Information leakage and opportunistic behavior before analyst recommendations: An analysis of the quoting behavior of Nasdaq market makers

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Abstract

We document evidence consistent with the presence of information leakage and opportunistic behavior before analyst recommendation revisions for Nasdaq-listed stocks. We examine the quoting behavior of market makers affiliated with the same brokerage house as the recommending analysts ("recommending market makers"). In the hour and a half (three hours) before upgrades (downgrades), recommending market makers change their quoting behavior. These changes anticipate the direction of pending recommendations and are highly significant, even after controlling for their own non-announcement behavior and for the contemporaneous quoting behavior of other market makers. Further, the recommending market makers' quoting behavior has explanatory power for stock returns immediately preceding the public announcements. These findings are consistent with non-public information being impounded into stock prices due to opportunistic behavior by recommending market makers or by investors who trade through recommending market makers.

Keywords: market microstructure, quoting behavior, analyst recommendation revisions, conflicts of interest, information leakage

1. Introduction

Conflicts of interest among market participants are nothing new. However, recent market events have generated renewed interest in whether these conflicts of interest compromise market integrity. In this paper, we evaluate Nasdaq market makers' quoting behavior for evidence that their behavior is influenced by analysts' conflicts of interest that are due to their relationships with their firms' trading departments. The underlying cause of the recommending analysts' conflicts of interest is that both research departments' and individual analysts' compensation are based on the value they add to the investment banking and trading departments of their firms. Following the meltdown of internet and technology stocks and the high profile corporate bankruptcies that have occurred since 2000, lawmakers, regulators, and investors have questioned whether the biased incentives created by these compensation arrangements have led to behavior that is disadvantageous to other market participants.[1]

To investigate this issue, we evaluate the quoting behavior of market makers before analysts announce revisions in their recommendations. We compare the quoting behavior of the market maker affiliated with the analyst's brokerage firm ("recommending market maker") both to her own normal quoting behavior and to the quoting behavior of other market makers. Not only do we find strong evidence that recommending market makers systematically change their quoting behavior well before the public announcement, but we also find strong evidence that they change their quoting behavior earlier, and more dramatically, than other market makers. Further, the recommending market makers' changes in quoting behavior anticipate the direction of the pending revisions and predict stock returns before the pending revisions. Overall, these findings are consistent with analysts leaking information to someone—whether it be to recommending market makers, to investors affiliated with the analysts' brokerage firms, or to outside investors—and with subsequent opportunistic actions by the information recipients.

Researchers have previously investigated analysts' conflicts of interest due to their relationships with the investment banking business of their brokerage firms. They have found that analysts issue more

[1] The current focus of attention is the relationship between investment banking and research departments. However, the Securities and Exchange Commission (SEC) is also investigating whether brokerage firms are trading ahead of their own stock research reports [for example, see Smith (2004)].

optimistic earnings forecasts for their firms' investment banking clients than do non-affiliated analysts. The buy recommendations of affiliated analysts are less informative, while their sell recommendations are more informative than the comparable recommendations of non-affiliated analysts [e.g., Dugar and Nathan (1995), Lin and McNichols (1998), and Michaely and Womack (1999)]. Hong and Kubik (2003) show that analysts whose forecasts are more accurate and more optimistic are more likely to move to brokerage firms with better reputations. Further, accuracy is less important and optimism is more important when analysts cover initial public offerings (IPOs) underwritten by their own firms.

Researchers have also examined the relationship between investment banking and trading departments [e.g., Aggarwal (2000), Ellis, Michaely, and O'Hara (2000), and Schultz and Zaman (1994)]. Our paper is closest in spirit to contemporaneous work by Irvine, Lipson, and Puckett (2004), who examine the conflicts of interest between research and trading departments, and to Kim, Lim, and Slovin (1997), who examine intraday stock price reactions to analyst recommendations.

Using daily data, Irvine et al. (2004) find large buying imbalances for institutional investors beginning five days prior to the release of analysts' buy initiations. They interpret their findings as evidence that institutional investors receive tips about upcoming research reports, which is consistent with our findings. Our paper is different from Irvine et al. in several ways. We analyze intraday quoting behavior rather than daily price and volume data; we find evidence of information leakage in the two to three hour period before the release of analyst reports. Further, we compare the quoting behavior of recommending market makers to the quoting behavior of other market makers, rather than examining unadjusted aggregate market data. This comparison allows us to infer the potential presence of opportunistic behavior by recommending market makers.

Kim, et al. (1997) compare the efficiency of the NYSE/AMEX and Nasdaq in processing private information. They use a 1991 sample of initial coverage, buy recommendations for which *Dow Jones Interactive* (DJI) gives the public release time and indicates that the recommendations have been pre-released to selected clients before the stock market opens. They document a strong positive price effect at the open that lasts about 5 minutes for NYSE/AMEX stocks and 15 minutes for Nasdaq stocks, but they find no significant price reaction to the public announcement. This is consistent with the prediction in Holden and Subrahmanyam (1992) that competition among informed traders leads to private information being impounded rapidly into stock prices. The regulatory environment has changed fundamentally since Kim et al.'s sample period. As we discuss in the next section and in appendices A and B, the NYSE, in 1991, and the National Association of Securities Dealers (NASD), in 1995, passed regulations to prevent information leakage to recommending market makers, to investors affiliated with the analysts' brokerage firms, and to outside investors. The SEC, the NASD, and the NYSE have taken disciplinary action against analysts and brokerage firms for all three types of information leakage. Since Kim et al.'s (1997) focus is not to identify potential conflicts of interest, their approach is very different from ours. They examine price reactions, whereas we compare the quoting behavior of recommending market makers to that of other market makers in order to evaluate the potential presence of opportunistic behavior.

This paper adds substantive evidence to previous research on whether analysts conflicts of interest are associated with behavior that disadvantages the average investor; i.e., with information leakage and opportunistic behavior before analyst recommendations. We find that for an hour and a half before upgrade announcements, the recommending market makers quote at the inside bid a greater proportion of time than they usually do, but they do not change the proportion of time that they quote at the inside ask. The recommending market makers increase the time they quote at the inside bid from about 11% during the control period to as much as 15.7% before the announcement, a 43% increase. Conversely, for three hours before downgrade announcements, the recommending market makers quote at the inside ask a greater proportion of time than they usually do, but they do not change the proportion of time that they quote at the inside bid. They increase their time at the inside ask from 8.3% during the control period to as much as 13.2% before the announcement, a 59% increase.

Further, starting more than two hours before the public announcements, we document absolute abnormal returns that range from 0.26% to 2.7% per half hour and that anticipate the direction of the pending recommendation revisions. Variance decomposition and Granger causality tests reveal that the quoting behavior of recommending market makers is a predictor of stock returns immediately preceding the recommendation revisions. The variance decomposition reveals that before upgrades (downgrades), an average of 32.4% (42.5%) of the variation in stock returns can be explained by innovations in the time recommending market makers quote at the inside bid (ask). This compares with an average of 49.2% (49.4%) of the variation in stock returns explained by innovations in stock returns. The Granger causality tests suggest that an increase of one standard deviation in the recommending market makers' time at the inside bid (ask) results in an increase (decrease) of 0.432 (0.350) standard deviations in future stock returns. These findings are consistent with non-public information being impounded into stock prices, as a result of opportunistic quoting behavior by recommending market makers or as a result of informed trading by investors who trade through recommending market makers. Such behavior may be illegal, and it certainly appears to be unfair to other market participants.

The paper is organized as follows. Section 2 develops the test hypotheses. Section 3 describes the sample construction and the data. Section 4 reports the empirical results and Section 5 concludes.

2. Hypotheses

As background for our first hypothesis, it is helpful to review the potential recipients of leaked information, the analysts' motives for leaking information to them, and the behavior that will lead to anticipatory quote adjustments by the recommending market makers. Early quote reaction by a recommending market maker could potentially be generated by leakage to the recommending market maker, to the firm's trading department (inside investors), or to the firm's customers (outside investors).

