periods, 1/8th, 1/16th, and 1/100th, and three different firm sizes, small, medium, and large, according to market capitalization. The long-term volatility before and after decimalization after the stock split is expressed as,

Volatility$_{T1T2}$ = $\frac{1}{T}\sum_{t=1}^{T}[The\ average\ daily\ Daily\ Standard\ Deviation]$,

where, T_1T_2 = (+6, +27), (+6, +48), (+6, +69), (+6, +132), and (+6, +258) trading days after stock split ex-date for one month, two month, three month, six month, and one year, respectively, for long-term. A T-test is used to measure the significance of return standard deviation.

5.3.2 Evaluating Return Volatility Effect between Groups

An analysis of variance (ANOVA) is used to evaluate more formally whether a difference exists in daily return volatility before and after decimalization among three different tick size periods and three different firm sized groups. An ANOVA will determine whether the differences among the sample means are too large to be attributed to the chance errors of drawing the samples from the same population. If the determination is made, then the null hypothesis is rejected and the alternate hypothesis, that there is a difference in daily return volatility before and after decimalization among three different tick size periods and three different firm sized groups, should be accepted.

Specifically, the null hypothesis, that there is no difference in daily return volatility after stock split ex-date among the three different tick size periods and three different firm sized groups, is tested by the ANOVA. The overall null hypothesis to be tested by ANOVA is expressed as,

Ho1: $Vo_{T1T21S} = Vo_{T1T21M} = Vo_{T1T21L} = Vo_{T1T22S} = Vo_{T1T22M} = Vo_{T1T22L} = Vo_{T1T23S} = Vo_{T1T23M} = Vo_{T1T23L}$, where Vo = the ratio of the average standard deviation of one year before announcement date and one year after split ex-date; T_1T_2 = (+6,+27) for one month, (+6,+48) for two month, (+6,+69) for three month, (+6,+132) for six month, and (+6,+258) for one year; 1= $1/8^{th}$, 2 = $1/16^{th}$, and 3 = $1/100^{th}$; S = Small cap., M = Medium cap., and L = Large cap. An *f-test* is used to measure the significance of overall result for return volatility.

For long-term volatility between groups, T_1T_2 = (+6,+258) the return standard deviation for one year after stock split ex-date is further analyzed by size, period, and

size*period by comparing to that of one year before the split announcement. For the size, the tested null hypothesis is,

Ho2: $Vo_{T1T2S} = Vo_{T1T2M} = Vo_{T1T2L,}$ and for period,

Ho3: $Vo_{T1T21} = Vo_{T1T22} = Vo_{T1T23,}$ by employing the Waller Duncan k-ratio test, Duncan's multiple range test, *t* tests (LSD), and Tukey's studentized range (HSD) test. For size*period, the tested null hypothesis is,

Ho4: $Vo_{T1T21*S} = Vo_{T1T21*M} = Vo_{T1T21*L} = Vo_{T1T22*S} = Vo_{T1T22*M} = Vo_{T1T22*L} = Vo_{T1T23*S} = Vo_{T1T23*M} = Vo_{T1T23*L,}$ by employing BonFerroni test. *t* tests (LSD), Tukey's studentized range (HSD) test, and the BonFerroni test are used with $\alpha=0.05$.

CHAPTER 6

EMPIRICAL RESULTS

This chapter reports the results from testing hypotheses developed in Chapter 3. I divide this chapter into four main sections. Section 6.1 contains the sample statistics for three different tick size periods and three different firm size categories. The results of tests for the market reaction to stock splits before and after decimalization for split announcements and split ex-dates are presented in Section 6.2. The results of the tests for the liquidity effect on stock splits are presented in Section 6.3. Finally, the results of the tests for return volatility effect on stock splits are exhibited in Section 6.4.

6.1 Sample Description

Table 3 presents summary statistics of all variables employed in this study. The cross-sectional distributions for the average daily share price, daily returns, share outstanding, daily trading volume, quoted spread, relative spread, daily turnover, market maker count, and return volatility are calculated. The return is based on closing price calculated as $[(P_t\ (1+f) + D_t)/P_{t-1}] - 1$, where P_t is the closing price, D_t is the dividend, P_{t-1} is the closing price on the day prior to, and f is the split factor. The quoted spread is the difference between ask and bid quotes. The relative bid-ask spread is defined as (Ask price – Bid price)/[(Ask price + Bid Price)/2]. The turnover rate is measured by the ratio of average daily shares traded to average daily shares outstanding. The return volatility is measured by the standard deviation of daily returns.

Table 3 shows overall market performance for one year before the split announcement day in panel A, on the split announcement day in panel B, on the split

ex-date in pane C, and for one year after split ex-date in panel D. Also, Table 3 presents the change between the one year pre-split announcement date and one year post split ex-date as a fraction of the before level in panel E.

Generally, stock prices of small firms for all tick periods are smaller than medium and large firms, but their raw returns are mostly higher with higher return volatility compared to that of medium and large firms. Also bid-ask spreads for small firms are higher than that of medium and large firms during all different tick periods. However, trading volume and market maker counts for large firms are greater than for small firms. Turnover ratio does not show a clear pattern among different sized firms and different tick periods.

Sample variables behave somewhat differently during the $1/16^{th}$ tick period. During this time period, stock prices for small, medium, and large firms are higher than those of during the $1/8^{th}$ and $1/100^{th}$ tick periods. Stock raw returns are also very high and almost twice as large as the $1/100^{th}$ tick period for all firms during the$1/16^{th}$ tick period. Overall liquidity factors such as trading volume and turnover ratio during the $1/16^{th}$ period are higher, bid ask spread is smaller than $1/8^{th}$ tick period but higher than $1/100^{th}$ tick period. However, there are not many differences in the average of market makers during the $1/16^{th}$ tick period compared to that of $1/8^{th}$ and $1/100^{th}$ tick periods. Also, stock return volatility during the $1/16^{th}$ tick period is very high for all firms compared to that of $1/16^{th}$ and $1/100^{th}$ tick periods. This unusual behavior of the stock market during the $1/16^{th}$ tick period, maybe because of the Dot Com era effects, and also can be observed on the split announcement date (Panel B), split ex-date (Panel C), and one year after split ex-date (Panel D).

Panel A compares stock price, raw returns, liquidity factors, and return volatility of small, medium, and large firms during the three different tick size periods for one year before the stock split announcement date. The one year average pre-split announcement date of the 1/16th tick period stock returns and turnover are higher than the 1/8th or 1/100th tick period for all firm sized groups. However, during the 1/16th tick period, the one year average volatility before the announcement is very high compare to during the 1/8th and 1/100th tick periods. On the other hand, stock raw return during the 1/8th tick period is higher while the bid ask spread is wider, trading volume, turnover ratio, and number of market makers is smaller than those of 1/100th tick period for all firm sized groups. One year average pre-announcement, return volatility of the 1/8th tick period is higher than the 1/100th tick period for all firms sized groups. Generally, small firms show higher raw returns, higher bid-ask spread, higher volatility, but fewer market makers in all tick sized periods. We can observe that decimalization reduced bid-ask spread and return volatility, and liquidity improved if we consider only 1/8th and 1/100th tick periods.

Panel B reports the stock market behavior on the stock split announcement date of all different tick periods and different firm sized groups. The stock split ratio of all firm size groups in different tick periods shows that there is not much difference in terms of split ratio except for 1/16th large firms. During the 1/16th tick period, the stock split ratio of large firms is about 1.049, more than doubling the number of shares outstanding. Generally, panel B also shows similar results as panel A that the 1/16th tick period of small, medium, and large firms behaves differently from the firms of 1/8th and 1/100th tick periods. Stock price, raw returns, and turnover during the 1/16th tick period are very

high compared to 1/8th or 1/100th tick periods. If we consider only the 1/16th and 1/100th periods, during the decimalization period, trading volume, turnover, and market maker count increased and return volatility decreased compared to the 1/8th tick period. As previous studies report on decimalization, decimalization improved market quality as the bid ask spread narrowed, liquidity improved, and volatility decreased. However, we do not observe that decimalization has any adverse effect on small stocks as the argument of Bessembinder (2003) and the SEC report to Congress (July, 2012). They argue that decimalization narrowed bid-ask spread and discouraged market maker promotion of small firms. However, the results of this study show that decimalization actually improved performance of small firms. Market maker counts increased for small firms during the 1/100th tick period compared to that of 1/8th or 1/16th tick periods. Among all firms in all tick periods, the difference between announcement dates and ex-split dates is about 32 trading days.

Panel C presents stock market performance on the split ex-date of all different sized firm groups in three different tick periods. Overall stock prices have been reduced on the split ex-date but still the market performance of the 1/16th tick period differs from the 1/8th or 1/100th tick periods. During the 1/16th tick period, stock price and return volatility are higher for all firms than the 1/8th and 1/100th periods. However, bid-ask spreads are reduced but market maker counts increase as tick size becomes smaller from 1/18th to 1/16th or from 1/16th to 1/100th. So this result is not consistent with previous literature reported [Bessembinder (2003) and SEC report to Congress (July, 2012)].

Panel D shows stock market performance for one year after the stock split ex-date. The result shows that the market performance during the 1/16th tick period does not differ compared to the above panels. Even though stock price, turnover, and return volatility of all firm sized groups during the 1/16th tick period are higher than those of 1/8th or 1/100th tick periods, stock raw returns performance are higher than 1/8th or 1/100th tick periods. However, it is clear that the bid-ask spread gets narrow or return volatility gets smaller as tick size is reduced from 1/8th to 1/16th and 1/100th. Again, Panel D reports that smaller tick size does not discourage market maker from promoting small firms. The average market maker counts, trading volumes and turnover increase for small firms as tick size reduced from 1/8th to 1/16th or 1/100th.

Panel E presents the market performance of one year pre-split announcement and one year post split ex-date periods. So this panel shows that difference between the one year pre-split announcement period and the one year post split ex-date period. The raw returns for all splitting firms during all tick periods decrease about 65% to 84% compared to that of one year before split announcement dates. The stock price of small firms during the 1/8th tick period, and small and medium firms during the 1/16th tick period increased (2.34%, 5.76%, and 20.9%, respectively) but the other firm sized groups show all decreases in stock price during all tick periods. On the other hand, share outstanding and trading volume for all firms increased during the 1/8th, 1/16, and 1/100th tick periods and turnover also increased all firm sized groups except for medium sized firms in 1/18th period and large firms in 1/100th period. Also, turnover ratio increased for most of the firms except for medium firms during the 1/8th and large firms during the 1/100th tick periods. But these two firm groups show a little decrease in

turnover, 5.07% and 0.55%, respectively. Also, bid ask spreads are reduced for most of the firms after splitting except for an increase in relative spread for medium firms in the 1/8th period and large firms in the 1/16th period. This result is also contradictory compared to previous studies that report bid ask spread increase and volatility increase after splitting stocks [Copeland (1979), Ohlson and Penman (1985), and Debofsky (1991)]. The market maker count increased for most of the firm sized group but it decreased for large firms during the 1/8th and 1/100 tick periods. Surprisingly, market maker count for small firms increase by a large amount after splitting their stocks. The market maker count for small firms increased about 31% after splitting their stocks while large firms decreased about 0.26% during the 1/100th tick period. This result also shows that decimalization does not have an adverse effect on small firms as other studies on decimalization report. On the other hand, volatility of most of the firms increases after splitting in all tick periods except for medium firms during the 1/100th tick period. Among all firm sized groups, the increase in volatility for small firms is very high compared to that of medium and large firms during all tick periods. Also, the increase in volatility one year after split ex-date compared to one year before announcement for large firms is relatively small compared to small and medium firms during all tick periods. This result confirms the previous literature that volatility increases after splitting stocks and volatility for small firms is higher than large firms.

Table 3

Sample Description

This table reports summary statistics of all variables employed in this study. The cross-sectional distributions for the average daily share price, daily returns, shares outstanding, daily trading volume, quoted spread, relative spread, daily turnover, market maker count, and return volatility for the one year before announcement date, announcement date, ex-date, and one year after ex-date are calculated. The share price is measured by the mean value of daily share price. The return is based on closing price calculated as $([P_t (1+f) + D_t]/P_{t-1}) - 1$, where P_t is the closing price, D_t is dividends, P_{t-1} is the closing price on the day prior to, and f is the split factor. The share outstanding is measured by the mean daily share outstanding. Trading volume is measured by the average daily trading volume. The quoted spread is the difference between ask and bid quotes at closing price. The relative bid-ask spread is defined as (Ask price – Bid price)/[(Ask price + Bid Price)/2]. The turnover rate is measured by the ratio of average daily trading volume to average daily shares outstanding. The market maker count is measured by the average daily market maker count. The return volatility is measured by the standard deviation of daily returns.

