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Three Essays on Quote Stuffing, Dealer Liquidity and Stub Quoting

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THREE ESSAYS ON QUOTE STUFFING, DEALER LIQUIDITY AND STUB QUOTING

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ABSTRACT

This dissertation consists of three essays on quote stuffing, dealer provided liquidity, and stub quoting. The first essay examines the impact that intense episodic spikes in quoting activity (frequently referred to as "quote stuffing") has on market conditions. We find that quote stuffing is pervasive with several hundred events occurring each trading day and that over 74% of US exchange traded securities experience at least one episode during 2010. We find that during periods of intense quoting activity stocks experience decreased liquidity, higher trading cost, and increased short term volatility.

In the second we examine the role of the NASDAQ market marker over time. Specifically, we study the liquidity providing behavior of NASDAQ market markers in the trading environment in 2010 compared to 2004. We examine the frequency with which market makers are at the inside quote, the market and stock specific factors that influence market maker participation, changes in the number of market makers over time, and the relation between market maker participation and intraday bid-ask spread patterns. We find that the role of NASDAQ market makers declines over time. In 2004, the percentage of the trading day that market makers quote at the inside bid (ask) is 60% (62%) compared to 2010 when NASDAQ dealers quote at the inside bid (ask) just 12% (11%). The number of market makers declines. We also find evidence that the influence market makers have on intraday variations in the bid-ask declines over time.

Finally in the third essay, we examine the liquidity providing behavior of NASDAQ market makers surrounding two periods of changing dealer obligation. The first period is the relaxation of Rule 4613 in November of 2007 which required NASDAQ market makers to place two-sided quotes that must be "reasonably related" to the current best bid and offer. This rule change permitted NASDAQ market makers to post quotes far away from the prevailing market (frequently referred to as a "Stub Quote"). The second is the Securities and Exchange Commission ban on stub quoting in December 2010 which requires that market makers quote within a predefined distance from market prices. We find evidence in both the 2007 and 2010 rule change periods that placing restrictions on stub quoting alters market makers liquidity providing behavior. Stub quote restrictions increase the time that market makers quote at the NBBO. We also find evidence that stub quoting restrictions increase the percent of daily volume executed by market makers. However, we find little evidence that stub quoting rules impact the participation of market makers during days with excessive volatility.

DEDICATION

To Kristin, Christian, and Benson

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ESSAY 1: QUOTE STUFFING

1.1 Introduction

Quote stuffing is a practice in which a large number of orders to buy or sell securities are placed and then canceled almost immediately. These intense episodic spikes in order submissions and cancelations have come under scrutiny from the media and regulators.[1] Market participants criticize the practice stating that it creates a false sense of the supply and demand for a stock. Sean Hendelman, chief executive officer at T3 Capital, expressed his concern stating, "People are relying on the [stock quote data] and the data is not real" (Lauricella and Stasburg, 2010, page A. 1). Others have likened the practice to an auctioneer placing "plants" and "shills" in the audience in an attempt to manipulate prices thru fake bidding (Elder, 2010). Are these concerns justified? How prevalent is quote stuffing? Does quote stuffing adversely affect market conditions, and if so, to what degree? This paper seeks to address these questions.

The practice of quote stuffing is often linked to high frequency trading (hereafter, HFT). HFT garnered increased attention in the wake of the May 6, 2010 "flash crash" when the Dow Jones Industrial Average collapsed 700 points in a few minutes. HFT is an investment strategy where investors rapidly buy and sell securities thru the use of high speed computer algorithms. Holding periods for securities bought and sold by high frequency traders are typically very short, lasting just seconds or milliseconds. Further, high frequency traders may move in and out of positions thousands of times per day. The Securities and Exchange Commission (SEC) calls high frequency trading "One of the most significant market structure developments in recent years" SEC (2010). SEC chairwoman

[1] See for example Lauricella and Strasburg (2010).

Mary Schapiro describes the regulatory scheme that applies computer based low-latency trading as "[an] area that warrants close review" (Schapiro, 2010). Today HFT makes up a significant portion of U.S. equities market volume.[2]

Despite the criticism of HFT by the popular press and market participants, early academic work finds little evidence that the practice is detrimental to financial markets. Recent studies show that, in aggregate, HFT improves traditional measures of market quality and contributes to price discovery (Hasbrouck and Saar, 2010, and Brogaard, 2010). Additionally, Menkveld (2011) examines high frequent traders' role as a modern market maker and finds it to be critical to the operation of a new market.

Many HFT strategies rely on the ability to trade fast and frequently.[3] Latency arbitrage is one such strategy in which high frequency traders attempt to profit from inefficiencies in data between exchanges or other market centers. By submitting large numbers of orders that are canceled very quickly, a high frequent trader may create exploitable latency arbitrage opportunities. Brogaard (2010) explains that latency arbitrage opportunities from quote stuffing may arise from requiring other high frequency traders to process large amounts of volume giving the high frequency trader submitting the orders an advantage. A large number of order submissions may also cause the exchange receiving the quotes to lag other exchanges, creating arbitrage opportunities.

In this study, we identify and analyze the impact intense episodic spikes in quoting activity have on market conditions, including liquidity and volatility. We find that quote stuffing is pervasive with several hundred events occurring each trading day and it impacts over 74%

[2] Brogaard(2010) estimates that HFT makes up 77% of dollar trading volume in U.S. equities.
[3] See Gomber, Arndt, Lutat, and Uhle (2011) and Brogaard (2010) for detailed descriptions of HFT strategies.

of US listed equities. Our results suggest that, in periods of intense quoting activity, stocks experience decreased liquidity, higher trading costs, and increased short term volatility. Thus, quote stuffing may exhibit some of the market degrading features criticized in the media.

The remainder of the paper is structured as follows. Section 2 summarizes related literature. Section 3 describes the data as well as the procedure we employ to identify quote stuffing events. Section 4 outlines the methodology and studies the impact of quote stuffing intervals on traditional measures of market quality. Section 5 provides discussion on the implications of the study's results and concludes.

1.2 Background

This paper is most closely related to a small but growing body of literature that addresses questions concerning high frequency and algorithmic trading (hereafter, AT)[4]. Hendershott, Jones, and Menkveld (2011) explain that declining technology costs, as well as trading becoming increasing electronic, has made it easier and cheaper for firms to implement computer programs to make trading decisions, submit orders and modify those orders after submission. Today, orders submitted via computer algorithms make up over two thirds of U.S. equities market volume.

Hendershott and Riordan (2009) use data from the 30 largest DAX stocks on the Deutche Boerse to determine the role of AT in the price discovery process. They find AT represents a large fraction of the order flow. For sample stocks, AT demand (supply) represents 52%

[4] AT is broadly defined as the use of a computer algorithm to automatically submit, cancel, and otherwise manage orders. HFT is a subset of AT.

(50%) of trading volume.[5] Algorithmic traders also contribute more to price discovery than their human counterparts. Algorithmic traders are more likely to be at the inside quote when spreads are high than when spreads are low suggesting that algorithmic traders supply liquidity when it is expensive and demand liquidity when it is cheap. The authors find no evidence that AT increases volatility. Hendershott, Jones, and Menkveld (2011) examine the impact AT has on the market quality of New York Stock Exchange (NYSE) listed stocks. Using a normalized measure of NYSE message traffic, they measure the causal effect of AT on liquidity surrounding the NYSE's implementation of automatic quote dissemination in 2003. They find that AT narrows spreads, reduces adverse selection, and increases the informativeness of quotes, especially for larger stocks. These results suggest that AT improves liquidity and market quality.

Others project the impact HFT has on financial markets. Theoretical models of HFT trading show that it is possible for HFT to enhance or degrade market quality. Cvitanic and Kirilenko (2010) develop a theoretical model that predicts the presence of high frequency traders is likely to cause a change in average transaction prices with more mass around the center and thinner tails. This price distribution arises as high frequency traders "snipe" out human orders, which are away from the inside of the book. Volume, intertrade duration, and liquidity should all increase with changes in the speed and quantity of human order submissions. As the proportion of transactions submitted by computers grows, the forcastability of transactions prices should increase.

[5] Liquidity demanding trades are trades that occur via marketable orders (i.e market orders, limit orders to buy above the current ask, or limit orders to sell below the current bid). Liquidity supplying trades are trades from non-marketable orders (i.e. limit orders to sell above the current bid or limit orders to buy below the current ask). Marketable orders take liquidity from the market whereas non-marketable orders add liquidity.

Cartea and Penalva (2011) examine the impact of HFT on financial markets using a model with three types of traders: liquidity traders, market makers, and high frequency traders. According to their model, high frequency traders increase the price impact of liquidity trades, increasing (decreasing) the price at which liquidity traders buy (sell). These costs increase with the size of the trade, suggesting that large liquidity traders (i.e. large institutional traders making sizable changes to their portfolio) will be most affected by HFT. Market makers are compensated for losses in revenues to high frequency traders by a higher liquidity discount. Thus, HFT does not affect the number of market makers. The authors also propose that HFT increases price volatility and doubles volume.

Most empirical studies on HFT find it to have a moderate to significantly positive impact on traditional market quality measures. Brogaard (2010) examines the impact of HFT on the US equities market using a unique HFT dataset for 120 stocks listed on NASDAQ. Brogaard finds that HFT improves market conditions. HFT adds to the price discovery process, provides the best bid and offer quotes for a significant portion of the trading day, and reduces volatility. However the extent to which HFT improves liquidity is mixed as the depth high frequency traders provide to the order book is one-fourth of that provided by non-high frequency traders. Broggard's analysis also suggests that HFT is a profitable venture generating trading profits of $2.8 billion annually. Hasbrouck and Sarr (2010) use NASDAQ order level data to examine the impact that low latency traders have on market characteristics including volatility, total price impact, and book depth. They measure HFT activity by identifying "strategic runs" of submission, cancellation, and executions. The authors find that HFT improves market quality thru decreasing short term volatility, spreads, and depth of the order book.

Contrary to the aforementioned empirical studies, Zhang (2010) finds that HFT may increase stock price volatility and impede the market's ability to incorporate firm fundamentals into asset prices. Zhang uses CRSP and Thomason Reuters Institutional Holdings databases to estimate HFT dollar volume. He finds a positive correlation between HFT and quarterly volatility and this relation is strongest for larger stocks. Zhang also finds that firms with more HFT tend to overreact to firm fundamental news such as earnings surprises.

Other studies examine the role of high frequency traders in the May 6, 2010 flash crash. Kirilenko, Kyle, Samadi, and Tuzun (2010) examine the behavior of high frequency traders in E-mini S&P 500 futures contracts during the events surrounding the flash crash. HFT patterns surrounding the flash crash are inconsistent with traditional market making. They conclude that, while high frequency traders did not cause the flash crash, their response to the high selling pressure exacerbated volatility. Madhavan (2012) analyzes the relation between market structure and the flash crash. He finds that firms with higher fragmentation prior to the flash crash were disproportionately susceptible to rapid price movements on the day of the crash and provides a framework with which to evaluate new market structure reforms.

HFT is also described as modern market making. Menkveld (2011) examines HFT and its role as a modern market maker. Menkveld documents how one large high frequency trader that acts as a market maker is critical to the operation of a new market, Chi-X. He provides detailed analysis on the trading behavior of the high frequency trader. The high frequency trader provides liquidity and its entrance corresponds with a decrease in spreads.

Our study adds to the literature by exploring quote stuffing, a strategy in which a large number of orders to buy or sell securities are placed and then canceled almost immediately. Market participants criticize this practice stating that it creates a false sense of the true supply and demand for a stock and may adversely impact market quality. Also, unlike previous empirical studies of HFT in U.S. equities markets, which use data from a single market center, we examine HFT behavior across all U.S. exchanges. Considering the fragmentation of order flow in U.S. markets, we believe that using data from all US exchanges will glean a more complete picture of the impact of quote stuffing on overall market conditions.

1.3 Data and Identification of Quote Stuffing

1.3.1 Data

The primary data source for this paper is the NYSE Trade and Quote (TAQ) data. Our sample includes all trades and quotes for NYSE and NASDAQ listed stocks for all trading days in 2010. We apply conventional filters to TAQ, excluding trades and quotes that are coded as having an error or a correction, or are reported out of time sequence. In addition, we omit a quote if the bid is greater than the ask, or the bid and/or ask price is less than zero. Securities with an average trade price less than $3 are also eliminated.

We use TAQ data to both identify quote stuffing episodes and calculate measures of market quality. Our analysis is restricted to normal trading hours (9:30am to 4:00 pm). When merging trades and quotes we follow Bessembinder (2003) and do not lag quote time

stamps. CRSP data is used to compute daily trading statistics and to determine listing exchange.

1.3.2 Use of TAQ Data to Identify Quote Stuffing

It is not typically possible to identify orders that are generated by computer algorithms in U.S. equity markets. As a result, previous studies use proxies to measure the level of AT and HFT.[6] These proxies are typically derived using system order data, which identify electronic messages including order submissions, cancelations, and executions handled by an individual exchange. For example, Hendershott, Jones, and Menkveld (2011) use the number of electronic messages handled by NYSE's SuperDOT system and captured in the NYSE's System Order Data (SOD) database as a proxy measure of AT. Hasbrouck and Saar (2010) compute their proxy for low-latency trading using NASDAQ TotalView-ITCH, which includes submission, cancelations, and trade executions for orders received by NASDAQ. Using this data the authors develop a proxy for HFT by identifying "strategic runs," which the authors define as "linked submissions that are likely to be parts of a dynamic strategy" (Page 19).

Unlike the proxies developed by the aforementioned studies, we use TAQ data to identify heightened periods of low latency activity. In contrast to system order data, TAQ data does not include information on individual order submissions and cancelations, but contains consolidated quotes from all exchanges in the national market system. Despite

[6] A notable exception is Borgaard (2010), who uses a proprietary date set to identify high frequency traders' orders on NASDAQ.

not containing information on individual orders, submissions and cancelations of marketable orders are reflected in consolidated quote updates of TAQ. Thus, frequent quote updates in TAQ are likely to be highly correlated proxies of HFT based on system order data[7].

An attractive feature of TAQ, as opposed to order data, for our study is that it includes quote updates for all exchanges that trade U.S. equities. Unlike the U.S. equity market of just over a decade ago where a few venues commanded an overwhelming share of market activity, today's market is fragmented with order flow going to an increasing number of trading venues. Egginton, Van Ness, and Van Ness (2012) note that, in 2000, the NYSE garnered over 80% of trading volume for NYSE listed securities. NYSE market share has decreased dramatically to a 2010 level of approximately 30%. Egginton, Van Ness, and Van Ness (2012) observe a similar pattern for NASDAQ listed securities. Virtually all trades for NASDAQ listed securities execute on NASDAQ in 2001, by 2010 the share of trading volume had declined to 40%. Quote stuffing is likely to involve order submission strategies that span multiple trading venues possibly in an attempt to exploit inefficiencies that may arise in prices across exchanges. Thus examining HFT behavior across market centers should provide a more complete picture of the impact of quote stuffing on overall market conditions.

1.3.3 Identification of Quote Stuffing

[7] We spot check several instances where Hasbrouck and Saar (2010) identify an elevated number of "strategic runs", all instances are marked with an increase in quoting activity reported in TAQ.

We examine quote stuffing events by identifying intense episodic spikes in quoting activity. To identify spikes we first divide the trading day (9:30-4:00) into 390 one-minute segments. Next, we calculate the intraday variation in quoting activity by computing the average standard deviation of one-minute segments for rolling twenty-day windows. We identify intense quoting episodes as segments in which the level of quoting activity exceeds the previous twenty-day mean number of quotes-per-minute by at least 20 standard deviations. We also require the average number of quotes for the entire trading day not exceed its previous twenty-day rolling average by more than two standard deviations. The latter requirement is implemented to exclude trading days with an unusually high level of quoting activity.

We group multiple one-minute segments into a single quote stuffing event when the duration between high quoting episodes is less than or equal to 10 minutes. Grouping of one-minute segments yields a total of 58,737 unique quote stuffing events with durations ranging from one to ten minutes.[8] As our goal is to identify information-free intense episodes of quoting activity, we attempt to eliminate conflicting events by using CRSP and Compustat to identify corporate announcements. We exclude any quote stuffing event that occurs within a [-3; +3] window surrounding an earnings or dividend announcement as identified in Compustat and CRSP.

Finally, we eliminate events if there is an influx in trading in the ten minutes prior to the spike in quoting activity. This later restriction is implemented to eliminate large episodes of quote updating driven by increased trading. Additionally, increases in liquidity

[8] Events with duration longer than 10 minutes are excluded from the sample.

demanding trades may inflate market quality measures. Filtering events with increased trading in the minutes prior to the influx in quoting activity yields a final sample size of 25,418 events.

Panel A of Table 1 reports summary statistics for sample firms that undergo at least one quote stuffing event during the year. Mean daily volume of shares traded ranges from 240 to 562 million, with a mean of 141,000 thousand shares. Sample firm size also spans a large range from $530,000 to $237 billion. Median closing price and daily returns are $14.28 and 0.08% respectively. Daily statistics are computed as the average over the entire trading year.

[Insert Table 1 Here]

Panel C of table 1 lists the number of events by duration. The majority (72%) of events lasts less than one minute with over 94% lasting less than six minutes. The magnitude of events ranges from 20 to 925 standard deviations above its previous 20 day average, 36% of the events fall between 20 and 30 standard deviations and an additional 42% of events occur between 30 and 40 standard deviations (see Table 1 Panel B).

Figure one displays standardized quotes and trades in the window [-10, +10] surrounding the quote stuffing events. As expected quoting activity peaks at time 0 at a level of over 4 times the pre and post 10 minute averages. Trading activity peaks at time +1 and remains elevated through minute +10.

[Insert Figure 1 Here]

Several summary statistics not tabulated in table 1 are noteworthy. First, large spikes in quoting activity occur relatively frequently with an average of roughly 125 such events occurring each day. These large spikes in activity also impact a large number of firms; 5292 or roughly 74.7% of all US listed equities experience at least one event during the 2010 trading year.

1.4 Impact of Quote Stuffing on Market Quality

1.4.1 Measures of Market Quality

We employ an event study methodology to gauge the impact quote stuffing has on market conditions. We use TAQ data to compute several measures of market quality. For each minute in the ten-minute window immediately prior to and after the quote stuffing event. Our measures of market quality include two measures of short-term volatility and three measures of liquidity. *Voltil* is the one-minute standard deviation of trade prices. As an alternative measure of short term volatility we calculate *HighLow,* which is the highest quoted midpoint in the one-minute interval minus the lowest quoted midpoint in the interval (this measure is similar to the *HighLow* measure of Hasbrouck and Saar, 2010). To measure liquidity we use Quoted, Percent-Quoted, and Effective Spreads (*QSprd, Pqsprd,* and *Effsprd*). *Qsprd* is the average spread (ask price minus bid price) of the one minute

interval. *Pqsprd* is the spread scaled by the midpoint, $\left[\frac{(ask-bid)}{\left(\frac{ask+bid}{2}\right)}\right]$, then averaged over the one-minute interval. *Effsprd* is a measure of the price impact of a trade and is computed as the average effective half spread (absolute value of the trade price minus the prevailing midpoint) of all trades during the one-minute interval.

Figure 2 and 3 graphically depict while table 2 reports mean market quality statistics for the quote stuffing interval (time 0), the ten minutes prior (time -10 thru -1), and the ten minutes immediately following (+1 thru +10) the events. All three measures of liquidity (*Qsprd ,Pqsprd,* and *Effsprd)* remain relativity constant in the minutes prior to the influx of quoting activity then abruptly increase during the event window. In the minutes following the event both *Qsprd and Pqsprd* decline gradually until reaching their pre-event average in minute 4. In the pre-event window *Effsprd* follows a similar patten to *Qsprd and Pqsprd* remaining relatively constant before increasing sharply to a level of $0.04. In the minutes following the event period *Effsprd* declines but unlike *Qsprd and Pqsprd,* it remains elevated, not dropping below $0.026 in minutes +1 thru +10.

Measures of market quality also follow the pattern of the liquidity measures increasing sharply during the event period. *Voltil* begins increasing in minute -2 and declines to its pre event window average by minute +5. *Highlow* rises from a minute -10 level of $0.025 to an event period level of $0.061 and subsequently declines to a minute +10 level of $0.026.

[Insert Table 2 Here]

[Insert Figure 2 Here]

[Insert Figure 3 Here]

The identified intense episodes of quoting activity are associated with decreased liquidity, higher trading costs, and increased short-term volatility.

1.4.2 Regression Results

To further explore the impact of quote stuffing on market quality we run a series of panel regressions, which control for other factors that may impact market quality. Each regression uses data from the event period as well as the ten one-minute periods immediately preceding (pre periods) and following (post periods) the event. We estimate the following equation to test for a relation between quote stuffing and effective spread:

$$Effsprd_{i,t} = \beta_0 + \beta_1 Post + \beta_2 During + \beta_3 Midpvolit_{i,t} + \beta_4 Nts_{i,t} + \epsilon_{i,t}. \qquad (1)$$

Where $Effsprd_{i,t}$ is the average effective half spread for stock *i* in minute *t*; $During$ is a dummy variable equal to 1 for event segments and 0 otherwise; $POST$ is also a dummy variable equal to 1 for the period following the event; $Midpvolit_{i,t}$ is the standard deviation of the midpoint for stock *i* in minute *t*; $Nts_{i,t}$ is a measure of activity and is computed as the number of trades that execute in minute *t* for stock *i.* For this model as well as all subsequent regressions, we include event window fixed effects, which uniquely identify each event window.

We estimate similar models to examine the impact quote stuffing has on quoted and percent quoted spreads:

$$Qsprd_{i,t} = \beta_0 + \beta_1 Post + \beta_2 During + \beta_3 Midpvolit_{i,t} + \beta_4 Nts_{i,t} + \epsilon_{i,t}, \qquad (2)$$

$$Pqsprd_{i,t} = \beta_0 + \beta_1 Post + \beta_2 During + \beta_3 Midpvolit_{i,t} + \beta_4 Nts_{i,t} + \epsilon_{i,t}. \qquad (3)$$

Where $Qsprd_{i,t}$ and $Pqsprd_{i,t}$ are the average quoted and percent quoted spreads for stock *i* in minute *t*; and all other variables are as previously described.

We also estimate a similar model for one minute $Volitil_{i,t}$ (see Equation (4)).

$$Volitil_{i,t} = \beta_0 + \beta_1 Post + \beta_2 During + \epsilon_{i,t}, \qquad (4)$$

Table 3 presents the estimated coefficients for market quality regressions. The positive sign of the $Midpvolit$ coefficient is expected. This positive sign is consent with previous work on the determinants of spreads. The coefficient on Nts has the expected sign for regressions with Qsprd and Pqsprd as the dependent variable.

The coefficient of primary interest is β_2, which measures the impact that identified quote stuffing events have on market quality. The coefficient of *DURING* is positive significant for all regression specifications. This positive coefficient suggests that intervals

experiencing a large influx of quoting activity are associated with higher posted and effective spreads and increased short-term volatility.