Information leaked directly to a recommending market maker would allow this market maker to manage inventory in anticipation of post-recommendation order flow and price movement. To adjust her inventory, the recommending market maker would change her quotes before the announcement and before other market makers, thus reacting early.

Information might also be leaked to either inside or outside investors. If information is leaked to the trading department of the recommending market maker's firm, the traders in her firm would profit from trading before the public announcement. If it is leaked to an outside investor, her firm is giving the outside investor an opportunity to profit from trading before the public announcement. In return, her firm hopes for future investment banking or trading business from the outside investor.

If the informed investors (either inside or outside) place their opportunistic trades with the recommending market maker, she would adjust her quotes early in reaction to these informed trades. The informed investors might choose to place their orders with her to conceal their information from the rest of the market. They might also choose to trade through her in order to give the analyst credit for their trading volume, thus encouraging the analyst to provide non-public information in the future.[2]

It is important to remember that investors can trade either by placing market orders or by placing limit orders. Market orders do not directly affect the quotes posted by the recommending market maker. However, she tries to infer information from incoming order flow, and she adjusts her quotes in response to increased activity on one side of the spread.[3] Limit orders could directly affect her quotes, because Nasdaq market makers are obliged to display customer limit orders.[4] Consequently, the quotes displayed by market makers can be either their own quotes or investor limit orders. While we are not able to distinguish between market maker quotes and investor limit orders due to data limitations, this does not diminish the significance of our empirical findings, as we explain below. Henceforth, the term "quotes" may refer to market maker quotes or investor limit orders.

Each type of information leakage may violate the rules of the SEC, the NASD, and the NYSE. Antilla (1993) reports that leakage "would violate Securities and Exchange Commission disclosure rules if the trading took place in accounts of … [a broker's] customers or employees, and it would violate Federal insider-trading laws if the leaks made their way to stock investors who trade outside the firm."[5]

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[2] For example, Solomon Smith Barney analyst Jack Grubman claimed that he had generated $300 million in trading commissions and $400 million in investment banking fees in 2000, for which he received tens of millions of dollars in compensation [Smith and Craig (2003)].
[3] For example, see Glosten and Milgrom (1985), Kyle (1985), Easley and O'Hara (1987), and Holden and Subrahmanyam (1992), and see O'Hara (1995) for a thorough survey.
[4] The Order Handling Rules (OHRs) introduced by the NASD in 1997 stipulate this requirement. These rules were introduced in reaction to the seminal work by Christie and Schultz (1994) and by Christie, Harris, and Schultz (1994), and to subsequent class action lawsuits.
[5] The investors who profit from early access to research report information may kick back part of the profits to the leaking firms by giving them extra business. This would allow a leaking firm to capture a significant portion of the profits without violating any regulations narrowly aimed at prohibiting leakage within the analyst's firm. This is

The NASD Interpretative Memo IM-2110-4, titled "Trading Ahead of Research Reports" and approved by the Securities and Exchange Commission (SEC) in August 1995, aims specifically at prohibiting a member firm "from purposefully establishing, creating or changing the firm's inventory position" in a particular security "in anticipation of the issuance of a research report regarding such security by the member firm." In our consultations with NASD attorneys, they indicate that the NASD may use Rule 2110 or other rules against a member firm that uses early access to research reports to solicit order flow from its clients. See Appendix A for the complete text of Rule 2110 and IM-2110-4.

A 1991 NYSE official memo [Power (1991)] and NYSE Rule 401 prohibit leakage within brokerage firms and to outside investors. For example, Rule 401/01 states that "Transactions … shortly before or after the firm issues a purchase or sale recommendation raise questions of the motive. Firm personnel who participate in making the recommendation or have any pre-publication knowledge of it should refrain from any action in contemplation of the report, such as making a transaction for their own account or accounts in which they have an interest or discretion, or passing on advance information concerning the report to persons outside the firm." Further, according to SEC attorneys, the NYSE may be the "designated examining authority" (DEA) and NYSE rules may be applied to activities in Nasdaq-listed stocks. See Appendix A for the complete text of Rule 401 and 401/01.

Since the passage of the regulations mentioned above, regulators have used them to initiate investigations and to take disciplinary actions against violators. Appendix B summarizes several investigations by regulators and disciplinary actions taken in reaction to different types of leakage. Attorneys at the SEC, the NYSE, and the NASD also state that regulators can take actions under other regulations, which have broader scope, if no specific regulation applies. For example, even before the 1991 memo [Power (1991)], the NYSE punished information leakage within the same brokerage firm and to outside investors on the basis that these actions were "inconsistent with just and equitable principles of trade" [e.g., an article from the St. Petersburg Times (1987) and Brannigan (1993) about the case against

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similar to investment banks' allocating underpriced IPO shares to institutional investors in exchange for the institutions' agreeing to pay excessive trading commissions [for example, see, Smith and Pulliam (2002) regarding the settlement between regulators and Credit Suisse First Boston].

a Raymond James analyst, and a 1985 Wall Street Journal article about a case against PaineWebber].[6]

Brokerage firms themselves have rules against information leakage. After the $1.4 billion settlement between regulators and several major brokerage firms resulting from the firms having issued biased research reports in exchange for investment banking business, Merrill Lynch, Morgan Stanley, and Smith Barney have used their own rules to fire analysts for leaking information to outside investors [see Smith and Morse (2002) and Smith (2003)]. Industry associations have also issued such guidelines. For example, officials at the CFA Institute, the trade association for both buy- and sell-side financial analysts, indicate that any type of information leakage by member analysts may violate its code of ethics, which requires its members to "deal fairly and objectively with all clients and prospects when disseminating investment recommendations, disseminating material changes in prior investment recommendations, and taking investment action" [Code of Ethics and Standards of Professional Conduct (1999)].

Although all three types of information leakage described above might cause an early reaction, the objective of this paper is not to determine the path of information leakage and the type of opportunistic behavior, but rather it is to investigate whether recommending market makers react early. Specifically, we investigate whether recommending market makers change their quoting behavior before the pending public announcements and whether these changes occur before other market makers change their quoting behavior. We test the following hypothesis:

> *H1 (Quoting Behavior): If information leakage and subsequent opportunistic behavior occur before upgrade (downgrade) recommendations, recommending market makers will increase the time they quote at the inside bid (ask) before the public announcements and before other market makers change their quoting behavior. Recommending market makers will reduce or will not change the time they quote at the inside ask (bid).*

[6] Attorneys at the SEC, the NASD, and the NYSE indicate that decisions about the prosecution of violators are made on a case-by-case basis, as they are all for legal prosecutions. Out-of-court settlements occur frequently. If a settlement is made without the accused admitting wrongdoing, the questionable behavior is not officially categorized as a violation.

The recommending market maker will change her quoting behavior regardless of whether the information is leaked directly to her or to investors who trade through her. Consider the case of an upgrade. If the information is leaked to the recommending market maker, she would like to build a long position before the announcement. By quoting aggressively at the inside bid, she attracts traders who want to sell stock to her. Alternatively, if the information is leaked to either inside or outside investors, these investors can place market orders or marketable limit orders to buy through her. If investors place market orders to buy, then she will adjust her quotes upward in response to the order flow and, as a result, she will be more likely to quote at the inside bid. If investors place marketable limit orders, these limit orders will be at the inside bid. If the recommending market maker's change in quoting behavior occurs not only before the public announcement, but also before changes in the quoting behavior of other market makers, we can infer that her quoting behavior change cannot be explained by overall market anticipation, but instead is unique to her.

Recommending market makers could potentially use alternative mechanisms to build their inventories. For example, they could buy shares by hitting other market makers' quotes, or they could trade and quote through ECNs (electronic communication networks). Further, institutional arrangements such as internalization, preferencing, and payment for order flow enable market makers to execute orders at the national best bid or offer (NBBO) without quoting at the NBBO [see, e.g., Smith (2000)]. Recommending market makers may well engage in such behaviors, which makes it less critical for them to quote actively at the inside. However, Smith (2000) finds that the routing decision of interdealer orders is predominantly based on the quotes of the potential recipient dealers and not on preferencing arrangements. This indicates that quotes do attract order flow and that quote adjustment is an effective means of managing inventory. Because these alternative mechanisms and institutional arrangements create a bias against finding results, their presence only increases the significance of the changes in recommending market makers' quoting behavior documented in our study.