	1/8th (1991/01/01 – 1996/05/31)			1/16th (1998/06/24 – 2000/03/31)			1/100th (2002/05/01 – 2011/12/31)		
	Small cap. Obs.: 511	Mid-cap. Obs.:108	Large cap. Obs.: 24	Small cap. Obs.: 105	Mid-cap. Obs.: 73	Large cap. Obs.: 67	Small cap. Obs.: 214	Mid-cap. Obs.: 155	Large cap. Obs.: 87
Panel A: One Year Average Before Split Announcement									
Stock Price ($)	21.83	38.94	58.17	24.98	43.98	72.16	26.53	45.13	55.87
Raw Returns	0.003685	0.002903	0.003343	0.004487	0.005815	0.004795	0.002898	0.002428	0.002215
Share Outstanding	7,954,000	35,045,000	137,759,714	9,785,505	25,655,676	229,481,228	10,672,051	35,396,022	180,332,805
Trading Volume	67,201	328,373	954,942	100,962	371,971	2,867,318	115,800	495,976	2,541,073
Quoted Spread	0.580901	0.451090	0.395507	0.406282	0.358450	0.225788	0.181374	0.074538	0.048570
Relative Spread	0.031143	0.012044	0.007539	0.021184	0.009380	0.003970	0.009037	0.001809	0.000847
Turnover	0.008345	0.011345	0.01085	0.010797	0.016916	0.020721	0.010626	0.013946	0.013287
Market Maker Count	12.32	22.26	37.51	12.92	20.75	38.43	19.63	38.59	58.62
Return Volatility	0.034718	0.0269	0.025398	0.047195	0.050418	0.036579	0.025936	0.023544	0.020406

(table continues)

Table 3 *(continued)*

	1/8th (1991/01/01 – 1996/05/31)			1/16th (1998/06/24 – 2000/03/31)			1/100th (2002/05/01 – 2011/12/31)		
	Small cap. Obs.: 511	Mid-cap. Obs.:108	Large cap. Obs.: 24	Small cap. Obs.: 105	Mid-cap. Obs.: 73	Large cap. Obs.: 67	Small cap. Obs.: 214	Mid-cap. Obs.: 155	Large cap. Obs.: 87
Panel B: Split Announcement Day (t =0)									
Stock Price ($)	33.42	52.76	77.72	42.13	85.64	119.12	36.83	58.17	73.22
Raw Returns	0.018812	0.007532	0.014874	0.036488	0.031508	0.023823	0.022043	0.005557	0.006849
Share Outstanding	8,277,637	37,245,738	142,504,370	10,308,590	27,478,192	193,479,299	11,157,127	36,400,045	168,277,381
Trading Volume	109,546	555,495	1,299,085	242,274	697,514	2,922,982	267,321	659,265	3,395,554
Quoted Spread	0.708117	0.447704	0.3920	0.532767	0.410959	0.400187	0.185000	0.071032	0.052791
Relative Spread	0.023111	0.009027	0.005356	0.014674	0.005496	0.003460	0.005757	0.001217	0.000683
Turnover	0.014515	0.017897	0.013793	0.032273	0.032769	0.027179	0.035855	0.018137	0.016604
Market Maker Count	9.58	18.90	39.00	15.51	25.35	40.38	22.43	43.24	64.75
Return Volatility	0.041303	0.031045	0.02971	0.075719	0.086194	0.051835	0.034848	0.023409	0.026386
Split Ratio	0.7304	0.8956	0.8816	0.7038	0.8836	1.049	0.7771	0.8796	0.9008
Difference (Ex-Date and Announcement Date)	32.21	34.44	32.83	29.94	31.16	33.39	29.82	32.86	34.02
Panel C: Split Ex-Date (t =0)									
Stock Price ($)	20.70	29.79	43.91	25.64	49.35	74.12	21.49	31.89	40.81
Raw Returns	0.020553	0.006139	-0.000553	0.007986	0.015070	0.008784	0.008981	-0.000896	0.005893
Share Outstanding	14,159,200	68,037,879	262,314,316	17,257,190	50,312,219	374,686,940	19,186,613	67,293,019	327,137,357
Trading Volume	162,772	651,677	1,834,933	235,142	1,207,659	4,473,562	338,130	950,281	3,983,109
Quoted Spread	0.605120	0.425505	0.315217	0.373775	0.267979	0.269590	0.108632	0.035032	0.033488
Relative Spread	0.031968	0.015001	0.008094	0.017495	0.006733	0.003761	0.006481	0.001036	0.000863
Turnover	0.012009	0.010881	0.010287	0.015137	0.028309	0.022849	0.022320	0.015320	0.012781
Market Maker Count	10.12	16.90	28.67	14.21	23.72	38.83	20.29	31.59	35.79
Return Volatility	0.057155	0.032198	0.040942	0.055725	0.079014	0.031957	0.033415	0.023268	0.020904

(table continues)

Table 3 *(continued)*

	1/8th (1991/01/01 – 1996/05/31)			1/16th (1998/06/24 – 2000/03/31)			1/100th (2002/05/01 – 2011/12/31)		
	Small cap. Obs.: 511	Mid-cap. Obs.:108	Large cap. Obs.: 24	Small cap. Obs.: 105	Mid-cap. Obs.: 73	Large cap. Obs.: 67	Small cap. Obs.: 214	Mid-cap. Obs.: 155	Large cap. Obs.: 87
Panel D: One Year Average After Split Ex-Date									
Stock Price ($)	22.34	31.32	49.05	26.42	53.17	71.63	22.52	33.28	43.70
Raw Returns	0.000874	0.000649	0.000970	0.000711	0.001612	0.000876	0.000652	0.000663	0.000779
Share Outstanding	16,087,498	71,101,846	271,954,194	20,250,567	63,693,317	491,171,920	20,648,115	69,966,287	319,537,591
Trading Volume	161,884	680,578	2,009,460	275,692	1,217,785	6,365,935	308,630	1,013,633	3,321,751
Quoted Spread	0.557427	0.369532	0.313269	0.289108	0.243051	0.152709	0.090294	0.036387	0.029913
Relative Spread	0.028813	0.013188	0.007402	0.015748	0.006487	0.00399	0.005003	0.001171	0.000768
Turnover	0.009435	0.010770	0.011068	0.013551	0.020981	0.02078	0.013109	0.014130	0.013214
Market Maker Count	14.39	24.81	37.08	17.57	32.20	52.29	25.66	44.40	58.47
Return Volatility	0.038838	0.029831	0.026928	0.057399	0.062412	0.037014	0.028432	0.020337	0.022325
Panel E: Change Between One Year Before Split Announcement(P_A) and One Year After Split Ex-Date (P_D): ((P_D –P_A)/P_A)									
Stock Price ($)	0.0234	-0.1957	-0.1568	0.0576	0.2090	-0.0073	-0.1511	-0.2626	-0.2178
Raw Returns	-0.7628	-0.7764	-0.7098	-0.8415	-0.7228	-0.8173	-0.7750	-0.7269	-0.6483
Share Outstanding	1.0226	1.0289	0.9741	1.0694	1.4826	1.1404	0.9348	0.9767	0.7719
Trading Volume	1.4090	1.0726	1.1043	1.7307	2.2739	1.2202	1.6652	1.0437	0.3072
Quoted Spread	-0.0404	-0.1808	-0.2079	-0.2884	-0.3219	-0.3237	-0.5022	-0.5118	-0.3841
Relative Spread	-0.0748	0.0950	-0.0182	-0.2566	-0.3084	0.0050	-0.4464	-0.3527	-0.0933
Turnover	0.1306	-0.0507	0.0201	0.2551	0.2403	0.0029	0.2337	0.0132	-0.0055
Market Maker Count	0.1680	0.1146	-0.0115	0.3599	0.5518	0.3605	0.3072	0.1506	-0.0026
Return Volatility	0.1187	0.1090	0.0602	0.2162	0.2379	0.0119	0.0962	-0.1362	0.0940

6.2 Market Reaction to Stock Splits

According to the signaling hypothesis, stock splits are used to convey favorable inside information about future prospects a firm, and the market reacts to stock splits as splitting firms signal their future prospects. The market reaction to stock splits is usually measured by abnormal returns around the split announcement. Empirical studies report that the existence of positive abnormal returns around split announcements is consistent with the signaling hypothesis [Fama, Fisher, Jensen, and Roll (FFJR) (1969), Grinblatt, Masulis, and Titman (1984), Lamoureux and Poon (1987), Brennan and Copeland (1988), Asquith, Healy, and Palepu (1989), Brennan and Hughes (1991), and Boehme and Danielsen (2007)]. Some studies used the split ex-date to examine evidence relating to efficient market anomalies [Grinblatt et al. (1984) and Maloney and Mulherin (1992)]. On the other hand, several stock split studies on decimalization also used split ex-dates to examine stock price behavior around the ex-split dates both before and after decimalization [Chou, Lee, and Chen (2005), Kadapakkam, Krishnamurthy, and Tse (2005), and Lipson and Mortal (2006)]. Therefore, this study examines market reaction to stock splits before and after decimalization by using both the split announcement date and split ex-date. Table 4 presents market reaction to stock split announcements before and after decimalization, Table 5 presents market reaction on stock split ex-dates before and after decimalization, and Table 6 and 7 reports the significance of market reaction between groups.

6.2.1 Market reaction to Stock Split Announcements

6.2.1.1 Short-Term Market Reaction

In this study, market reaction is measured by abnormal returns and buy and hold abnormal returns (BHARs) using the market adjusted returns model. Table 4 presents the market reaction to stock split announcements measured by abnormal returns (Panel A) and BHARs (Panel B and Panel C).

Panel A presents market reaction around the split announcement day by employing abnormal returns[20]. Most of the previous literature about signaling with splits report that there are positive abnormal returns around split announcements. However, previous studies do not show the degree of market reaction of different firm sized groups because they did not segment by firm size. This study clearly presents that market reaction to stock splits of the three different firm sized groups are different. Specifically, the market reaction of small firms around stock split announcements is higher in all tick periods compared to medium and large firms.

Panel B presents short-term market reaction around the split announcement by employing BHARs with seven different short-term periods around stock split announcement day. Market reaction is significant during the $1/16^{th}$ and $1/100^{th}$ tick periods for all firm sized groups while only small and medium sized firms show significant market reaction during the $1/8^{th}$ tick period. Overall BHARs are higher for all firms during the $1/16^{th}$ tick period. If we compare only $1/8^{th}$ and $1/100^{th}$ tick periods, the

20 Initially, Collins-Dent cross-sectional independence test (Collins and Dent, 1984) was employed to measure the significance of abnormal returns. However, the results of Collins-Dent cross-sectional independence test showed abnormality and could not confirm a robustness test. Therefore, this study utilized the standardized cross-sectional test [Boehmer, Musumeci and Poulsen (1991)] to measure the significance of abnormal returns. Also, non-parametric Rank test (Corrado, 1989) is used for a robustness check (See the appendix tables 1 and 2).

overall BHARs during the 1/100th tick period are higher than the 1/8th tick period. During the three days (-1,+1) around the split announcement, an average increase in shareholders wealth measured by BHARs is significantly positive for all firm sizes in all tick periods. Especially, an average increase in shareholders wealth during three days (-1,+1) around the split announcement measured by BHARs for small firms during the 1/8th, 1/16th, and 1/100th tick periods are higher, (3.24%, 6.89%, and 4.37%, respectively), than that of medium and large firms. The results are consistent with signaling based studies that stock splits convey favorable private information about the firm and the market reacts to stock splits that signal about the future prospects of a firm. Grinblatt et al. (1984) used 1,380 stock splits during 1967-1976 and find consistent results with the previous literature [FFJR (1969)] that an average increase in shareholders wealth of about 3.9% in the two days around the split announcement. These results indicate that split announcements convey information to the market. Grinblatt et al. (1984) also report that smaller firms' stock split announcements contain greater information. They conclude that firms signal information about their future earnings or equity values through their split decision.

6.2.1.2 Long-Term Market Reaction

Panel C presents long-term market reaction after split announcements measured by BHARs of five different periods. In Panel C, the BHARs cover one month (+6, +27), two month (+6, +48), three month (+6, +69), six month (+6, +132), and one year (+6, +258) periods. Market reaction of small firms during all different tick periods is greater compared to medium and large firms. During the 1/8th and 1/16th tick periods, market

reaction of small firms is greater than medium and large firms. However, during the 1/100th tick period, there is some significant market reaction for small and large firms but not for medium firms. We also can observe significant negative BHARs for longer holding periods. The split literature documents that splitting firms typically experience a price run-up before the announcement of the split [Ikenbery and Ramnath (2002)]. Empirical evidence on stock splits also documents that when the information effects of stock splits are taken into account, the apparent price effects of the stock splits vanishes following the stock split announcements [FFJR (1969) and Fama (1998)]. Therefore, an average decrease in shareholders wealth measured by BHARs for longer holding periods after the split announcement for all firms during all tick periods may be attributed to a price run-up before the announcement or information effects.

Griffin (2010) documented that under the decimalized system abnormal returns tend to be closer to zero throughout the period, while under the fractional system (1/8th tick period) as a whole abnormal returns tended to be more positive in the period around the split announcements. However, the results of this study show that there is no big difference in overall market reaction before and after decimalization. Griffin (2010) argues that despite a reduction in transaction costs under the new decimalization system, there are no long-term benefits of splitting. However, this study evidenced that there are no long-term positive returns of splitting not only during decimalization period but also in the 1/8th and 1/16th tick periods.

Table 4

Market Reaction to Stock Split Announcements before and after Decimalization

Market reaction is measured by abnormal returns and buy and hold abnormal returns (BHARs) with market adjusted returns model. This table presents the mean abnormal returns and BHARs of 1,344 stock split announcements for NYSE and Nasdaq from 1991 to 2011 according to the different price-quoting periods and market capitalization. Firms with less than 60 days stock returns from CRSP are removed from the analysis. The 1/8th period extends January 1, 1991 to May 31, 1996 for NYSE and Nasdaq, the 1/16th period extends for NYSE from June 24, 1998 to January 28, 2000 and for Nasdaq from October 1, 1998 to March 31, 2000, and the decimal (1/100th) period from May 1, 2002 to December 31, 2011 for NYSE and Nasdaq. Abnormal returns are individual stock raw returns less market adjusted index returns. The CRSP equal-weighted index is used as a proxy for the market index. For each day relative to the split announcement day (day 0), individual abnormal returns are averaged across the splitting securities in the sample for that day. The BHARs are the mean compound abnormal returns. In Panel C, the BHARs in month is expressed as 1 month (+6, +27), 2 month (+6, +48), 3 month (+6, +69), 6 month (+6, +132), and 12 month (+6, +258). Standardized cross-sectional test (BMP, 1991) is used to measure the significance of mean abnormal returns. T-test is used to measure the significance of BHARs. "***", "**", and "*" denote significance levels of 1%, 5%, and 10%, respectively for the standardized cross-sectional test and t-test.