The coefficient on the $Post$ dummy variable is positive in the *Effsprd, Qsprd,* and *Volitil* regressions. However it is nearly an order of magnitude smaller than the coefficient on during in all three regressions. Our regression suggests that, in the post-event window, both spreads and short-term volatility remain slightly elevated compared to their pre-event level.

[Insert Table 3 Here]

Given that our quote stuffing episodes are of varying durations, it is feasible that the impact of quote stuffing on market quality depends on the duration of the quote stuffing event. Therefore, we estimate panel regressions separately for events of varying durations. Table 4 reports regression results for subsamples consisting of four subdivided event period duration lengths. (0,1] refers to event periods that last one minute or less, (1,4] includes event periods with a duration longer than one minute and up to 4 minutes, (4,7] and (7,10] are similarly defined. The coefficient on $During$ remains significantly positive for all duration lengths for all measures of market quality. There is a notable pattern when examining quote stuffing across duration lengths. For *Effsprd,* the coefficient on $During$ declines from a level of .004 for events with one minute duration to .002 for the (4-7] events. The coefficient on $During$ in the $Volitil$ regression also displays this declining

pattern. The overall conclusions reached from the analysis reported in Table 3 are unaltered.

[Insert Table 4 Here]

For the $Qsprd$ regression $During$ follows a slightly altered pattern as event period duration increases. It increases from a level of .009 for (0,1] to .01 for (1,4] before declining to .004 for events lasting between seven and ten minutes. The coefficient of $During$ implies that periods of quote stuffing experience an average spreads of .4¢ to 1¢ higher during than pre-event levels.

Hence, quote stuffing may impact the market quality of large market capitalization stocks differently than small capitalization stocks. We report market quality regression estimates for four quartiles of firm size in table 5. Size quartiles are based on firms' average market capitalizations computed over the 2010 trading year. Q1 represents the smallest market capitalization quartile. Consistent with our previous analysis, the coefficient on *During* is positive for all size quartiles and measures of market quality. However the coefficient on *During* is smaller for larger firms suggesting that the impact of quote stuffing on the market quality of smaller firms is less pronounced than for large stocks. *Effsprd* remains somewhat elevated in the period following the heightened quoting activity across size quartiles although this result is more pronounced for smaller firms.

[Insert Table 5 Here]

To test if quotes stuffing impacts the market quality of NYSE/ARCA and NASDAQ listed stocks differently we run our analysis separately for samples for stocks listing on the NYSE/ARCA and NASDAQ exchanges and report results in table 6. Consistent with our previous analysis, the coefficient on *During* is positive for both NYSE/ARCA and NASDAQ listed stocks for all measures of market quality.

[Insert Table 6 Here]

Overall, our results imply that quote stuffing can adversely impact traditional measures of market quality regardless of the duration of event or the market capitalization of the firm. Our results confirm that in periods of intense quoting activity stocks experience decreased liquidity, higher trading costs, and increased short-term volatility.

1.5. Conclusion

In this study we analyze the impact intense episodic spikes in quoting activity has on market conditions including liquidity and volatility. We find that quote stuffing is pervasive with several hundred events occurring each trading day and that quote stuffing impacts over 74.7% of US listed equities during our sample period. Our results show that, in periods of intense quoting activity, stocks experience decreased liquidity, higher trading

costs, and increased short-term volatility. Our results suggest that the HFT strategy of quote stuffing may exhibit some features that are criticized in the media.

Table 1: Summary Statistics

This table presents summary statistics for sample firms and events. The sample period is from January 2010 to December 2010 and includes all stocks that experience at least one period of intense quoting activity ("quote stuffing" event) during that time frame. In Panel A MktCap is the average market capitalization for sample firms(in $ millions), *Daily Volume* is the average daily volume(in thousands), *Return* is the average daily close-to-close return, and *Closing Price* is the average closing price. All statistics in panel A are computed as daily averages for the 2010 trading year and are computed using CRSP data. All averages are computed on an individual stock basis and then averaged across stocks. Panel B presents information on the distribution of the magnitude of events. Events are defined as episodic spikes in quoting activity in which the level of quoting activity exceeds the previous twenty-day mean number of quotes-per-minute by at least 20 standard deviations. The number of events that are between 20-30, 30-50, 50-100, 100-250, and >250 standard deviations of their previous twenty day mean number of quotes-per-minute are reported. Panel C lists the number of events by duration and their cumulative distribution.

Panel A: Firm Characteristics

	Mean	Median	Std	Min	Max
MktCap($Million)	1973	260	8,934	0.53	237,123
Daily Volume(1000s)	1006	141	8,159	0.24	562,836
Return(%)	0.10	0.08	0.26	-10.04	5.16
Closing Price ($)	21.88	14.28	33.10	0.03	1567.75

Panel B: Quote Stuffing Events

#Of Standard Deviations above Mean	Number of Events	Cumulative Percent
20-29	9,199	36.2%
30-49	10,754	78.5%
50-99	4,246	95.2%
100-249	1,115	99.6%
>250	104	100.0%

Panel C: Quote Stuffing Events Duration

Number of Events	Length in Minutes	Cumulative Percent
18349	< 1	72.2%
3158	1-2	84.6%
1213	3-4	89.4%
730	4-5	92.3%
520	5-6	94.3%
450	6-7	96.1%
307	7-8	97.3%
269	8-9	98.3%
228	9-10	99.2%
194	10-11	100%

Table 2: Market Quality Stats by period

This table reports mean market quality statistics for the quote stuffing interval (time 0) and the ten minutes prior (time -10 thru -1) and the ten minutes immediately following (+1 thru +10) the event. *Voltil* is the one-minute standard deviation of trade prices, *HighLow* is the highest quoted midpoint in the one-minute interval minus the lowest quoted midpoint in the interval, *Qsprd* is the average spread (ask price minus bid price) of the one minute interval, *Pqsprd* is the spread scaled by the midpoint $\left[\frac{(ask-bid)}{\left(\frac{ask+bid}{2}\right)}\right]$ and then averaged over the one-minute interval, *Effsprd* measures the price impact of a trade and is computed as the average effective half spread (absolute value of the trade price minus the prevailing midpoint) of all trades during the one-minute interval.

	Qsprd	*Pqsprd*	*Effsprd*	*Voltil*	*HighLow*
-10	0.082	0.006	0.019	0.012	0.025
-9	0.080	0.006	0.020	0.011	0.025
-8	0.080	0.006	0.020	0.011	0.025
-7	0.081	0.006	0.021	0.012	0.026
-6	0.082	0.006	0.021	0.012	0.026
-5	0.081	0.006	0.021	0.012	0.026
-4	0.082	0.006	0.022	0.014	0.027
-3	0.084	0.006	0.023	0.012	0.029
-2	0.086	0.006	0.024	0.013	0.030
-1	0.094	0.007	0.027	0.015	0.040
0	0.116	0.009	0.039	0.021	0.061
+1	0.103	0.008	0.033	0.015	0.039
+2	0.092	0.007	0.029	0.016	0.032
+3	0.087	0.007	0.028	0.016	0.030
+4	0.086	0.006	0.029	0.016	0.030
+5	0.084	0.006	0.027	0.013	0.028
+6	0.082	0.006	0.027	0.015	0.027
+7	0.081	0.006	0.027	0.015	0.027
+8	0.079	0.006	0.026	0.012	0.026
+9	0.079	0.006	0.027	0.013	0.026
+10	0.080	0.006	0.026	0.013	0.026

Table 3: Regression Results

This table reports the results of regression analyses in which we examine what impact quote stuffing has on market quality. We use TAQ data to compute several measures of market quality: *Voltil* is the one-minute standard deviation of trade prices, *HighLow* is the highest quoted midpoint in the one-minute interval minus the lowest quoted midpoint in the interval, *Qsprd* is the average spread (ask price minus bid price) of the one minute interval, *Pqsprd* is the spread scaled by the midpoint $\left[\frac{(ask-bid)}{\left(\frac{ask+bid}{2}\right)}\right]$ and then averaged over the one-minute interval, *Effsprd* measures the price impact of a trade and is computed as the average effective half spread (absolute value of the trade price minus the prevailing midpoint) of all trades during the one-minute interval. The following model is then estimated:

$$MktQuality_{i,t} = \beta_0 + \beta_1 Post + \beta_2 During + \beta_3 Midpvolit_{i,t} + \beta_4 Nts_{i,t} + \epsilon_{i,t}$$

During is a dummy variable equal to 1 for event segments and 0 otherwise; *Post* is a dummy variable equal to 1 for the period following the event, *Midpvolit,* is the standard deviation of the midpoint, $NTS_{i,t}$ is the number of trades executed in each minute. We include event window fixed effects in each regression which uniquely identifies each event window. T-Stats are reported in parenthesis and are based on cluster corrected robust standard errors.

	Effsprd	*Qsprd*	*Pqsprd*	*Voltil*
Post	0.00100***	-0.00133***	-0.00012***	0.00231***
	(5.048)	(-2.780)	(-2.992)	(3.462)
During	0.00326***	0.00908***	0.00062***	0.00535***
	(10.108)	(13.500)	(11.367)	(4.966)
Nts	0.03095	0.25797**	0.01178**	
	(1.463)	(2.277)	(2.305)	
Midpvolit	0.00002***	-0.00002***	-0.00000***	
	(3.105)	(-2.938)	(-2.959)	
Constant	0.01556***	0.08104***	0.00606***	0.01261***
	(64.459)	(85.904)	(131.768)	(37.243)
Observations	260,798	475,674	475,674	222,128
R-squared	0.69	0.89	0.89	0.28
F test	30.28	92.51	70.75	16.75

*,**,*** Statistically significant at the 10%, 5%, and 1% level respectively

Table 4: Regressions by Length of Quote Stuffing Event

This table reports the results of regression analysis separately for events that last different durations. (0,1] refers to event periods that last one minute or less, (1,4] includes event periods with a duration longer than one minute and up to 4 minutes, (4,7] and (7,10] are similarly defined. We use TAQ data to compute several measures of market quality: *Voltil* is the one-minute standard deviation of trade prices, *HighLow* is the highest quoted midpoint in the one-minute interval minus the lowest quoted midpoint in the interval, *Qsprd* is the average spread (ask price minus bid price) of the one minute interval, *Pqsprd* is the spread scaled by the midpoint $\left[\frac{(ask-bid)}{\left(\frac{ask+bid}{2}\right)}\right]$ and then averaged over the one-minute interval, *Effsprd* measures the price impact of a trade and is computed as the average effective half spread (absolute value of the trade price minus the prevailing midpoint) of all trades during the one-minute interval. The following model is then estimated:

$$MktQuality_{i,t} = \beta_0 + \beta_1 Post + \beta_2 During + \beta_3 Midpvolit_{i,t} + \beta_4 Nts_{i,t} + \epsilon_{i,t}$$

During is a dummy variable equal to 1 for event segments and 0 otherwise; *Post* is a dummy variable equal to 1 for the period following the event, *Midpvolit,* is the standard deviation of the midpoint, $NTS_{i,t}$ is the number of trades executed in each minute. We include event window fixed effects in each regression which uniquely identifies each event window. T-Stats are reported in parenthesis and are based on cluster corrected robust standard errors.

Panel A: Market Quality *Effsprd*

	Duration			
	(0,1]	(1-4]	(4-7]	(7-10]
Post	0.00112***	0.00072	-0.00004	-0.00014
	(5.146)	(1.399)	(-0.044)	(-0.078)
During	0.00360***	0.00295***	0.00175**	0.00318*
	(8.809)	(4.299)	(2.238)	(1.886)
Midpvolit	0.02145	0.11927	0.09884	0.40232
	(1.298)	(1.187)	(0.722)	(1.191)
Nts	0.00002**	0.00001**	0.00001	0.00002
	(2.476)	(1.988)	(0.786)	(0.420)
Constant	0.01467***	0.01703***	0.01820***	0.01705***
	(66.474)	(16.910)	(14.382)	(5.388)
Observations	192,597	49,749	11,313	7,139
R-squared	0.68	0.72	0.65	0.68
F test	23.37	14.73	2.288	1.772

Cont.

Panel B: Market Quality *Qsprd*

	Duration			
	(0,1]	(1-4]	(4-7]	(7-10]
Post	-0.00025	-0.00273**	-0.0083***	-0.00914***
	(-0.465)	(-2.232)	(-3.669)	(-2.969)
During	0.00859***	0.00973***	0.00316	0.00439*
	(11.819)	(7.136)	(1.556)	(1.690)
Midpvolit	0.16732**	0.95720***	1.05939***	1.27127***
	(2.047)	(6.522)	(5.673)	(5.013)
Nts	-0.0000***	-0.0001***	-0.0000***	-0.00011***
	(-2.613)	(-5.309)	(-3.134)	(-2.975)
Constant	0.07549***	0.08601***	0.09713***	0.10032***
	(104.723)	(64.452)	(47.855)	(35.235)
Observations	330,235	99,762	28,399	17,278
R-squared	0.89	0.88	0.89	0.90
F test	60.41	44.69	13.77	14.53

Panel C: Market Quality *Volatil*

	Duration			
	(0,1]	(1-4]	(4-7]	(7-10]
Post	0.00204***	0.00510**	0.00041	-0.00868
	(2.949)	(2.412)	(0.548)	(-1.143)
During	0.00534***	0.00426***	0.00198*	0.01059
	(6.160)	(3.846)	(1.834)	(1.014)
Constant	0.01208***	0.01289***	0.01370***	0.02489***
	(33.754)	(12.121)	(28.699)	(8.476)
Observations	166,909	40,584	8,902	5,733
R-squared	0.22	0.36	0.55	0.19
F test	19.26	7.398	1.737	0.772

*,**,*** Statistically significant at the 10%, 5%, and 1% level respectively
T-Stats in Parentheses

Table 5: Regressions by firm size

This table reports the results of regression analyses preformed separately for each firm-size quartile. Where Q1 (Q4) is comprised of the smallest (largest) firms as measured by market capitalization. We use TAQ data to compute several measures of market quality: *Voltil* is the one-minute standard deviation of trade prices, *HighLow* is the highest quoted midpoint in the one-minute interval minus the lowest quoted midpoint in the interval, *Qsprd* is the average spread (ask price minus bid price) of the one minute interval, *Pqsprd* is the spread scaled by the midpoint $\left[\frac{(ask-bid)}{\left(\frac{ask+bid}{2}\right)}\right]$ and then averaged over the one-minute interval, *Effsprd* measures the price impact of a trade and is computed as the average effective half spread (absolute value of the trade price minus the prevailing midpoint) of all trades during the one-minute interval. The following model is then estimated:

$$MktQuality_{i,t} = \beta_0 + \beta_1 Post + \beta_2 During + \beta_3 Midpvolit_{i,t} + \beta_4 Nts_{i,t} + \epsilon_{i,t}$$

During is a dummy variable equal to 1 for event segments and 0 otherwise; *Post* is a dummy variable equal to 1 for the period following the event, *Midpvolit,* is the standard deviation of the midpoint, $NTS_{i,t}$ is the number of trades executed in each minute. We include event window fixed effects in each regression which uniquely identifies each event window. T-Stats are reported in parenthesis and are based on cluster corrected robust standard errors.

Panel A: Market Quality *Effsprd*

	Size			
	Q1	Q2	Q3	Q4
Post	0.00455***	0.00127**	0.00051	0.00053**
	(3.355)	(2.393)	(1.525)	(2.342)
During	0.00949***	0.00392***	0.00280***	0.00194***
	(4.569)	(7.667)	(6.468)	(3.487)
Midpvolit	0.00979	0.05229	0.39541***	-0.03801
	(0.705)	(1.111)	(3.929)	(-0.625)
Nts	0.00008*	0.00005***	-0.00000	0.00002***
	(1.726)	(2.777)	(-0.275)	(2.700)
Constant	0.04128***	0.01662***	0.00950***	0.01206***
	(46.654)	(36.192)	(12.476)	(20.661)
R-squared	0.74	0.65	0.53	0.71
F test	7.624	17.99	18.82	6.868

Cont.

Panel B: Market Quality *Qsprd*

	Size			
	Q1	Q2	Q3	Q4
Post	-0.00375**	0.00059	-0.0014***	-0.00177***
	(-2.471)	(0.581)	(-3.403)	(-2.810)
During	0.00714***	0.01737***	0.00723***	0.00581***
	(4.179)	(12.707)	(10.788)	(5.070)
Midpvolit	0.09553*	0.54967	1.23208***	0.68662***
	(1.709)	(1.588)	(10.295)	(4.061)
Nts	-0.00013***	-0.00009	-0.0001***	-0.00003***
	(-2.754)	(-1.450)	(-4.634)	(-3.640)
Constant	0.16109***	0.08043***	0.03942***	0.03571***
	(163.521)	(35.009)	(47.109)	(23.789)
R-squared	0.87	0.88	0.89	0.90
F test	18.88	78.53	58.46	10.35

Panel C: Market Quality *Volatil*

	Size			
	Q1	Q2	Q3	Q4
Post	0.01323	0.00258	0.00225**	0.00109***
	(1.383)	(1.141)	(2.322)	(2.929)
During	0.01388***	0.00952*	0.00303***	0.00425***
	(3.093)	(1.736)	(5.689)	(3.844)
Constant	0.01668***	0.01218***	0.01031***	0.01324***
	(3.299)	(10.373)	(21.019)	(60.779)
R-squared	0.13	0.33	0.31	0.48
F test	6.178	2.388	17.16	8.637

*,**,*** Statistically significant at the 10%, 5%, and 1% level respectively
T-Stats in Parentheses

Table 6: Regressions by listing exchange

This table reports the results of regression analysis separately stock are listed on NYSE/ARCA and Nasdaq stock exchanges. We use TAQ data to compute several measures of market quality: *Voltil* is the one-minute standard deviation of trade prices, *HighLow* is the highest quoted midpoint in the one-minute interval minus the lowest quoted midpoint in the interval, *Qsprd* is the average spread (ask price minus bid price) of the one minute interval, *Pqsprd* is the spread scaled by the midpoint $\left[\frac{(ask-bid)}{\left(\frac{ask+bid}{2}\right)}\right]$ and then averaged over the one-minute interval, *Effsprd* measures the price impact of a trade and is computed as the average effective half spread (absolute value of the trade price minus the prevailing midpoint) of all trades during the one-minute interval. The following model is then estimated:

$MktQuality_{i,t} = \beta_0 + \beta_1 Post + \beta_2 During + \beta_3 Midpvolit_{i,t} + \beta_4 Nts_{i,t} + \epsilon_{i,t}$

During is a dummy variable equal to 1 for event segments and 0 otherwise; *Post* is a dummy variable equal to 1 for the period following the event, *Midpvolit,* is the standard deviation of the midpoint, $NTS_{i,t}$ is the number of trades executed in each minute. We include event window fixed effects in each regression which uniquely identifies each event window. T-Stats are reported in parenthesis and are based on cluster corrected robust standard errors.

Panel A:NYSE/ARCA

	Effsprd	*Qsprd*	*Pqsprd*	*Voltil*
Post	0.00102***	-0.00203***	-0.00009***	0.00295***
	(4.129)	(-4.394)	(-4.733)	(3.110)
During	0.00280***	0.00527***	0.00021***	0.00424***
	(7.765)	(8.282)	(7.949)	(2.920)
Midpvolit	0.07631	0.43252**	0.01028**	
	(1.350)	(2.202)	(2.219)	
Nts	0.00001	-0.00003**	-0.00000**	
	(1.518)	(-2.361)	(-2.491)	
Constant	0.01161***	0.04958***	0.00212***	0.01180***
	(24.350)	(38.209)	(66.152)	(24.974)
Observations	172,502	283,693	283,693	150,192
R-squared	0.57	0.88	0.81	0.26
F test	19.24	38.74	46.50	8.569

Cont.

Panel B:Nasdaq

	Effsprd	*Qsprd*	*Pqsprd*	*Voltil*
Post	0.00095***	0.00192*	0.00002	0.00066***
	(2.944)	(1.866)	(0.155)	(2.591)
During	0.00416***	0.01778***	0.00149***	0.00502***
	(6.024)	(12.154)	(10.581)	(8.446)
Midpvolit	0.04751	0.44917***	0.01983**	
	(1.328)	(3.243)	(2.262)	
Nts	0.00002**	-0.00003***	-0.00000***	
	(2.397)	(-3.043)	(-2.697)	
Constant	0.02174***	0.12434***	0.01203***	0.01391***
	(43.586)	(81.276)	(114.605)	(94.841)
Observations	78,122	166,799	166,799	64,315
R-squared	0.76	0.89	0.89	0.64
F test	11.94	71.05	51.18	35.67

*,**,*** Statistically significant at the 10%, 5%, and 1% level respectively
T-Stats in Parentheses