Because the recommending market maker wants to hold a long position before an upgrade, she does not want to sell shares to investors. This implies that she will reduce the time she quotes at the inside ask. However, it is not clear that we can observe this. First, she might habitually quote infrequently at the inside ask and thus a reduction would not be possible. Second, even if she moved her dealer quote away from the inside ask, customer limit orders could still be at the inside ask. This is especially true because, as documented below, upgrades are often preceded by price increases, potentially resulting in stale customer limit orders at the ask. For downgrades, the situation is analogous.

If the information leaked to the recommending market maker or to investors who trade through her has value, we expect a stock price reaction to the recommending market maker's quoting behavior as the revision information is impounded into stock prices. This leads to our second hypothesis:

> *H2 (Relation between Quoting Behavior and Stock Returns): If information leakage and subsequent opportunistic behavior occur before upgrade (downgrade) recommendations, the more aggressive quoting at the inside bid (ask) by recommending market makers will predict positive (negative) abnormal stock returns in the time intervals leading up to the upgrade (downgrade) recommendations.*

From market microstructure theory we know that market participants infer information from the trading process and behavior of other market participants [see footnote 3]. If there is opportunistic trading behavior based on non-public information before pending public announcements, the information will be gradually impounded into prices. If we find that the recommending market makers' quoting behavior explains stock returns before pending announcements, we may infer that this reflects the process of information dissemination.

3. Data Description and Methodology

3.1. Sample Selection

From *Dow Jones Interactive* (DJI), we collect all analyst recommendations for Nasdaq-listed firms during the period from January 1, 1999 to July 31, 1999. DJI reports public announcements of analyst recommendations. For each announcement, we retrieve the company name, ticker, analyst's brokerage house affiliation, type of recommendation, date, and time (to the minute) of the first announcement on DJI. The number of analyst recommendations in this initial sample is 4,959.

To be included in the final sample, Center for Research in Security Prices (CRSP) and Nastraq data must be available for a company during the sample period. This yields 3,811 recommendations. Further, the brokerage house's previous recommendation must be available. For 3,280 analyst recommendations, we are able to match the brokerage house with the respective market maker ID used in the Nastraq database. The Nastraq database supplies intraday trade, inside quote, and dealer quote data. Appendix C describes the data filters that are used to ensure the integrity of the trade and quote data. The dealer quote files from the Nastraq database identify the market maker or ECN associated with each quote.[7]

Stocks are restricted to ordinary stocks of firms incorporated in the U.S.; we exclude ADRs (American Depository Receipts), SBIs (Shares of Beneficial Interest), REITs (Real Estate Investment Trusts), and foreign companies. For each recommendation, the sample window (i.e., the event and control period described in detail in Section 3.2) is defined as the 26 trading days centered on the analyst recommendation. We exclude recommendations for which the stock price is less than $1 or the number of shares outstanding changes by more than 5% during the sample window. Recommendations for stocks that have non-ordinary dividends (i.e., exchanges and reorganizations) during the sample window are also excluded. The sample window for each recommendation must start after January 4, 1999, the starting date of the Nastraq database. Further, to prevent any potential contamination, we exclude all revisions occurring within 15 trading days of another recommendation by the same analyst and for the same stock.

We define a brokerage house to be an active market maker in a stock if there is at least one valid quote observation from that brokerage house during the six trading days centered on the revision announcement. If the brokerage house is not an active market maker, the analyst recommendation is

[7] We use the expression market maker throughout the paper to refer to both Nasdaq market makers and electronic communication networks (ECNs).

excluded because there are no quotes to analyze and because there are no potential conflicts of interest due to the relationship between research and trading departments. We consider only analyst recommendations that occur during regular trading hours (9:30 AM to 4 PM EST).

The analyst recommendations are standardized by applying the I/B/E/S (Institutional Broker Estimate System) conversion system whenever possible, and by augmenting the system manually when necessary. The conversion system has five categories: "strong buy", "buy", "hold", "sell", and "strong sell".[8] Our sample includes only recommendation revisions: that is, upgrades and downgrades. Initial coverage or reiterations of previous recommendations are excluded. This leaves us with 844 analyst recommendation revisions in our final sample, of which 411 are upgrades and 433 are downgrades. Panel A of Table 1 reports the distribution of recommendation revisions. Consistent with previous studies, sell recommendations ("sell" and "strong sell") are very rare during our sample period [see, e.g., Womack (1996), Barber, Lehavy, McNichols and Trueman (2001), and Jegadeesh, Kim, Krische, and Lee (2004)]. Changes of one category are more common than changes of two or more categories. For example, there are 140 downgrades from "strong buy" to "buy", and 205 downgrades from "buy" and "hold", but only 81 downgrades from "strong buy" to "hold".

Panel B of Table 1 summarizes the intraday distribution of recommendation revisions. It is apparent that for both upgrades and downgrades most observations occur in the morning hours. Because this would give the recommending market maker or informed investors little or no time to trade before the announcement, they might take positions in pre-opening trading, in after-hour trading on the previous day, or even on previous trading days. In this study, we are not able to analyze behavior that occurs outside of regular trading hours because the Nastraq database does not contain the necessary data. This concern is mitigated by the fact that informed traders will trade during regular trading hours on preceding days, if possible, to avoid the limited liquidity in after-hour trading. Further, this problem is not critical if we find results, because its effect is to bias our tests against finding significant results.

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[8] This should not affect our results, because we form two sub-samples, upgrades and downgrades.

3.2. Event vs. Non-Event Period

For each recommendation revision, the event half hour is the half-hour interval in which the recommendation was reported on DJI. Because a calendar trading day has 13 half-hour trading intervals during regular trading hours, we define a "day" as 13 half-hour trading intervals. For example, "day +1" comprises the 13 half-hour trading intervals immediately following the event half hour. These 13 half-hour trading intervals usually span two calendar trading days. The event period contains the event half hour, the three days before, and the three days after the recommendation revision. Thus, the event period is defined as the 79 half-hour intervals centered on the event half hour. The control period is defined as the 260 half-hour intervals surrounding the event period, i.e., ten days before and ten days after the event period. Thus, the sample window for each revision has 339 half-hour intervals centered on the event half hour.

3.3. Sample Firm Characteristics

Table 2 provides descriptive statistics for the sample companies. Within our sample, there is significant cross-sectional variation in firm characteristics. For example, market capitalization averages about $3.3 billion, with a median of about $442 million. Daily share volume averages about 974 thousand shares, with a median of about 281 thousand shares. The proportional inside half-spread has a mean of 0.6% and a median of 0.45%.[9] The last row in Table 2 reports descriptive statistics for each firm's number of active market makers. Most stocks in our sample attract a relatively large number of market makers. On average, there are about 27 market makers active and the median number of active market makers is 23. More than 75% of our sample has 16 or more active market makers.

3.4. Methodology

We focus on differences between the event period and the control period values of our variables of interest. For each recommendation and for each of the 13 half-hour intervals of a calendar trading day,

[9] We compute time-weighted spread measures. The percentage half-spread is defined as (Ask-Bid) / (Ask+Bid).

we compute the mean of all variables of interest over the 20 trading days of the control period, which we call the *Control Means*. Because there is potential intraday variation in market microstructure variables, we match each of the 79 event-period half-hour intervals with the *Control Mean* for the same time of day.[10] We then compute the difference between the event interval value of the variable of interest, *Event*, and the *Control Mean*. For example, the volume between 10:00 AM and 10:30 AM on a day during the event period is compared to the mean volume in all 20 half-hour intervals between 10:00 AM and 10:30 AM in the control period. Differences are computed as raw deviations or as percentage deviations:

$$\textit{Raw Deviation} = \textit{Event} - \textit{Control Mean}, \tag{1}$$

$$\textit{Percentage Deviation} = \frac{\textit{Event} - \textit{Control Mean}}{\textit{Control Mean}} \cdot 100. \tag{2}$$

Finally, the measures reported in the tables and figures are "event-period means," which are the cross-sectional means of the deviations in the variables of interest across our upgrade and downgrade recommendation samples.