Event Day or Interval	1/8th (1991/01/01 – 1996/05/31)			1/16th (1998/06/24 – 2000/03/31)			1/100th (2002/05/01 – 2011/12/31)		
	Small cap. Obs.: 502	Mid-cap. Obs.:107	Large cap. Obs.: 24	Small cap. Obs.: 103	Mid-cap. Obs.: 70	Large cap. Obs.: 64	Small cap. Obs.: 212	Mid-cap. Obs.: 154	Large cap. Obs.: 87
Panel A: Mean Abnormal Returns (%)									
-5	0.56***	0.20	0.54	0.77	1.74**	1.35	0.35**	0.08	0.04
-4	0.15	0.15	0.22	1.32***	0.62	0.09	0.97***	0.18	0.28
-3	0.54***	0.01	0.91*	0.54	0.67	-0.30	0.24	0.07	0.51**
-2	0.44**	0.45*	-0.43	1.12***	0.17	-0.01	0.67***	0.08	-0.10
-1	0.49***	0.09	-0.19	1.14***	0.61	1.04*	0.36***	0.04	0.05
0	1.71***	0.51*	1.34*	3.58***	2.92***	1.87***	2.09***	0.67***	0.68**
+1	0.99***	0.86**	0.14	1.95**	2.81***	2.98***	1.92***	0.96***	0.84*
+2	0.42***	0.26	-0.37	0.44	-0.22	0.81	0.44*	0.13	0.69***
+3	-0.02	-0.09	-0.23	0.31	0.20	0.81	0.30	0.04	0.08
+4	0.21*	0.01	0.22	-0.34	0.86	0.58	0.38**	0.30*	-0.08
+5	0.24	-0.11	0.61	-0.56	0.65	0.30	0.29	0.18	-0.02
Panel B: Buy and Hold Abnormal Returns (%)									
(-5,0)	3.97***	1.41	2.42*	9.01***	6.82***	3.82**	4.79***	1.08***	1.44***
(-2,0)	2.68***	1.06**	0.75	6.06***	3.7***	2.93**	3.13***	0.78**	0.62*
(-1,0)	2.21***	0.62	1.21	4.78***	3.52***	2.94***	2.44***	0.7***	0.72**
(-1,+1)	3.24***	1.49***	1.35	6.89***	6.13***	5.93***	4.37***	1.66***	1.56***
(0,+1)	2.74***	1.39***	1.6	5.65***	5.68***	4.79***	4.01***	1.62***	1.53***
(0,+2)	3.18***	1.66***	1.12	5.44***	5.41***	5.77***	4.5***	1.75***	2.25***
(0,+5)	3.44***	1.45**	1.29	5.39***	7.39***	7.33***	5.51***	2.29***	2.24***

(table continues)

Table 4 *(continued)*

Event Day or Interval	1/8th (1991/01/01 – 1996/05/31)			1/16th (1998/06/24 – 2000/03/31)			1/100th (2002/05/01 – 2011/12/31)		
	Small cap. Obs.: 502	Mid-cap. Obs.:107	Large cap. Obs.: 24	Small cap. Obs.: 103	Mid-cap. Obs.: 70	Large cap. Obs.: 64	Small cap. Obs.: 212	Mid-cap. Obs.: 154	Large cap. Obs.: 87
Panel C: Buy and Hold Abnormal Returns after Announcement Date (Months) (%)									
1 (+6,+27)	3.58***	2.61**	3.87*	1.53	1.00	3.69	0.79	0.76	2.13*
2 (+6,+48)	3.91***	1.63	0.71	-1.74	-1.59	2.90	2.14*	0.76	2.81*
3 (+6,+69)	1.14***	-1.51	3.10	-6.69*	0.31	-0.23	1.04	0.39	3.04
6 (+6,+132)	-5.81***	-4.25	0.27	-17.01***	-8.28	-3.23	-1.31	-0.43	3.65
12(+6,+258)	-17.33***	-15.03***	0.48	-16.50***	-17.17**	-24.00***	-7.67***	-3.06	0.38

6.2.2 Market reaction to Stock Split Ex-Dates

6.2.2.1 Short-Term Market Reaction

Table 5 reports market reaction on split ex-dates before and after decimalization for small, medium, and large firms. Panel A presents market reaction measured by abnormal returns around split ex-dates. There is some sign of market reaction measured by abnormal returns as the significance level shows the existence of positive abnormal returns for all sized firms in all tick periods. However, during the 1/8th period, market reaction is larger compared to 1/16th and 1/100th periods.

Panel B reports the market reaction around split ex-dates measured by BHARs of seven different periods. The market reaction during the 1/8th tick period is different compared to that of the 1/16th and 1/100th tick periods. During the 1/8th tick period, there are significant BHARs around seven different periods around the split ex-date for small firms while medium and large firms show some existence of BHARs. During the 1/16th tick period, we still can observe some degree of market reaction around split ex-dates, but this result is very different from result of split announcements in Table 4. On the other hand, 1/100th tick period also presents some significant market reaction as BHARs are positive for small and large firms around split ex-date. But we do not observe any evidence of market reaction as measured by BHARs for medium firms during the 1/100th tick period.

6.2.2.2 Long-Term Market Reaction to Stock Split Ex-Dates

Panel C presents market reactions as measured by BHARs of five different periods after the split ex-date. During the 1/8th and 1/100th tick periods, we observe

some significant buy and hold abnormal returns for small and medium firms but not for large firms. The BHARs for all tick periods are significantly negative as the holding period is increased for all firms during all tick periods except large firms in the 1/8th and 1/100th tick periods.

Chou, Lee, and Chen (2005) document the stock price behavior around the ex-split dates both before and after the decimalization on the NYSE. They find the abnormal ex-split day returns decrease as the tick size and hence the bid-ask spread decrease. Kadapakkam, Krishnamurthy, and Tse (2005) also report significant positive abnormal returns and significant relative spread increases around the ex-date during the 1/8th tick period, but not in the decimal pricing period. However, this study can partly agree with their results because the result of this study also shows that small firms during the 1/8th tick period show significant positive abnormal returns and BHARs, but we also observe significant positive abnormal returns and BHARs for small firms during the 1/100th tick period around ex-split date, but they are smaller in magnitude than in before the decimalization periods.

6.2.3 ANOVA Results for Market reaction

An analysis of variance (ANOVA) is used to evaluate more formally whether a difference exists in market reaction before and after decimalization among three different tick periods and three different firm sized groups. An ANOVA will determine whether the differences among the sample means are too large to be attributed to the chance errors of drawing the samples from the same population.

Table 5

Market Reaction to Stock Split Ex-Dates before and after Decimalization

Market reaction is measured by abnormal returns and buy and hold abnormal returns (BHARs) with market adjusted returns model. This table presents the mean abnormal returns and BHARs of 1,344 stock ex-split dates for NYSE and Nasdaq from 1991 to 2011 according to the different price-quoting periods and market capitalization. Firms with less than 60 days stock returns from CRSP are removed from the analysis. The 1/8th period extends January 1, 1991 to May 31, 1996 for NYSE and Nasdaq, the 1/16th period extends for NYSE from June 24, 1998 to January 28, 2000 and for Nasdaq from October 1, 1998 to March 31, 2000, and the decimal (1/100th) period from May 1, 2002 to December 31, 2011 for NYSE and Nasdaq. Abnormal returns are individual stock raw returns less market adjusted index returns. The CRSP equal-weighted index is used as a proxy for the market index. For each day relative to the split ex-date (day 0), individual abnormal returns are averaged across the splitting securities in the sample for that day. The BHARs are the mean compound abnormal returns. In Panel C, the BHARs in month is expressed as 1 month (+6, +27), 2 month (+6, +48), 3 month (+6, +69), 6 month (+6, +132), and 12 month (+6, +258). Standardized cross-sectional test (BMP, 1991) is used to measure the significance of mean abnormal returns. T-test is used to measure the significance of BHARs. "***", "**", and "*" denote significance levels of 1%, 5%, and 10%, respectively for the standardized cross-sectional test and t-test.

Event Day or Interval	1/8th (1991/01/01 – 1996/05/31)			1/16th (1998/06/24 – 2000/03/31)			1/100th (2002/05/01 – 2011/12/31)		
	Small cap. Obs.: 510	Mid-cap. Obs.:108	Large cap. Obs.: 24	Small cap. Obs.: 105	Mid-cap. Obs.: 72	Large cap. Obs.: 67	Small cap. Obs.: 213	Mid-cap. Obs.: 155	Large cap. Obs.: 87
Panel A: Mean Abnormal Returns (%)									
-5	0.08	-0.22	-1.02**	0.08	-0.49	1.58***	0.26	0.09	0.07
-4	0.11	0.52***	0.20	0.51	0.11	0.49	-0.22*	0.29*	-0.08
-3	0.20	-0.06	0.29	-0.16	0.58	1.49	0.16	0.12	0.28*
-2	0.49***	-0.03	0.98**	-0.91**	1.12**	1.37	0.23	0.04	0.09
-1	0.44***	0.52*	0.22	0.96*	1.14**	0.86	0.85	0.00	0.40*
0	1.96***	0.50	-0.34	0.59	1.40*	0.55	0.97***	-0.18	0.26
+1	0.71***	-0.20	1.51*	0.15	1.60	0.22	-0.18	-0.28	0.25
+2	0.33*	-0.06	1.32**	-0.35	-0.02	-0.14	0.26	-0.26	-0.07
+3	-0.16	0.51	-0.94**	2.25***	-1.10*	0.95*	0.02	-0.30*	0.04
+4	-0.20	-0.12	-0.53	0.06	-0.07	1.60	-0.07	0.21	0.03
+5	-0.26	0.24	1.02	-0.64	-0.18	-0.63*	-0.04	0.12	-0.10
Panel B: Buy and Hold Abnormal Returns (%)									
(-5,0)	3.35***	1.26*	0.32	1.00	4.31*	5.36***	1.40**	0.36	1.02*
(-2,0)	2.94***	1.02*	0.86	0.60	4.15**	2.90*	1.27**	-0.15	0.78*
(-1,0)	2.44***	1.05**	-0.11	1.74**	2.77*	1.46	1.08**	-0.18	0.67**
(-1,+1)	3.15***	0.88	1.34	1.70*	4.42**	1.58	1.78*	-0.47	0.92***
(0,+1)	2.66***	0.32	1.13	0.74	3.07**	0.78	0.80*	-0.45	0.52*
(0,+2)	2.96***	0.27	2.46*	0.50	2.95*	0.67	1.05**	-0.72	0.43
(0,+5)	2.31***	0.83	1.83	1.98	1.53	2.94	0.87	-0.71	0.40

(table continues)

Table 5 *(continued)*

Event Day or Interval	1/8th (1991/01/01 – 1996/05/31)			1/16th (1998/06/24 – 2000/03/31)			1/100th (2002/05/01 – 2011/12/31)		
	Small cap. Obs.: 510	Mid-cap. Obs.:108	Large cap. Obs.: 24	Small cap. Obs.: 105	Mid-cap. Obs.: 72	Large cap. Obs.: 67	Small cap. Obs.: 213	Mid-cap. Obs.: 155	Large cap. Obs.: 87
Panel C: Buy and Hold Abnormal Returns after Ex-Date (Months) (%)									
1 (+6,+27)	0.74	-1.49	-2.60	-2.20	-1.16	-3.04	1.89*	0.75	0.59
2 (+6,+48)	-1.83*	-3.50*	-1.09	-3.31	-2.07	-1.23	1.99	-0.11	0.73
3 (+6,+69)	-3.48***	-5.25**	-5.12	-6.55**	-5.23	2.20	1.31	-0.23	1.33
6 (+6,+132)	-9.87***	-10.21***	-3.29	-13.77***	-10.66**	-13.79***	-2.66	-1.69	1.72
12(+6,+258)	-20.18***	-18.25***	-2.81	-21.86***	-12.34**	-32.31***	-7.71***	-4.48*	-2.46

If the determination is made, then the null hypothesis is rejected and the alternate hypothesis that there is a significant difference in market reaction before and after decimalization among three different tick periods and three different firm sized groups should be accepted.

Table 6 presents the short-term ANOVA tests for market reaction to stock splits of three different tick periods and three different firm sized groups. Specifically, in Panel A, the overall ANOVA test for null hypothesis is, Ho1: $BHAR_{T1T21S} = BHAR_{T1T21M} = BHAR_{T1T21L} = BHAR_{T1T22S} = BHAR_{T1T22M} = BHAR_{T1T22L} = BHAR_{T1T23S} = BHAR_{T1T23M} = BHAR_{T1T23L}$, where, BHAR = the average buy and hold abnormal returns; T_1T_2 = (-5,0), (-2,0), (-1,0), (-1,+1), (0,+1), (0,+2), and (0,+5); 1= $1/8^{th}$ tick period, 2 = $1/16^{th}$ tick period, and 3 = $1/100^{th}$ tick period; S = Small cap., M = Medium cap., and L = Large cap. "***", "**", and "*" denote significance levels of 1%, 5%, and 10%, respectively for the *f*-test.