Figure 1
Standarized Quotes and Trades

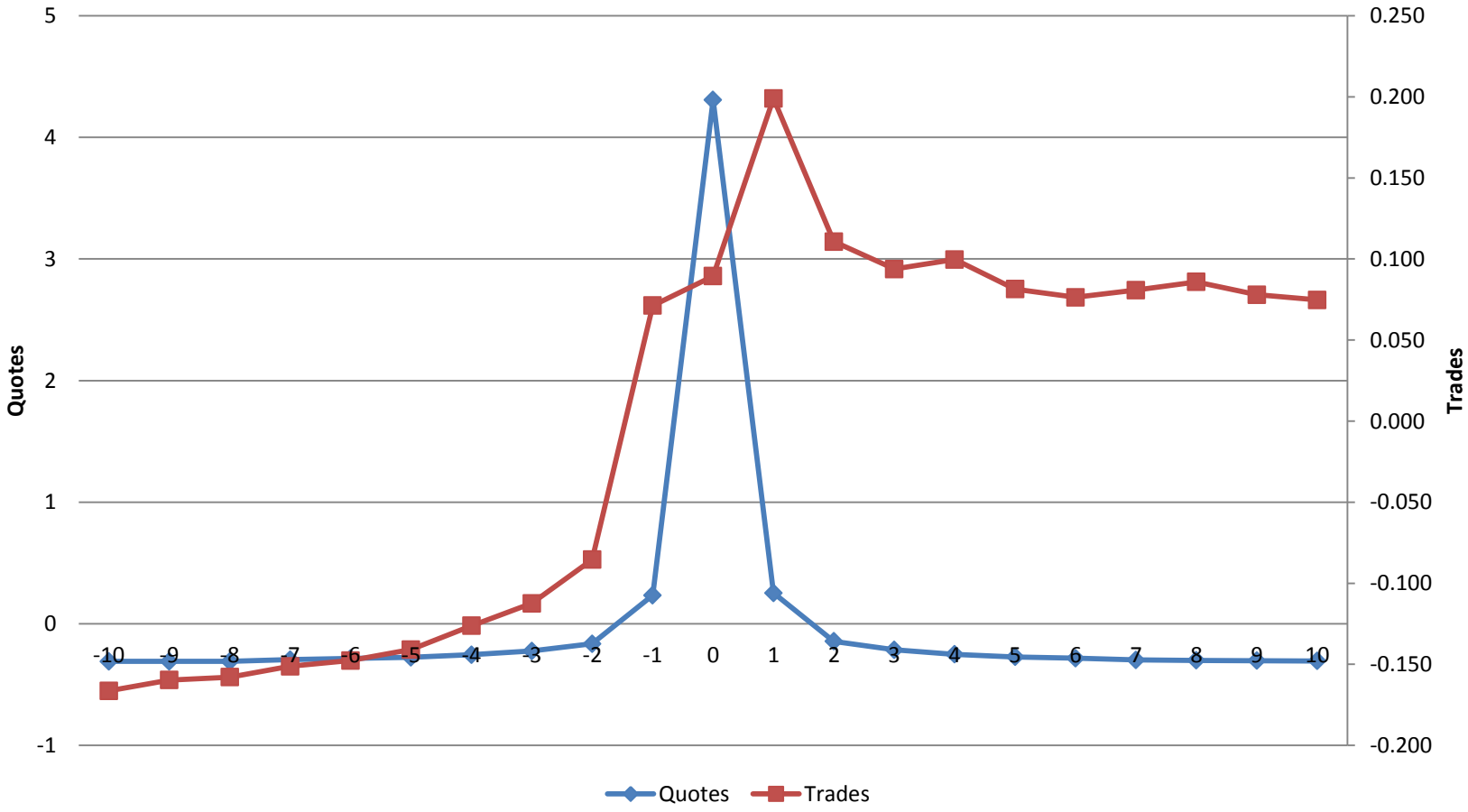


Figure 2
Spread by Period

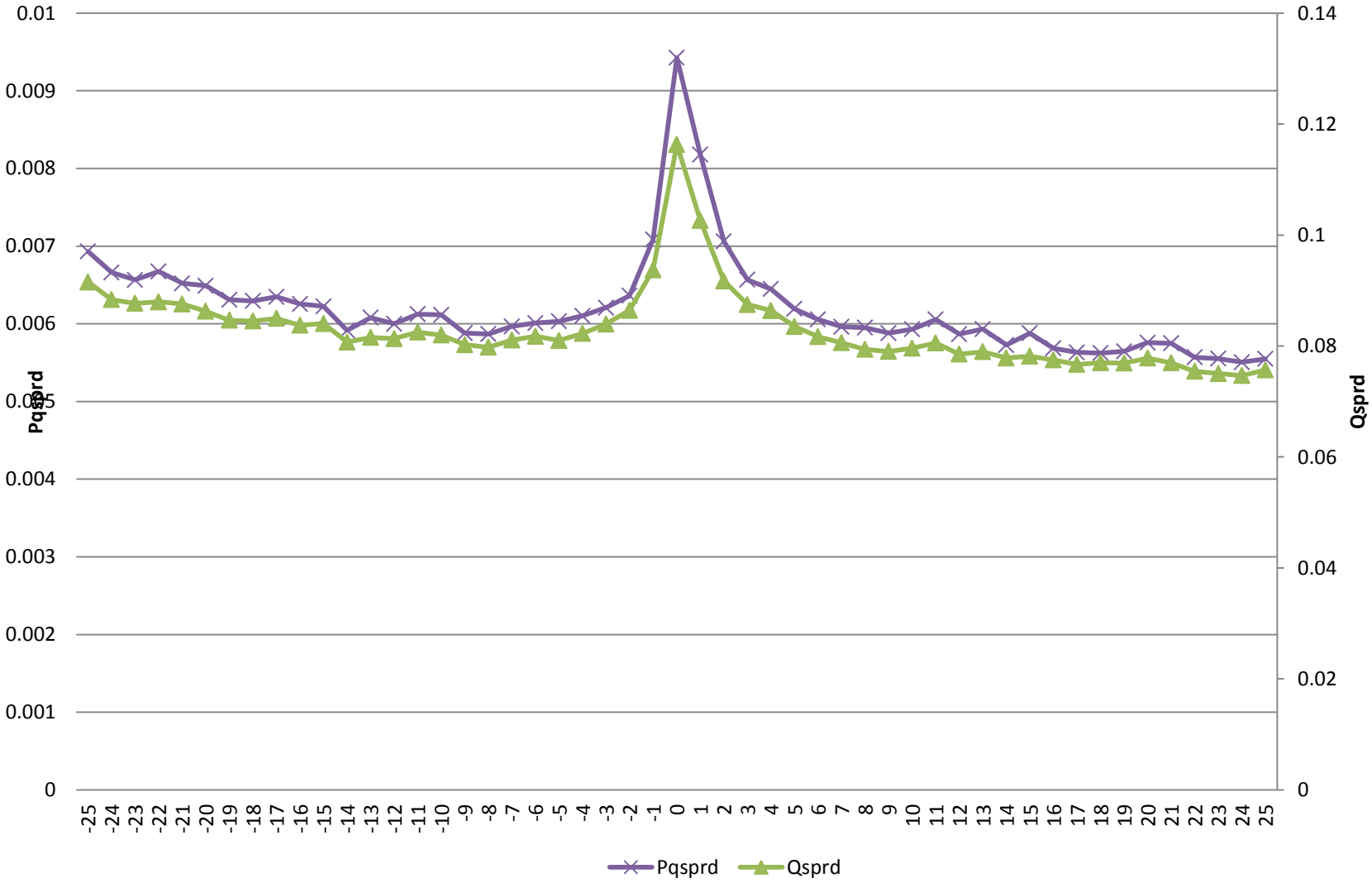
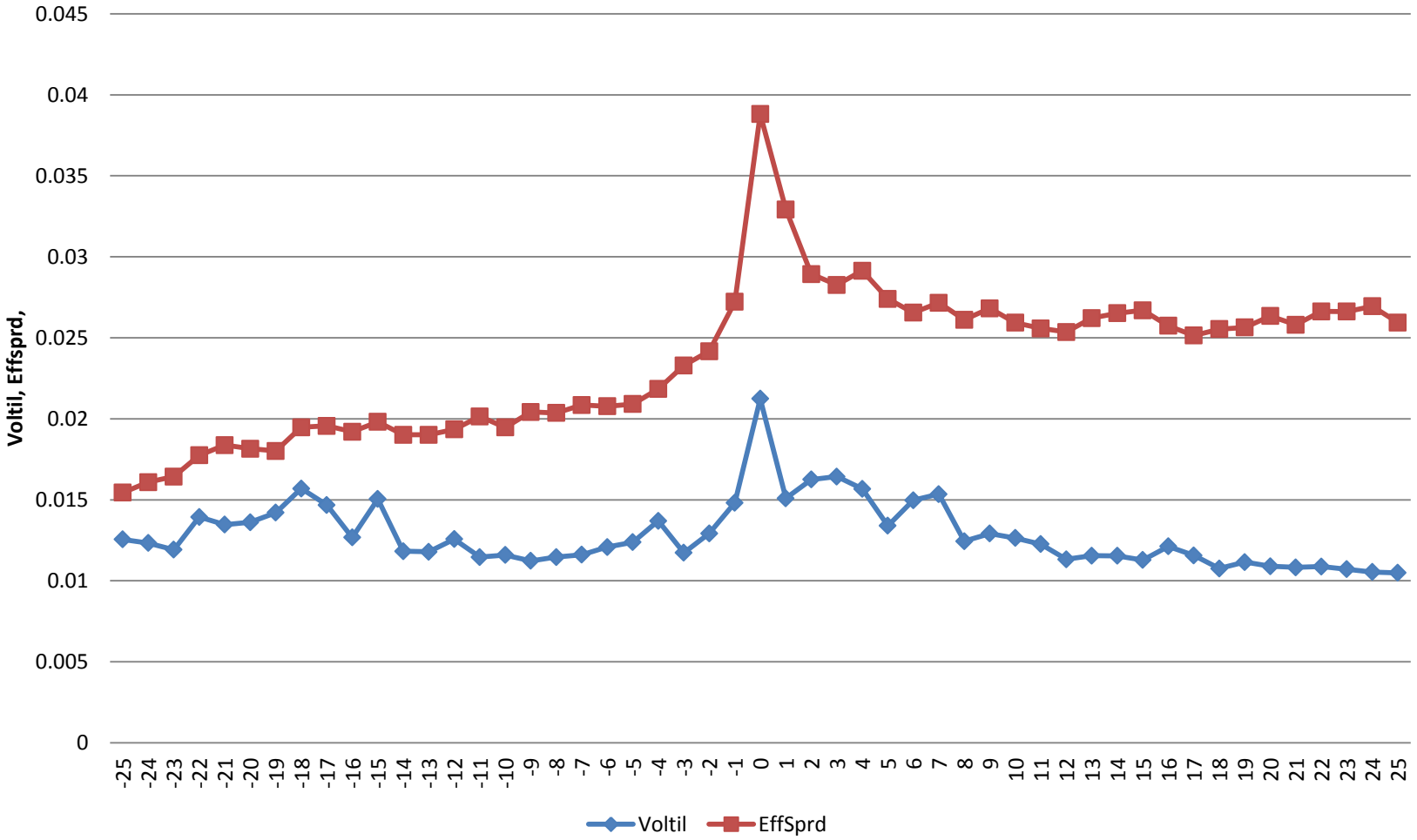


Figure 3
Effective Spread and Volatility by Period



ESSAY 2: THE DECLINING ROLE OF THE NASDAQ MARKET MAKERS

2.1 Introduction

Market makers provide valuable services to traders by providing liquidity to buyers and sellers when no trading counterparty is immediately available. However, unlike the NYSE and other designated specialist markets, dealers on NASDAQ have no explicit obligation to maintain a fair and orderly inside market. Moreover, NASDAQ market makers face increased competition from electronic based non-intermediated market centers, and new market participants such as high frequency traders engaging in market making strategies.

We study the role of the NASDAQ market maker in 2010 and compare it to an earlier time period. Specifically, we study the liquidity providing behavior of the NASDAQ market marker in May and June 2010 and May and June 2004.[9] We compare the following in the 2004 and 2010 time periods: the frequency with which NASDAQ market makers are at the inside quotes; the stock specific factors influencing market makers' behavior; the number of market makers who actively quote the stock in our NASDAQ sample; and the relation between market maker quoting activity and intraday bid-ask spread patterns.

We classify all bid and ask quotes according to whether or not a quote reflects the trading interest of a NASDAQ market maker or another market participant. We calculate the inside bid and ask and classify each side of the spread as reflecting the trading interest of the NASDAQ dealer or other market participants. We use our quote information in the 2004 and 2010 time periods to determine if market makers have a greater relative impact

[9] Hereafter we refer to the May and June 2004 as the 2004 period and May and June 2010 as 2010 period.

on intraday quoted spreads across time periods. We also look at the number market makers across time periods.

We find that the percentage of time market makers quote at the inside spread declines substantially from 2004 to 2010. In 2004, the percentage of the trading day that market makers quote at the inside bid (ask) is 60% (62%) compared to 2010 where NASDAQ dealers quote at the inside bid (ask) just 12% (11%). The number of market makers declines from 2004 to 2010. In 2004, NASDAQ listed securities have an average of 12.3 dealers that quote at least 5 times day compared to 7.8 in 2010. We also find evidence that the influence market makers have on intraday variations in the bid-ask spread declines over time.

While we observe a decline in dealer provided liquidity from 2004 to 2010 for both actively and lightly traded securities, this decline is less severe in less actively traded stocks. In 2010, dealers quote more competitively in stocks with less trading activity and higher return volatility, suggesting that dealers may still provide valuable liquidity providing services.

The remainder of the paper is structured as follows. Section 2 discuss background literature and develops our testable hypothesizes. Section 3 describes the data used in the study. Section 4 reports the results of our analyses and Section 5 concludes.

2.2 Background/Hypothesis

2.2.1 The changing role of NASDAQ Market Makers

Changes in NASDAQ dealer market making obligations may impact their liquidity providing behavior. Unlike the NYSE and other designated specialist markets, dealers on

NASDAQ have no explicit obligation to maintain fair and orderly inside markets. NASD only requires market makers to maintain firm bid and ask quotes for the securities in which they make markets. In 2007, NASDAQ amended trading rule 4613, eliminating the requirement that dealer quotes be reasonably related to the prevailing price. This elimination allows for dealers to more easily "back away" from providing liquidity or post competitive quotes on only one side of the market.[10]

Past research shows that a substantial proportion of orders on NASDAQ are preferenced (Chung, Chuwonganant, and McCormick, 2004). Frequently, brokers and dealers on NASDAQ agree to direct, or preference, customers' orders to dealers as long as the dealer will honor the best prevailing price regardless of whether or not she currently has the best price. Chung, Chuwonganant, and McCormick find that preferenced trades have a smaller price impact than unpreferenced trades and preferenced trades are less likely to receive price improvement. Preferencing of orders may cause maker makers to quote less aggressively and may affect their liquidity providing behavior.

Non-intermediated trading platforms based on an open electronic limit order book have become increasing prevalent. This increase in non-intermediated markets suggests the viability of a non-human intermediated market structure. Glosten (1994) develops a model of an open electronic limit order book. His model suggests that an electronic limit order structure is "inevitable" in that it should be a center of significant trading volume, and other market structures, including anonymous dealer markets, will have a difficult time competing with the electronic limit order book's market structure. Using an

[10] "Stub quoting" is a practice in which market markers place a bid or offer that is a drastically different than the prevailing price. For example, suppose a stock is trading at $50, a market maker may place a stub bid at 1 cent or a stub offer at $1000. Stub quoting receives considerable attention in the popular press, especially after the flash crash of May 6, 2010.

experimental electronic asset market without designated liquidity providers, Bloomfield, O'Hara, and Saar (2005) find evidence that supports Glosten(1994). They find that informed traders use more limit orders than do liquidity traders. Informed traders use limit orders to supply liquidity when the value of their information is high. The authors' findings suggest that, in electronic markets, a market making role emerges endogenously by informed traders that are less subject to adverse selection.

Competition from other market participants and venues may also impact the liquidity providing behavior of market makers and crowd out the number of participating dealers. Market makers face increased competition from high frequency traders. Gomber, Arndt, Lutat, and Uhle, 2011 document that market making is a high frequency trading strategy in which simultaneous buy and sell limit orders are submitted to profit from the bid-ask spread. To execute this strategy high frequency traders often employ sophisticated "quote matching" programs that update and delete orders based on computer algorithms. Menkveld (2011) documents how one high frequency trader on the Chi-X exchange acts as a modern market marker. The high frequency trader provides liquidity and the entrance of the high frequency trader corresponds with a decrease in spreads.

However, despite changes to market environments and increasing participation of new market participants, such as high frequency traders, some postulate that the number of traditional market makers may not be impacted. Cartea and Penalva (2011) develop a theory of market maker behavior in the presence of high frequency traders. The model predicts that high frequency traders generate revenue by intermediating trades between market makers and liquidity traders (equity investors) and charging market prices plus or minus a "haircut". Market makers are compensated for losses in revenues to high frequency

traders by receiving a higher liquidity discount (i.e. less price risk and greater speed) from trading with high frequency traders. So, increased competition from high frequency trading may not impact the number of traditional market makers.

Given consideration of the previously discussed literature relating to the viability of non-intermediated market structures, regulation that alters the obligation of market makers, and the increased competition faced by market makers, we propose the following two testable hypothesizes:

H1: The percentage of time that dealer quotes are at the inside spread decreases over time.

and

H2: The number of NASDAQ market makers decreases over time.

2.2.2 Intraday Bid-Ask Spread Patterns and Dealer Participation

Previous studies examine intraday variations in the bid-ask spread (McInish and Wood, 1992; Chan, Christie, and Schultz, 1995; Barclay , et. al, 1999; etc.). Chung, Van Ness, and Van Ness (1999) examine the intraday behavior of limit-order traders and the NYSE specialist. They find that the specialist tends to quote most actively for low activity stocks and during the morning trading hours when fewer limit orders are submitted. The majority of posted bid-ask quotes reflect the limit order book and only 6% of posted bid-ask quotes are the specialist alone at both the bid and the offer. Chung, Van Ness, and Van Ness also find that intraday variation in bid-ask spread largely reflect the participation of limit-order traders versus the NYSE specialist.

Due to reasons outlined for hypothesis 1, we believe market maker participation at the inside quote is decreasing. We question if observed patterns of bid-ask spreads is

driven, in part, by NASDAQ market maker participation and if the relation between intraday patterns in the bid-ask and market maker participation has changed over time. If the relation between NASDAQ dealer quoting behavior and the intraday pattern of the bid-ask spread declines over time, it suggests that market makers have become less significant in importance on NASDAQ. We propose as our final hypothesis:

H3: The relation between NASDAQ market makers quoting behavior and observed intraday patterns in bid-ask spreads decreases over time.

2.3 Data

We compare the behavior of NASDAQ market makers across two time periods, May and June 2004 and May and June 2010. Data for the study come from several sources. Data for the 2004 period is obtained from the Nastraq trade and quote data set. Nastraq data includes trade data, inside quote data, and market maker quote data. Most critical to our study, the data identifies the participant posting the quote.

We use TotalView-Itch data to identify market maker quotes in the 2010 period, which includes information about orders and executions on the NASDAQ system. These data are detailed and include submissions, cancelations, and executions of displayed orders and executions of non-displayed orders. We use the market participant identification (MPID) field to identify market participants. We then cross-reference MPIDs against a list of NASDAQ market participants to identify orders submitted by registered market makers.

We limit our sample to stocks that are listed on the NASDAQ stock exchange. We exclude stocks that have an average price less than $3, and stocks that average less than five quote updates per 15 minutes. These filters yield a sample of 2,868 stocks in the 2004 period and 2,221 in the 2010 period.

We are interested in the activity during the trading day only, so we exclude quotes that occur before the open (9:30am) and after the close (4:00pm). To minimize data errors we eliminate quotes in which the bid price is greater than the ask price, quotes where the bid or ask price is less than zero, and quotes where the bid or ask size is less than or equal to zero.

Sample summary statistics are reported in table I. Mean daily prices for sample stocks are $18.33 in 2004 and $17.81 in 2010 and are not statically different from each other across the two time periods. Similarly, average intraday return volatility for the 2004 and 2010 time periods are consistent, 0.02 in 2004 and 0.02 in 2010. Inside bid-ask spreads decline from a 2004 level of $0.16 to a 2010 level of $0.11. However, differences from 2004 and 2010 in the percentage spread (inside spread scaled by the quote midpoint) and effective spread are not significantly different across time periods.

Both volume and the market value of shares executed ($Volume) increase substantially from 2004 to 2010. The average number of shares executed per day rises from 496,226 in 2004 to 913,560 in 2010. Market value of shares executing per day more than doubles from 2004 to 2010. Similarly, the mean number of daily trades for sample stocks increases 2.4 times from 1,198 in 2004 to 4,080 in 2010. Average depth at the inside bid (ask) increases from 836 (765) shares 2004 to 2617 (2739) in 2010 a 213% (258%) increase.

2.4 Results

2.4.1 Market Maker Participation: Test of Hypothesis 1

We examine the liquidity providing behavior of NASDAQ market makers, in aggregate. To this end, we identify individual market makers quotes for each stock. Next,

we identify market maker quotes with the highest bid and lowest ask to generate an intraday market maker best bid and offer (mmBBO). We compare the mmBBO to the to the national market system (NMS) highest bid and lowest ask (NBBO).[11] If the bid or ask price of the mmBBO is equal to the inside bid or ask price of the NBBO for a particular stock at a point in time, we classify the mmBBO as being *At Bid* or *At Ask*, respectively. When the bid and ask prices of the mmBBO and NBBO are both equal, we classify the mmBBO as being *At Both*. We also examine the number of shares at the inside quote for both market makers and the national market system. The mmBBO is classified as being *Alone Bid* (*Alone Ask*) if market makers quotes make up all shares available at the NBBO bid (ask) price. We indicate the mmBBO is *Alone Both* if the mmBBO is equal to the NBBO for both bid and ask prices and quantities. Finally, if neither the bid or ask prices of the mmBBO is equal to the NBBO, the mmBBO is classified as *At Neither*.

We divide the number of seconds during the trading day (9:30am-4:00pm) when marker makers quote at the inside by the total number of seconds in a trading day to obtain the percentage of the trading day that market makers are *At Bid, At Ask, At Both, Alone Bid, Alone Ask, Alone Both,* or *At Neither*.[12]

We report the proportion of the trading day that market makers quote at the national market system best bid and ask price in table II. Panel A reports that, in 2004, market makers quotes are *At Bid* (*At Ask*) 60.1% (62.7%) of the trading day. In the 2010 time period, market makers are at the bid (ask) only 12.3% (11.0%) of the day, a reduction

[11] The Nastraq data, used in the 2004 period, includes an NBBO file. We use NYSE trade and quote data (TAQ) to compute the NBBO for the 2010 period.

[12] Note mmBBO classifications are not mutually exclusive. For example if the mmBBO and NBBO ask price and size were both equal to $10 and 200 shares then the mmBBO would be classified as being both *At Ask*, and *Alone Ask*.

of 48% (52%) from 2004. The percentage of time that market makers are on both sides of the NBBO decreases from a 2004 level of 39.3% to a 2010 level of 1.7%. The percentage of time during the trading day when market makers are alone at the inside quote also declines substantially across time periods. *Alone Bid, Alone Ask*, and *Alone Both* decline 29.6%, 42.0%, and 15.5% respectively, from 2004 to 2010. *At Neither* increases from 16.0% in 2004 to 78.4% in 2010, a percentage increase of 390%. NASDAQ market makers participate less frequently at the NBBO in the 2010 period compared to the 2004 period, which supports hypothesis 1, that the liquidity providing role of NASDAQ market makers is declining.

Liquidity providing services of market makers is most beneficial to stocks that are lightly traded. Venkataram and Wasisburd (2007) examine the role of designated dealers on the Paris Bourse, an electronic limit order market. The authors find that stocks with designated market makers have better market quality that those without designated market makers, especially stocks that are less frequently traded. As less liquid, lightly traded stocks tend to, by definition, have fewer market participants actively quoting and trading them, these securities benefit the most from the liquidity providing services of market makers. We divide sample stocks into quartiles based on the average number of daily transactions in each sample period to explore if market makers participate differently for stocks with different levels of trading activity. Quartile 1 (Q1) consists of stocks with the fewest number of daily trades and Quartile 4 (Q4) contains the most active stocks, based on the mean number of daily transactions. We report the percentage of time market makers quote at the inside across stock activity quartiles in panel B of table II. Consistent

with the proportions reported in panel A of table II, the percentage of time that market makers are at the inside quotes is lower in 2010 than in 2004 for all activity quartiles. The differences between the 2004 and 2010 time period for *At Bid, At Ask*, and *At Both* are systematically larger for stocks in higher activity quartiles. *At Bid* (*At Ask, At Both*) decline 31.0% (36.7%, 25.5%) in Q1 from 2004 to 2010 and decline 64.2%(65.8, 55.2) in Q4 from 2004 to 2010. Differences in At Neither for the 2004 and 2010 sample periods are larger for stocks in more active quartiles.