To assess statistical significance, we employ a Monte Carlo simulation similar to Lee, Mucklow, and Ready (1993). For each interval in the event period, the event-period mean is compared to an empirical distribution of the same variable, obtained by random sampling with replacement, from the control period data. This procedure yields the significance level for the test of the null hypothesis that the event period observations represent random draws from the empirical distribution in the control period.

In the following paragraphs, we describe the procedure for the computation of event-period means and control-period empirical distributions. We illustrate the procedure with one variable in one half hour of the event period: the proportion of time the recommending market maker quotes at the inside ask during the half-hour interval immediately preceding the announcement, interval -1. The proportion of time the recommending market maker quotes at the inside ask is calculated as follows; if a market maker quotes an ask price equal to the inside ask for 6 minutes during interval -1, the proportion of time at the

[10] See, e.g., Chan, Christie, and Schultz (1995) for intraday variation of inside and dealer spreads for a sample of Nasdaq-listed stocks.

inside ask equals 20%. The procedure is identical for each of the remaining 78 half-hour intervals in the event period and for each of the other measures we consider in the analysis.

The procedure comprises two steps. First, we obtain the event-period mean. For each recommendation, we compute the raw deviation for interval -1 as defined in Equation (1) with the recommending market maker's proportion of time at the inside ask as variable of interest. We then compute the equally-weighted mean of the raw deviations across all recommendations, which yields the event-period mean for interval -1. We call this mean "time at inside ask."

Second, we create the empirical distribution. For each recommendation included in the event-period mean for interval -1, we draw a random observation with replacement from the control period for the same recommendation, the same recommending market maker, and the same time of the day. For example, if a recommendation announcement occurs at 11:47 AM, interval -1 is the half hour between 11:00 AM and 11:30 AM and we randomly draw one of the half-hour intervals between 11:00 AM and 11:30 AM from the control period. Then, we compute the raw deviation as defined in Equation (1) with *Event* being the recommending market maker's proportion of time at the inside ask during that randomly selected half-hour interval. This raw deviation is denoted as a "control observation." The equally-weighted mean of the control observations is computed across all recommendations, and is denoted as "random sample mean." This sampling procedure is repeated 1,000 times, generating 1,000 random sample means for each event-period mean and yielding empirical distributions for the statistical tests.

4. Empirical Evidence

4.1. Inside Spreads, Volume, and Stock Returns

In all figures discussed in this section and in the remainder of the paper, solid data points indicate significance at 5% based on the Monte Carlo simulation procedure. The measures tested are the cross-sectional means of the deviations between event and control period, for upgrades and downgrades respectively, as described above. For brevity of exposition, we only report results for intervals –13 to +26 (day –1 to day +2), although the event period includes intervals –39 to +39 (day –3 to day +3). Statistical significance is mostly concentrated in the shortened window for which we report results.

Figure 1 plots the percentage deviations of proportional inside spreads during the event period.[11] Spreads tend to be lower than normal during the event period for both upgrades and downgrades. However, spreads are not significantly lower until one or two half-hour intervals before the analyst recommendation and they stay significantly lower for more than two days.

Figure 2 plots the percentage deviations of share volume during the event period. Volume spikes during the event half hour, and is significantly higher during the entire event period. The increase in volume is more dramatic for downgrades, which is eight times normal volume during the event half-hour, interval 0, compared to about four times normal volume for upgrades. The increased volume might partially explain the decreased spreads documented in Figure 1 [see, e.g., Stoll (2000)].

Figure 3 plots cross-sectional mean abnormal returns during the event period. Returns are defined as percentage changes in the quote midpoint, which is the average of the bid and ask prices. We use the mean-adjusted method to compute abnormal returns, which are identical to the raw deviations defined in Equation (1). For upgrades, the greatest abnormal return, 1.39%, occurs during the event half hour. Figure 3 documents significant positive abnormal returns during the two and a half hours leading up to the public announcement. The abnormal returns range from 0.26% to 0.78%, and they are greater for intervals closer to the event half hour. After the event half hour, there are significant positive abnormal returns of approximately 0.3% for an hour and a half. For downgrades, Figure 3 shows a similar but more pronounced pattern. The greatest abnormal return, -2.8%, occurs during the event half hour. There are significantly negative abnormal returns starting four and a half hours before the announcement. However, the abnormal returns during intervals -9 to -4, which range from -0.27% to -0.55%, are relatively small compared to the abnormal returns during intervals -3 to -1, which range from -1.61% to -2.27%.[12] The

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[11] All spread measures are based on half-spreads and are time-weighted. We often refer to half-spreads simply as spreads.

[12] Womack (1996) documents significant positive (negative) abnormal returns for three-day windows around upgrades (downgrades). Further, he finds the price reaction to be more pronounced for downgrades than for

evidence in Figure 3 highlights the economic significance of the recommendation revisions in our sample. There are substantial price reactions to both upgrades and downgrades during the half hour of the public announcement. Information about pending recommendation revisions offers significant profit opportunities. Further, the statistically and economically significant abnormal returns leading up to the event half hour are consistent with information leakage and subsequent opportunistic behavior before the public announcement. The pre-announcement pattern in returns suggests gradual incorporation of non-public information into stock prices.

4.2. Market Maker Quoting Behavior

In this and the following section, we test hypothesis H1. For each recommendation revision, we examine the proportion of time that the recommending market maker is at the inside quote, and the average proportion of time at the inside quote both for all non-recommending ("other") market makers and for a peer group for each recommending market maker. The proportions are calculated separately for bid and ask prices. We follow Huang (2002) in defining five peer groups: institutional brokers, wire houses, wholesalers, electronic communication networks (ECNs), and minors. Appendix D provides a list of the brokerage firms in each peer group. Each recommending market maker is compared to the other market makers in its peer group. Due to a lack of peers for some of the recommendations, there are 393 upgrades and 403 downgrades in the peer market maker sample. According to hypothesis H1, if we find changes in recommending market makers' quoting behavior that anticipate the pending announcement, and that these changes are made before peer and other market makers change their quoting behavior, then we may conclude that information leakage is present.

For our initial test, we analyze the proportion of time that market makers quote at the inside, adjusted for their own control period behavior. Figures 4 and 5 plot the results for upgrades and Figures 6 and 7 for downgrades. Each graph reports event-period means of the raw deviations, as defined in Section

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upgrades, which is consistent with our findings. In contemporaneous work, Green (2004) analyzes the price reaction after overnight analyst recommendation revisions. He finds that most of the price reaction occurs overnight, that is, at the opening price, which is consistent with the large abnormal returns we find during the event half hour.

3.4, for the recommending market makers, for the other market makers, and for the peer market makers. For the group of other (peer) market makers, we first compute the average raw deviation across all other (peer) market makers for a particular recommendation. We then compute the mean of these average raw deviations across the recommendations in our upgrade and downgrade samples, respectively.

Hypothesis H1 predicts that before an upgrade announcement, the recommending market maker will not quote more aggressively at the ask side, but will quote more aggressively at the bid side in order to build up her inventory in anticipation of the positive price reaction to an upgrade. Figure 4 shows that for upgrades, the recommending market maker's time at the inside ask decreases non-significantly before the announcement. Recall that even if a recommending market maker does move her own quotes away from the inside ask, she might be displaying customer limit orders, which may obscure her ask quotes. On day +1, she increases the time at the inside ask significantly in 5 out of 13 intervals.

The other market makers increase the time they quote at the inside ask around the announcement, and this increase is highly significant from interval -7 to at least interval +13. However, the economic significance of this result is of less importance because the difference between the time at the inside ask during the event and the control period is about 1%. The results for the peer market makers have a similarly insignificant, less pronounced pattern.