6.2.3.1 Short-Term ANOVA Results for Market Reaction

6.2.3.1.1 Stock Split Announcement Dates

Table 6, Panel A presents the overall result that market reaction measured by BHARs of all firms during all tick periods are significantly different around split announcement dates for all seven examined short-term periods.

Panel B presents the market reaction measured by BHARs around stock split announcement date, interval (-1, +1). All four tests report the same results for size comparisons that mean BHARs of small firms are significantly different from that of medium firms. The mean BHARs of small firms are greater by 0.014% than that of medium firms. The mean BHARs are not significantly different between small and large

firms, and medium and large firms. Also, all four tests show the same results for period comparisons that mean BHARs of 1/8th tick period is significantly different from that of 1/16th tick period. The mean BHARs of the 1/16th tick period are greater by 0.035% than that of the 1/8th tick period. Also, mean BHARs of the 1/16th period are significantly different from that of the 1/100th tick period. The mean BHARs of the 1/16th tick period is greater by 0.035% than that of 1/100th tick period.

Combined size and tick period comparisons results can be found from the BonFerroni tests. The results show that market reaction of small firms during the 1/16th tick period is greater than small and medium firms during the 1/8th tick period, 0.037% and 0.054%, respectively, and medium and large firms during the 1/100th tick period, 0.052% and 0.053%, respectively. Market reaction of small firms during the 1/100th tick period is greater than medium firms during the 1/100th and 1/8th tick periods, 0.027% and 0.029%, respectively. Also, market reaction of medium firms during the 1/16th tick period is greater than medium firms during the 1/8th and 1/100th tick periods, 0.046% and 0.044%, respectively. Lastly, market reaction of large firms during the 1/16th tick period is greater than medium firms during the 1/8th and 1/100th tick periods, 0.044% and 0.042%, respectively, and large firms during the 1/100th tick period by 0.043%.

6.2.3.1.2 Stock Split Ex-Date

In Table 6, Panel A presents the overall result that market reaction measured by BHARs of all firms during all tick periods are significantly different around split ex-dates for all seven examined short-term periods.

Panel C presents the market reaction around the stock split ex-date, interval (-1, +1). All three tests report the same results for size comparisons except the Waller Duncan k-ratio test. The Waller Duncan k-ratio test finds that there is no significant difference between all firms. However, Duncan's multiple range test, *t*-test (LSD), and Tukey's studentized range (HSD) test results are identical that market reaction of small firms are greater by 0.016% than that of medium firms, but market reaction of small and large, and medium and large firms are not significantly different.

All tests show no difference between the $1/8^{th}$ and $1/16^{th}$ periods. All tests except Tukey's studentized range (HSD) test show that ex-date market reaction is significantly smaller in the decimal period compared to the $1/8^{th}$ and $1/16^{th}$ periods. Tukey's studentized range (HSD) test shows that the decimal period reaction is significantly smaller than the $1/8^{th}$ period reaction.

The BonFerroni test presents the result of combined size and tick period comparisons. The results show that market reaction of small firms as measured by BHARs during the $1/8^{th}$ tick period is greater than that of medium firms during the $1/100^{th}$ tick period by 0.036%. Also, market reaction of medium firms as measured by BHARs during the $1/16^{th}$ tick period is greater than that of medium firms during the $1/100^{th}$ tick period by 0.049%.

Table 6

Short-Term ANOVA Results for Market Reaction to Stock Splits

ANOVA test is used to measure the significance of market reaction measured by BHARs between groups. This table presents short-term ANOVA test for market reaction of three different tick periods and three different firm sized groups. Specifically, in Panel A, the overall ANOVA test for null hypothesis is, Ho1: $BHAR_{T1T21S} = BHAR_{T1T21M} = BHAR_{T1T21L} = BHAR_{T1T22S} = BHAR_{T1T22M} = BHAR_{T1T22L} = BHAR_{T1T23S} = BHAR_{T1T23M} = BHAR_{T1T23L}$, where, BHAR = the average buy and hold abnormal returns; T_1T_2 = (-5,0), (-2,0), (-1,0), (-1,+1), (0,+1), (0,+2), and (0,+5); 1= $1/8^{th}$ period, 2 = $1/16^{th}$ period, and 3 = $1/100^{th}$ period; S = Small cap., M = Medium cap., and L = Large cap. "***", "**", and "*" denote significance levels of 1%, 5%, and 10%, respectively for F-test. In Panel B, the short-term market reaction between groups with the period of T_1T_2 = (-1, +1) around split announcement and ex-dates is further analyzed by size, period, and size*period. For the size, the tested null hypothesis is, Ho2: $BHAR_{T1T2S} = BHAR_{T1T2M} = BHAR_{T1T2L}$, and for period, Ho3: $BHAR_{T1T21} = BHAR_{T1T22} = BHAR_{T1T23}$ by employing Waller Duncan K-ratio Test, Duncan's Multiple Range Test, T Tests (LSD), and Tukey's Studentized Range (HSD) Test. For size*period, the tested null hypothesis is Ho4: $BHAR_{T1T21*S} = BHAR_{T1T21*M} = BHAR_{T1T21*L} = BHAR_{T1T22*S} = BHAR_{T1T22*M} = BHAR_{T1T22*L} = BHAR_{T1T23*S} = BHAR_{T1T23*M} = BHAR_{T1T23*L}$ by employing BonFerroni test. T Tests (LSD), Tukey's Studentized Range (HSD) Test, and the BonFerroni test are used with α=0.05. The mean BHARs are expressed in %.

Panel A: Overall Cumulative Result - F Ratio		
Interval	Split Announcement Dates	Split Ex-Dates
(-5,0)	8.4415***	3.5775***
(-2,0)	6.3081***	4.1979***
(-1,0)	6.0304***	3.1727***
(-1,+1)	8.0480***	3.3362***
(0,+1)	6.7816***	5.0424***
(0,+2)	4.7715***	4.9544***
(0,+5)	5.1897***	1.7428*

(table continues)

Table 6 *(continued)*

Panel B: Market Reaction around Stock Split Announcement Date (-1, +1)					
Test	Waller Duncan K-ratio Test	Duncan's Multiple Range Test	T Tests (LSD)	Tukey's Studentized Range (HSD) Test	BonFerroni Test
Size: Small vs. Medium Small vs. Large Medium vs. Large	S>M (0.040/0.025) S=L M=L	S>M (0.040/0.025) S=L M=L	S-M: S>M (0.014) S-L: S=L M-L: M=L	S-M: S>M (0.014) S-L: S=L M-L: M=L	Size*Period S*1/16th > S*1/8th (0.069/0.032) S*1/16th > M*1/8th (0.069/0.015) S*1/16th > M*1/100th (0.069/0.017) S*1/16th > L*1/100th (0.069/0.016) S*1/100th >M*1/100th (0.044/0.017) S*1/100th > M*1/8th (0.044/0.015) M*1/16th >M*1/8th (0.061/0.015) M*1/16th >M*1/100th (0.061/0.017) M*1/16th> L*1/100th (0.061/0.016) L*1/16th >M*1/8th (0.059/0.015) L*1/16th >M*1/100th (0.059/0.017) L*1/16th >L*1/100th (0.059/0.016)
Period: 1/8th vs. 1/16th 1/8th vs. 1/100th 1/16th vs. 1/100th	1/8th <1/16th (0.029/0.064) 1/8th = 1/100th 1/16th > 1/100th (0.064/0.029)	1/8th <1/16th (0.029/0.064) 1/8th = 1/100th 1/16th > 1/100th (0.064/0.029)	1/8th-1/16th: 1/8th < 1/16th (-0.035) 1/8th-1/100th: 1/8th=1/100th 1/16th-1/100th: 1/16th>1/100th (0.035)	1/8th-1/16th: 1/8th < 1/16th (-0.035) 1/8th-1/100th: 1/8th=1/100th 1/16th-1/100th: 1/16th>1/100th (0.035)	
Panel C: Market Reaction around Stock Split Ex-Date (-1, +1)					
Size: Small vs. Medium Small vs. Large Medium vs. Large	S=M S=L M=L	S>M (0.026/0.010) S=L M=L	S-M: S>M (0.016) S-L: S=L M-L: M=L	S-M: S>M (0.016) S-L: S=L M-L: M=L	Size*Period S*1/8th >M*1/100th (0.031/-0.005) M*1/16th >M*1/100th (0.044/-0.005)
Period: 1/8th vs. 1/16th 1/8th vs. 1/100th 1/16th vs. 1/100th	1/8th = 1/16th 1/8th > 1/100th (0.027/0.008) 1/16th > 1/100th (0.025/0.008)	1/8th = 1/16th 1/8th > 1/100th (0.027/0.008) 1/16th > 1/100th (0.025/0.008)	1/8th-1/16th: 1/8th =1/16th 1/8th-1/100th: 1/8th>1/100th (0.019) 1/16th-1/100th: 1/16th>1/100th (0.017)	1/8th-1/16th: 1/8th =1/16th 1/8th-1/100th: 1/8th>1/100th (0.019) 1/16th-1/100th: 1/16th=1/100th	

6.2.3.2 Long-Term ANOVA Results for Market Reaction to Split Announcement Dates

6.2.3.2.1 Stock Split Announcement Dates

Long-Term ANOVA for market reaction to stock splits is analyzed to examine if there is significance of market reaction between groups for five periods, a one month, a two month, a three month, a six month, and a one year period following the split ex-date. An ANOVA test is used to measure the significance of market reaction between groups. Table 7 presents the ANOVA test for market reaction measured by BHARs of three different tick periods and three different firm sized groups. Specifically, in Panel A, the overall ANOVA tests for null hypothesis is, Ho1: $BHAR_{T1T21S}$ = $BHAR_{T1T21M}$ = $BHAR_{T1T21L}$ = $BHAR_{T1T22S}$ = $BHAR_{T1T22M}$ = $BHAR_{T1T22L}$ = $BHAR_{T1T23S}$ = $BHAR_{T1T23M}$ = $BHAR_{T1T23L}$, where, BHAR = the average buy and hold abnormal returns; T_1T_2 = (+6,+27), (+6,+48), (+6,+69), (+6,+132), and (+6,+258); 1= $1/8^{th}$ tick period, 2 = $1/16^{th}$ tick period, and 3 = $1/100^{th}$ tick period; S = Small cap., M = Medium cap., and L = Large cap. “***”, “**”, and “*” denote significance levels of 1%, 5%, and 10%, respectively for F-test.

In Table 7, Panel A shows the overall result that market reaction of all firms during all tick periods are significantly different for six month and for one year for split announcements, but there is no significant difference in market reaction for one month, two month, and three month intervals periods around split announcements.

6.2.3.2.2 Stock Split Ex-Date

In Table 7, Panel A shows the overall result that market reaction of all firms during all tick periods are significantly different for six month and for one year periods

for split ex-dates. But, there is no significant difference in market reaction for one month and two month after split ex-dates.

Panel B, the long-term market reaction between groups with the one year interval of T_1T_2 = (+6, +258) after split ex-dates is further analyzed by size, period, and size*period. For the size, the tested null hypothesis is Ho2: $BHAR_{T1T2S} = BHAR_{T1T2M} = BHAR_{T1T2L}$, and for period, Ho3: $BHAR_{T1T21} = BHAR_{T1T22} = BHAR_{T1T23}$ by employing the Waller Duncan k-ratio test, Duncan's multiple range test, *t* tests (LSD), and Tukey's studentized range (HSD) test. For size*period, the tested null hypothesis is, Ho4: $BHAR_{T1T21*S} = BHAR_{T1T21*M} = BHAR_{T1T21*L} = BHAR_{T1T22*S} = BHAR_{T1T22*M} = BHAR_{T1T22*L} = BHAR_{T1T23*S} = BHAR_{T1T23*M} = BHAR_{T1T23*L}$ by employing BonFerroni test. T tests (LSD), Tukey's studentized range (HSD) test, and the BonFerroni test are used with α=0.05. The mean BHARs are expressed in %.

The results for size comparisons for the Waller Duncan k-ratio test reports that market reaction of all firms are not significantly different. However, Duncan's multiple range test, *t* test (LSD), and Tukey's studentized range (HSD) test report that market reaction measured by BHARs of the small firms is significantly more negative by -0.064% than medium firms. All three tests report that market reaction comparisons of small and large firms, and medium firms and large firms show no differences. All four tests report the same result for period comparisons that there is no significant difference in market reaction between $1/8^{th}$ and $1/16^{th}$ tick periods. But market reaction of the $1/100^{th}$ tick period is less negative than the $1/8^{th}$ and $1/16^{th}$ tick periods, by -0.135% and -0.166%, respectively. The BonFerroni test presents the result of combined size and tick period comparisons. The results show that market reaction of small firms as measured

by BHARs during the 1/100th tick period is less negative than that of small firm during the 1/8th tick period and large firms during the 1/16th tick period, by 0.125% and 0.246%, respectively. Also, market reaction of medium firms as measured by BHARs during the 1/100th tick period is less negative than that of small firms during the 1/8th and 1/16th tick period, and large firms during the 1/16th tick period, by 0.157%, 0.174%, and 0.278%, respectively. Market reaction for large firms during the 1/8th period is less negative by 0.295% than large firm during the 1/16th period. Lastly, market reaction of large firms during the 1/100th period is less negative than small firms during the 1/8th and 1/16th periods, and large firms during the 1/16th tick period, by 0.177%, 0.194% and 0.298%, respectively.