Table III reports a comparison of market maker participation within sample periods across activity quartiles. For both the 2004 and 2010 periods, the percentage of time that market makers are alone at the inside quote decreases with activity. In the 2004 period *Alone Bid, Alone Ask,* and *Alone Both* decrease from 34.8%, 48.6%, and 19.2%, respectively, for activity quartile 1 to 33.1%, 41.2%, and 13.4%, respectively, in quartile 4. We observe a similar decrease in the 2010 period with *Alone Bid, Alone Ask,* and *Alone Both* decreasing from 12%, 10%, and 2%, respectively for activity quartile 1 to 0.7%, 0.7%, and 0.0% in quartile 4. Stocks that are more actively traded are likely to have more market participants and thus, more competition in liquidity providing services. Put another way, an increase in the number of market participants should decrease the chance that NASDAQ dealers will be alone at the inside quote.

We observe differences in the 2004 and 2010 time periods when looking at the variations in *At Bid, At Ask*, and *At Both* across trading activity portfolios. *At Bid, At Ask*, and *At Both* are all increasing with activity in the 2004 time period. The difference in mean market maker participation from activity Q1 to activity Q4 for *At Bid, At Ask*, and *At Both* are 24.0%, 19.7%, and 25.2%, respectively. This finding implies that, for the 2004 sample,

market makers quotes are more competitive for actively traded stocks than for more lightly traded equities.

We observe market maker participation decreasing with activity in the 2010. The lowest activity quartile is *At Bid, At Ask*, and *At Both* 19.2%, 18.2%, and 5.0% of the trading day, respectively. For stocks in activity quartiles 2, 3, and 4, market makers are *At Bid, At Ask,* and *At Both* on average 9%, 8%, and 0.5% of the time.

Figure 1 depicts the percentage of time market makers quote at either the inside bid or ask price and the variations in market maker participation across activity quartiles. In 2004, dealer participation has an upward trend for higher stock activity quartiles. Dealer participation in 2004 for the least actively traded stocks (quartile 1) is 75%, 81% for quartile 2, 86% for quartile 3, and 93% for quartile 4. In the 2010 sample period, the trend in dealer participation across activity quartiles is generally downward, decreasing from 32% in quartile 1 to 16% in quartile 3 then increasing slightly to 18% for quartile 4.
As with the participation reported in table III the graphical depiction suggests that changes in market maker participation across activity quartiles imply that, in the 2010 period, market makers provide liquidity more competitively in lightly traded stocks compared to more actively traded securities. These less actively traded stocks are also more likely to benefit from market maker liquidity providing services (see Venkataram and Wasisburd, 2007).

NASDAQ market maker quoting behavior is shown to vary systemically based on market conditions and stock characteristics. Chung and Zhao (2004) examine cross-sectional variations in NASDAQ dealer quoting behavior and find that dealer quoting patterns are consistent with profit maximizing behavior. Chung and Zhao show that

dealers are more likely to quote at the inside when opportunities for market making revenues are greater, including when spreads are large, there are fewer market makers, and there is more frequent trading. Chung and Zhao also show market makers avoid quoting at the inside when stocks have heightened volatility.

To further explore the change in market maker participation over time we estimate the following two regressions, which control for cross-sectional variations in stock characteristics shown to impact dealer quoting behavior:

(1) $PercentInside_{i,t} =$

$\beta_0 + \beta_1 Price_{i,t} + \beta_2 Spread_{i,t} + \beta_3 Return\ Volit_{i,t} + \beta_4 RelNum\ Trades_{i,t} +$

$\beta_5 Num\ Mkt\ Makers_{i,t} + \beta_6 in2010_i + \beta_7 \text{in2010} * active\_Q2_i + \beta_8 \text{in2010} * active\_Q3_i +$

$\beta_9 \text{in2010} * active\_Q4_i + \varepsilon_{i,t}$

(2) $PercentInside_{i,t} =$

$\beta_0 + \beta_1 Price_{i,t} + \beta_2 Spread_{i,t} + \beta_3 Return\ Volit_{i,t} + \beta_4 RelNum\ Trades_{i,t} +$

$\beta_5 Num\ Mkt\ Makers_{i,t} + \beta_6 Active\_Q2 + \beta_7 Active\_Q3 + \beta_8 Active\_Q4 + \varepsilon_{i,t}$

where $PercentInside_{i,t}$ the percentage of time market makers quote at the inside bid or ask for stock *i* on day *t*. $Price_{i,t}$is the mean intraday stock price. $Spread_{i,t}$ is the average difference between the lowest ask and the highest bid scaled by the inside quote midpoint for stock *i* during the trading day t. $Return\ Volit_{i,t}$ is the intraday trade-to-trade return standard deviation stock for *i* on day *t*. $RelNum\ Trades_{i,t}$ is the daily number of transactions for sample stock *i* on day *t* scaled by the average daily number of transactions for all sample stocks in the same period. We scale the number of trades for stock *i* on day *t*

by the average number of daily transactions to adjust for the large increase in average number of daily trades from the 2004 to 2010. $Num\ Mkt\ Makers_{i,t}$ is the number of market makers that update their quotes for stock *i* at least five times on trading day *t*. in2010_i is dummy variable equal to 1 for observations in the 2010 period. *Active_Q2, Active_Q3*, and *Active_Q4* are dummy variables indicating a stocks level of trading activity. $\text{in2010} * active\_Q2_i$, $\text{in2010} * active\_Q3_i$, $\text{in2010} * active\_Q4_i$ are dummy variables that interact the 2010 dummy variables with dummy variables representing stock *i*'s trading quartile in 2010.

We report regression results of two specifications of model (1) in table IV panel A. In the first specification, we exclude our interactive 2010 activity quartile variables. We observe a positive relation between the number of actively participating market makers and the time that market makers quote at the inside ask or bid price in both model specifications. This observation suggests that a stock with more dealers actively making a market will have a higher probability that at least one of the dealers is quoting at the inside bid or offer.

In both specifications of model (1) *Price* is negatively related to dealer participation suggesting that higher priced stocks have lower market maker participation at the inside quote. However, the economic significance of the price participation relation is small. A $1 increase in stock price increases the percentage daily market maker participation by only 0.05%.

The coefficient of *Spread* is positive in the first specification of model (1) suggesting that market makers participate at the inside more when spreads are wider. This finding is consistent with Chung and Zhao (2004), who find that dealers quote at the inside when

opportunities for market making revenues are greater, including when stocks spreads are large. In the second specification of model (1), where we include our interactive 2010 activity quartile variables, the sign of the spread coefficient is negative. This negative coefficient is likely due to differences in the relation between quoting at the inside and the bid-ask spread in the 2004 and 2010 periods. We explore the relation between bid-ask spreads and dealer participation at the inside across time periods further when we estimate model (2).

Return Volit is negatively related to dealer participation at the inside in the first specification of model (1). This coefficient is also consistent with Chung and Zhao (2004), who show that market makers are more hesitant to place competitive quotes in periods of heightened uncertainty.

As an additional test of hypothesis 1, we include a dummy variable that indicates the day is in the 2010 time period. *In2010* is negative for both specifications of model (1). The coefficient of -0.6066 observed for *In2010* suggests that the time market makers quote at the inside is 61% lower in the 2010 period than in 2004. This finding is consistent with hypothesis 1, which predicts that the percentage of time that dealer quote at the inside spread decreases over time.

We test for changes in market maker participation from 2004 to 2010 for stocks with different levels of trading activity in specification 2 of model (1). We include variables which indicate a stock trading activity quartile and the trading period is 2010 to assess if changes in market maker participation from 2004 to 2010 is more pronounced for stocks with different levels of trading activity. The coefficient of $in2010 * active\_Q2_i$, $in2010 * active\_Q3_i$,and $in2010 * active\_Q4_i$ are all negative. The coefficients of -0.1490 on

in2010 $*$ $active\_Q4$ implies that the percentage of time market makers spend at the inside bid or ask declines 15% more for stocks in the most active quartile from 2004 to 2010 than stocks in the least active quartile. The negative coefficient of in2010 $*$ $active\_Q4$ suggests that, the decline in market maker participation at the inside is particularly pronounced for the most actively traded equities compared to the most lightly traded securities.

We estimate model (2) for both the 2004 and 2010 time periods and report results in table IV panel B. Similar to the estimation results of model (1), we observe a positive correlation between the number of actively participating market makers and the percentage of time they quote at the inside ask or bid price. Also consistent with the result in model (1), the number of trades and dealer participation are negatively related.

The relation between the percentage of time that market makers quote at the inside and both *Spread* and *Return Volit* change from positive in 2004 to negative in 2010. The negative coefficient for spread implies that, in 2010, market makers provide less liquidity to stocks with higher spreads. The negative coefficient for spread and volatility is consistent with past research that shows in times of increased uncertainty an increase in the proportion of orders executed by market makers (Li, McCormick, and Zhao, 2005).

The signs of the coefficients for the activity quartile dummy variables are consistent with our univariate and model (1) analyses. In the 2004 time period, market makers are more likely to be at the inside for more actively traded securities. A coefficient of 0.0770 for *Active_Q4* implies that market makers spend 8% more time at the inside quote for the most active stocks versus the stocks the in the lowest activity quartile. In the 2010 period the coefficient of *Active_Q4* suggest that market makers are at the inside quote 12% less for actively traded stocks relative to lightly traded securities. The finding that dealers quote

more competitively in stocks with less trading activity and higher return volatility in 2010 suggests that dealers may still provide valuable liquidity providing services as less actively traded stocks are more likely to benefit from market maker liquidity providing services (Venkataram and Wasisburd, 2007).

2.4.2 Variation in number of NASDAQ Market Makers: Test of Hypothesis 2

We determine if the average number of market makers changes from the 2004 to 2010 time periods. Table V panel A reports the mean number of market makers participating in sample stocks in both the 2004 and 2010 time periods. Consistent with the methodology of Chung and Zhao (2004), market makers are classified as "active" if they submit at least five quote updates during the trading day. We report daily means for both the total number of market makers and active market makers. We find that the number of market makers declines across time periods. From 2004 to 2010, the average number of active (total) market makers per stock declines from 12.3 (35.4) to 7.8 (29.5). This reduction is consistent with hypothesis 2 that number of NASDAQ dealers decreases over time.

We also report the number of participating market makers by stock trading activity quartile. The number of market makers participating (both aggregate and actively) declines from 2004 to 2010 in all quartiles. This decline appears to be much larger for actively traded stocks. The changes in active market makers from 2004 to 2010 for activity quartile 4 is 14.2 compared to no decline in the number of active market makers in quartile 1. These statistics are consistent with those reported in section 4.1, showing that market makers participate more in less actively traded stocks in the 2010 period.

2.4.3 Intraday Bid-Ask Spread and Market Maker Participation: Test of Hypothesis 3

Changes in market maker participation are likely to alter the impact market makers have on the intraday pattern of the bid-ask spread. We explore if intraday patterns in bid-ask spreads for NASDAQ listed stocks reflect the participation of NASDAQ market makers and test if the influence market makers have on intraday bid-ask spread patterns have changed over time.

We first divide the 6.5 hour trading day (9:30am-4:00pm) into 26 15-minute segments. Table VI reports and figure II depicts intraday variations in standardized bid-ask spreads and market maker participation. Market maker participation is computed for each 15-minute segment by tabulating the amount of time that at least one market maker's quote is equal the NMS highest bid or lowest ask price and dividing this amount of time by the total number of seconds in a 15 minute segment (900 seconds). Market maker participation is the percentage of time that dealers are at the bid or ask quote during each 15-minute segment. Standardized intraday spreads are is computed as $(s_{i,t,j}-m_{i,t})/sd_{i,t}$ where $s_{i,t,j}$ is the average bid-ask spread for stock i on day t, in the 15-minute intraday trading segment j; $m_{i,t}$ is the mean spread for the stock i on day t; and $sd_{i,t}$ is the standard deviation in spreads for stock i over day t. We also standardized the time market makers quote at the inside spread for figure II.

The intraday pattern of bid-ask spreads is similar in both the 2004 and 2010 sample periods. Spreads are wider near the beginning of the trading day and decline at a decreasing rate through the close of trading. The declining patterns observed in bid-ask

spreads in both time periods are similar to that observed in prior studies of NASDAQ bid-ask spreads (Chan, Christie, and Schultz, 1995; Barclay , et. al, 1999).

Intraday variations in market maker participation differ in 2004 compared to 2010. In 2004 market maker participation is lowest during the early periods and generally increases at a decreasing rate throughout the trading day. This pattern in market maker participation appears to be negatively related to the intraday patterns of bid-ask spreads in 2004. Participation of market makers is more sporadic in 2010. It is difficult to see a clear pattern in the relation between intraday spread variations and market maker participation. To more formally explore the relation of the intraday bid-ask spread and intraday NASDAQ market maker participation we estimate the following models:

(3) $$StdSpread_{i,t,j} = \beta_1 Segment_j + \beta_2 Return\ Volit_{i,t,j} + \beta_3 Num\ Trades_{i,t,j} + \varepsilon_{i,t,j}$$

(4) $$StdSpread_{i,t,j} = \beta_1 Segment_j + \beta_2 PercentInside_{i,t,j} + \beta_3 Return\ Volit_{i,t,j} + \beta_4 Num\ Trades_{i,t,j} + \varepsilon_{i,t,j}$$

where $StdSpread_{i,t,j}$ is the standardized spread for stock *i* on day *t* in segment *j*. $Segment_j$ is a vector of dummy variables for each of the 26 15-minute segments. $PercentInside_{i,t,j}$ is a vector of variables that indicate market maker participation variables for each segment. Market maker participation is computed as the percentage of time that market makers are at either the inside bid or ask price for stock *i* on day *t* in segment *j*. $Return\ Volit_{i,t,j}$ is the standard deviation of trade-to-trade returns for stock *i* on day *t* in segment *j*. $Num\ Trades_{i,t,j}$ is the number of trades which execute for stock *i* on day *t* in segment *j*. $Return\ Volit$ and $Num\ Trades$ are included as controls for risk and activity, respectively, which are shown to be determinant of the bid-ask spread (McInish and Wood, 1992).

Table VII Panel A reports regression results for the estimation of model (3) for both the 2004 and 2010 time period. As the primary purpose in estimating the first model is to show how spreads vary throughout the trading day we report only the coefficients from the segment indicators variables for brevity. Regression results confirm the graphical observation in figure 2. Spreads are wider near the beginning of the trading day and decline at a decreasing rate through the close of trading in both the 2004 and 2010 time periods.

Table VII Panel B reports regression results from estimation of model (4) for both the 2004 and 2010 time periods. We report only market maker participation variables for each segment. All coefficients for intraday market maker participation variables are negative in the regression for the 2004 period. The negative sign on all participation variable coefficients indicates that there is a negative relation between the participation of market makers and intraday bid-ask spreads in the 2004 time period.

The relation between bid-ask spreads and market maker participation in the 2010 period is less clear. Coefficients for market maker participation variables near the open of trading are negative which indicates that more market maker participation lowers bid-ask spreads during these segments. For other segments throughout the trading day the relation between market maker participation and bid-ask spreads is more sporadic. Coefficients on market maker participation variables are either insignificant or positive.

The finding that market maker participation has a more sporadic relation with the bid-ask spread in 2010 coupled with lower market maker participation observed in the 2010 time period is consistent with hypothesis 3 that market maker influence on bid-ask spreads is declining. The reduced influence of market maker participation on variations in

the bid-ask spread in 2010 is additional evidence that the impact of market makers on NASDAQ is declining.

2.5 Conclusion

We examine if the role of the NASDAQ market marker is declining. We include an analysis of the quoting behavior of NASDAQ dealers, the number of dealers that make markets in NASDAQ-listed securities over time, and the relation of intraday market maker participation and intraday bid-ask spread patterns.

We document a declining role of NASDAQ market makers. Market maker participation declines substantially over our sample period. In 2004, the percentage of the trading day that market makers quote at the inside bid (ask) is 60% (62%) compared to 2010 when NASDAQ dealers quote at the inside bid (ask) just 12% (11%). The number of market makers declines. We also find evidence that the relation between market maker participation and intraday variations in the bid-ask declines over time. While we observe a decline in dealer provided liquidity from 2004 to 2010 for both actively and lightly traded securities, this decline is less severe in less actively traded stocks suggesting that dealers may still provide valuable liquidity providing services.

Table I: Summary Statistics

Price is the mean stock price during each period. Inside spread is the average distance between the lowest ask and the highest bid. *P. Spread* is the inside spread scaled by the quote midpoint. *Bid Depth* and *Ask Depth* are the average number of shares quoted at the highest bid and lowest ask, respectively. *Eff. Spread* is the absolute value of the trade price minus the prevailing midpoint. *Return Volit*. is the average intraday trade to trade return standard deviation. *Volume* is the mean number of shares per stock which execute per day. *$Volume* is the mean total market value of shares which execute for sample firms per trading day. *Num. Trades* is the average daily number of transaction for sample stock. Data sources include TAQ, Nastraq, and NASDAQ TotalView Itch for May and June 2004 and 2010.

*,**,*** Indicate statistically significant at the 10%, 5%, and 1% level respectively

	Whole Sample	**2004**	**2010**	**Diff [2010-2004]**
Price	18.10	18.33	17.81	-0.52
Inside Spread	0.14	0.16	0.11	-0.05***
P. Spread (%)	1.2	1.2	1.2	-0.02
Bid Depth (100s)	16	8	26	18***
Ask Depth (100s)	16	7	27	20***
Eff Spread	0.06	0.06	0.06	0.00
Return Volit	0.02	0.02	0.02	0.00
Volume (*1000s)*	678	496	913	417***
$Volume (*1000s)*	16,970	10,602	25,193	14,591***
Num. Trades	2,456	1,198	4,080	2,881***
Number of Firms	5,089	2,868	2,221	

Table II: Market Maker Participation

This table reports the mean percentage of the trading day that NASDAQ market makers quote at the NBBO. At Bid (At Ask) is the total number of seconds that at least one market maker quotes at the NMS (National Market System) highest (lowest) bid (ask) price divided by the total number of seconds in the trading day. At Both is the total number of seconds that NASDAQ market makers quote at both the NMS highest bid and lowest ask price divided by the total number of seconds in the trading day. Alone At Bid (Alone At Ask) is the total number of seconds that market makers quotes are the only quotes at the NMS highest (lowest) bid (ask) price divided by the total number of seconds in the trading day. Alone at both is the total number of seconds that market makers quotes are the only quotes at the NMS highest bid and lowest ask price divided by the total number of seconds in the trading day. At Neither is the percentage of time during the trading day that market makers do not quote at either the inside bid or ask. Sample stocks are divided into quartiles based on year and trading activity with quartile 1 (Q1) consisting of stocks with the lowest number of average daily trades and quartile 4 (Q4) consisting of stocks with the largest number of average daily trades. Data sources include TAQ, Nastraq, and NASDAQ TotalView Itch for May and June 2004 and 2010.

*,**,*** Statistically significant at the 10%, 5%, and 1% level respectively

Panel A:

	2004	2010	Diff [2010-2004]
At Bid (%)	60.1	12.3	-47.8***
At Ask (%)	62.7	11.0	-51.7***
At Both (%)	39.3	1.7	-37.6***
Alone Bid (%)	33.9	4.3	-29.6***
Alone Ask (%)	45.7	3.7	-42.0***
Alone Both (%)	16.0	0.5	-15.5***
At Neither (%)	16.0	78.4	62.4***

Panel B: Activity

	Q1 (Least Trades)			Q2			Q3			Q4 (Most Trades)		
	2004	2010	Diff [10-04]	2004	2010	Diff [10-04]	2004	2010	Diff [10-04]	2004	2010	Diff [10-04]
At Bid (%)	50.1	19.2	-31.0***	54.6	10.8	-43.7***	61.4	9.0	-52.4***	74.2	10.0	-64.2***
At Ask (%)	54.8	18.2	-36.7***	57.7	9.8	-47.9***	63.9	7.4	-56.6***	74.5	8.7	-65.8***
At Both (%)	30.5	5.0	-25.5***	31.7	0.9	-30.8***	39.3	0.5	-38.9***	55.8	0.6	-55.2***
Alone Bid (%)	34.8	11.8	-23.0***	34.5	3.3	-31.2***	33.0	1.2	-31.8***	33.1	0.7	-32.4***
Alone Ask (%)	48.6	10.0	-38.6***	47.3	3.0	-44.4***	45.7	1.1	-44.7***	41.2	0.7	-40.4***
Alone Both (%)	19.2	2.0	-17.2***	16.5	0.1	-16.4***	15.0	0.01	-15.0***	13.4	0.0	-13.4***
At Neither (%)	24.0	67.4	43.5***	19.3	80.2	60.9***	13.9	84.1	70.2***	6.9	81.8	74.9***

Table III: Activity

This table reports the mean percentage of the trading day that NASDAQ market makers quote at the NBBO. At Bid (At Ask) is the total number of seconds that at least one market maker quotes at the NMS (National Market System) highest (lowest) bid (ask) price divided by the total number of seconds in the trading day. At Both is the total number of seconds that NASDAQ market makers quote at both the NMS highest bid and lowest ask price divided by the total number of seconds in the trading day. Alone At Bid (Alone At Ask) is the total number of seconds that market makers quotes are the only quotes at the NMS highest (lowest) bid (ask) price divided by the total number of seconds in the trading day. Alone at both is the total number of seconds that market makers quote are the only quotes at the NMS highest bid and lowest ask price divided by the total number of seconds in the trading day. At Neither is the percentage of time during the trading day that market makers do not quote at either the inside bid or ask. Sample stocks are divided into quartiles based on year and trading activity with quartile 1 (Q1) consisting of stocks with the lowest number of average daily trades and quartile 4 (Q4) consisting of stocks with the largest number of average daily trades. Data sources include TAQ, Nastraq, and NASDAQ TotalView Itch for May and June 2004 and 2010. *,**,*** Statistically significant at the 10%, 5%, and 1% level respectively

Panel A: 2004

	Q1 (Least Trades)	Q2	Q3	Q4 (Most Trades)	Q1-Q4
At Bid (%)	50.1	54.6	61.4	74.2	24.0***
At Ask (%)	54.8	57.7	63.9	74.5	19.7***
At Both (%)	30.5	31.7	39.3	55.8	25.2***
Alone Bid (%)	34.8	34.5	33.0	33.1	-1.8***
Alone Ask (%)	48.6	47.3	45.7	41.2	-7.4***
Alone Both (%)	19.2	16.5	15.0	13.4	-5.8***
At Neither (%)	24.0	19.3	13.9	6.9	17.1***

Panel B: 2010

At Bid (%)	19.2	9.0	10.0	10.0	-9.2***
At Ask (%)	18.2	7.4	8.7	8.7	-9.5***
At Both (%)	5.0	0.5	0.6	0.6	-4.4***
Alone Bid (%)	11.8	1.2	0.7	0.7	-11.1***
Alone Ask (%)	10.0	1.1	0.7	0.7	-9.3***
Alone Both (%)	2.0	0.0	0.0	0.0	-2.0***
At Neither (%)	67.4	80.2	84.1	81.8	-14.4***