Figure 5 shows that the recommending market makers quote more aggressively on the bid side before upgrades. The increase in the proportion of time at the inside bid is significant for about an hour and a half before the announcement, and the increase is as large as 4.7%. Compared to the average proportion of time at the inside bid during the control period, which is 11%, this constitutes a 43% increase and appears economically meaningful. In contrast, the other market makers and the peer market makers slightly decrease the proportion of time at the inside bid. Thus, these results, combined with the inside ask results, are consistent with hypothesis H1.

Hypothesis H1 predicts that before a downgrade announcement, the recommending market maker will quote more aggressively on the ask side, but not on the bid side. Figure 6 reports the results for the time at the inside ask. The reaction of recommending market makers to downgrades is even more dramatic than to upgrades. The proportion of time recommending market makers quote at the inside ask increases significantly three hours before the announcement. The recommending market makers increase the proportion of time they quote at the inside ask by as much as 4.9% before the announcement. Compared to the average proportion of time at the inside ask during the control period, which is 8.3%, this constitutes a 59% increase and is economically meaningful. The other market makers also experience a slight increase in the proportion of time at the inside ask, but the increase is neither economically meaningful, at around 0.7%, nor is it consistently significant. Similarly, the peer market makers do not exhibit a significant increase in time at the inside ask.

On the other hand, Figure 7 shows that recommending market makers do not quote more aggressively on the bid side before downgrades. There is no apparent pattern and none of the changes in the proportion of time at the inside bid are significant. For the other market makers, there is a slight increase for two or three half-hour intervals before the announcement and a significant increase after the announcement. As discussed before, this might be due, at least in part, to limit orders being picked off in a down market. The evidence for the peer market makers does not show any pattern.

In summary, the evidence presented in Figures 4 through 7 is consistent with hypothesis H1 regarding anticipatory quoting behavior by recommending market makers before recommendation revisions, and thus it suggests the presence of information leakage. The results are statistically significant and economically meaningful, with an increase in the proportion of time at the inside quotes of up to 43% (59%) compared to the control period for upgrades (downgrades). The evidence is stronger for downgrades than for upgrades, which is consistent with results shown both in Figure 3 and in related studies [see, e.g., Womack (1996)]. Therefore, it appears that downgrades offer opportunity for greater profits from non-public information.

4.3. Comparison of Recommending and Non-Recommending Market Makers' Quoting Behavior

In the results reported above, each market maker's quoting behavior is adjusted only for her own behavior during the control period. To control for the quoting behavior of the other market makers and of the peer market makers, we subtract the other (peer) market makers' mean quoting behavior change during the event period[13] from the recommending market maker's quoting behavior change during the event period. Figures 8 through 11 and Tables 3 and 4 report the mean of these differences in quoting behavior changes across all recommendations, with significance levels based on empirical distributions created by the Monte Carlo simulations.

Table 3 shows that before the announcement of upgrades, the recommending market maker is less often at the inside ask compared to both other and peer market makers, as predicted in H1. The differences are not statistically significant. The recommending market maker is more aggressive on the ask side starting in interval +4 and extending for about one day, but again, most differences are not significant. Figure 8 plots the results.

Table 3 also reports the results for the bid quotes. As predicted for upgrades, the recommending market maker is more aggressive on the bid side than the control groups before the announcement. The differences are highly statistically significant starting in interval -3. They are around 5%, which is meaningful when compared to 11%, which is the average proportion of time that the recommending market maker quotes at the inside bid during the control period. Figure 9 gives a plot of the results.

The results for downgrades are also consistent with information leakage and opportunistic behavior. Table 4 shows that the differences in quoting behavior on the ask side between the recommending market maker and the two control groups are significant for about three hours before the announcement. The recommending market maker is more aggressive in her quoting behavior on the ask side. The differences, which range from 3% to 5%, are economically meaningful when compared to 8.3%, which is the average proportion of time that the recommending market maker quotes at the inside ask during the control period. Figure 10 plots the results.

Table 4 also reports the results for bid quotes around downgrades. Before the recommendation announcement, the difference in quoting behavior between the recommending market maker and the control groups is not statistically significant. Figure 11 plots the results.

[13] The change is the raw deviation from the own control-period time-of-day-matched mean, as defined in Eq. (1).

To summarize, the quoting behavior of the recommending market maker changes significantly in the direction of the recommendation revision well before the public announcement, even after controlling for her own behavior during the non-event period and for the quoting behavior changes of other market makers. This evidence further supports our hypothesis, H1, regarding information leakage and opportunistic behavior before analyst recommendation revisions.

As a robustness check, we also perform a rank order test. The rank order test is a second method to control for the quoting behavior of other and of peer market makers. Hong and Kubik (2003) use a similar rank score to rate the relative performance of analysts. Each market maker's rank is based on the proportion of time at the inside quote. We use the rank to compute a rank score for each market maker, which is defined as

$$Score_{i,j,t} = 100 - \left[\frac{Rank_{i,j,t} - 1}{Number\ of\ Market\ Makers_{j,t} - 1} \right] \times 100, \tag{3}$$

where $Rank_{i,j,t}$ is the rank of market maker *i*, for security *j*, during half-hour interval *t*, for the proportion of time a market maker quotes at the inside, and $Number\ of\ Market\ Makers_{j,t}$ is the number of market makers for security *j* during half-hour interval *t*. This score is computed for ask and bid quotes separately. If a market maker quotes at the inside more often than any other market maker during a given half-hour interval, then she has a rank of one and a score of 100 for that interval. On the other hand, a market maker who is the least often at the inside receives a score of 0. The rank score compares one market maker's behavior to the behavior of all other market makers, and thus controls for factors that impact all market makers.

We compare the rank score of each market maker during every event period interval to the mean rank score of that market maker during the corresponding half-hour intervals in the control period. Figures 12 and 13 plot the cross-sectional means of the raw deviations in rank scores for upgrades and downgrades, respectively. The results are consistent with our previous findings. Figure 12 shows that for upgrades, the rank score of the recommending market maker does not change significantly for the ask quotes, but does increase significantly for the bid quotes. The rank score increases are significant for three hours before the announcement, and they are quite large for an hour and a half before the announcement. The increased rank score implies that the recommending market maker quotes more aggressively on the bid side in anticipation of the announcement. For downgrades, Figure 13 shows that the rank score for the recommending market maker does not significantly change for bid quotes, but does increase significantly for ask quotes. The increase in rank score is highly significant for two hours before the announcement. Thus, recommending market makers are more aggressive on the ask side before downgrades. To summarize, the rank score analysis confirms our earlier results and provides additional evidence consistent with the presence of information leakage and opportunistic behavior before recommendation revisions, and it therefore supports hypothesis H1.

4.4. Market Maker Quoting Behavior and Stock Returns

In the previous sections, we test hypothesis H1 and we find that the recommending market makers change their quoting behavior well before the public announcements and they anticipate the direction of the pending recommendation revisions. Further, we find significantly positive (negative) abnormal returns in the half-hour intervals leading up to upgrades (downgrades). In this section, we turn to hypothesis H2 and we analyze the relation between the recommending market makers' early reaction and stock returns. If the change in quoting behavior of the recommending market makers reflects non-public information, we expect this non-public information to be impounded in stock prices leading up to the public announcement. To capture the interaction among stock prices, the quoting behavior of recommending market makers, and the quoting behavior of peer market makers, we use a five-variable reduced-form vector autoregression (VAR) proposed by Sims (1980),[14]

$$X_t = a_0 + \sum_{i=1}^{N} a_{t-i} X_{t-i} + e_t \, , \tag{4}$$

where X_t is a (5 x 1) vector that includes the following variables: stock returns based on midpoints, the

[14] Similar applications of VAR systems to questions in market microstructure can be found in Stephan and Whaley (1990) and Easley, O'Hara, and Srinivas (1998).

proportion of time at the inside bid for recommending and for peer market makers, and the proportion of time at the inside ask for recommending and for peer market makers.[15] To be consistent with our previous analyses, we use half-hour intervals. We estimate the VAR system over the periods [-39, -14], [-39, -1], and [0, 39], respectively, in our analysis of time variation in quoting behavior and stock returns.[16] For brevity of exposition, we report only the results for the stock return equation in the VAR system. Additional estimation results are available from the authors upon request.