6.3 The Effect of Decimalization on Liquidity

The empirical results of the effect of decimalization on liquidity around stock split ex-dates are discussed in this section. In this study, liquidity is measured by the means of daily turnover, relative bid-ask spread, and market maker count. This study considers each trade in a stock is weighted equally to compute the mean for the stock and the mean for the market is obtained as the simple average across stocks. This method gives results that pertain to an average trade in an average sample stock.

The two competing liquidity effects of decimalization are narrower spread that reduces transaction costs and increase liquidity but also reduce the market maker's incentive to promote stocks, especially small ones, so liquidity may be reduced. Therefore, the liquidity could increase or decrease after decimalization. Also, more shares outstanding at lower prices may result in higher turnover.

Table 7

Long-Term ANOVA Results for Market Reaction to Stock Splits

ANOVA test is used to measure the significance of market reaction between groups. This table presents ANOVA test for market reaction of three different tick periods and three different firm sized groups. Specifically, in Panel A, the overall ANOVA tests for null hypothesis is, Ho1: $BHAR_{T1T21S} = BHAR_{T1T21M} = BHAR_{T1T21L} = BHAR_{T1T22S} = BHAR_{T1T22M} = BHAR_{T1T22L} = BHAR_{T1T23S} = BHAR_{T1T23M} = BHAR_{T1T23L}$, where, BHAR = the average buy and hold abnormal returns; T_1T_2 = (+6,+27), (+6,+48), (+6,+69), (+6,+132), and (+6,+258); 1= 1/8th period, 2 = 1/16th period, and 3 = 1/100th period; S = Small cap., M = Medium cap., and L = Large cap. "***", "**", and "*" denote significance levels of 1%, 5%, and 10%, respectively for F-test. In Panel B, the long-term market reaction between groups with the period of T_1T_2 = (+6, +258) after split ex-dates is further analyzed by size, period, and size*period. For the size, the tested null hypothesis is, Ho2: $BHAR_{T1T2S} = BHAR_{T1T2M} = BHAR_{T1T2L}$, and for period, Ho3: $BHAR_{T1T21} = BHAR_{T1T22} = BHAR_{T1T23}$ by employing Waller Duncan k-ratio test, Duncan's multiple range Test, T tests (LSD), and Tukey's studentized range (HSD) test. For size*period, the tested null hypothesis is Ho4: $BHAR_{T1T21*S} = BHAR_{T1T21*M} = BHAR_{T1T21*L} = BHAR_{T1T22*S} = BHAR_{T1T22*M} = BHAR_{T1T22*L} = BHAR_{T1T23*S} = BHAR_{T1T23*M} = BHAR_{T1T23*L}$ by employing BonFerroni test. T tests (LSD), Tukey's studentized range (HSD) test, and the BonFerroni test are used with α=0.05. The mean BHARs are expressed in %.

Panel A: Overall Cumulative Result in Months- F Ratio		
Interval	Split Announcement Dates	Split Ex-Dates
1 (+6,+27)	1.0307	1.3295
2 (+6,+48)	1.2127	1.0115
3 (+6,+69)	1.2127	1.9473**
6 (+6,+132)	3.5106***	3.7550***
12 (+6,+258)	5.3310***	7.6765***

Panel B: Market Reaction One Year after Stock Split Ex-Date					
Test	Waller Duncan K-ratio Test	Duncan's Multiple Range Test	T Tests (LSD)	Tukey's Studentized Range (HSD) Test	BonFerroni Test
Size: Small vs. Medium Small vs. Large Medium vs. Large	S=M S=L M=L	S<M (-0.166/-0.102) S=L M=L	S-M: S<M (-0.064) S-L: S=L M-L: M=L	S-M S<M (-0.064) S-L: S=L M-L: M=L	Size*Period S*1/100th >S*1/8th (-0.077/-0.202) S*1/100th > L*1/16th (-0.077/-0.323) M*1/100th >S*1/8th (-0.045/-0.202) M*1/100th >S*1/16th (-0.045/-0.219) M*1/100th >L*1/16th (-0.045/-0.323) L*1/8th >L*1/16th (-0.028/-0.323) L*1/100th >S*1/8th (-0.025/-0.202) L*1/100th >S*1/16th (-0.025/-0.219) L*1/100th >L*1/16th (-0.025/-0.323)
Period: 1/8th vs. 1/16th 1/8th vs. 1/100th 1/16th vs. 1/100th	1/8th = 1/16th 1/8th <1/100th (-0.191/-0.056) 1/16th <1/100th (-0.222/-0.056)	1/8th = 1/16th 1/8th <1/100th (-0.191/-0.056) 1/16th <1/100th (-0.222/-0.056)	1/8th-1/16th: 1/8th =1/16th 1/8th-1/100th: 1/8th<1/100th (-0.135) 1/16th-1/100th: 1/16th<1/100th (-0.166)	1/8th-1/16th: 1/8th =1/16th 1/8th-1/100th: 1/8th<1/100th (-0.135) 1/16th-1/100th: 1/16th<1/100th (-0.166)	

6.3.1 Liquidity after Stock Split Ex-Dates

The long-term liquidity effect after stock split ex-dates before and after decimalization is evaluated in Table 8. Table 8 reports the cross-sectional distributions for the average daily turnover (Panel A), relative spread (Panel B), and market maker count (Panel C) for one month, two month, three month, six month, and one year periods after the split ex-date. Each period begins on day +6 relative to the split ex-date. The turnover rate is measured by the ratio of average daily shares traded to average daily shares outstanding. The relative bid-ask spread is defined as (Ask price – Bid price)/[(Ask price + Bid Price)/2]. The market maker count is measured by the average daily market maker count. A *t*-test is used to measure the significance of turnover, relative spread, and market maker count.

6.3.1.1 Turnover

In Table 8, Panel A reports the means of the cross-sectional distribution for the average daily turnover. The turnover compares pre-announcement date with the post ex-date turnover. The overall turnover during the $1/16^{th}$ tick period is higher than $1/8^{th}$ and $1/100^{th}$ tick periods. However, if we compare $1/8^{th}$ and $1/100^{th}$ tick periods, the $1/100^{th}$ tick period shows higher turnover for all sized firms for all post-stock split periods. It clearly shows that as tick size gets smaller from $1/8^{th}$ to $1/16^{th}$ or to $1/100^{th}$ the turnover increases for all firms. Liquidity based studies argue that managers split stock in order to improve liquidity. However, during the $1/8^{th}$ tick period, turnover of small and medium firms significantly decrease for the most of the periods after splitting their stocks, but this may be the result of the unusually large turnover in the period leading up

to the split. The one year comparisons which may represent the long-term steady state show that turnover increases significantly for small firms. During the 1/16th tick period, the one month turnover for small and large firms decrease but turnover for six and 12 month increase significantly after splitting their stocks. Turnover of small firms significantly increase after split for all periods during decimalization compared to before announcement periods. This result is inconsistent with SEC report to Congress (2012) that decimalization reduced liquidity of small firms.

6.3.1.2 Relative Spread

In Table 8, Panel B presents the means of the cross-sectional distributions for the average daily relative spread of one month, two month, three month, six month, and one year periods. The relative spread compares pre-announcement date with the post ex-date relative spread. Panel B clearly shows that relative spread decreased as tick size reduced from 1/8th to 1/16th and 1/100th. Also, the relative spreads of small firms are greater than that of medium and large firms in all three different tick periods. The literature on stock splits often reports that bid-ask spreads increase after splitting stocks. However, this appears to be the case only during the 1/8th tick period for all firms except for small firms in the one year period and for large firms for some intervals during all different tick periods. Kadapakkam, Krishnamurthy, and Tse (2005) also observe that the relative spread increases significantly around the ex-date during the 1/8th pricing period, but not in the decimal pricing period. After splitting, relative spreads significantly decrease for small and medium firms during the 1/16th and 1/100th periods in most of the post-stock split ex-date periods. Previous studies on decimalization argue that after

decimalization, the reduction in spreads may have reduced broker incentives to promote stocks but with no apparent reduction in market maker profitability. They further claim that tighter market maker compensation has resulted in less liquidity for small-cap stocks, since most broker-dealers will not find the reduced compensation enticing enough to invest in making a market in small-cap stocks which typically have lower volumes and therefore less trading flow [Bessembinder (2003)]. However, the previous results are inconsistent with this study result. During decimalization, trading volume is significantly increased while bid-ask spread is significantly decreased for small firms after splitting their stocks. On the other hand, for large firms, trading volume is significantly decreased while bid-ask spread is significantly increased after splitting their stocks.

6.3.1.3 Market Maker Count

In Table 8, Panel C presents the means of the cross-sectional distributions for the average daily market maker count of one month, two month, three month, six month, and one year periods. The market maker count compares pre-announcement date with the post ex-date market maker count. Overall market maker count increases as tick size decreases from $1/8^{th}$ to $1/16^{th}$ and $1/100^{th}$ for all firms. However, after splitting, market maker count decreases for large firms during the $1/8^{th}$ and $1/100^{th}$ tick periods, while market maker count increases for all small and medium firms during all tick periods and large firms during the $1/16^{th}$ tick period. The decrease in market maker count for large firms after splitting their stock is inconsistent with the broker promotion hypothesis. The broker promotion hypothesis suggests that brokers tend to promote splitting firms if the

bid-ask spread of splitting firms gets wider, so that brokers get more compensation. Since brokers are promoting more for splitting firms, their liquidity improves compare to before the split announcement period. For large firms during the 1/100th tick period, after splitting their stock, bid-ask spread is increased significantly while turnover and market maker count decreased significantly. On the other hand, for small firms, the result shows opposite of the large firms during the 1/100th tick period that after splitting their stock, bid-ask spread is decreased significantly while turnover and market maker count increased significantly. This result is also inconsistent with empirical studies on decimalization. Empirical studies find the reduced spreads after stock market decimalization reduced market maker compensation and consequently reduced the incentives for brokers to promote a stock after split especially for small firms [Bessembinder (2003), Kadapakkam, Krishnamurthy, and Tse (2005), and Chou, Lee, Chen (2005)].

6.3.2 ANOVA Results for Liquidity

An analysis of variance (ANOVA) is used to evaluate whether a difference exists in liquidity before and after decimalization among three different tick periods and three different firm sized groups. An ANOVA will determine whether the differences among the sample means are too large to be attributed to the chance errors of drawing the samples from the same population. If the determination is made, then the null hypothesis is rejected and the alternate hypothesis that there is a significant difference in liquidity before and after decimalization among three different ticks size periods and three different firm sized groups should be accepted. Long-Term ANOVA for liquidity on

stock splits is analyzed to examine if there is significance of liquidity between groups for five periods. One month, two month, three month, six month, and one year periods are used to measure the significance of liquidity in terms of turnover, relative spread, and market maker count.

Table 9 presents ANOVA tests for liquidity of three different tick size periods and three different firm sized groups. Specifically, in Panel A, the overall ANOVA tests for null hypotheses are, Ho1: $TO_{T1T21S} = TO_{T1T21M} = TO_{T1T21L} = TO_{T1T22S} = TO_{T1T22M} = TO_{T1T22L} = TO_{T1T23S} = TO_{T1T23M} = TO_{T1T23L}$, Ho2: $RBAS_{T1T21S} = RBAS_{T1T21M} = RBAS_{T1T21L} = RBAS_{T1T22S} = RBAS_{T1T22M} = RBAS_{T1T22L} = RBAS_{T1T23S} = RBAS_{T1T23M} = RBAS_{T1T23L}$, and Ho3: $MMC_{T1T21S} = MMC_{T1T21M} = MMC_{T1T21L} = MMC_{T1T22S} = MMC_{T1T22M} = MMC_{T1T22L} = MMC_{T1T23S} = MMC_{T1T23M} = MMC_{T1T23L}$, where TO = the ratio of average turnover ratio of one year before announcement date and one year after split ex-date, RBAS = the ratio of average relative bid-ask spread of one year before announcement date and one year after split ex-date, and MMC = the ratio of average market maker count of one year before announcement date and one year after split ex-date; T_1T_2 = (+6,+27) for one month, (+6,+48) for two month, (+6,+69) for three month, (+6,+132) for six month, and (+6,+258) for one year; 1 = $1/8^{th}$ period, 2 = $1/16^{th}$ period, and 3 = $1/100^{th}$ period; S = Small cap., M = Medium cap., and L = Large cap. “***”, “**”, and “*” denote significance levels of 1%, 5%, and 10%, respectively for *f*-test.

Table 8

Liquidity after Split Ex-date for Small, Medium, and Large Firms

This table reports liquidity effect after split ex-date. The cross-sectional distributions for the average daily turnover, relative spread, and market maker count of one month, two month, three month, six month, and one year after split ex-date are calculated. The turnover rate is measured by the ratio of average daily shares traded to average daily shares outstanding. The relative bid-ask spread is defined as, (Ask price – Bid price)/[(Ask price + Bid Price)/2]. The market maker count is measured by the average daily market maker count. Split ex-dates around +1 to +5 are excluded in calculation. T-test is used to measure the significance of turnover, relative spread, and market maker count. "***", "**", and "*" denote significance levels of 1%, 5%, and 10% for t-test. Result format = Before/After***, where before is the n-month period before the announcement date and after is the n-month after the ex-date, with n = 1, 2, 3, 6, 12.