Table IV: Market Maker Participation

OLS regression results are reported for NASDAQ market maker's quoting participation. Dependent variable is the percentage of time during the trading day that market makers quote at the NMS (National Market System) highest bid or lowest ask. $Price_{i,t}$ is the mean intraday stock price. $Spread_{i,t}$ is the average distance between lowest ask and the highest bid during the trading day. $Return\ Volit_{i,t}$ is the intraday trade-to-trade return standard deviation. $Num\ Trades_{i,t}$ the daily number of transactions for sample stock *i*. $Num\ Mkt\ Makers_{i,t}$ is the number of market makers that quote at least five times in a trading day. $in2010_i$ is dummy variables equal to 1 for observations in the 2010 period. $Active\_Q2_i$, $Active\_Q3_i$, $Active\_Q4_i$ are dummy variables indicating a stocks level of trading activity Where *Active_Q4* is 1 for the 25% most actively traded stocks. *In2010*active_Q2, In2010*active_Q3, and In2010*active_Q4* are dummy variables that interact the 2010 dummy variable with a dummy variable representing stock *i*'s trading quartile in 2010. Data sources include TAQ, Nastraq, and NASDAQ TotalView Itch for May and June 2004 and 2010. *,**,*** Statistically significant at the 10%, 5%, and 1% level respectively

Panel A: Market Maker Participation		
Price	-0.0005***	-0.0005***
	(-20.55)	(-20.97)
Spread	1.2648***	-0.1120***
	(39.47)	(-3.18)
Return Volit	-0.0429***	-0.0159
	(-2.90)	(-1.09)
Num Trades	-0.0025***	-0.0019***
	(-17.99)	(-13.76)
Num Mkt Makers	0.0067***	0.0066***
	(94.72)	(95.01)
In2010	-0.6066***	-0.4948***
	(-655.16)	(-310.45)
In2010*active_Q2		-0.1176***
		(-60.96)
In2010*active_Q3		-0.1666***
		(-84.31)
In2010*active_Q4		-0.1490***
		(-73.51)
Constant	0.7585***	0.7712***
	(624.85)	(641.88)
Observations	197,360	197,360
R-squared	0.75	0.76
F test	96452	67748

(*cont.)*

Panel B: Market Maker Participation by Year

	2004	2010
Price	-0.0013***	-0.0001***
	(-39.00)	(-3.58)
Spread	-1.6791***	1.7173***
	(-29.73)	(34.30)
Return Volit	-0.4172***	0.3262***
	(-19.42)	(16.27)
Num Trades	-0.0004**	-0.0006***
	(-2.39)	(-2.84)
Num Mkt Makers	0.0028***	0.0082***
	(26.65)	(27.84)
Active_Q2	0.0111***	-0.0786***
	(6.34)	(-34.00)
Active_Q3	0.0400***	-0.1238***
	(19.66)	(-47.60)
Active_Q4	0.0770***	-0.1166***
	(28.70)	(-39.24)
Constant	0.8194***	0.2014***
	(403.02)	(80.74)
Observations	108,133	89,227
R-squared	0.16	0.08
F test	2589	1005

Table V: Number of Market Maker

The table reports the mean number of market makers that participate daily in NASDAQ stocks. All MM is the mean number of market makers per stock that quote during the trading day. Active MM is the mean number of active market makers per stock that quote during the trading day. We classify a market maker as active if the market maker quotes at least five times in a trading day. Sample stocks are divided into quartiles based on year and trading activity with quartile 1 (Q1) consisting of stocks with the lowest number of average daily trades and quartile 4 (Q4) consisting of stocks with the largest number of average daily trades. Data sources include TAQ, Nastraq, and NASDAQ TotalView Itch for May and June 2004 and 2010. *,**,*** Statistically significant at the 10%, 5%, and 1% level respectively

Panel A: Number of NASDAQ Market Makers

	2004	2010	Diff [2010-2004]
All MM	35.4	29.5	-5.9***
			(-11.1)
Active MM	12.3	7.8	-4.5***
			(-21.7)

Panel B: Number of NASDAQ Market Makers by Trading Activity

	Q1 (Least Trades)			Q2			Q3			Q4 (Most Trades)		
	2004	2010	Diff [10-04]	2004	2010	Diff [10-04]	2004	2010	Diff [10-04]	2004	2010	Diff [10-04]
All MM	17.0	15.4	-1.5***	24.5	23.7	-0.7**	35.3	33.3	-2.0***	64.9	45.3	-19.5***
			(-6.2)			(-2.0)			(-4.2)			(-18.6)
Active MM	4.2	3.8	-0.2	7.7	7.0	-0.7***	12.3	8.9	-3.5***	25.3	11.2	-14.2***
			(-1.5)			(-7.1)			(-25.8)			(-34.4)

Table VI: Intraday Market Maker Participation

This table reports intraday variations in standardized bid-ask spreads and the intraday quoting patterns of NASDAQ market makers at the NBBO. We divide the 6.5 hour trading day (9:30am-4:00pm) into 26, 15-minute segments. Market maker participation is the percentage of time the NASDAQ market makers quote at either the inside bid or ask price. Standardized intraday spreads are is computed as $(s_{i,t,j}-m_{i,t})/sd_{i,t}$ where $s_{i,t,j}$ is the bid-ask spread from for stock *i* on day *t,* in 15 minute intraday trading segment *j*, m is the mean spread for the trading day for stock *i* on day *t*, and $sd_{i,t}$ is the standard deviation in spreads for stock *i* over day *t*. Data sources include TAQ, Nastraq, and NASDAQ TotalView Itch for May and June 2004 and 2010.

	2004		2010	
Segment	**Standardized Spread**	**Marker Maker Participation**	**Standardized Spread**	**Marker Maker Participation**
1	2.01	81.9%	2.78	20.5%
2	0.70	82.5%	0.79	20.1%
3	0.40	83.0%	0.48	19.8%
4	0.26	83.1%	0.28	19.8%
5	0.14	83.2%	0.17	22.6%
6	0.08	83.3%	0.09	22.6%
7	0.01	83.4%	0.04	22.2%
8	-0.01	83.6%	-0.02	21.9%
9	-0.03	84.0%	-0.07	22.1%
10	-0.03	83.9%	-0.11	22.3%
11	-0.09	83.9%	-0.13	22.2%
12	-0.10	84.1%	-0.17	22.3%
13	-0.16	84.2%	-0.19	22.0%
14	-0.18	84.1%	-0.21	22.0%
15	-0.21	84.1%	-0.23	23.2%
16	-0.22	84.5%	-0.25	23.2%
17	-0.25	84.6%	-0.27	22.9%
18	-0.24	84.3%	-0.30	23.0%
19	-0.26	84.2%	-0.32	22.0%
20	-0.23	84.3%	-0.33	21.6%
21	-0.26	84.3%	-0.37	21.5%
22	-0.28	84.1%	-0.34	21.3%
23	-0.30	84.3%	-0.37	20.8%
24	-0.34	84.4%	-0.40	20.4%
25	-0.35	84.5%	-0.47	19.6%
26	-0.21	84.2%	-0.58	18.8%

Table VII: Intraday variations in bid-ask spread and Market Maker Participation

This table reports regression analysis for the following two models:

$$\text{StdSpread}_{i,t,j} = \beta_1 \text{Segment}_j + \beta_2 \text{Return Volit}_{i,t,j} + \beta_3 \text{Num Trades}_{i,t,j} + \varepsilon_{i,t,j}$$

$$\text{StdSpread}_{i,t,j} = \beta_1 \text{Segment}_j + \beta_2 \text{PercentInside}_{i,t,j} + \beta_3 \text{Return Volit}_{i,t,j} + \beta_4 \text{Num Trades}_{i,t,j} + \varepsilon_{i,t,j}$$

where $\text{StdSpread}_{i,t,j}$ is the standardized spread for stock i on day t in segment j. Segment_j is a vector of dummy variables for each of the 26 15-minute segments. $\text{PercentInside}_{i,t,j}$ is a vector of market maker participation variables. Market maker participation is computed as the percentage of time that market makers are at either the inside bid or ask price for stock i on day t in segment j. $\text{Return Volit}_{i,t,j}$is the standard deviation of trade-to-trade returns for stock i on day t in segment j. $\text{Num Trades}_{i,t,j}$ is the number of trades which execute for stock i on day t in segment j. For brevity we report only indicator variables for each of the 26 15min intraday segments in Panel A. In panel B we report only *PercentInside* intraday segment variables. Data sources include TAQ, Nastraq, and NASDAQ TotalView Itch from May and June 2004 and 2010. We exclude t-stats for brevity. *,**,*** Statistically significant at the 10%, 5%, and 1% level respectively

Panel A: Model (3)

	2004	2010
Seg_1	1.9813***	2.9436***
Seg_2	0.6460***	0.7498***
Seg_3	0.3128***	0.4415***
Seg_4	0.1664***	0.2265***
Seg_5	0.0260***	0.1321***
Seg_6	-0.0296***	0.0518***
Seg_7	-0.1117***	0.0039
Seg_8	-0.1258***	-0.0570***
Seg_9	-0.1508***	-0.1061***
Seg_10	-0.1477***	-0.1522***
Seg_11	-0.1980***	-0.1632***
Seg_12	-0.2056***	-0.2118***
Seg_13	-0.2705***	-0.2256***
Seg_14	-0.2848***	-0.2409***
Seg_15	-0.3307***	-0.2625***
Seg_16	-0.3339***	-0.2783***
Seg_17	-0.3657***	-0.3001***
Seg_18	-0.3442***	-0.3246***
Seg_19	-0.3614***	-0.3429***
Seg_20	-0.3095***	-0.3535***
Seg_21	-0.3507***	-0.3888***
Seg_22	-0.3573***	-0.3565***
Seg_23	-0.3849***	-0.3896***
Seg_24	-0.4399***	-0.4219***
Seg_25	-0.4534***	-0.4940***
Seg_26	-0.3127***	-0.6034***
Observations	1,959,162	1,682,289
R-squared	0.32	0.52
F test	32937	65674

Panel B: Model (4)		
	2004	**2010**
PercentInside_1	-0.1672***	-0.9451***
PercentInside_2	-0.0873***	-0.1025***
PercentInside_3	-0.1767***	-0.0795***
PercentInside_4	-0.1150***	-0.0238*
PercentInside_5	-0.1304***	-0.0752***
PercentInside_6	-0.1268***	-0.0545***
PercentInside_7	-0.1704***	-0.0193*
PercentInside_8	-0.1051***	-0.0193*
PercentInside_9	-0.1323***	-0.0025
PercentInside_10	-0.1630***	0.0019
PercentInside_11	-0.1190***	0.0086
PercentInside_12	-0.1118***	0.0485***
PercentInside_13	-0.1422***	0.0661***
PercentInside_14	-0.0856***	0.0500***
PercentInside_15	-0.1009***	0.0717***
PercentInside_16	-0.1400***	0.0451***
PercentInside_17	-0.1366***	0.0569***
PercentInside_18	-0.0919***	0.0782***
PercentInside_19	-0.0741***	0.0872***
PercentInside_20	-0.0431***	0.0901***
PercentInside_21	-0.0795***	0.1054***
PercentInside_22	-0.0831***	0.1748***
PercentInside_23	-0.0801***	0.1842***
PercentInside_24	-0.1395***	0.1744***
PercentInside_25	-0.1883***	0.2395***
PercentInside_26	-0.0887***	0.2660***
Observations	1,959,162	1,682,289
R-squared	0.32	0.52
F test	17130	34401

Figure I: Market Maker Behavior and Stock Trading Activity
This figure plots mean percentage of the trading day that NASDAQ market makers quote at the NBBO across stocks with different levels of trading activity. We form activity quartiles for both sample periods based on trading activity with Activity Q1 consisting of stocks with the lowest number of average daily trades and Activity Q4 consisting of stocks with the largest number of average daily trades Sample stocks include all NASDAQ listed firms. Data sources include TAQ, Nastraq, and NASDAQ TotalView Itch for May and June 2004 and 2010..

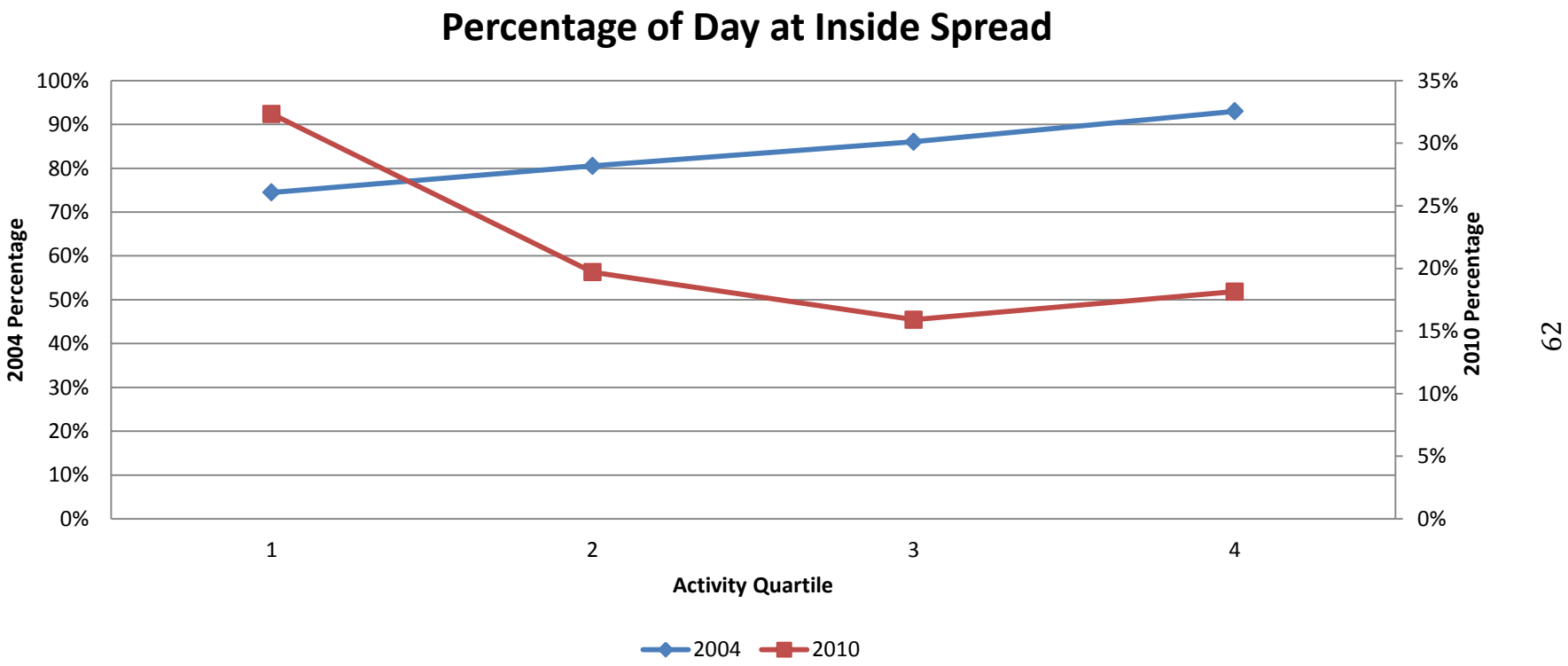
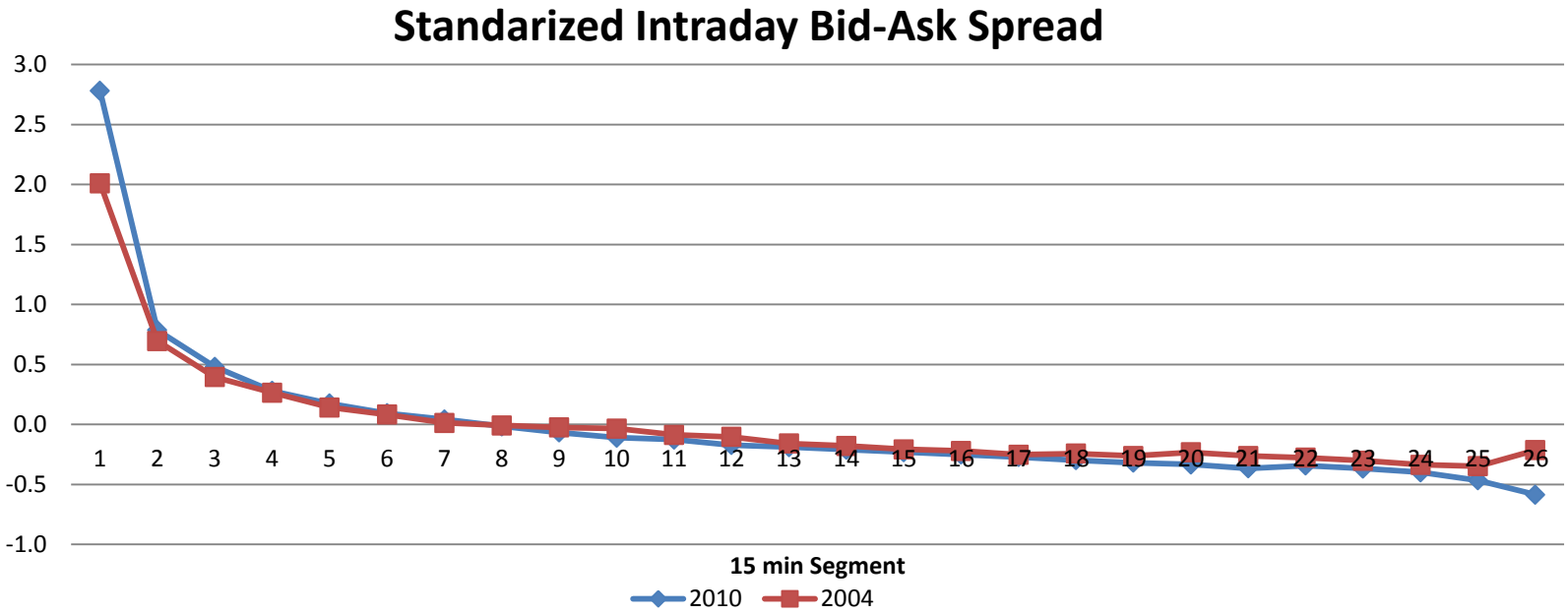
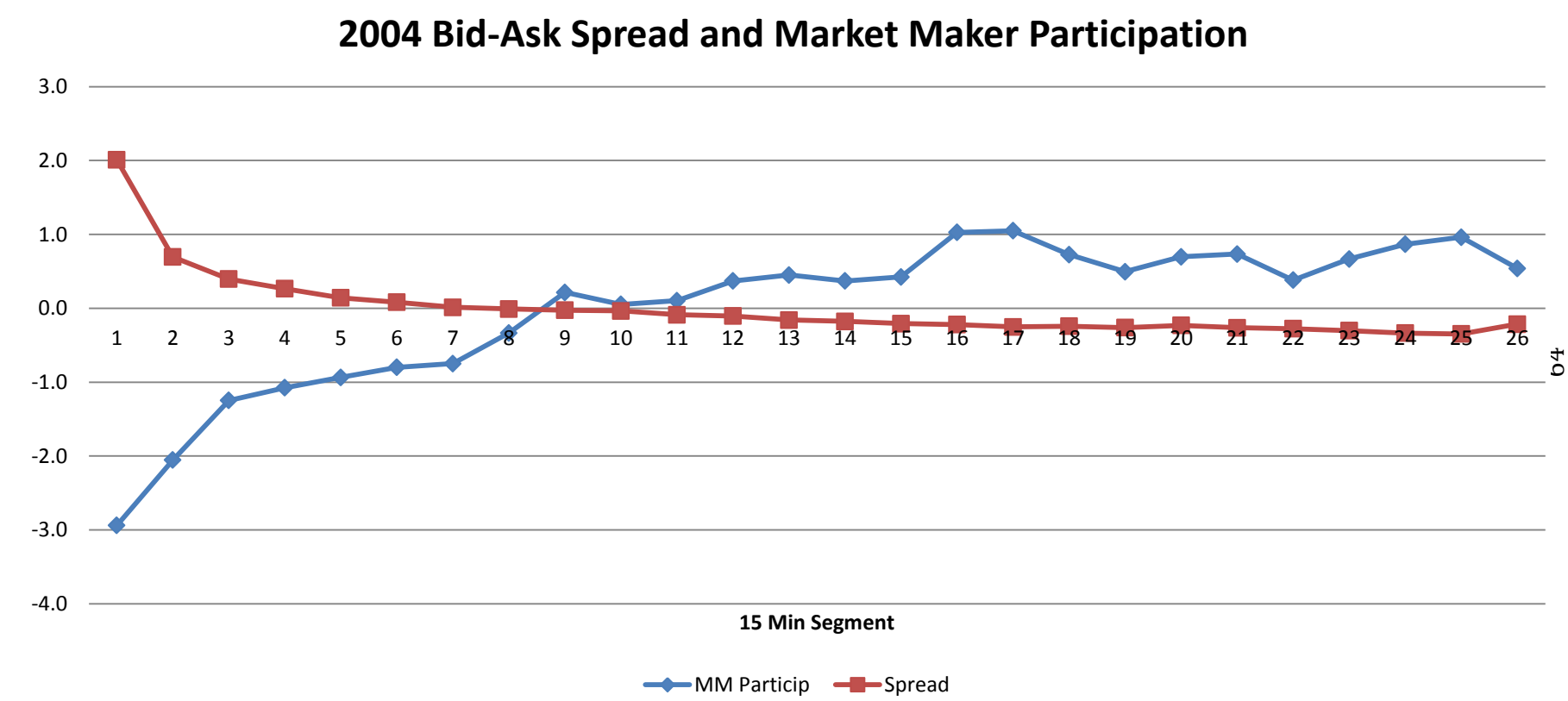
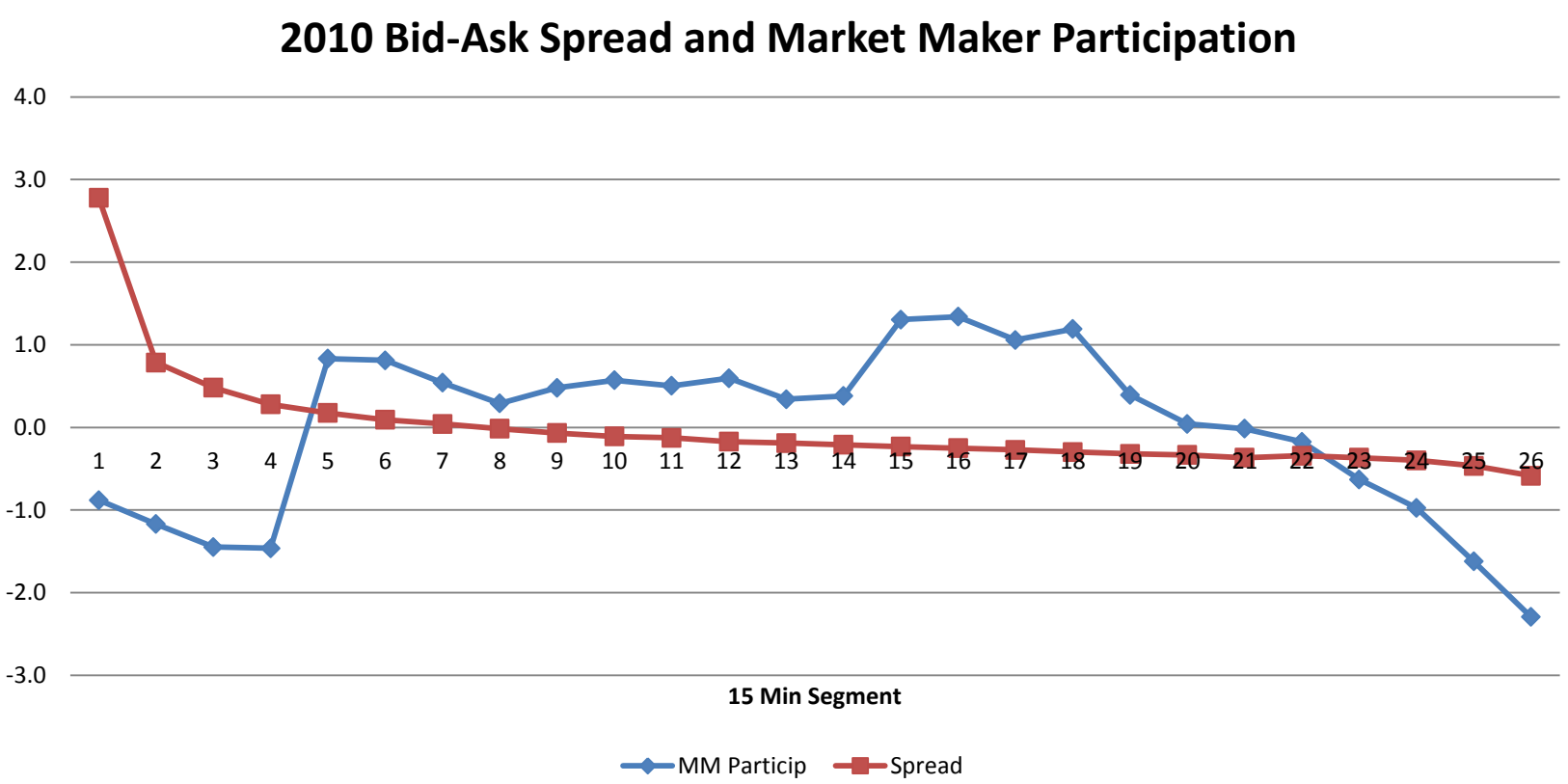


Figure II: Intraday Market Maker Behavior

This figure plots intraday variations in mean standardized bid-ask spread and the standardized intraday quoting behavior of NASDAQ market makers quotes at the NBBO. Market maker participation is the percentage of time that dealers are at the bid or ask quote during each 15-minute segment. Standardized intraday spread is computed as $(s_{i,t,j}-m_{i,t})/sd_{i,t}$ where $s_{i,t,j}$ is the bid-ask spread for stock *i* on day *t,* in each 15 minute intraday trading segment *j*, m is the mean spread for the trading day for stock *i* on day *t*, and $sd_{i,t}$ is the standard deviation in spreads for stock *i* over day *t*. Market maker participation is standardized in similar fashion. Sample stocks include all NASDAQ listed firms. Data sources include TAQ, Nastraq, and NASDAQ TotalView Itch for May and June 2004 and 2010.