For the 393 upgrades and 403 downgrades in our peer market maker samples, we define the variables used in the estimation of the VAR system as follows. We use stock returns for the upgrade sample to illustrate our procedure. First, we compute the raw deviations of the returns during the event period from the time-of-day-matched mean returns during the control period, i.e., the abnormal returns [see Equation (1)]. Second, we calculate the cross-sectional mean abnormal returns during the event period for the upgrade sample, the "event-period means." Third, we standardize the event-period means by subtracting the mean of the event-period means during the estimation period, e.g., period [-39, -14], and by dividing by the standard deviation of the event-period means during the same estimation period. This standardization allows comparison of coefficient estimates across VAR systems estimated for different periods.

We do not find the presence of unit roots in any of the time series. The Akaike Information Criterion (AIC) and the Schwarz Bayesian Criterion (SBC) indicate that the lag length of the VAR system is one. Each equation in the system is estimated with ordinary least squares (OLS), because OLS estimates are consistent and asymptotically efficient when each equation of a VAR system has identical independent variables [see, e.g., Greene (2002)].

We use variance decomposition to examine the proportion of the variation in stock returns that is

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[15] Using the proportion of time at the inside for other market makers instead of the proportion of time at the inside for peer market makers yields qualitatively similar results. Estimation results are available from the authors upon request.

[16] Ideally, we would like to estimate the VAR system for half-hour intervals close to the event half hour, e.g., [-13, -1], but that would not provide sufficient degrees of freedom. Estimating for the period [-39, -1] may understate any change in the importance of quoting behavior during the half-hour intervals immediately preceding the public announcement.

due to shocks to stock returns themselves, as opposed to shocks to the other variables in the VAR system. For identification purposes, we use the Choleski decomposition method to diagonalize the covariance matrix of innovations [see, e.g., Sims (1980)]. Because the ordering of the variables can affect the decomposition results, we estimate all of the 120 possible orderings for our five-variable VAR system and report the mean, median, maximum, and minimum of the variance decomposition estimates.

If the quoting behavior of the recommending market maker has increasing explanatory power for stock returns immediately preceding the public announcement, its pre-announcement variance decomposition estimates should become larger as we move closer to the event half hour. Simultaneously, the estimates for the recommending market maker's quoting behavior should become larger than the variance decomposition estimates for the peer market maker's quoting behavior. For example, we would expect that for downgrades, the decomposition estimates for the recommending market maker's time at the inside ask would be larger for period [-39, -1] than for period [-39, -14], and larger than the estimates for peer market makers' quoting behavior.

The minima and maxima provide the lower and upper bounds for the variance decomposition estimates. The following example illustrates how we use the minima and maxima to evaluate the relative importance of the independent variables. For downgrades, if the minimum of the variance decomposition estimates for the recommending market maker's time at the inside ask is larger than the maxima of the variance decomposition estimates for the other quoting behavior variables, then this would imply that, among the quoting behavior variables, the recommending market maker's time at the inside ask is the most important determinant of stock returns.

Panel A of Table 5 reports the variance decomposition results for the stock return equation. For period [-39, -14], stock returns are dominated by their own innovations for upgrades and downgrades. The decomposition estimates indicate that for upgrades (downgrades), on average, about 76% (85%) of the variation in stock returns can be explained by innovations in stock returns.

For period [-39, -1], the recommending market maker's time at the inside bid (ask) is the most important of the quoting behavior variables for upgrades (downgrades). For upgrades, the maximum estimates for the other quoting behavior variables (22.0%, 9.2%, 3.0%) are smaller than the minimum for the recommending market maker's time at the inside bid (22.5%). Innovations in the recommending market maker's time at the inside bid have an influence on the variation in stock returns that is similar in magnitude to that of the stock return innovations; the mean variance decomposition estimates are 32.4% and 49.2%, respectively. For downgrades, the variation in stock returns seems to be dominated equally by stock return innovations and by innovations in the recommending market maker's time at the inside ask; the mean decomposition estimates are 49.4% and 42.5%, respectively. The maximum estimates for the other quoting behavior variables are much smaller than the minimum estimate for the recommending market maker's time at the inside ask.

For period [0, 39], stock return innovations dominate the variation in stock returns. The mean variance decomposition estimate for stock returns is 49.4% (69.9%) for upgrades (downgrades). The recommending market maker's and peer market makers' quoting behavior are less important and have similar influences on stock returns.

Panel B of Table 5 reports the coefficient estimates and t-statistics for the independent variables in the stock return equation of the VAR system. Because the independent variables are lagged one period, the t-statistics give the results of Granger causality tests [see Granger (1969)]. Since we have standardized all time series, the coefficient estimates represent the change in stock returns, measured in standard deviations, when there is a one standard deviation change in the independent variable. For period [-39, -14], none of the coefficient estimates is statistically significant at conventional levels for either upgrades or downgrades.

For period [-39, -1], stock returns and the recommending market maker's time at the inside bid (ask) are highly significant for upgrades (downgrades), whereas the other quoting behavior variables are not significant. For upgrades, an increase of one standard deviation in the recommending market maker's time at the inside bid increases future stock returns by 0.432 standard deviations. In comparison, a one standard deviation increase in stock returns increases future stock returns by 0.793 standard deviations. For downgrades, a one standard deviation increase in the recommending market maker's time at the inside ask reduces future stock returns by 0.350 standard deviations. In comparison, a one standard deviation increase in stock returns increases future stock returns by 0.730 standard deviations.

For period [0, 39], only the recommending and peer market makers' time at the inside bid are significant for upgrades. A one standard deviation increase in the recommending and peer market makers' time at the inside bid increases future stock returns by 0.189 and 0.175 standard deviations, respectively. For downgrades, only stock returns are significant at conventional levels. A one standard deviation increase in stock returns increases future stock returns by 0.087 standard deviations.

In summary, we find strong support for hypothesis H2. The recommending market maker's time at the inside bid (ask) has substantial explanatory power for stock returns in the half-hour intervals immediately preceding the public announcement of upgrades (downgrades). The explanatory power of the recommending market maker's time at the inside bid (ask) is much larger than that of the other quoting behavior variables for upgrades (downgrades). In addition, the recommending market maker's time at the inside bid (ask) is nearly as important as stock returns in explaining future stock returns. These results suggest that changes in recommending market makers' quoting behavior have a relation with stock returns that appears strong enough to be economically meaningful. Overall, this evidence is consistent with non-public information being impounded into stock prices as a result of opportunistic quoting behavior by recommending market makers or as a result of informed trading by investors who trade through recommending market makers.

5. Conclusions

This study investigates the question of whether there is information leakage, and associated opportunistic behavior, before analyst recommendation revisions. We evaluate two types of evidence. First, we analyze the quoting behavior of market makers who are affiliated with the same brokerage firms as the recommending analysts. Their quoting behavior suggests that someone has prior knowledge of the analysts' pending announcements; it may be the recommending market makers, the proprietary traders in their firm, or outside investors who have this prior knowledge. We find that for an hour and a half before upgrades, the proportion of time that recommending market makers quote at the inside bid increases significantly, by as much as 43%, but their quoting behavior on the ask side does not change. For three hours before downgrades, the proportion of time that recommending market makers quote at the inside ask increases significantly, by as much as 59%, but their quoting behavior on the bid side does not change. The early reaction of the recommending market makers is highly significant after controlling for their own behavior during the non-event period and for the change in quoting behavior of other market makers. Thus, the evidence indicates that the recommending market makers react well before the public announcements and before other market makers.