Interval (Months)	1/8th (1991/01/01 – 1996/05/31)			1/16th (1998/06/24 – 2000/03/31)			1/100th (2002/05/01 – 2011/12/31)		
	Small cap. Obs.: 511	Mid-cap. Obs.:108	Large cap. Obs.: 24	Small cap. Obs.: 105	Mid-cap. Obs.: 73	Large cap. Obs.: 67	Small cap. Obs.: 214	Mid-cap. Obs.: 155	Large cap. Obs.: 87
Panel A: Turnover									
1 (+6,+27)	0.01120/0.00982***	0.01315/0.01033***	0.01242/0.01800**	0.01517/0.01342***	0.02064/0.02198	0.01909/0.01855**	0.01346/0.01555**	0.01539/0.01436***	0.01467/0.01221***
2(+6,+48)	0.01058/0.00962***	0.01260/0.01029***	0.01174/0.01083	0.01394/0.01454	0.02090/0.02172	0.01963/0.01953	0.01318/0.01659***	0.01497/0.01405***	0.01381/0.01245***
3(+6,+69)	0.01025/0.00942***	0.01225/0.01027***	0.01145/0.01138	0.01335/0.01430*	0.02042/0.02088	0.01958/0.01956	0.01298/0.01571***	0.01509/0.01380***	0.01390/0.01267***
6(+6,+132)	0.00929/0.00948**	0.01150/0.01043***	0.01061/0.01147**	0.01178/0.01404***	0.01844/0.02106***	0.01957/0.02050**	0.01237/0.01436***	0.01454/0.01383***	0.01366/0.01302***
12(+6,+258)	0.00835/0.00944***	0.01134/0.01077***	0.01085/0.01107	0.01080/0.01355***	0.01692/0.02098***	0.02072/0.02078	0.01063/0.01311***	0.01395/0.01413	0.01329/0.01321
Panel B: Relative Spread									
1 (+6,+27)	0.02429/0.03060***	0.00981/0.01421***	0.00570/0.00724**	0.00570/0.01648***	0.00735/0.00736	0.00312/0.00346*	0.00641/0.00540***	0.00121/0.00129	0.00062/0.00079***
2(+6,+48)	0.02508/0.03057***	0.01007/0.01424***	0.00603/0.00834***	0.01614/0.01616	0.00746/0.00714	0.00318/0.00346*	0.00664/0.00535***	0.00128/0.00131***	0.00065/0.00077***
3(+6,+69)	0.02577/0.03044***	0.01027/0.01416***	0.00620/0.00827***	0.01671/0.01583***	0.00765/0.00680***	0.00330/0.00356*	0.00680/0.00540***	0.00135/0.00128**	0.00069/0.00078***
6(+6,+132)	0.02775/0.02961***	0.01089/0.01361***	0.00668/0.00794***	0.01833/0.01573***	0.00831/0.00641***	0.00362/0.00368	0.00753/0.00535***	0.00150/0.00122***	0.00074/0.00078*
12(+6,+258)	0.03114/0.02881***	0.01204/0.01319***	0.00754/0.00740	0.02118/0.01575***	0.00938/0.00649***	0.00397/0.00399	0.00904/0.00500***	0.00181/0.00117***	0.00085/0.00077***
Panel C: Market Maker Count									
1 (+6,+27)	11.84/12.44*	20.88/21.32	32.08/33.96	14.14/15.33***	23.66/26.42***	37.38/45.21***	21.22/23.03***	41.41/42.69*	59.06/58.28
2(+6,+48)	12.21/12.79**	20.12/21.55**	34.35/33.62	14.10/15.61***	23.21/26.91***	37.83/45.86***	20.89/23.21****	41.53/42.40	59.22/57.93
3(+6,+69)	12.18/13.04***	20.46/22.27***	35.40/34.38	13.88/15.79***	22.78/27.29***	37.65/46.56***	20.83/23.31***	41.26/42.57***	59.54/57.67**
6(+6,+132)	12.22/13.78***	21.54/23.05***	36.86/35.00**	13.48/16.39***	21.92/28.81***	37.79/48.38***	20.31/24.27***	40.21/43.41***	59.22/57.95**
12(+6,+258)	12.32/14.39***	22.26/24.81***	37.51/37.08	12.92/17.57***	20.75/32.20***	38.43/52.29***	19.63/25.66***	38.59/44.40***	58.62/58.47

6.3.2.1 Turnover

In Table 9, Panel A reports the overall results for liquidity differences in terms of turnover in five different pre- and post-split ex-dates. For all periods, the one year average change in turnover is significantly different.

To examine long-term differences more closely, I compare liquidity measures using a one year period before the split announcement date with a one year period after the split ex-date. The differences are further analyzed by size, period, and size*period. Panel B presents the one year turnover comparisons. All four tests report the same results for size comparisons that mean turnover of small firms is significantly greater than that of medium and large firms while mean turnover of medium firms is not significantly different from large firms. Turnover increases for small firms are about 34% greater than medium firms and about 48% greater than large firms.

Also, all four tests report the same results for period comparisons that ratio of change in turnover of $1/100^{th}$ tick period is significantly greater than that of the $1/8^{th}$ tick period. There are no significant differences between $1/8^{th}$ and $1/16^{th}$ tick periods and between $1/16^{th}$ and $1/100^{th}$ periods. The average turnover increase for the decimal period is about 36% greater than that of $1/8^{th}$ tick period. Size and tick period combination comparisons are found in the BonFerroni tests. The results show that the increase in turnover of small firms during the $1/100^{th}$ tick period is significantly greater than other combined firm sizes and periods. The result clearly shows that turnover for small firms during the decimalization ($1/100^{th}$) period significantly improved compared to medium and large firms. Again, this result is inconsistent with previous literatures on

decimalization that decimalization has adverse effect on small firms [Bessembinder (2003) and SEC Report to Congress (2012)].

6.3.2.2 Relative Spread

In Table 9, Panel A reports the overall results for liquidity differences in terms of relative spread in five different pre- and post-split ex-dates. For all periods, the one year average change in relative spread is significantly different.

Panel C presents the one year relative comparison. All four tests report the same results for size comparisons that the change in mean relative spreads of large firms is significantly larger than the change for small and medium firms while the change in mean relative spreads of small firms is not significantly different from medium firms. The average increase in relative spreads for large firms is about 14% greater than small firms, and about 14.5% greater than medium firms.

All four tests report the same results for period comparisons that relative spreads tend to increase after splits in the $1/8^{th}$ period, but relative spreads decrease after splits in the $1/16^{th}$ and $1/100^{th}$ periods. The average increase in relative spread for $1/8^{th}$ tick period is about 24.5% greater than that of $1/16^{th}$ and $1/100^{th}$ tick periods. The BonFerroni test reports size and tick period comparisons. The results show that increase in relative spreads of small and medium firms during the $1/8^{th}$ tick period is greater than small and medium firms during the $1/16^{th}$ and $1/100^{th}$ tick periods. Also, the increase in relative spread for large firms during the $1/100^{th}$ tick period is greater than small and medium firms during the $1/16^{th}$ tick periods, and spread increases for large firms are greater than for small firms during the $1/100^{th}$ tick period. These results

provide evidence that relative spreads of small and medium firms during the 1/8th tick period increased after splitting stocks as previous literature documented that stock split increase bid-ask spreads.

6.3.2.3 Market Maker Count

In Table 9, Panel A reports the overall results for liquidity differences in terms of market maker count in five different pre- and post-split ex-dates. For all examined periods, the one year average change in relative spread is significantly different.

Panel D presents the one year comparisons for market maker count. For size comparisons, the Waller Duncan k-ratio test and Duncan's multiple range test report the same results that change in mean market maker count of medium firms is significantly larger than that of large firms while mean market maker count of small firms is not significantly different from medium and large firms. The average change of market maker count one year after the ex-split date compared to one year before split announcement for medium firms is about 10.2% greater than large firms. On the other hand, the *t* test (LSD) and Tukey's studentized range (HSD) test report, in addition to the results of Waller Duncan k-ratio test and Duncan's multiple range test, mean market maker count of medium firms is significantly larger than that of small firms. The average change ratio of market maker count of one year after ex-split date compared to one year before split announcement date for medium firms is about 6.3% greater than small firms. Size and tick period combination comparisons can be found in the BonFerroni tests. The results show that market maker count is significantly increased after splitting stocks for small and medium firms during the 1/16th and 1/100th tick periods. During the

decimalization period, there is strong evidence that market maker promote more of small firms than large firms. This result is inconsistent with previous report on decimalization the market makers are reluctant to promote small firms because their compensation reduced after the stock market decimalized. The result of this study show that decimalization reduced bid-ask spread for small firms but liquidity of small firms improved and market maker count also increased. On the other hand, for large firms, decimalization increased bid-ask spread, while liquidity and market maker count decreased.

6.4 Effect of Decimalization on Return Volatility

Ohlson and Penman (1985) find that return volatility increases following stock splits. Harris (1994) documents that as quote sizes reduce, decreased liquidity could be manifest in the form of more volatile prices. However, the literature on decimalization reports that bid-ask spread and return volatility decreased in the decimalization period compared to before decimalization period. This study examines the effect of decimalization on return volatility following stock splits. I expect that the return volatility will decrease after decimalization. In this study, volatility is computed as cross sectional standard deviation of daily returns for each stock before and after stock splits for $1/8^{th}$, $1/16^{th}$, and $1/100^{th}$ tick periods and for small, medium and large market capitalization firms.

6.4.1 Long-Term Return Volatility after Stock Split Ex-Date

Table 10 reports return volatility change after the split ex-date for five different periods. The cross-sectional distribution for the average daily return volatility is measured by the average standard deviation of the returns for a one month, a two month, a three month, a six month, and for a one year interval after split ex-date. The five days following the split ex-date are excluded in calculation.

A T-test is used to measure the significance of return volatility. "***", "**", and "*" denote significance levels of 1%, 5%, and 10% for t-test. The result of each period is presented the mean standard deviation of both, before split announcement and after ex-split dates.

Table 10 shows that return volatilities were unusually high during the 1/16th period, possibly due to the dot com boom. Longer term volatilities are lower in the decimal period. There are mixed results for the shorter term before/after split comparisons. During the 1/8th period, volatilities increase significantly after the split for all size categories and all intervals. For the 1/16th period, volatilities increase following the split for all small cap and medium cap firms for all intervals, but they are unchanged or significantly lower for large cap firms. For small cap firms in the decimal period, volatility increases for all intervals except one month. Volatilities decrease significantly for medium cap firms in the decimal period for all intervals. For large caps firms, volatilities increase for all intervals except one month, and are unchanged for the one month period.

Table 9

ANOVA Results for Liquidity

This table presents ANOVA tests for liquidity of three different tick size periods and three different firm sized groups. ANOVA test is used to measure if there are differences in liquidity between groups by comparing five different periods, one month, two month, three month, six month, and one year, before and after stock splits. Specifically, in Panel A, the overall ANOVA tests for null hypotheses are, Ho1: TO $_{T1T21S}$ = TO $_{T1T21M}$ = TO $_{T1T21L}$ = TO $_{T1T22S}$ = TO $_{T1T22M}$ = TO $_{T1T22L}$ = TO $_{T1T23S}$ = TO $_{T1T23M}$ = TO $_{T1T23L}$, Ho2: RBAS $_{T1T21S}$ = RBAS $_{T1T21M}$ = RBAS $_{T1T21L}$ = RBAS $_{T1T22S}$ = RBAS $_{T1T22M}$ = RBAS $_{T1T22L}$ = RBAS $_{T1T23S}$ = RBAS $_{T1T23M}$ = RBAS $_{T1T23L}$, and Ho3: MMC $_{T1T21S}$ = MMC $_{T1T21M}$ = MMC $_{T1T21L}$ = MMC $_{T1T22S}$ = MMC $_{T1T22M}$ = MMC $_{T1T22L}$ = MMC $_{T1T23S}$ = MMC $_{T1T23M}$ = MMC $_{T1T23L}$, where TO = the ratio of the turnover ratio of one year before announcement date and one year after split ex-date, RBAS = the ratio of average relative bid-ask spread of one year before announcement date and one year after split ex-date, and MMC = the ratio of average market maker count of one year before announcement date and one year after split ex-date; T_1T_2 = (+6,+27) for one month, (+6,+48) for two month, (+6,+69) for three month, (+6,+132) for six month, and (+6,+258) for one year; 1 = 1/8th period, 2 = 1/16th period, and 3 = 1/100th period; S = Small cap., M = Medium cap., and L = Large cap. "***", "**", and "*" denote significance levels of 1%, 5%, and 10%, respectively for F-test. For long-term liquidity between groups, T_1T_2 = (+6,+258) for turnover in Panel B, relative spread in Panel C, and market maker count in Panel D, for one year after stock split ex-dates is further analyzed by size, period, and size*period by comparing those of one year before announcement. For the size, the tested null hypotheses are, Ho4: TO $_{T1T2S}$ = TO $_{T1T2M}$ = TO $_{T1T2L}$, Ho5: RBAS $_{T1T2S}$ = RBAS $_{T1T2M}$ = RBAS $_{T1T2L}$, Ho6: MMC $_{T1T2S}$ = MMC $_{T1T2M}$ = MMC $_{T1T2L}$, and for period, Ho7: TO $_{T1T21}$ = TO $_{T1T22}$ = TO $_{T1T23}$, Ho8: RBAS $_{T1T21}$ = RBAS $_{T1T22}$ = RBAS $_{T1T23}$, Ho9: MMC $_{T1T21}$ = MMC $_{T1T22}$ = MMC $_{T1T23}$, by employing Waller Duncan K-ratio Test, Duncan's Multiple Range Test, T Tests (LSD), and Tukey's Studentized Range (HSD) Test. For size*period, the tested null hypothesis is, Ho10: TO $_{T1T21*S}$ = TO $_{T1T21*M}$ = TO $_{T1T21*L}$ = TO $_{T1T22*S}$ = TO $_{T1T22*M}$ = TO $_{T1T22*L}$ = TO $_{T1T23*S}$ = TO $_{T1T23*M}$ = TO $_{T1T23*L}$, Ho11: RBAS $_{T1T21*S}$ = RBAS $_{T1T21*M}$ = RBAS $_{T1T21*L}$ = RBAS $_{T1T22*S}$ = RBAS $_{T1T22*M}$ = RBAS $_{T1T22*L}$ = RBAS $_{T1T23*S}$ = RBAS $_{T1T23*M}$ = RBAS $_{T1T23*L}$, and Ho12: MMC $_{T1T21*S}$ = MMC $_{T1T21*M}$ = MMC $_{T1T21*L}$ = MMC $_{T1T22*S}$ = MMC $_{T1T22*M}$ = MMC $_{T1T22*L}$ = MMC $_{T1T23*S}$ = MMC $_{T1T23*M}$ = MMC $_{T1T23*L}$ by employing BonFerroni test. T tests (LSD), Tukey's studentized range (HSD) test, and the BonFerroni test are used with α=0.05.