2004 Bid-Ask Spread and Market Maker Participation
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
15 Min Segment
MM Particip
Spread


2010 Bid-Ask Spread and Market Maker Participation
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
15 Min Segment
MM Particip
Spread

ESSAY 3: Dealers in Times of Distress: The Case of Stub Quoting

3.1. Introduction

Prior research shows that market makers play an important role in providing liquidity in times of heightened price volatility and adverse selection (Corwin and Lipson, 2000; Goldstein and Kavajecz, 2004; Barclay, Hendershott, and Jones, 2008, Chung and Kim, 2009). Findings of these studies suggest that, despite the proliferation of non-intermediated electronic trading venues, market structures with market makers are viable. The intermediated market structure appears to increase in importance during periods of elevated uncertainty.

This study contributes by examining the liquidity providing behavior of market makers around two changes in dealer obligations. For one, we examine the prevalence of NASDAQ dealer "stub quoting" in the period surrounding the relaxation of NASDAQ trading rule 4613 in November of 2007, which required NASDAQ market makers to place two-sided quotes that must be "reasonably related" to the current best bid and offer.[13] Second, we examine the quoting behavior of NASDAQ market makers surrounding the SEC ban on stub quoting in December 2010, which required market makers to quote within 8% of the national best bid and offer price (NBBO).

Examining the behavior of NASDAQ market makers surrounding these events provides two natural experiments with which to gain insight in the role NASDAQ dealers play during times of changing quoting obligations. The first period represents a time of

[13] "Stub quoting" is a practice in which market markers place a bid or offer that is drastically different that the prevailing price. For example, suppose a stock is trading at $50, a market maker may place a stub bid at 1 cent or a stub offer at $1000.

diminished obligations of dealers to provide liquidity. In the second period, SEC regulation extends the obligations of NASDAQ market makers.

We address two issues in this study. We study marker makers liquidity providing behavior when required to place two-sided quotes at reasonably related prices. We also explore if the option for market makers to place quotes at prices not reasonably related to the NBBO changes market maker behavior during volatile periods.

We find evidence in both the 2007 and 2010 rule change periods that placing restrictions on stub quoting alters market makers' liquidity providing behaviors. Stub quoting restrictions increase the time that market makers quote at the NBBO. We also find evidence that stub quoting restrictions increase the percentage of daily volume which executes through market makers. However, we find little evidence that stub quoting rules impact the participation of market makers during days with excessive volatility.

The remainder of the paper is structured as follows. Section 2 discusses background literature and develops hypothesizes. Section 3 describes the data to be used in the study. Section 4 sets forth our results and Section 5 concludes.

3.2 Background and Hypothesis

2.1 Stub Quotes and NASDAQ

In August 2007 NASDAQ requested permission from the Securities and Exchange Commission to amend its Rule 4613 to eliminate the requirement that NASDAQ dealer quotes be "reasonably related to the prevailing market" (Staff, 2007). The rule amendment permits NASDAQ market makers, who are required to quote both sides of the market, to "step away" from providing liquidity or post competitive quotes on only one side of the

market. The practice of placing a quote far away from prevailing market quotes is termed stub quoting. At the time of the request, NASDAQ maintained that permitting market makers to stub quote would not adversely affect market conditions (Staff, 2007).[14]

In the wake of the May 6, 2010 "flash crash", in which the Dow Jones Industrial Average fell 700 points in a few minutes, the practice of stub quoting received renewed attention. According to the CFTC-SEC Preliminary Report to the Joint Advisory Committee on Emerging Regulatory Issues, short sales against stub quotes accounted for more than 70% of the busted trades between 2:45pm and 2:50pm, and 90% between 2:50pm and 2:55pm on May 6, 2010. Trades against stub quotes, which were not intended to execute, became a significant factor in the large price swings that occurred during the crash.

In response to the events of May 6, 2010 the Securities and Exchange Commission instituted a ban on stub quoting (SEC, 2010B). The new ban became effective on December 6, 2010 and included several provisions. For securities subject to the circuit breaker pilot program, which includes stocks in the S&P 500, Russell 1000 as well as some other exchange-traded products, market makers must enter quotes that are no more than 8% away from the National Market System Best Bid and Offer (NBBO) with the exception of periods near the open and close of the trading day. During periods near the open and close of trading, market makers must enter quotes no more than 20% away from the NBBO. Market makers must post quotes that are no more than 30% away from the NBBO for listed equities that are not in the circuit breaker pilot program. The rule permits a market maker's quote to "drift" an additional 1.5% away from the NBBO before a new quote within

[14] The official SEC announcement of the 2007 change to NASDAQ trading rule 4613 is included in Appendix I.

the applicable band (within 8% for pilot stocks and within 30% for non-pilot stocks) must be entered.[15]

In the SEC press release 2010-216 SEC Chairwoman Mary Schapiro stated, of the ban on stub quoting, "By prohibiting stub quotes, we are reducing the risk that trades will be executed at irrational prices, and then need to be broken, if the markets become volatile. While we continue to look at other potential obligations for market participants, this is an important step in our effort to improve the functioning of the U.S. markets, and restore investor confidence following the events of May 6" (SEC, 2010B).

Figure I includes outlines of both the 2007 NASDAQ modification to trading rule 4613 and the SEC stub quote rule implementation in 2010. The NASDAQ change to rule 4613 is a reduction in the quoting obligations of market makers, which has the potential to alter the liquidity market makers provide. The SEC rule enacted in December 2010, which bans sub quoting is an expansion of market maker quoting obligations and could also impact the liquidity providing behavior of market makers. We examine the impact the two rule changes have on the amount of liquidity provided by market makers by testing the following hypotheses:

H1: The percentage of time that dealer quotes are at the inside spread and the amount of trading volume executed through market makers decreases in the period after NASDAQ changed trading rule 4613.

H2: The percentage of time that dealer quotes are at the inside spread and the amount of trading volume executed through market makers increases in the period after the SEC imposed restrictions on stub quoting.

[15] Appendix II is a copy of the official SEC press release outlining the 2010 stub quoting rule.

[Insert Figure I Here]

3.2.2 Market maker behavior in times of heightened volatility

A second issue we address in the current study is if the option for market makers to place quotes at prices not reasonably related to the NBBO changes market maker behavior during volatile periods. Research shows that designated market makers play an important role in times of low liquidity, excessive price uncertainty, and adverse selection risk. Mahhaven and Sofianos (1998) examine the determinants of NYSE specialist trading, and find that specialists are more likely to trade in times of low activity and when internal and external competition is low. Their results suggest that the participation of specialists in trading increases when liquidity is low. Consistent with Mahhaven and Sofianos, Chung, Van Ness, Van Ness (1999) show that specialists are more likely to provide liquidity when limit order book spreads are wide.

The behavior of market makers surrounding periods of heightened volatility and uncertainty is also documented. Corwin and Lipson (2000) study order flow and liquidity around trading halts on the NYSE, which are triggered in response to large imbalances between buy and sell orders. The authors find that, prior to halts, the specialist widens or "spreads the quote" to convey information about the imbalance. They also find that the specialist and floor traders provide a significant amount of liquidity during these periods of uncertainty.

Goldstein and Kavajecz (2004) look at the behavior of NYSE traders during a period of high volatility in October 1997 that triggered a circuit breaker. The authors show that, during this period of extreme market movement, the cost of providing liquidity via the electronic limit order book increases and a dramatic amount of liquidity shifts to the floor of the NYSE. These results are consistent with the theoretical predictions of Grossman (1992) who predicts that markets become increasing valuable in times of heightened uncertainty. Lyons (2001) shows that foreign exchange traders favor the direct dealer market over the electronic broker market in times of uncertainty.

There is also evidence that NASDAQ market makers supply liquidity during high volatility days. Li, McCormick, and Zhao (2005) examine the liquidity providing behavior of NASDAQ dealers during the 2000 bubble burst of NASDAQ internet stocks. The authors find that NASDAQ dealers provide liquidity during periods of large price movements and order imbalances.

Chung and Kim (2009) compare the specialist system of the New York Stock Exchange (NYSE) to the dealer market structure of NASDAQ to determine which structure is better suited to provide liquidity in time of heightened volatility. The authors find evidence that the NYSE specialist system is better able to provide liquidity in times of high volatility relative to the dealer system of NASDAQ. The authors attribute this finding to the greater responsibility to provide liquidity placed on the designated market maker of NYSE. We anticipate that that the diminishing responsibility of NASDAQ market makers, being allowed to place stub quotes, will further decrease dealers' incentives to provide liquidity in time of rapid price movements.

Given the important role a market maker plays in times of elevated uncertainty, as documented in the aforementioned literature, we test if rules that alter the obligation of market makers to quote near the inside spread impacts the amount of liquidity market makers provide in volatile periods. We propose the following two hypotheses:

H3: The percentage of time that dealer quotes are at the inside spread, and the amount of trading volume executed through market makers decreases in times of high volatility in the period after NASDAQ changed trading rule 4613.

H4: The percentage of time that dealer quotes are at the inside spread, and the amount of trading volume executed through market makers increases in times of high volatility in the period after the SEC imposed restrictions on stub quoting.

3.3 Data

We use NASDAQ OMX TotalView-Itch data, which includes information about orders and executions on the NASDAQ system. These data are detailed and include submissions, cancelations, and executions of displayed orders and non-displayed orders. We use the market participant identification (MPID) field to uniquely identify market participants. We then cross-reference MPIDs against a list of NASDAQ market participants to identify orders submitted by registered market makers.

Because our study focuses on the behavior of NASDAQ dealers, we limit our sample to stocks listed on the NASDAQ stock exchange. We exclude stocks that have an average price less than $3. To further minimize data errors we exclude quotes that occur before the open (9:30am) and after the close (4:00pm), quotes in which the bid price is greater than the ask price, quotes where the bid or ask price are less than zero, and quotes where the

bid or ask size is less than or equal to zero. These filters yield a sample size of 2,635 stocks in the 2007 period and 2,132 in the 2010 period.

We focus on two time periods in our examination of NASDAQ dealers stub quoting and liquidity providing behavior. The first period is the one month window immediately surrounding the relaxation of Rule 4613 on November 7, 2007, which requires NASDAQ market makers to place two-sided quotes "reasonably related" to the current best bid and offer. The second period comprises the one month period surrounding to the SEC ban on stub quoting beginning December 6, 2010. A timeline of the two periods examined is included in figure II.[16]

[Insert Figure II Here]

Table I displays summary statistics for sample firms. *Price* is the mean stock price during the study period. *Inside Spread* is the average difference between the lowest ask and the highest bid. *P. Spread* is the inside spread scaled by the quote midpoint. *Bid Depth* (*Ask Depth*) is the average number of shares quoted at the highest bid (lowest ask). *Eff. Spread* is the absolute value of the trade price minus the prevailing midpoint. *Return Volit* is the intraday trade-to-trade return standard deviation. *Volume* is the mean number of shares executed per day. *$Volume* is the total market value of shares executed for a sample firm per trading day. *Num. Trades* the number of daily transactions for a sample stock.

Table I Panel B reports difference in trading statistics around rule changes for both the 2007 and 2010 time periods. The columns labeled "Restrict" contain trading and

[16] The primary reason we limit are sample period to one month windows surrounding the effective date of both rule changes is due to the computational requirement of the NASDAQ OMX TotalView Itch data.

quoting statistics for the periods where stub quoting rules are in effect. In 2007, the "Restrict" period is the 10 trading days preceding November 7, 2007 before the relaxation of rule 4613 became effective. The "Restrict" period for 2010 is the 10-trading-days following the December 6, 2010 enactment of the SEC's stub quoting rule. The columns labeled "Un-restrict" report means for the periods where market maker stub-quoting is permitted. Specifically, the 2007 Un-restrict sample is the 10-trading-day period starting November 7, 2007. The 2010 Un-restrict period is the 10-trading-days preceding December 6, 2007.

We compare the changes in trading and quoting variables surrounding rule changes With the exception of *P. Spread* all trading and quoting statistics do not change significantly from the Restrict to Un-Restrict time periods, suggesting that the rules had little effect on spreads or trading activity. As quoting and trading do not change appreciably, our task of comparing market maker behavior surrounding these rule changes is more straightforward and less likely to be driven by exogenous market factors.

[Insert Table I Here]

3.4 Results

3.4.1 Stub Quoting

To identify NASDAQ market maker stub quotes we compare market makers' quotes to the prevailing national market system (NMS) highest bid and lowest ask (NBBO) [17] using

[17] We use NYSE trade and quote data (TAQ) to compute the NBBO.

the following method. We identify buy and sell orders submitted by registered market makers using the NASDAQ TotalView Itch data. Next, we generate an intraday series of quotes for each market maker using information on market maker order submission, cancelation, and executions. Then, we compare market makers quotes to the NBBO to determine the distance between market maker's quote and the NBBO on both the bid and ask side. We use the distance from the market maker's quote to the NBBO to determine if the quote is a stub quote.

One criticism of NASDAQs restriction on stub quoting prior to November 2007 was that a stub quote was not well defined. The rule required that market maker post quotes that are "reasonably related" to the prevailing market. Due to this ambiguity, we use three separate definitions for a stub quote in the 2007 period. We use the 8% rule as our first definition of a stub quote. If a market maker quote is between 9:45am and 3:35pm and is more than 8% percent away from the NBBO then we classify the quote as stub quote. If the quote occurs near the open or close (before 9:45am and after 3:35pm) then the market maker's quote can be up to 20% away from the prevailing inside bid and offer before the quote is classified stub quote. We use the 8% rule with 20% at the open and close as our first method of stub quote classification (*Stub Quote 8*) because this is commonly accepted definition of a stub quote as defined by the SEC (SEC 2010 B).

We also use a 20% and a 30% rule in the 2007 period to define stub quotes (*Stub Quote 20* and *Stub Quote 30* respectively). A quote is classified as *Stub Quote 20* (*Stub Quote 30*) if the distance the maker maker's quote is from the NBBO is greater than 20% (30%) of the bid or ask price.

We use the definitions of stub quotes as set forth by SEC to identify sub quotes in the 2010 period. The SEC stub quoting rule establishes different requirements for the distance within which market makers must quote from the NBBO, which vary depending on the security that the market maker is quoting. Specifically, the SEC defines stub quotes for securities in the circuit breaker pilot program as market maker quotes submitted between 9:45am and 3:35pm that are more than 8% away from the NBBO. Quotes for stocks in the pilot program submitted before 9:45am and after 3:35pm are allowed to be 20% away from the NBBO before being classified as a stub quote.[18] Market maker quotes that are more than 30% away from the inside bid or ask price are classified as stub quotes for securities not in the circuit breaker pilot program.

We divide the number of stub quotes per day by the total number of market maker quotes that day to determine the percentage of dealer quotes that are stubbed. Table II Panel A reports the frequency with which market makers stub quote around the 2007 NASDAQ trading rule change. We report the percentage of market maker quotes that are stub quotes for the 10-day period prior to the relaxation of trading rule 4613 ("Restrict") and the 10-day trading period following ("Un-restrict"). Note that we observe evidence of stub quoting during the period when stub quoting is prohibited. One likely reason for this observation is that the language of trading rule 4613 was ambiguous. The rule required that market makers post quotes that are "reasonably related" to the prevailing market and did not explicitly define "reasonably related".

[18] In the aftermath of the May 6, 2010 flash crash, the SEC enacted a stock-by-stock circuit breaker program that halts trading in specific securities after the stock falls in price by a predetermined amount. During the months examined in the our study (November and December 2010), securities in the circuit breaker pilot program include all stock in the S&P 500, Russell 1000, and a list of other exchange traded products (see SEC, 2010A).

In the 2007 sample we observe that 17.5% (13.5%, 12%) of market maker quotes were *Stub Quotes 8* (*Stub Quotes 20*, *Stub Quotes 30*) prior to the rule change on November 7, 2007. After the rule change, the rate of dealer stub quotes increases to 21.5% for *Stub Quotes 8*, which is a 23% increase. *Stub Quotes 20* and *Stub Quotes 30* also increase when the restriction on stub quoting is lifted, rising 4.2% and 4%, respectively. We observe similar patterns of increasing market maker stub quoting for quotes where only the bid is stubbed (Stub Bid) or only the ask side of the quote is stubbed (Stub Ask).

We also observe decreases in stub quoting subsequent to the SEC enactment of stub quoting rules in the 2010 sample. Stub quoting for the all stock sample declines from a pre-rule rate of 13.7% to a post-rule level of 8.4%, a 38% decline. For stocks in the SEC circuit breaker pilot program, stub quoting declines from 26% to 10.8%, which is a 58% decline after the enactment of the rule. For non-pilot stocks, the rate of stub quoting declines to 4.1%, which is a 34% decrease from the period preceding the SEC stub quote rule. Similar declines are observed in one-sided stub quotes (stubbed only on the bid or ask side) after the implementation of the SEC stub quoting rules.

[Insert Table II Here]

The level of stub quoting is likely to change based on market and stock characteristics including the width of the bid-ask spread, risk, activity, and the number of market makers participating. Spreads are likely to be negatively related to the level of stub quoting. Chen and Zhao (2004) show that large spreads provide higher potential profits to

market makers and document an increase in the competitiveness of dealer quotes when spreads are wider.

We expect that risk will be positively correlated with the level of stub quoting. Increased uncertainty about a security is likely prompt market makers to step away from their liquidity providing roles. Chen and Zhao (2004) also document that dealer quotes become less competitive in periods of heightened volatility. We anticipate increased trading activity will lead to a decrease in stub quoting. Prior studies show that inventory and order processing costs are higher for low activity stocks (Stoll, 1978). Hence, dealer stub quoting is likely to be lower for stocks with higher activity because dealers face less inventory and order processing costs. Chen and Zhao (2004) observe the percentage of dealer quotes that are competitive increases with the number of daily transactions. Additionally, a large number of liquidity demanding trades may increase the NBBO (i.e. walking up or down the book) and lead to a decrease in the amount of stub quotes.

Market maker quotes become less competitive as the number of market makers increases (Chen and Zhao, 2004). Therefore, we expect a positive correlation between the number of market makers and the level of stub quoting. We relate firm characteristics and quote regulatory environments to stub quoting by estimating the following model:

$$Stubquote_{i,t} = \beta_0 + \beta_1 Price_{i,t} + \beta_2 Spread_{i,t} + \beta_3 Return\ Volit_{i,t} + \beta_4 Num\ Trades_{i,t} + \beta_5 Restrict_t + \beta_6 Num\ MM_{i,t} + \varepsilon_{i,t}$$

Where $Stubquote_{i,t}$ is the percentage of market maker quotes that are stub quotes for stock *i* on day *t.* $Price_{i,t}$is the mean intraday stock price. $Spread_{i,t}$ is the average

difference between the lowest ask and the highest bid for stock *i* during trading day *t*. $Volitility_{i,t}$ is the intraday trade-to-trade return standard deviation for stock *i* on day *t*. $Volitility$ is included in the regression models as a proxy for risk. $Num.Trades_{i,t}$ is they daily number of transactions for sample stock *i* on day *t* and is used as a proxy for activity. $Restrict_t$ is a variable that is equal to 1 for periods that have stub quoting restrictions and 0 when stub quoting is permitted. $Num\ MM_{i,t}$ is the number of market makers that update their quotes at least five times in a trading day.

Table III reports the output from the regression analysis. In this regression and all subsequent regression analyses we include firm fixed effects and report t-statistics based on cluster corrected standard errors. We observe that price is negatively related to the rate of stub quoting in both the 2007 and 2010 periods. A $1 increase in stock price decreases the amount of stub quoting by an average 0.1% in the 2007 period. In 2010, the decrease is 0.2% on average for each $1 stock price increase. The finding that price is negatively related to the level of stub quoting may be attributable to the increase in the absolute dollar amount that dealer quotes can be away from the inside spread for stocks with higher prices.[19]

Spread is also negatively correlated with the level of stub quoting, suggesting that market makers decrease the distance their quotes are away from the NBBO as spreads widen. This finding is consistent with market maker quoting behavior documented by Chen and Zhao (2004), who show that market makers quote more competitively when

[19] For example, if the inside ask price is $10 and the maximum distance a quote can be away from the NBBO is 8%, then the market maker quote can be no more than $0.80 higher than the inside ask. For a stock with an ask price of $100 and the same 8% quoting requirement, the market maker can quote up to $8 above the ask price.

spreads are wider due to the increase in potential liquidity providing profits with larger spreads.