Second, we analyze the relation between quoting behavior and stock returns in pre-announcement, announcement, and post-announcement periods. We not only document substantial price reactions—approximately 1.39% (-2.8%) for upgrades (downgrades)—during the half-hour public announcement periods, but we also find statistically and economically significant abnormal half-hour returns, ranging from 0.26% to 2.27% in absolute value, for more than two hours before the public announcements. These stock price reactions are consistent with the presence of information leakage and indicate the value of the leaked information. Further, we find that leading up to the public announcements of analyst recommendation changes, the quoting behavior of recommending market makers has substantial explanatory power for stock returns. Before upgrades (downgrades), an average of 32.4% (42.5%) of the variation in stock returns can be explained by innovations in the time recommending market makers quote at the inside bid (ask). The changes in the recommending market makers' quoting behavior before recommendation revisions are not only statistically significant, but are also economically meaningful. These findings are consistent with non-public information being gradually impounded into stock prices as a result of opportunistic quoting behavior by recommending market makers or as a result of informed trading by investors who trade through recommending market makers. In conclusion, this paper provides evidence consistent with the presence of information leakage and opportunistic behavior before analyst recommendation revisions.

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Appendix A. Related NASD and NYSE Regulations

NASD Rule 2110. Standards of Commercial Honor and Principles of Trade

A member, in the conduct of its business, shall observe high standards of commercial honor and just and equitable principles of trade.

IM-2110-4. Trading Ahead of Research Reports

The Board of Governors, under its statutory obligation to protect investors and enhance market quality, is issuing an interpretation to the Rules regarding a member firm's trading activities that occur in anticipation of a firm's issuance of a research report regarding a security. The Board of Governors is concerned with activities of member firms that purposefully establish or adjust the firm's inventory position in Nasdaq-listed securities, an exchange-listed security traded in the OTC market, or a derivative security based primarily on a specific Nasdaq or exchange-listed security in anticipation of the issuance of a research report in that same security. For example, a firm's research department may prepare a research report recommending the purchase of a particular Nasdaq-listed security. Prior to the publication and dissemination of the report, however, the trading department of the member firm might purposefully accumulate a position in that security to meet anticipated customer demand for that security. After the firm had established its position, the firm would issue the report, and thereafter fill customer orders from the member firm's inventory positions.

The Association believes that such activity is conduct which is inconsistent with just and equitable principles of trade, and not in the best interests of the investors. Thus, this interpretation prohibits a member from purposefully establishing, creating or changing the firm's inventory position in a Nasdaq-listed security, an exchange-listed security traded in the third market, or a derivative security related to the underlying equity security, in anticipation of the issuance of a research report regarding such security by the member firm.

Rule 2110 states that:

A member in the conduct of its business, shall observe high standards of commercial honor and just and equitable principles of trade.

In accordance with Article VII, Section 1(a)(ii) of the NASD By-Laws, the Association's Board of Governors has approved the following interpretation of Rule 2110:

Trading activity purposefully establishing, increasing, decreasing, or liquidating a position in a Nasdaq security, an exchange-listed security traded in the over-the-counter market, or a derivative security based primarily upon a specific Nasdaq or exchange-listed security, in anticipation of the issuance of a research report in that security is inconsistent with just and equitable principles of trade and is a violation of Rule 2110.

For purposes of this interpretation, a "purposeful" change in the firm's inventory position means any trading activities undertaken with the intent of altering a firm's position in a security in anticipation of accommodating investor interest once the research report has been published. Hence, the interpretation does not apply to changes in an inventory position related to unsolicited order flow from a firm's retail or broker/dealer client base or to research done solely for in-house trading and not in any way used for external publication.

Under this interpretation, the Board recommends, but does not require, that member firms develop and implement policies and procedures to establish effective internal control systems and procedures that would isolate specific information within research and other relevant departments of the firm so as to prevent the trading department from utilizing the advance knowledge of the issuance of a research report. Firms that choose not to develop “Chinese Wall” procedures bear the burden of demonstrating that the basis for changes in inventory positions in advance of research reports was not purposeful.

[Adopted by SR-NASD-95-28 eff. Aug. 15, 1995; amended by SR-NASD-98-86 eff. Nov. 19, 1998.]

NYSE Rule 401. Business Conduct

Every member, allied member and member organization shall at all times adhere to principles of good business practice in the conduct of his or its business affairs.

401/01 Trading Against Firm Recommendations

Transactions in a security by a member organization or its personnel shortly before or after the firm issues a purchase or sale recommendation raise questions of the motive. Firm personnel who participate in making the recommendation or have any pre-publication knowledge of it should refrain from any action in contemplation of the report, such as making a transaction for their own account or accounts in which they have an interest or discretion, or passing on advance information concerning the report to persons outside the firm.

At the time that customers generally learn of the recommendation, firm personnel should be free to act for unaffiliated discretionary accounts but should refrain from acting for accounts in which they have an interest, either in accordance with or contrary to the recommendation, until the market effect of the recommendation is spent.

The time duration of the market effect is very difficult to determine and varies greatly with circumstances. Some firms have lessened the difficulty of individual decisions by selecting a minimum period following a recommendation during which firm personnel are restricted from acting for accounts in which they have an interest.

The period of time which elapses before customers generally learned of the recommendation is also difficult to determine and, therefore, it is advisable that a similar policy be adopted with respect to the accounts over which personnel have discretion but in which they have no interest.

Appendix B. Agencies, Regulations, and Disciplinary Actions

Type of Information Leakage	Agency	Applicable Rules	Examples of Disciplinary Actions
Leakage within the same brokerage firms	SEC	Disclosure Rules	Bank of America is being investigated for trading ahead of its own research reports [Smith (2004)]. Lucchetti and Craig (2004) report on an SEC investigation into "whether Wall Street firms are cheating bond investors with research that is … leaked ahead of time to the firms' own traders."
	NYSE	Rule 401 and 401/01	PaineWebber is disciplined for trading ahead of its own research reports in 1982 [WSJ (1985)].
	NASD	IM 2110-4	Needham & Company is disciplined for trading ahead of its own research report [NASD (2002)].
Leakage to outside investors	SEC	Insider Trading Rules	Merrill Lynch is disciplined for leaking upcoming research reports to investment bankers in Merrill Lynch and outside investors [SEC litigation release 18115 on April 28, 2003].
	NYSE	Rule 401 and 401/01	Raymond James is disciplined for leaking upcoming research reports to outside investors in 1987 [Brannigan (1993)]. Merrill Lynch and its employees are disciplined for leaking upcoming research reports to outside investors in 2003 [NYSE (2004a, b, and c)].
	NASD	Rule 2110 and IM 2110-4	No examples of disciplinary action were found in our search of news reports.

Appendix C. Data Filters

We apply the following filters to the intraday Nastraq data. Observations violating these filters are classified as invalid. Invalid observations are not deleted, but subsequent analysis of intraday trade and quote data take the classification into account.

Dealer Quote Data Filters

- The market maker must be open to trade the stock.
- Ask quotes must be greater than bid quotes, which in turn must be greater than zero.
- Both bid and ask depths must be greater than zero.
- The time stamp must be before 4PM EST.
- We retrieve the last quote for each market maker before 9:30AM EST and all subsequent quotes.
- For each stock and day, we compute the minimum ask quote and the maximum bid quote. We require that dealer bid quotes are not less than 65% of the minimum daily ask quote, and that dealer ask quotes are not greater than 135% of the maximum daily bid quote.

Inside Quote Data Filters

- If there is an opening inside quote for a stock, we require the time stamp to be after the opening. If there is no opening inside quote, we keep the last quote before 9:30AM EST and all subsequent quotes.
- The time stamp must be before 4PM EST.
- Ask quotes must be greater than bid quotes, which in turn must be greater than zero.
- We require that bid and ask quotes are within 7.5 standard daily deviations from their respective daily means.

Trade Data Filters

- The time stamp must be within regular trading hours: 9:30AM to 4PM EST.
- We restrict trades to regular trades.
- Both the trade price and the trade size must be greater than zero.
- Trade prices must be within 7.5 standard daily deviations from the daily mean.