Panel A: Overall Cumulative Result in Months- F Ratio			
Interval	Turnover	Relative Spread	Market Maker Count
1 (+6,+27) 2 (+6,+48) 3 (+6,+69) 6 (+6,+132) 12 (+6,+258)	2.76*** 3.76*** 3.86*** 3.02*** 5.54***	11.39*** 1.83* 16.89*** 8.62*** 12.52***	1.99* 3.01*** 4.40*** 8.32*** 14.40***

Panel B: Turnover One Year after Stock Split Ex-Date					
Test	Waller Duncan K-ratio Test	Duncan's Multiple Range Test	T Tests (LSD)	Tukey's Studentized Range (HSD) Test	BonFerroni Test
Size: Small vs. Medium Small vs. Large Medium vs. Large	S>M (0.491/0.150) S> L (0.491/0.0103) M=L	S>M (0.491/0.150) S> L (0.491/0.0103) M=L	S-M: S>M (0.341) S-L: S>L (0.481) M-L: M=L	S-M: S>M (0.341) S-L: S>L (0.481) M-L: M=L	Size*Period S*1/100th >S*1/8th (1.046/0.255) S*1/100th >M*1/8th (1.046/0.053) S*1/100th >M*1/100th (1.046/0.134) S*1/100th >L*1/8th (1.046/-0.563) S*1/100th >L*1/100th (1.046/0.072)
Period: 1/8th vs. 1/16th 1/8th vs. 1/100th 1/16th vs. 1/100th	1/8th = 1/16th 1/100th >1/8th (0.552/0.190) 1/16th = 1/100th	1/8th = 1/16th 1/100th >1/8th (0.552/0.190) 1/16th = 1/100th	1/8th-1/16th: 1/8th = 1/16th 1/8th-1/100th: 1/8th<1/100th (0.362) 1/16th-1/100th: 1/16th =1/100th	1/8th-1/16th: 1/8th = 1/16th 1/8th-1/100th: 1/8th<1/100th (0.362) 1/16th-1/100th: 1/16th =1/100th	

(table continues)

Table 9 *(continued)*

Test	Waller Duncan K-ratio Test	Duncan's Multiple Range Test	T Tests (LSD)	Tukey's Studentized Range (HSD) Test	BonFerroni Test
Panel C: Relative Spread One Year after Stock Split Ex-Date					
Size: Small vs. Medium Small vs. Large Medium vs. Large	S=M S<L (-0.098/0.042) M<L (-0.103/0.042)	S=M S<L (-0.098/0.042) M<L (-0.103/0.042)	S-M: S=M S-L: S<L (-0.140) M-L: M<L (-0.145)	S-M: S=M S-L: S<L (-0.140) M-L: M<L (-0.145)	Size*Period S*1/8th >S*1/100th (0.032/-0.348) S*1/8th >M*1/16th (0.032/-0.292) S*1/8th >M*1/100th (0.032/-0.157) S*1/8th > S*1/16th (0.032/-0.180) M*1/8th > S*1/16th (0.131/-0.180) M*1/8th > S*1/100th (0.131/-0.348) M*1/8th >M*1/16th (0.131/-0.292) M*1/8th > M*1/100th (0.131/-0.157 L*1/100th >S*1/16th (0.121/-0.180) L*1/100th >S*1/100th (0.121/-0.348) L*1/100th >M*1/16th (0.121/-0.292)
Period: 1/8th vs. 1/16th 1/8th vs. 1/100th 1/16th vs. 1/100th	1/8th > 1/16th (0.048/-0.197) 1/8th >1/100th (0.048/-0.197) 1/16th= 1/100th	1/8th > 1/16th (0.048/-0.197) 1/8th >1/100th (0.048/-0.197) 1/16th= 1/100th	1/8th-1/16th: 1/8th >1/16th (0.245) 1/8th-1/100th: 1/8th>1/100th (0.245) 1/16th-1/100th: 1/16th =1/100th	1/8th-1/16th: 1/8th >1/16th (0.245) 1/8th-1/100th: 1/8th>1/100th (0.245) 1/16th-1/100th: 1/16th =1/100th	
Panel D: Market Maker Count One Year after Stock Split Ex-Date					
Size: Small vs. Medium Small vs. Large Medium vs. Large	S=M S=L M>L (0.296/0.194)	S=M S=L M>L (0.296/0.194)	S-M: S<M (-0.063) S-L: S=L M-L: M>L (0.102)	S-M: S<M (-0.063) S-L: S=L M-L: M=L	Size*Period S*1/16th > S*1/8th (0.430/0.167) S*1/16th >M*1/8th (0.430/0.239) S*1/16th >M*1/100th (0.430/0.155) S*1/16th >L*1/100th (0.430/0.045) S*1/100th > S*1/8th (0.292/0.045) S*1/100th >L*1/100th (0.292/0.045) M*1/16th >S*1/8th (0.538/0.430) M*1/16th >S*1/100th (0.538/0.292) M*1/16th> M*1/8th (0.538/0.239) M*1/16th >M*1/100th (0.538/0.155) M*1/16th> L*1/8th (0.538/0.151) M*1/16th > L*1/100th (0.538/0.045) L*1/16th >L*1/100th (0.333/0.045)
Period: 1/8th vs. 1/16th 1/8th vs. 1/100th 1/16th vs. 1/100th	1/8th < 1/16th (0.177/0.447) 1/8th =1/100th 1/16th > 1/100th (0.447/0.177)	1/8th < 1/16th (0.177/0.447) 1/8th =1/100th 1/16th > 1/100th (0.447/0.177)	1/8th-1/16th: 1/8th <1/16th (-0.270) 1/8th-1/100th: 1/8th =1/100th 1/16th-1/100th: 1/16th>1/100th (0.227)	1/8th-1/16th: 1/8th <1/16th (-0.270) 1/8th-1/100th: 1/8th =1/100th 1/16th-1/100th: 1/16th>1/100th (0.227)	

6.4.2 ANOVA Results for Return Volatility

An analysis of variance (ANOVA) is used to evaluate whether a difference exists in daily return volatility before and after decimalization among three different tick size periods and three different firm sized groups. An ANOVA will determine whether the differences among the sample means are too large to be attributed to the chance errors of drawing the samples from the same population.

If the determination is made, then the null hypothesis is rejected and the alternate hypothesis that there is a difference in daily return volatility before and after decimalization among three different tick size periods and three different firm sized groups should be accepted.

In this study, the ANOVA test is used to measure if there are differences in return volatility between groups over five different periods, one month, two months, three months, six months, and one year, before and after stock splits. Table 11 presents ANOVA tests for return volatility for the three different tick size periods and three different firm sized groups. Specifically, in Panel A, the overall ANOVA test for null hypothesis is, Ho1: $Vo_{T1T21S} = Vo_{T1T21M} = Vo_{T1T21L} = Vo_{T1T22S} = Vo_{T1T22M} = Vo_{T1T22L} = Vo_{T1T23S} = Vo_{T1T23M} = Vo_{T1T23L}$, where Vo = the ratio of the average standard deviation of one year before announcement date and one year after split ex-date; T_1T_2 = (+6,+27) for one month, (+6,+48) for two month, (+6,+69) for three month, (+6,+132) for six month, and (+6,+258) for one year; 1= $1/8^{th}$, 2 = $1/16^{th}$, and 3 = $1/100^{th}$; S = Small cap., M = Medium cap., and L = Large cap. "***", "**", and "*" denote significance levels of 1%, 5%, and 10%, respectively for the F-test.

Table 10

Long-Term Return Volatility after Split Ex-Date for Small, Medium, and Large Firms

This table reports return volatility change after split ex-date. The cross-sectional distributions for the average daily return volatility is measured by the average standard deviation of the returns for one month, two month, three month, six month, and for one year periods after split ex-date. Split ex-dates around +1 to +5 are excluded in calculation. T-test is used to measure the significance of return volatility. "***", "**", and "*" denote significance levels of 1%, 5%, and 10% for t-test. Result format = Before/After***, where before is the n-month period before the announcement date and after is the n-month after the ex-date, with n = 1, 2, 3, 6, 12.

Months	1/8th (1991/01/01 – 1996/05/31)			1/16th (1998/06/24 – 2000/03/31)			1/100th (2002/05/01 – 2011/12/31)		
	Small cap. Obs.: 511	Mid-cap. Obs.:108	Large cap. Obs.: 24	Small cap. Obs.: 105	Mid-cap. Obs.: 73	Large cap. Obs.: 67	Small cap. Obs.: 214	Mid-cap. Obs.: 155	Large cap. Obs.: 87
Long-term Standard Deviation									
1 (+6,+27)	0.0354/0.0409***	0.0281/0.0335***	0.0268/0.0315**	0.0527/0.0556***	0.0540/0.0678***	0.0489/0.0374	0.0340/0.0333***	0.0231/0.0224***	0.0199/0.0218
2(+6,+48)	0.0348/0.0399***	0.0272/0.0344***	0.0246/0.0308***	0.0503/0.0579***	0.0540/0.0643***	0.0485/0.0340***	0.0330/0.0334*	0.0231/0.0219***	0.0191/0.0221***
3(+6,+69)	0.0350/0.0397***	0.0275/0.0349***	0.0247/0.0304***	0.0487/0.0517***	0.0548/0.0623***	0.0463/0.0408	0.0312/0.0336***	0.0225/0.0216***	0.0194/0.0221***
6(+6,+132)	0.0345/0.0391***	0.0268/0.0340***	0.0235/0.0287***	0.0464/0.0564***	0.0526/0.0601***	0.0419/0.0362**	0.0276/0.0344***	0.0221/0.0206***	0.0200/0.0227***
12(+6,+258)	0.0347/0.0388***	0.0269/0.0298***	0.0254/0.0269	0.0472/0.0574***	0.0504/0.0624***	0.0366/0.0370	0.0259/0.0284***	0.0235/0.0203***	0.0204/0.0223***

Panel A present the overall result that the return volatility of all firms during all tick periods is not significantly different except for a six month period. In the six month period, the mean of the return volatility after ex-split date of all firms during all tick periods is significantly different from that of before split announcement.

In Panel B, for long-term volatility between groups, T_1T_2 = (+6,+258), is further analyzed by size, period, and size*period. For size, the tested null hypothesis is, Ho2: $Vo_{T1T2S} = Vo_{T1T2M} = Vo_{T1T2L,}$ and for period, Ho3: $Vo_{T1T21} = Vo_{T1T22} = Vo_{T1T23}$ by employing Waller Duncan k-ratio test, Duncan's multiple range test, t tests (LSD), and Tukey's studentized range (HSD) test. For size*period combined, the tested null hypothesis is, Ho4: $Vo_{T1T21*S} = Vo_{T1T21*M} = Vo_{T1T21*L} = Vo_{T1T22*S} = Vo_{T1T22*M} = Vo_{T1T22*L} = Vo_{T1T23*S} = Vo_{T1T23*M} = Vo_{T1T23*L}$ by employing BonFerroni test. T tests (LSD), Tukey's studentized range (HSD) test, and the BonFerroni test are used with α=0.05.

Panel B presents the results for size comparisons that all tests report that the return volatility of one year after ex-split date for all sized firms is not significantly different from that of one year before split announcement. On the other hand, for period comparisons, Waller Duncan k-ratio test and Duncan's multiple range test report that the return volatility of all tick periods is not significantly different. However, t test (LSD) and Tukey's studentized range (HSD) test report that the increase in return volatility of $1/8^{th}$ tick period one year after split ex-date compared to one year before announcement is higher than $1/100^{th}$ tick period by 21.1%. These two tests also report that the return volatility change one year before the announcement and one year after split ex-date of $1/16^{th}$ tick period is not significantly different from $1/8^{th}$ and $1/100^{th}$ tick periods.

BonFerroni tests present the result of size and tick period comparisons. The result show that the return volatility of all size*period groups are not statistically significant.