With the exception of pilot stocks in the 2010 period, return volatility is positively related to the level of stub quoting. These positive coefficients suggest that, in times of heightened price movement, market makers increase the rate at which they remove themselves from liquidity providing roles. The coefficients of the *Restrict* dummy variables are negative. These negative coefficients are consistent with our analysis reported in table II that stub quoting decreases when rules go into effect restricting the practice.

The coefficients for the number of market makers in the 2007 period are mixed. The coefficient on *Num MM* suggests in the *Stub Quotes 8* that additional market makers increase the rate of stub quoting. The positive coefficient is consistent with the finding of Chung and Zhao (2004), who show that market maker quotes become less competitive as the number of market makers increases. The opposite result is observed for Stub Quotes 30. However, the magnitude of each additional market maker decreases the amount of stub quoting by 0.06% in the case the *Stub Quotes 30*.

The number of market makers and stub quoting are negatively related for the all stocks and non-pilot stocks samples in the 2010 period. However, like the 2007 regression, the magnitude of the coefficient of *Num MM* in the all stocks regression is relatively small with each additional market maker decreasing stub quoting by an average of 0.2%.

[Insert Table III Here]

3.4.2 Market Maker Participation: Test of Hypothesis 1 and 2

A goal of the current study is to examine the liquidity providing behavior NASDAQ market makers around the rule changes outlined in section 2.1. To this end, after identifying individual market makers' quotes for each stock, we identify market marker quotes with the highest bid and lowest ask to generate an intraday market maker best bid and offer (mmBBO). We then compare the mmBBO to the NMS highest bid and lowest ask (NBBO). If the bid or ask price of the mmBBO is equal to the inside bid or ask price of the NBBO at the same time and for the same stock, we classify the mmBBO to being as *At Bid* or *At Ask,* respectively. We classify the mmBBO as being *At Both* for periods when the bid and ask prices of the mmBBO and NBBO are both equal. We also examine the number of shares at the inside quote for both market makers and other participants in the NMS. The mmBBO is classified as being *Alone Bid* (*Alone Ask*) if market maker quotes make up all shares available at the NBBO bid (ask) price. Similarly, we indicate the mmBBO is *Alone Both* if the mmBBO is equal to the NBBO for both bid and ask prices and quantities. Finally, if neither the bid or ask prices of the mmBBO is equal to the NBBO, the mmBBO is classified as *At Neither*.

We divide the number of seconds during the trading day (9:30am-4:00pm) that marker makers quote at the inside by the total number of seconds in a trading day to obtain percentage of the trading day that market makers are *At Bid, At Ask, At Both, Alone Bid, Alone Ask, Alone Both*, or *At Neither*. [20]

[20] Note that the mmBBO quote classifications are not mutually exclusive. For example, if the mmBBO and NBBO ask price and size were both equal to $10 and 200 shares then the mmBBO would be classified as being both *At Ask* and *Alone Ask*.

Table IV reports how often market makers quote at the NBBO around both rule changes. In 2007, the percentage of time that market makers quote at the inside bid and offer decrease in the period after trading rule 4613 is altered, removing the requirement that market makers post quotes that are reasonably close to the prevailing market. The time market makers quote at the inside bid decreases by 2.1% after stub quotes were permitted, a 10% decline. The decline is 2.5% for the time market makers quote at the inside ask price, a 12% reduction. The finding that the percentage of time market makers spend at the inside quote declines after NASDAQ relaxes trading rule 4613 is consistent with hypothesis 1, which predicts the percentage of time that dealer quotes are at the inside spread decreases in the period after the NASDAQ rule change.

In 2010, we observe an increase in the time market makers are at the inside quote following the SEC implementation of stub quoting rules. For all stocks, we find a 2.1% (1.7%) increase market maker time *At Bid* (*At Ask*), a 12% (12%) increase. Consistent with the prediction of hypothesis 2, regression results reported in this table suggest that SEC stub quoting rule increases the percent of time that market makers quote at the inside bid and offer prices. [21]

[Insert Table IV Here]

Studies show that NASDAQ market maker liquidity providing behavior varies systemically based on market conditions and stock characteristics. Chung and Zhao (2004)

[21] While it is possible that NASDAQ dealers altered their quoting behavior to reflect new rule changes prior to the effective date of the rule, doing so would bias us away from finding any difference in market maker behavior surrounding rule changes.

examine cross-sectional variations in NASDAQ market maker inside quoting behavior and find that dealer quoting patterns are consistent with profit maximizing behavior. Chung and Zhao show that dealers are more likely to quote at the inside when opportunities for market making revenues are greater, including when stocks spreads are large, there are fewer market makers, and there is more frequent trading. Market makers avoid quoting at the inside when stocks have heightened volatility. We further explore the behavior of market makers during periods of increased quoting obligations and test hypothesis 1 and 2 by estimating the following models, which control for cross-sectional variations in stock characteristics shown to impact dealer quoting and trading behavior:

$$AtInside_{i,t}=\beta_0+\beta_1 Price_{i,t}+\beta_2 Spread_{i,t}+\beta_3 Return\ Volit_{i,t}+\ \beta_4 Num\ Trades_{i,t}\ +\ \beta_5 Restrict_t+\beta_6 Num\ MM_{i,t}+\beta_7 Stubquote_{i,t}+\varepsilon_{i,t}$$

$$PerVolume_{i,t}=\beta_0+\beta_1 Price_{i,t}+\beta_2 Spread_{i,t}+\beta_3 Return\ Volit_{i,t}+\ \beta_4 Num\ Trades_{i,t}\ +\ \beta_5 Restrict_t+\beta_6 Num\ MM_{i,t}\ +\beta_7 Stubquote_{i,t}+\varepsilon_{i,t}$$

where $AtInside_{i,t}$ is the proportion of time NASDAQ market makers quote at the NBBO. $PerVolume_{i,t}$ is the percentage of daily trading volume where NASDAQ market makers are on at least one side of the trade. $Price_{i,t}$ is the mean intraday stock price. $Spread_{i,t}$ is the average distance between lowest ask and the highest bid during the trading day. $Volitility_{i,t}$ is the intraday trade-to-trade return standard deviation. $Num.Trades_{i,t}$ is the daily number of transactions for sample stock *i* in time period *t*. $Restrict_t$is a variable that is equal to 1 for periods that have stub quoting restrictions and 0 when stub quoting is

permitted. $Num\ MM_{i,t}$ is the number of market makers that update their quotes at least five times in a trading day. $StubQuote_{i,t}$ is the percentage of NASDAQ dealer quotes that are stub quotes for stock *i* on day *t*. Due to the different requirements for dealers to quote near the inside spread around the SEC stub quoting rule implementation in the 2010 period, we estimate regressions models separately for pilot and non-pilot stocks.

Estimation results for market maker participation regressions are reported in table V. We observe that spread is positively related to the percentage of time market makers quote at the NBBO and the proportion of volume executed through market makers in the 2007 period. The positive coefficient on *Spread* suggests that market maker participate more when spreads are wider. This finding is consistent with that of Chen and Zhao (2004), who find that dealers quote at the inside when opportunities for market making revenues are greater, including when stocks spreads are large.

In 2007 we find that volatility is positively correlated with *AtInside* and *PerVolume*. The positive coefficient for V*olatility* in both the time at the inside and percentage of volume regressions suggests that market makers are more likely to quote at the inside and execute an increased proportion of volume on days with heightened volatility. This result is consistent with prior research outlined in section 2.2, that market makers play an important liquidity providing role during periods of increased uncertainty.

The number of actively participating market makers has a positive correlation with the time maker makers quote at the inside and the percentage of trading volume market makers execute. The positive coefficient of *Num MM* in the *AtInside* regression likely reflects that a stock with more dealers making a market, has an increased likelihood that at least one of them is quoting at the inside bid or offer.

Our two primary variables of interest in assessing the liquidity providing behavior of market makers around stub quote rule changes are *Stubquote* and *Restrict*. We observe that the percentage of dealer quotes that are stub quotes decreases both the amount of time that market makers quote at the inside and the percentage of volume that executes through market makers. We also observe that market makers quote more at the inside and execute a higher proportion of share volume during periods of stub quoting restriction. The coefficient of *Restict* for the 2007 period suggests that, during the period when stub quoting is restricted, market makers spend an average of 4%, or roughly 16 minutes more, of the trading day at the NBBO and execute an average of 1.4%, or 11,304, more shares for the average sample stock. The findings that the percentage of time market makers spend at the inside quote and the amount of volume market makers executes declines after NASDAQ relaxed trading rule 4613 is consistent with hypothesis 1.

Results from the Time At Inside regressions in 2010 period are consistent with the regression results for the period around the 2007 NASDAQ rule change. The percentage of dealer quotes that are stub quotes decreases the amount of time that market makers quote at the NBBO. Also, during the period after the SEC implements stub quoting restrictions, market makers quote an increasing percentage of time at the inside quote. However, we find limited evidence that the percentage of trading volume which executes through market makers is impacted by the SEC's stub quoting restriction in the 2010 period as the coefficient for *Restrict* is not significant. The regression results from the 2010 period provide only partial support for hypotheses 2. We find support for the hypothesis that the 2010 SEC ban on stub quoting increases the percentage of time market makers quote at the

NBBO, but do not find evidence to suggest that the percentage of trading volume executed by market makers increases as a result of the SEC stub quoting rule.

[Insert Table V Here]

3.4.3 Market Maker Participation During Times of High Volatility: Test of Hypothesis 3 and 4

Prior research shows that maker makers play an important liquidity providing role in times of heightened price volatility as outlined in *section 2.2*. In this section we test hypothesis 3 and 4 by analyzing if changes in dealer obligations to quote near the NBBO alter their behavior during these periods of increased uncertainty.

We first identify days during our two sample periods when volatility is unusually high. We compute the mean intraday return volatility for each sample stock for rolling twenty day-windows. We classify a day as having high volatility if it exceeds its previous 20-day average volatility by three standard deviations. This classification procedure yields 1,556 high volatility stock days for the 2007 period and 945 high volatility days for the 2010 sample.

To test if market makers change their liquidity providing behavior, as a results of stub quoting restrictions during days with high volatility we estimate the following regression for stocks with at least one high volatility day during the sample period:

$$AtInside_{i,t}=\beta_0+\beta_1 Price_{i,t}+\beta_2 Spread_{i,t}+\beta_3 Return\ Volit_{i,t}+\ \beta_4 Num\ Trades_{i,t}\ +$$

$$\beta_5 Restrict_t+\beta_6 Num\ MM_{i,t}\ \beta_7 Stubquote_{i,t}+\beta_7\ HighVolDay_{i,t}+\beta_8 HighVolDay*Restrict_{i,t}+\varepsilon_{i,t}$$

$$PerVolume_{i,t}=\beta_0+\beta_1 Price_{i,t}+\beta_2 Spread_{i,t}+\beta_3 Return\ Volit_{i,t}+\ \beta_4 Num\ Trades_{i,t}\ +$$

$$\beta_5 Restrict_t+\beta_6 Num\ MM_{i,t}\ \beta_7 Stubquote_{i,t}+\beta_7\ HighVolDay_{i,t}+\beta_8 HighVolDay*Restrict_{i,t}+\varepsilon_{i,t}$$

where $\text{HighVolDay}_{i,t}$ is an indicator variable equal to 1 if the trading day for stock *i* has a level of price volatility that exceeds its previous 20-day average volatility by three standard deviations. $HighVolDay*Restrict_{i,t}$ is an indicator variable equal to one on stock days when which both *HighVolDay* and *Restrict* are equal to 1. Other variables are as previously defined.

Table VI reports estimation results. We observe a positive relation between days with high levels of volatility and the percentage of time market makers quote at the prevailing best bid and offer in the 2007 time period. However, inconsistent with the prediction of hypotheses 3, we find no evidence that dealer share of volume increases on days with high levels of volatility or on high volatility days when stub quoting rules are effective as the coefficients of *HighVolDay*Restrict* is negative.

We also find no evidence to support hypothesis 4 as the coefficients on both *HighVolDay* and *HighVolDay*Restrict* are not statistically significant in the 2010 period. Therefore, we find no evidence to suggest that NASDAQ market makers increase the amount of time they quote at the NBBO or their percentage of volume during stock days with high levels of volatility and stub in period with quoting restrictions.

[Insert Table VI Here]

3.5 Conclusion

We examine the liquidity providing behavior of NASDAQ dealers in the period around the relaxation of Rule 4613 on November 7, 2007, which required NASDAQ market makers to place two-sided quotes "reasonably related" to the current best bid and offer. We also examine the quoting and trading behavior of NASDAQ market makers surrounding the SEC ban on stub quoting on December 6, 2010, which requires that market makers quote within 8% of market prices for circuit breaker pilot stocks. Both the NASDAQ relation of Rule 4613 and the SEC stub quote ban represent changes in the obligations of market makers. The 2007 NASDAQ rule change is a time of decreasing responsibility for market makers. The 2010 SEC stub quote ban is a time of increasing obligations. These events provide two natural experiments with which to gain insight into the impact the changes in quoting obligations have on the roles of NASDAQ dealers.

We find evidence in both the 2007 and 2010 rule change periods that placing restrictions on stub quoting alters market makers' liquidity providing behavior. Stub quote restrictions increase the time that market makers quote at the NBBO. We find that stub quoting restrictions increase the percentage of daily volume which market makers execute in the 2007 period. Yet, we find little evidence that stub quoting rules impact the participation of market makers during days with excessive volatility.

Taken together, our results suggest that restrictions on stub quoting, which increase dealers' obligations to quote near the NBBO, may benefit financial markets in that it encourages dealers to provide liquidity.

Table I: Summary Statistics

Price is the mean stock price during the study period. *Inside spread* is the average distance between lowest ask and the highest bid. *P. spread* is the inside spread scaled by the quote midpoint. *Bid Depth* is the average number of shares quoted at the highest bid and lowest ask. *Eff. Spread* is the absolute value of the trade price minus the prevailing midpoint. *Return Volit.* is the intraday trade-to-trade return standard deviation. *Volume* is the mean number of shares executed per day. *$Volume* is the mean total market of shares executed for sample firms per trading day. Num. Trades the average daily number of transactions for sample stock. *Num MM* is the average number of market makers that participate in a stock each day. Restrict is the period when stub quoting rules are active. Un-restrict are periods when there is no restriction on marker maker stub quoting. The 2007 sample period is from October 21, 2007 through November 21 (20 trading days). The 2010 period is from November 19, 2010 through December 17, 2010 (20 trading days). Data sources include TAQ, and NASDAQ TotalView Itch.

*,**,*** Indicate statistically significance at the 10%, 5%, and 1% level respectively

Panel A:

	2007		**2010**	
	Mean	St. Dev	Mean	St. Dev
Price	20.45	23.56	20.20	26.15
Inside Spread	0.1591	0.28	0.1022	0.1831
P. Spread (%)	1.11	1.7	0.93	1.65
Bid Depth (100s)	17	121	48	627
Ask Depth (100s)	16	116	36	328
Eff Spread	0.0742	0.1002	0.0524	0.0882
Return Volit	0.1037	0.1727	0.1087	0.1732
Volume (*1000s)*	845	5,682	741	3,242
$Volume (*1000s)*	29,848	302,496	22,010	144,094
Num. Trades	2,985	10,562	2,974	8,706
Num MM	28	13	29	12
N	2635		2132	

Panel B:

	2007			**2010**		
	Restrict	**Un-restrict**	**Diff (R-UR)**	**Restrict**	**Un-restrict**	**Diff (R-UR)**
Price	21.02	19.93	1.09	20.60	19.84	0.75
Inside Spread	0.1564	0.1616	-0.0052	0.0983	0.1062	-0.0079
P. Spread (%)	1.05	1.16	-0.10**	0.88	0.98	-0.10**
Bid Depth (100s)	18	15	3	43	51	-2
Ask Depth (100s)	16	15	1	34	37	-3
Eff Spread	0.0748	0.0735	0.0013	0.0521	0.0528	-0.0007
Return Volit	0.1052	0.1017	0.0034	0.1030	0.1141	-0.0111*
Volume (*1000s)*	810	883	-73	771	714	57
$Volume (*1000s)*	28,560	31,222	-2662	22,908	21,203	1,704
Num. Trades	2,862	3,119	-256	3,051	2,914	137

Table II: Stub Quotes

Table reports percentage of market maker marker quotes that are stub quotes. *Stub Quotes 8* is the percentage of market maker quotes that are at least 8% away from the prevailing NBBO from 9:45am-3:35pm and more than 20% away from the NBBO for the period near the open and close of trading (prior to 9:45am and after 3:35pm). *Stub Quotes 20* (*Stub Quote 30*) is the percentage of market maker quotes that are 20% (30%) away from the prevailing NBBO. Stub Bid 8, 20, and 30 are the percentage of market maker quotes that are "stubbed" on the bid price side of the quote. Stub Ask 8, 20, and 30 are the percentage of market maker quotes that are "stubbed" on the ask price side of the quote. Stub Quotes in the 2010 time period are defined for pilot stocks as the percentage of market maker quotes that are at least 8% away from the prevailing NBBO from 9:45am-3:35pm and more than 20% away from the NBBO for the period near the open and close of trading (prior to 9:45am and after 3:35pm). For non-pilot stocks *Stub Quotes* are the percentage of market maker quotes that are 30% away from the prevailing NBBO. Pilot stocks include stocks in the S&P 500, Russell 1000, as well as other exchange-traded products (See SEC 2010A). The 2007 sample period is from October 21, 2007 through November 21 (20 trading days). The 2010 period is from November 19, 2010 through December 17, 2010 (20 trading days). Restrict is a period when stub quoting rules are active. Un-restrict is a period when there is no restriction on marker maker stub quoting. Data sources include TAQ, and NASDAQ TotalView Itch.

*,**,*** Indicate statistically significance at the 10%, 5%, and 1% level respectively

Panel A: 2007 NASDAQ Rule

	Restrict	Un-restrict	Diff
Stub Quotes 8	17.5%	21.5%	-4.0%***
Stub Quotes 20	13.5%	17.7%	-4.2%***
Stub Quotes 30	12.0%	16.1%	-4.0%***
Stub Bid 8	11.5%	13.9%	-2.4%***
Stub Bid 20	9.5%	12.0%	-2.5%***
Stub Bid 30	12.0%	16.1%	-4.0%***
Stub Ask 8	10.4%	12.6%	-2.2%***
Stub Ask 20	8.0%	10.3%	-2.3%***
Stub Ask 30	10.4%	14.0%	-3.6%***

Panel B: 2010 SEC Rule

	All Stocks			Pilot Stocks			Non-Pilot Stocks		
	Restrict	Un-restrict	Diff	Restrict	Un-restrict	Diff	Restrict	Un-restrict	Diff
Stub Quotes	8.4%	13.7%	-5.2%***	10.8%	26.0%	-15.2%***	8.1%	12.2%	-4.1%***
Stub Bid	4.9%	6.8%	-1.9%***	6.3%	13.1%	-6.8%***	4.8%	6.1%	-1.3%***
Stub Ask	4.5%	8.4%	-3.9%***	5.0%	13.7%	-8.7%***	4.4%	7.8%	-3.4%***

Table III: Determinates Stub Quoting

This table report results for estimating the following model:

$$\text{Stubquote}_{i,t} = \beta_0 + \beta_1 \text{Price}_{i,t} + \beta_2 \text{Spread}_{i,t} + \beta_3 \text{Return Volit}_{i,t} + \beta_4 \text{Num Trades}_{i,t} + \beta_5 \text{Restrict}_t + \beta_6 \text{Num MM}_{i,t} + \varepsilon_{i,t}$$

Where $Stubquote_{i,t}$ is one of the following measures of stub quoting: *Stub Quotes 8* is the percentage of market maker quotes that are at least 8% away from the prevailing NBBO from 9:45am-3:35pm and greater than 20% away from the NBBO for the period near the open and close of trading (prior to 9:45am and after 3:35pm). *Stub Quotes 20 (30*) is the percentage of market maker quotes that are 20% (30%) away from the prevailing NBBO. Stub Quotes in the 2010 time period are defined for pilot stocks as the percentage of market maker quotes that are at least 8% away from the prevailing NBBO from 9:45am-3:35pm and more than 20% away from the NBBO for the period near the open and close of trading (prior to 9:45am and after 3:35pm). For non-pilot stocks Stub Quotes are the percentage of market maker quotes that are 30% away from the prevailing NBBO. Pilot stocks include stocks in the S&P 500, Russell 1000 as well as other exchange-traded products (See SEC 2010A). $Price_{i,t}$ is the mean intraday stock price. $Spread_{i,t}$ is difference between the average distance between lowest ask and the highest bid during the trading day. $Volitility_{i,t}$ is the intraday trade-to-trade return standard deviation. $Num.Trades_{i,t}$ is the daily number of transaction for sample stock. $Restrict_t$ is an variable that is equal to 1 for periods that have stub quoting restrictions and 0 when stub quoting is permitted. $Num\ MM_{i,t}$ is the number of market makers that update their quote at least five times in a trading day. The 2007 sample period is from October 21, 2007 through November 21 (20 trading days). The 2010 period is from November 19, 2010 through December 17, 2010 (20 trading days). T-statistics based on cluster corrected standard errors are in parentheses. Data sources include TAQ, and NASDAQ TotalView Itch.