Table 11

ANOVA Results for Return Volatility

ANOVA test is used to measure if there are differences in return volatility between groups by comparing five different periods, one month, two month, three month, six month, and one year, before and after stock splits. This table presents ANOVA tests for return volatility of three different tick size periods and three different firm sized groups. Specifically, in Panel A, the overall ANOVA test for null hypothesis is, Ho1: $Vo_{T1T21S} = Vo_{T1T21M} = Vo_{T1T21L} = Vo_{T1T22S} = Vo_{T1T22M} = Vo_{T1T22L} = Vo_{T1T23S} = Vo_{T1T23M} = Vo_{T1T23L}$, where Vo = the ratio of the average standard deviation of one year before announcement date and one year after split ex-date; T_1T_2 = (+6,+27) for one month, (+6,+48) for two month, (+6,+69) for three month, (+6,+132) for six month, and (+6,+258) for one year; 1= $1/8^{th}$, 2 = $1/16^{th}$, and 3 = $1/100^{th}$; S = Small cap., M = Medium cap., and L = Large cap. "***", "**", and "*" denote significance levels of 1%, 5%, and 10%, respectively for F-test. In Panel B, for long-term volatility between groups, T_1T_2 = (+6,+258) for return standard deviation of one year after stock split ex-date is further analyzed by size, period, and size*period by comparing that of one year before announcement. For the size, the tested null hypothesis is, Ho2: $Vo_{T1T2S} = Vo_{T1T2M} = Vo_{T1T2L,}$ and for period, Ho3: $Vo_{T1T21} = Vo_{T1T22} = Vo_{T1T23}$ by employing Waller Duncan k-ratio test, Duncan's multiple range test, t tests (LSD), and Tukey's studentized range (HSD) test. For size*period, the tested null hypothesis is, Ho4: $Vo_{T1T21*S} = Vo_{T1T21*M} = Vo_{T1T21*L} = Vo_{T1T22*S} = Vo_{T1T22*M} = Vo_{T1T22*L} = Vo_{T1T23*S} = Vo_{T1T23*M} = Vo_{T1T23*L}$ by employing BonFerroni test. t tests (LSD), Tukey's studentized range (HSD) test, and the BonFerroni test are used with α=0.05.

Panel A: Overall Cumulative Result in Months					
Interval	F-Ratio				
1 (+6,+27) 2 (+6,+48) 3 (+6,+69) 6 (+6,+132) 12 (+6,+258)	0.67 0.81 0.77 3.18*** 1.33				
Panel B: Return Volatility One Year after Stock Split Ex-Date					
Test	Waller Duncan K-ratio Test	Duncan's Multiple Range Test	T Tests (LSD)	Tukey's Studentized Range (HSD) Test	BonFerroni Test
Size: Small vs. Medium Small vs. Large Medium vs. Large	 S=M S=L M=L	 S=M S=L M=L	 S-M: S=M S-L: S=L M-L: M=L	 S-M: S=M S-L: S=L M-L: M=L	Size*Period No groups are statistically significant.
Period: $1/8^{th}$ vs. $1/16^{th}$ $1/8^{th}$ vs. $1/100^{th}$ $1/16^{th}$ vs. $1/100^{th}$	 $1/8^{th} = 1/16^{th}$ $1/8^{th} = 1/100^{th}$ $1/16^{th} = 1/100^{th}$	 $1/8^{th} = 1/16^{th}$ $1/8^{th} = 1/100^{th}$ $1/16^{th} = 1/100^{th}$	 $1/8^{th}$-$1/16^{th}$: $1/8^{th} = 1/16^{th}$ $1/8^{th}$-$1/100^{th}$ $1/8^{th} > 1/100^{th}$ (0.211) $1/16^{th}$-$1/100^{th}$: $1/16^{th} = 1/100^{th}$	 $1/8^{th}$-$1/16^{th}$: $1/8^{th} = 1/16^{th}$ $1/8^{th}$-$1/100^{th}$: $1/8^{th} > 1/100^{th}$ (0.211) $1/16^{th}$-$1/100^{th}$: $1/16^{th} = 1/100^{th}$	

CHAPTER 7

SUMMARY AND CONCLUSIONS

This study examines the impact of decimalization on stock splits for small, medium, and large firms by utilizing stock split announcements and split ex-dates data from three different tick size periods, $1/8^{th}$, $1/16^{th}$, and $1/100^{th}$ for 1,344 stock splits. For each tick period the sample is segmented into three different firm sized groups, small, medium, and large firms, according to market capitalization. Based on previous studies, the impact of decimalization on stock splits is examined using market reaction, the liquidity effect, and the volatility effect of stock splits before and after decimalization for small, medium, and large firms.

First, the short-term market reaction around the stock split announcement date measured by the abnormal returns of small firms is positive and significant compared to medium and large firms. The results are supportive of the signaling hypothesis that the existence of positive abnormal returns around stock split is consistent with the signaling hypothesis that stock splits convey favorable private information about the firm and market reacts to stock splits that signal about the future prospects of a firm. These results indicate that split announcements convey information to the market. Grinblatt et al. (1984) also report that smaller firms' stock split announcements contain greater information. They conclude that firms signal information about their future earnings or equity values through their split decision. The results of this study also find that market reaction to stock splits of small firms is more significant than for medium and large firms during the all tick periods. It may be the case that smaller firms' stock split announcements contain greater information as Grinblatt et al. (1984) documented.

The long-term market reaction around the stock split announcement date reveals that as the holding period lengthens, BHARs turn significantly negative. That does not support the market anomaly findings of previous studies.

We observe short-term significant positive abnormal returns around split ex-dates. Ex-date abnormal returns should be the result of liquidity or market microstructure effects since there should be no new information flow at the split ex-date. However, we do observe positive abnormal returns around the split ex-date, but they decline as the tick size declines as Chou et al. (2005) documented. This indicates that the market microstructure effect is smaller during the decimalization period. Further, since abnormal returns are larger for small firms that have greater need for liquidity, the remaining effect is likely mostly liquidity.

Kadapakkam, Krishnamurthy, and Tse (2005) also report significant positive abnormal returns and significantly relative spread increases around the ex-date during the $1/8^{th}$ tick period, but not in the decimal pricing period. However, this study can partly agree with their results because the results of this study also shows that small firms during the $1/8^{th}$ tick period show significant positive abnormal returns and BHARs, but we also observe significant positive abnormal returns and BHARs for small firms during the $1/100^{th}$ tick period around the ex-split date, although they are smaller than in the $1/8^{th}$ period.

Second, decimalization improved turnover, narrowed the bid-ask spread, and increased market maker count for small firms after splitting their stocks. On the other hand, the results of this study suggest that, for large firms, turnover decreased, bid-ask spread increased over same intervals, and market maker count decreased after splitting

their stocks during decimalization. This study results is inconsistent with previous studies on decimalization. Previous empirical studies find the smaller spreads after the stock market decimalized reduced market maker compensation and consequently reduced the incentives for brokers to promote a stock after the stock split, especially for small firms [Bessembinder (2003), Kadapakkam, Krishnamurthy, and Tse (2005), and Chou, Lee, Chen (2005)]. However, the results of this study evidenced that decimalization significantly increased trading volume for small firms as turnover increased significantly, bid-ask spread decreased significantly, and market maker count increased significantly after splitting their stocks.

Last, decimalization reduced overall return volatility of all firms. Especially, the return volatility of large firms is significantly reduced during the decimalization period. Ohlson and Penman (1985) and Dubofsky (1991) provided evidence that stock return variances increase subsequent to stock splits. The results of this study also confirm previous empirical evidence that stock return volatility increases subsequent to stock splits for all sized firms during all tick periods. These results are also consistent with previous literature arguments that shares of low priced and small sized firms are characterized by wider bid-ask spreads [Roll (1984)], and wider spreads can create more noise induced variance [Amihud and Mendelson (1987)]. Literature on volatility documents that as quote sizes reduced, decreased liquidity could also be manifest in the form of more volatile prices [Harris (1994)]. However, the results of this study do not support Harris (1994) because small firms' bid-ask spread reduced but liquidity improved while return volatility increased after splitting their stocks.

Based on these results, concerns raised in previous studies and the SEC Report seems unfounded. Decimalization significantly improved the market quality of small firms. After splitting their stocks, their turnover increased, bid-ask spread decreased, and market maker count increased while over the long-term return volatility decreased significantly as tick size reduced in the decimal period. On the other hand, the market quality of large firms decreases significantly as turnover decreases, spreads widen, and market maker count decreases after stock splits.

APPENDIX A

MARKET REACTION TO STOCK SPLIT ANNOUNCEMENT DATES

Market reaction is measured by abnormal returns and buy and hold abnormal returns (BHARs) with market adjusted returns model. This table presents the median abnormal returns of 1,344 stock split announcements for NYSE and Nasdaq from 1991 to 2011 according to the different price-quoting periods and market capitalization. Firms with less than 60 days stock returns from CRSP are removed from the analysis. The 1/8th period extends January 1, 1991 to May 31, 1996 for NYSE and Nasdaq, the 1/16th period extends for NYSE from June 24, 1998 to January 28, 2000 and for Nasdaq from October 1, 1998 to March 31, 2000, and the decimal (1/100th) period from May 1, 2002 to December 31, 2011 for NYSE and Nasdaq. Abnormal returns are individual stock raw returns less market adjusted index returns. The CRSP equal-weighted index is used as a proxy for the market index. For each day relative to the split announcement day (day 0), individual abnormal returns are ranked across the splitting securities in the sample for that day to get the median abnormal return. Rank Test is used to measure the significance of median abnormal returns and to check robustness. "***", "**", and "*" denote significance levels of 1%, 5%, and 10%, respectively for the Rank Test (Corrado, 1989).

Event Day	1/8th (1991/01/01 – 1996/05/31)			1/16th (1998/06/24 – 2000/03/31)			1/100th (2002/05/01 – 2011/12/31)		
	Small cap. Obs.: 502	Mid-cap. Obs.:107	Large cap. Obs.: 24	Small cap. Obs.: 103	Mid-cap. Obs.: 70	Large cap. Obs.: 64	Small cap. Obs.: 212	Mid-cap. Obs.: 154	Large cap. Obs.: 87
Median Abnormal Returns (%)									
-5	0.22*	0.00	0.59	0.05	0.50	1.16	0.21	0.00	0.12
-4	-0.09	-0.24	-0.21	0.48*	0.01	-0.37	0.42**	0.12	0.21
-3	0.17**	-0.06	0.50	0.10	-0.06	-0.86	-0.17	0.02	0.35
-2	0.06	0.22	-0.53	0.83*	-0.13	-0.58	0.25	0.14	-0.14
-1	0.19	-0.16	0.11	0.88**	0.79	0.75	0.18	-0.05	-0.33
0	1.20***	0.42*	1.12*	1.71***	1.45***	2.04**	1.39***	0.51***	0.70**
+1	0.55***	0.56**	-0.34	0.64	1.49***	1.89***	1.49***	0.77***	0.76***
+2	0.09	0.12	-0.47	0.34	-0.56	-0.54	0.38	0.08	0.17
+3	-0.29*	-0.08	-0.50	-0.19	0.35	0.62	0.18	0.02	-0.28
+4	0.04	-0.18	0.04	-0.13	0.06	-0.22	0.21	-0.08	-0.09
+5	-0.11	0.13	0.08	-0.68*	0.22	-0.55	-0.22	0.16	-0.24

APPENDIX B

MARKET REACTION TO STOCK SPLIT EX-DATES

Market reaction is measured by abnormal returns and buy and hold abnormal returns (BHARs) with market adjusted returns model. This table presents the median abnormal returns of 1,344 stock split ex-dates for NYSE and Nasdaq from 1991 to 2011 according to the different price-quoting periods and market capitalization. Firms with less than 60 days stock returns from CRSP are removed from the analysis. The 1/8th period extends January 1, 1991 to May 31, 1996 for NYSE and Nasdaq, the 1/16th period extends for NYSE from June 24, 1998 to January 28, 2000 and for Nasdaq from October 1, 1998 to March 31, 2000, and the decimal (1/100th) period from May 1, 2002 to December 31, 2011 for NYSE and Nasdaq. Abnormal returns are individual stock raw returns less market adjusted index returns. The CRSP equal-weighted index is used as a proxy for the market index. For each day relative to the split ex- day (day 0), individual abnormal returns are ranked across the splitting securities in the sample for that day to get the median abnormal return. Rank Test is used to measure the significance of median abnormal returns and to check robustness. "***", "**", and "*" denote significance levels of 1%, 5%, and 10%, respectively for the Rank Test (Corrado, 1989).

Event Day	1/8th (1991/01/01 – 1996/05/31)			1/16th (1998/06/24 – 2000/03/31)			1/100th (2002/05/01 – 2011/12/31)		
	Small cap. Obs.: 510	Mid-cap. Obs.:108	Large cap. Obs.: 24	Small cap. Obs.: 105	Mid-cap. Obs.: 72	Large cap. Obs.: 67	Small cap. Obs.: 213	Mid-cap. Obs.: 155	Large cap. Obs.: 87
Median Abnormal Returns (%)									
-5	-0.02	-0.20	-1.06**	-0.16	-0.87	0.93*	0.01	0.16	-0.18
-4	0.15	0.22**	0.07	0.37	-0.20	0.29	-0.19*	0.25	-0.08
-3	-0.09	-0.23	0.07	-0.14	0.00	0.72	0.28	0.00	0.11
-2	0.06	0.10	0.68**	-0.29	0.67	0.21	0.04	0.07	0.00
-1	0.20**	0.11	-0.09	0.96	0.31	-0.72	0.09	-0.10	0.25
0	1.47***	0.26	-0.45	0.26	1.14	0.14	0.25**	-0.27	0.28
+1	0.22**	-0.04	0.64*	-0.49	0.94	-0.14	-0.29	-0.10	0.02
+2	-0.02	-0.17	0.75**	-0.34	-0.20	-0.38	-0.08	-0.18**	-0.23
+3	-0.20*	-0.03	-0.94**	-0.26	-1.16***	0.45	-0.14*	-0.19*	-0.05
+4	-0.23*	-0.18	-0.77	-0.16	-0.68	0.12	-0.27	0.15	-0.12
+5	-0.16**	-0.10	0.36	-0.24	-0.42	-1.83***	-0.02	0.13	-0.09

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