*,**,*** Indicate statistically significance at the 10%, 5%, and 1% level respectively

Panel A: 2007 NASDAQ Rule

	Stub Quotes 8	**Stub Quotes 20**	**Stub Quotes 30**
Price	-0.0013***	-0.0005*	-0.0001
	(-3.97)	(-1.68)	(-0.47)
Spread	-0.0464***	-0.0620***	-0.0603***
	(-4.86)	(-6.17)	(-6.18)
Volatility	0.1204***	0.1928***	0.1902***
	(8.91)	(14.10)	(14.61)
Num. Trades	-0.00000	0.00000	0.0000
	(-0.83)	(0.48)	(1.02)
Restrict	-0.0371***	-0.0420***	-0.0410***
	(-24.85)	(-29.67)	(-30.75)
Num_MM	0.0029***	0.0002	-0.0006***
	(11.85)	(1.09)	(-2.74)
Constant	0.1888***	0.1568***	0.1436***
	(25.82)	(25.59)	(27.01)
Observations	54,976	54,976	54,976
R-squared	0.64	0.60	0.58
f test	165.9	191.3	195.9
Fixed Effects	Yes	Yes	Yes

Panel B: 2010 SEC Rule

	All Stocks	**Pilot**	**Non-Pilot**
Price	-0.0023***	-0.0034***	-0.0026**
	(-2.64)	(2.83)	(-2.53)
Spread	-0.0354***	-0.0609	-0.0355***
	(-3.71)	(-0.40)	(-3.73)
Volatility	0.0893***	-0.5400***	0.0956***
	(9.53)	(-3.05)	(10.08)
Num. Trades	0.0000	-0.0000*	0.0000
	(0.35)	(-1.73)	(0.02)
Restrict	-0.0284***	-0.1519***	-0.0244***
	(-9.67)	(-11.19)	(-8.40)
Num_MM	-0.0017***	-0.0003	-0.0011***
	(-10.98)	(-0.90)	(-6.61)
Constant	0.1854***	0.1272**	0.1618***
	(10.77)	(2.28)	(9.33)
Observations	41,113	4,558	36,555
R-squared	0.41	0.49	0.38
f test	110.3	51.14	72.39
Fixed Effects	Yes	Yes	Yes

Table IV: Market Maker Participation

This table reports mean percentage of the trading day that NASDAQ market makers quote at the NBBO. *At Bid* (*At Ask*) is the total number of seconds that at least one market maker quotes at the NMS (National Market System) highest (lowest) bid (ask) price divided by the total number of seconds in the trading day. *At Both* is the total number of seconds that NASDAQ market makers quote at both the NMS highest bid and lowest ask price divided by the total number of seconds in the trading day. *Alone Bid* (*Alone Ask*) is the total number of seconds that market makers' quotes are the only quotes at the NMS (National Market System) highest (lowest) bid(ask) price divided by the total number of seconds in the trading day. *Alone Both* is the total number of seconds that market makers' quotes are the only quotes at the NMS highest bid and lowest ask price divided by the total number of seconds in the trading day. Restrict represents a period when stub quoting rules are active. Un-restrict are periods in which there is no restrictions on marker maker stub quoting. The 2007 sample period is from October 21, 2007 through November 21 (20 trading days). The 2010 period is from November 19, 2010 through December 17, 2010 (20 trading days. Data sources include TAQ, and NASDAQ TotalView Itch. *,**,*** Statistically significant at the 10%, 5%, and 1% level respectively

Panel A: 2007 NASDAQ Rule

	Restrict	**Un-restrict**	**Diff**
At Bid (%)	23.4%	21.3%	2.1%***
At Ask (%)	22.7%	20.2%	2.5%***
At Both (%)	5.9%	5.6%	0.3%
Alone Bid (%)	9.7%	8.9%	0.7%**
Alone Ask (%)	8.6%	7.2%	1.4%***
Alone Both (%)	1.9%	1.8%	0.08%
At Neither (%)	59.8%	64.1%	-4.3%***

Panel B: 2010 SEC Rule

	All Stocks			**Pilot**			**Non-Pilot**		
	Restrict	**Un-restrict**	**Diff**	**Restrict**	**Un-restrict**	**Diff**	**Restrict**	**Un-restrict**	**Diff**
At Bid (%)	17.2%	15.3%	2.1%***	14.0%	12.8%	1.1%	17.6%	15.6%	2.1%***
At Ask (%)	14.7%	13.1%	1.7%***	13.1%	9.1%	4.0%***	14.9%	13.5%	1.4%***
At Both (%)	2.9%	2.6%	0.3%*	0.9%	0.8%	0.1%	3.1%	2.8%	0.3%*
Alone Bid (%)	3.0%	2.8%	0.1%	1.3%	1.5%	-0.1%	3.2%	3.0%	0.2%
Alone Ask (%)	2.7%	2.6%	0.1%	1.2%	0.8%	0.4%**	2.9%	2.8%	0.1%
Alone Both (%)	0.2%	0.2%	0.0%	0.01%	0.00%	0.002%	0.2%	0.2%	0.0%
At Neither (%)	70.9%	74.3%	-3.4%***	73.8%	78.8%	-5.1%	70.6%	73.7%	-3.1%***

Table V: MM Liquidity and Stub Quoting

This table reports regression results examining the impact stub quoting has on market maker participation. Time at Inside is the amount of time NASDAQ market makers quote at the NBBO. $\text{PerVolume}_{i,t}$ is the percentage of daily trading volume when NASDAQ market makers is on at least one side of the trade. $\text{Price}_{i,t}$ is the mean intraday stock price. $\text{Spread}_{i,t}$ is the average distance between the lowest ask and the highest bid during trading day t. $\text{Volitility}_{i,t}$ is the intraday trade-to-trade return standard deviation. $Num.Trades_{i,t}$ is the daily number of transactions for sample stock i. $Restrict_t$ is an variable that is equal to 1 for periods that have stub quoting restrictions and 0 when stub quoting is permitted. $Num\ MM_{i,t}$ is the number of market makers that update their quotes at least five times on trading day t. Stubquote is the percentage of NASDAQ dealer quotes that are stub quotes. Pilot stocks include stocks in the S&P 500, Russell 1000 as well as other exchange-traded products (See SEC 2010A). The 2007 sample period is from October 21, 2007 through November 21 (20 trading days). The 2010 period is from November 19, 2010 through December 17, 2010 (20 trading days). T-statistics based on cluster corrected standard errors are in parentheses. Data sources include TAQ, and NASDAQ TotalView Itch. *,**,*** Indicate statistically significance at the 10%, 5%, and 1% level, respectively

Panel A: 2007 NASDAQ Rule

	Time At Inside	**Percent Volume**
Price	0.0020**	-0.0001
	(2.17)	(-0.69)
Spread	0.0461***	-0.0016
	(2.95)	(-0.18)
Volatility	0.1663***	0.1712***
	(8.40)	(9.35)
Num. Trades	-0.0000	-0.0000***
	(-0.22)	(-4.42)
Restrict	0.0394***	0.0141***
	(15.62)	(15.04)
Num_MM	0.0119***	0.0019***
	(23.32)	(13.36)
Stubquote	-0.1258***	-0.0127**
	(-10.06)	(-2.01)
Constant	0.1816***	0.0529***
	(9.21)	(15.31)
Observations	54,976	52,383
R-squared	0.51	0.52
f test	153.2	79.85
Fixed Effects	Yes	Yes

Panel B: 2010 SEC Rule

	Time At Inside			Percent Volume		
	All Stocks	**Pilot**	**Non-Pilot**	**All Stocks**	**Pilot**	**Non-Pilot**
Price	-0.0008	-0.0007	-0.0013	0.0000	0.0002***	-0.0000
	(-0.94)	(-0.53)	(-1.20)	(0.247)	(3.25)	(-0.08)
Spread	0.1376***	0.8089*	0.1342***	-0.0401***	0.0210	-0.0413***
	(5.31)	(1.90)	(5.17)	(-3.47)	(1.27)	(-3.54)
Volatility	0.0145	-0.3750	0.0158	0.0934***	-0.1812**	0.0958***
	(0.75)	(-1.11)	(0.82)	(7.09)	(-2.42)	(7.23)
Num. Trades	0.0000***	0.0000***	0.0000***	-0.0000***	-0.0000**	-0.0000***
	(7.79)	(5.59)	(6.02)	(-2.61)	(-2.32)	(-3.10)
Restrict	0.0273***	0.0249**	0.0293***	0.0008	-0.0014	0.0008
	(7.70)	(2.28)	(7.72)	(0.86)	(-1.66)	(0.70)
Num_MM	0.0005***	0.0010***	0.0002	0.0001**	0.0001*	0.0001***
	(2.99)	(2.67)	(1.26)	(2.55)	(1.87)	(2.87)
Stubquote	-0.0339***	-0.0293*	-0.0333***	0.0035*	-0.0020	0.0041
	(-4.16)	(-1.74)	(-3.58)	(1.81)	(-1.21)	(1.68)
Constant	0.2461***	0.1864***	0.2610***	0.0274***	0.0020	0.0313***
	(14.19)	(2.85)	(14.43)	(8.44)	(0.55)	(7.89)
Observations	41,113	4,558	36,555	35,847	4,476	31,371
R-squared	0.51	0.48	0.51	0.44	0.57	0.42
f test	62.37	17.04	48.65	15.03	5.96	14.72
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Table VI: MM Liquidity during days with high volatility

This table reports regression results relating the impact of stub quoting on market maker participation. Time at Inside is the proportion of time NASDAQ market makers quote at the NBBO. PerVolume$_{i,t}$ is the percentage of daily trading volume where NASDAQ market makers are on at least one side of the trade. $\text{Price}_{i,t}$ is the mean intraday stock price. $\text{Spread}_{i,t}$ is the average distance between the lowest ask and the highest bid during trading day t. $\text{Volitility}_{i,t}$ is the intraday trade-to-trade return standard deviation. $Num.Trades_{i,t}$ is the daily number of transactions for sample stock i. $Restrict_t$ is an variable that is equal to 1 for periods that have stub quoting restrictions and 0 when stub quoting is permitted. $Num\ MM_{i,t}$ is the number of market makers that update their quotes at least five times on trading day t. Stubquote is the percentage of NASDAQ dealer quotes that are stub quotes. $HighVolDay$ is an indicator variable equal to 1 if the trading day for stock *i* has a level of price volatility that exceeds its previous 20-day average volatility by 3 standard deviations The 2007 sample period is from October 21, 2007 through November 21 (20 trading days). The 2010 period is from November 19, 2010 through December 17, 2010 (20 trading days). T-statistics based on cluster corrected standard errors are in parentheses. Data sources include TAQ, and NASDAQ TotalView Itch. *,**,*** Indicate statistically significance at the 10%, 5%, and 1% levels respectively

	2007 NASDAQ Rule		**2010 SEC Rule**	
	Time At Inside	**Percent Volume**	**Time At Inside**	**Percent Volume**
Price	0.0026**	0.0000	-0.0004	-0.0001
	(2.54)	(0.26)	(-0.29)	(-0.26)
Spread	0.0142	-0.0205*	0.1232***	-0.0376***
	(0.76)	(-1.81)	(3.45)	(-2.80)
Volatility	0.1488***	0.1603***	-0.0251	0.0707***
	(6.38)	(6.99)	(-0.84)	(4.14)
Num. Trades	0.0000	-0.0000***	0.0000***	-0.0000
	(0.23)	(-4.03)	(5.36)	(-0.71)
Restrict	0.0350***	0.0124***	-0.0282***	-0.0035***
	(10.84)	(9.59)	(-5.26)	(-2.68)
Num_MM	0.0116***	0.0015***	0.0005**	0.0000
	(16.15)	(8.39)	(2.24)	(0.12)
Stubquote	-0.1087***	-0.0179**	-0.0232*	0.0031
	(-6.41)	(-2.28)	(-1.83)	(1.18)
HighVolDay	0.0323***	0.0026	0.0097	-0.0023
	(3.94)	(0.82)	(1.34)	(-1.38)
HighVolDay* Restrict	-0.0331***	-0.0017	0.0075	0.0021
	(-2.90)	(-0.43)	(0.66)	(0.77)
Constant	0.1752***	0.0572***	0.2553***	0.0325***
	(7.70)	(13.25)	(9.34)	(5.94)
Observations	32,351	30,873	18,259	16,260
R-squared	0.51	0.50	0.48	0.44
f test	65.06	29.58	29.91	5.169
Fixed Effects	Yes	Yes	Yes	Yes

Figure I: Summary of Stub Quoting Rules Changes

NASDAQ 2007 Stub Quote Rule Change

- Modified Rule 4613 to remove requirement governing the relation of market maker's quotations to the prevailing market
- Rule change removed requirement that market makers must post quotes that are "reasonably related" to NBBO
- Change Proposed August 1,2007
- Change effective November 7, 2007

SEC 2010 Stub Quote Rule Change

- Securities in circuit breaker pilot program market makers must enter quotes that are not more than 8% away from the NBBO.
- Before 9:45 a.m. and after 3:35 p.m., market makers must enter quotes no further than 20% away from the NBBO.
- Exchange-listed equities not in the circuit breaker pilot program must enter quotes that are no more than 30% away from the NBBO.
- In each of these cases, a market maker's quote will be allowed to "drift" an additional 1.5% away from the NBBO before a new quote within the applicable band must be entered.
- For NASDAQ stocks SEC rule superseded Rule 4613 Modification implement in November 2007
- NASDAQ subsequently modified rule 4613 to reflect SEC stub quote rule
- Announced November 8, 2010
- Rule effective December 6, 2010

Figure II


November 7, 2007: Nasdaq relaxes dealers obligation to post resonably related quotes
December 6, 2010: SEC requitres market makers to quote with 8% of NBBO for pilot stock, and withing 30% for all other securities, banning stub quoting
2007
2010
Oct 24, 2007 - Nov 6, 2007
Dealers obligated to quote near NBBO
Nov 7, 2007-Nov 21, 2007
Dealers can stub quote
Nov 19, 2010-Dec 5, 2010
Dealers can stub quote
Dec 6, 2010-Dec, 17 2010
SEC ban prohibits dealers from stub quoting

Appendix I: NASDAQ Market Maker Quotations to the Prevailing Market Rule Change

SECURITIES AND EXCHANGE COMMISSION

(Release No. 34-56759; File No. SR-NASDAQ-2007-069)

November 7, 2007

Self-Regulatory Organization; The NASDAQ Stock Market LLC; Order Approving Proposed Rule Change and Amendment No. 1 Thereto to Amend Its Rule Governing the Relation of a NASDAQ Market Maker's Quotations to the Prevailing Market

On August 1, 2007, The NASDAQ Stock Market LLC ("NASDAQ") filed with the Securities and Exchange Commission ("Commission"), pursuant to Section 19(b)(1) of the Securities Exchange Act of 1934 ("Act")1 and Rule 19b-4 thereunder,2 a proposed rule change to eliminate a requirement governing the relation of NASDAQ market makers' quotations to the prevailing market. On September 19, 2007, NASDAQ filed Amendment No. 1 to the proposed rule change. The proposed rule change, as amended, was published for comment in the Federal Register on October 5, 2007.3 The Commission received no comments regarding the proposal, and is thereby approving the proposed rule change as modified by Amendment No. 1.

The Commission finds that the proposed rule change is consistent with the requirements of the Act and the rules and regulations thereunder applicable to a national securities exchange.4 In particular, the Commission finds that the proposed rule change is consistent with Section 6(b)(5) of the Act,5 which requires that the rules of an exchange be designed to promote just and equitable principles of trade, to remove impediments to and perfect the mechanism of a free and open market and a national securities system, and, in general, to protect investors and the public interest.

NASDAQ proposes to amend Rule 4613(c) to eliminate the requirement that a NASDAQ market maker's quotations be "reasonably related to the prevailing market." The requirement was adopted in 1987, at which time NASDAQ was part of the National Association of Securities Dealers, Inc. and operated an over-the-counter market with competing dealers. NASDAQ states that the requirement is no longer meaningful, given the regulatory changes, as well as the changes NASDAQ has made to the way its market operates in the last 20 years. However, for each security in which they are registered, market makers would continue to be required to be willing to buy and sell the security for their own account on a continuous basis and at all times maintain a two-sided, attributable quotation that is displayed in the NASDAQ Quotation Montage. The Commission believes that the proposal is reasonable in that it mirrors the market maker definition set forth in Section 3(a)(38) of the Act6 and is consistent with market maker obligations contained in rules of other national securities exchanges.7 Furthermore, the Commission notes that NASDAQ has represented that it will carefully monitor the performance of market makers to determine if the proposal has any impact on the extent to which market makers quote at or near the inside market.8

IT IS THEREFORE ORDERED, pursuant to Section 19(b)(2) of the Act,[9] that the proposed rule change (SR-NASDAQ-2007-069), as modified by Amendment No. 1, be, and it hereby is, approved.

For the Commission, by the Division of Market Regulation, pursuant to delegated authority.[10]

Florence E. Harmon
Deputy Secretary

1 15 U.S.C. 78s(b)(1).
2 17 CFR 240.19b-4.
3 See Securities Exchange Act Release No. 56586 (October 1, 2007), 72 FR 57085.
4 In approving this proposed rule change, the Commission has considered the proposed rule's impact on efficiency, competition, and capital formation. See 15 U.S.C. 78c(f).
5 15 U.S.C. 78f(b)(5).
6 15 U.S.C. 78c(a)(38).
7 See, e.g., NYSE Arca Rule 7.23.
8 In addition, the Commission notes that this rule change does not affect the market maker exception from the "locate" requirement of Regulation SHO under the Act. Rule 203(b)(2)(iii) of Regulation SHO provides an exception from the "locate" requirement for short sales executed by market makers, as defined in Section 3(a)(38) of the Act, but only in connection with bona-fide market making activities.
To qualify for Regulation SHO's "locate" exception, a broker-dealer must be both a market maker in the specific security and engaged in bona fide market making at the time of the short sale for which the broker-dealer is claiming the exception. Thus, a broker-dealer's general status as a market maker or its status as a market maker in the security being sold short does not qualify it for the exception. Further, Regulation SHO's "locate" requirement applies on a transaction-by-transaction basis and, therefore, a market maker must determine whether it is engaged in bona fide market making for each short sale transaction. See Securities Exchange Act Release No. 50103 (July 28, 2004), 69 FR 48008 (August 6, 2004).
9 15 U.S.C. 78s(b)(2).
10 17 CFR 200.30-3(a)(12).

Appendix II: Sec Stub Quote Rule

SEC Approves New Rules Prohibiting Market Maker Stub Quotes

FOR IMMEDIATE RELEASE
2010-216

Washington, D.C., Nov. 8, 2010 — The Securities and Exchange Commission approved new rules proposed by the exchanges and FINRA to strengthen the minimum quoting standards for market makers and effectively prohibit "stub quotes" in the U.S. equity markets.

A stub quote is an offer to buy or sell a stock at a price so far away from the prevailing market that it is not intended to be executed, such as an order to buy at a penny or an offer to sell at $100,000. A market maker may enter stub quotes to nominally comply with its obligation to maintain a two-sided quotation at those times when it does not wish to actively provide liquidity. Executions against stub quotes represented a significant proportion of the trades that were executed at extreme prices on May 6, and subsequently broken.

"By prohibiting stub quotes, we are reducing the risk that trades will be executed at irrational prices, and then need to be broken, if the markets become volatile," said SEC Chairman Mary L. Schapiro. "While we continue to look at other potential obligations for market participants, this is an important step in our effort to improve the functioning of the U.S. markets, and restore investor confidence following the events of May 6."

The new rules address the problem of stub quotes by requiring market makers in exchange-listed equities to maintain continuous two-sided quotations during regular market hours that are within a certain percentage band of the national best bid and offer (NBBO). The band would vary based on different criteria:

> For securities subject to the circuit breaker pilot program approved this past summer, market makers must enter quotes that are not more than 8% away from the NBBO.
> For the periods near the opening and closing where the circuit breakers are not applicable, that is before 9:45 a.m. and after 3:35 p.m., market makers in these securities must enter quotes no further than 20% away from the NBBO.
> For exchange-listed equities that are not included in the circuit breaker pilot program, market makers must enter quotes that are no more than 30% away from the NBBO.
> In each of these cases, a market maker's quote will be allowed to "drift" an additional 1.5% away from the NBBO before a new quote within the applicable band must be entered.

The new market maker quoting requirements will become effective on Dec. 6, 2010.

Since May 6, the Commission has taken several steps to reduce the chance that the events of that day would happen again. Among other things, the Commission:

- approved the above-mentioned circuit breaker pilot program, in which trading would pause if a stock price moved more than 10% in five minutes. That program now applies to stocks in the S&P 500 or the Russell 1000, as well as certain exchange-traded products.
- approved new rules requiring the exchanges to clarify up-front how and when trades would be broken.
- proposed a new rule that would require the self regulatory organizations to establish a consolidated audit trail system the would enable regulators to track information related to trading orders received and executed across the securities markets.
- adopted rules that would effectively prohibit broker-dealers from providing their customers with unfiltered access to exchanges and alternative trading systems by assuring that broker-dealers implement appropriate risk controls.

At Chairman Schapiro's request, Commission staff is continuing to evaluate further initiatives to address market structure issues revealed by the events of May 6 such as refining the single stock circuit breakers by incorporating a limit-up/limit-down type mechanism.

# # #

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Education	**University of Mississippi, University, Mississippi** **PhD -Major: Finance** **Minor: Econometrics and Microeconomics**	Expected *Summer-* 2012
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Publication	What effect did AIG's bailout, and the preceding events, have on its competitors? with J. Hilliard, A. Liebenberg and I. Liebenberg, 2010, Risk Management and Insurance Review.	
Dissertation	**Quote Stuffing, Dissertation Essay #1, with B. Van Ness, and R. Van Ness.** Abstract*:* This study examines the impact intense episodic spikes in quoting activity (frequently referred to as "quote stuffing") has on market conditions. We find that quote stuffing is pervasive with several hundred events occurring each trading day and that over 92% of NYSE and NASDAQ listed securities experience at least one episode during 2010. Our results also suggest that in periods of intense quoting activity stocks experience decreased liquidity, higher trading cost, and increased short term volatility. **The Evolving Role of the Nasdaq Market Makers, Dissertation Essay #2, with B. Van Ness, and R. Van Ness.** Abstract: We examine the role of the NASDAQ market marker in the modern trading environment. Specifically we study the liquidity providing behavior of market marketer in the trading environment of today compared to market maker's behaviors in a prior period. This includes analysis of how frequently market makers are at the inside quote, the level of depth that market markers provides, and what market and stock specific factors influence market	

	makers' behavior. We also investigate if the contribution of market makers to price discovery has changed over time. **Dealers in Times of Distress: The Case of Stub Quoting, Dissertation Essay #3.** Abstract: We examine the liquidity providing behavior of NASDAQ market makers during times of elevated volatility surround two distinct events The first is period is relaxation of Rule 4613 in September of 2007 which required NASDAQ market makers to place two-sided quotes that must be "reasonably related" to the current best bid and offer. This rule change permitted NASDAQ market makers to post quotes far away from the prevailing market (frequently referred to as a "Stub Quote"). The second is the Securities and Exchange Commission (SEC) ban on stub quoting in December 2010 which requires that market makers quote to within 8% of market prices. A major question we address in the current study is does the diminished responsibility of dealers impact the amount of liquidly they provide during volatile periods? We also explore if the option for market makers to place quotes at prices unreasonably related to the NBBO causes markets to become more susceptible to rapid price movements
Working Papers	The Impact of Revenue Diversification on Expected Revenue and Volatility for Nonprofit Organizations, with W. Mayer, H. Flint, and H. Wang, Under Review. Market Friction: Comparing REITs and Common Stocks, with B. Blau, and M. Hill 2011, *Under Review* Exchange Entrances, Mergers and the Evolution of Order Flow on Nasdaq 1993-2010, with R. Battalio, B. Van Ness, and R. Van Ness, FMA and SFA Program 2011. An Analysis of the FMA Annual Meetings: Presentation Activity of Institutions and Individuals, 1996 – 2010, with B. Van Ness, and R. Van Ness, FMA Program 2011. The Trading of NYSE Stocks: 1993 – 2010, with B. Van Ness, and R. Van Ness. Does REIT Data Source Matter? with W. Hardin, M. Hill, S. Moser. What Factors Determine Market Share of Designated Market Makers?, with E. Watson.

Teaching Experience	**Fin 533 Security Analysis and Portfolio Management, 2011** **Fin 334 Investments 2009-2011 (4 Sections)**
Work Experience	**Instructor Fellowship, University of Mississippi** **2011-Present** **Instructor, University of Mississippi** **2009-Present** **Research Assistant University of Mississippi** **2008-Present** Hedge Fund Consultant, **Western Investments, Salt Lake City, Utah** 2007-2008
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