Appendix D. ECNs and Market Makers

We follow Huang (2002) in classifying market participants in the Nasdaq market into four major groups: institutional brokers, wire houses, wholesalers, ECNs. Remaining market participants are labeled "Minors."

ID	Name
Institutional brokers	
BEST	Bear Stearns
BTAB	BT Alex. Brown
DBKS	Deutsche Bank Securities
DLJP	Donaldson, Lufkin & Jenrette
FBCO	Credit Suisse First Boston
GSCO	Goldman Sachs
HMQT	Hambrecht & Quist
JPMS	J. P. Morgan Securities
LEHM	Lehman Brothers
MONT	Banc of America Securities
MSCO	Morgan Stanley
RSSF	Robertson Stephens
WARR	UBS Warburg
Wire houses	
DEAN	Dean Witter Reynolds
MLCO	Merrill Lynch, Pierce, Fenner & Smith
PRUS	Prudential Securities
PWJC	Painewebber
SBSH	Salomon Smith Barney
Wholesalers	
FLTT	Fleet Trading
HRZG	Herzog, Heine, Geduld
MASH	Mayer & Schweitzer
NAWE	Nash Weiss
NITE	Knight/Trimark Securities
SHWD	Sherwood Securities
SLKC	Spear Leeds & Kellogg Capital
TSCO	Troster Singer
USCT	US Clearing Corporation
Electronic communication networks	
ARCA	Archipelago
ATTN	Attain
BRUT	Brass Utility
BTRD	B-Trade Services
INCA	Instinet
ISLD	Island
MKXT	Marketxt
NTRD	Pim Global Equities
REDI	REDI
STRK	Strike Technologies
TNTO	Terra Nova Trading

Table 1. Distribution of Analyst Recommendations

Panel A. Transition Matrix of Analyst Recommendations

From Recommendation of:	To Recommendation of: Strong Buy	Buy	Hold	Sell	Strong Sell	Total
Strong Buy		140	81	0	0	221
Buy	196		205	1	0	402
Hold	37	172		5	1	215
Sell	0	2	1		0	3
Strong Sell	0	0	3	0		3
Total	233	314	290	6	1	844

Panel B. Intraday Distribution of Analyst Recommendation Revisions

Time Interval From	To	Number of Upgrades	Number of Downgrades	Number of Recommendations
09:30	10:00	90	76	166
10:00	10:30	57	80	137
10:30	11:00	43	52	95
11:00	11:30	53	49	102
11:30	12:00	28	37	65
12:00	12:30	19	21	40
12:30	13:00	16	19	35
13:00	13:30	27	22	49
13:30	14:00	13	16	29
14:00	14:30	17	22	39
14:30	15:00	18	12	30
15:00	15:30	9	15	24
15:30	16:00	21	12	33
Total		411	433	844

Table 2. Descriptive Statistics of Firms in Analyst Recommendation Revision Sample

There are 844 recommendation revisions in the sample. The event period is defined as the 79 half-hour intervals centered on the recommendation revision, i.e., three days before and three days after the announcement half-hour interval. The control period is defined as the 260 half-hour intervals surrounding the event period, i.e., the ten days before and ten days after the event period. Market capitalization is computed as the mean daily market capitalization during the control period using Center for Research in Security Prices (CRSP) data. Price per share is the mean daily CRSP closing price during the control period. Daily share volume, daily dollar volume, and daily turnover are the daily means during the control period. Volumes are computed using Nastraq transaction data. Turnover is defined as the share volume on a given day divided by the number of shares outstanding, as given by CRSP on that day. Volatility is the standard deviation of daily returns during the control period; daily returns are collected from CRSP. Proportional spread is the time-weighted mean inside half-spread during the control period. Number of market makers is defined as the number of market makers who are active in a stock for a specific recommendation. We define a market maker to be active in a stock if there is at least one valid quote observation from that market maker during the event period.

			Quartile		
Variable	**Mean**	**Standard Deviation**	**25%**	**50% (Median)**	**75%**
Market Capitalization *(in $ million)*	3,296	20,426	172	442	1,155
Price Per Share *(in $)*	25.47	24.88	9.92	17.99	31.78
Daily Share Volume *(in thousand shares traded)*	974	2,424	92	281	756
Daily Dollar Volume *(in $ thousand)*	46,138	167,716	1,077	5,140	17,440
Daily Turnover *(in %)*	1.41	1.28	0.55	1.04	1.86
Volatility *(in %)*	4.45	1.91	3.12	4.05	5.37
Proportional Spread *(in %)*	0.60	0.51	0.27	0.45	0.75
Number of Market Makers	26.85	14.76	16	23	35

Table 3. Upgrades - Differences in Proportion of Time at Inside Quotes Between Recommending Market Maker and Control Groups: Raw Deviations From Control Period

We compute the difference between the proportion of time at inside quotes during the event period and during the control period for all market makers. We then calculate the difference in the quoting behavior changes between recommending market makers and the mean of all other market makers and peer market makers, respectively. The other market maker sample contains 411 upgrades and 433 downgrades. Due to a lack of peers, there are 393 observations for upgrades and 403 observations for downgrades in the peer market maker sample. The means are calculated across all recommendations and p-values are obtained from empirical distributions created by Monte Carlo simulations. Boldface indicates significance at the 5% level.

		Differences in Proportion of Time at Inside Ask				Differences in Proportion of Time at Inside Bid			
	Half-Hour	Other Market Makers		Peer Market Makers		Other Market Makers		Peer Market Makers	
Day	Interval	Mean (%)	p-value	Mean (%)	p-value	Mean (%)	p-value	Mean (%)	p-value
	-13	-0.65	0.560	-0.04	1.000	-2.15	0.072	**-2.55**	0.036
	-12	0.17	0.780	0.69	0.466	-1.15	0.334	-1.82	0.136
	-11	-0.18	0.864	0.05	0.946	-0.89	0.482	-0.60	0.676
	-10	-0.09	0.920	0.12	0.902	0.00	1.000	0.62	0.596
	- 9	-1.92	0.046	-1.64	0.100	-0.34	0.840	0.81	0.538
	- 8	-1.85	0.058	-1.25	0.234	0.41	0.716	1.13	0.354
-1	- 7	-0.74	0.502	-0.55	0.614	0.20	0.900	0.89	0.502
	- 6	-1.69	0.088	-1.51	0.136	0.21	0.864	0.95	0.420
	- 5	-1.39	0.172	-0.99	0.360	0.61	0.596	1.41	0.262
	- 4	**-1.98**	0.050	-1.55	0.154	1.77	0.132	**2.71**	0.036
	- 3	-1.45	0.122	-0.43	0.720	**3.22**	0.004	**4.81**	0.000
	- 2	-1.38	0.176	-0.80	0.440	**4.30**	0.000	**5.28**	0.000
	- 1	-1.82	0.078	-1.03	0.348	**4.74**	0.000	**5.37**	0.000
Event	0	-0.97	0.326	-0.90	0.400	**4.19**	0.002	**4.62**	0.000
	1	-1.13	0.248	-1.15	0.294	**3.18**	0.008	**3.59**	0.006
	2	-1.44	0.162	-0.88	0.428	**4.06**	0.000	**4.70**	0.000
	3	-1.15	0.254	-0.89	0.382	**3.88**	0.002	**4.98**	0.000
	4	1.10	0.284	1.90	0.092	**3.99**	0.000	**5.33**	0.000
	5	-0.28	0.764	0.27	0.792	**3.57**	0.000	**4.42**	0.000
	6	0.05	0.924	0.47	0.634	**3.54**	0.000	**3.58**	0.004
+1	7	0.53	0.644	1.02	0.350	1.97	0.096	1.74	0.166
	8	1.23	0.254	**2.52**	0.026	**2.51**	0.040	**2.52**	0.040
	9	**2.72**	0.010	**3.50**	0.002	**4.22**	0.000	**4.96**	0.000
	10	1.66	0.098	**2.28**	0.028	**2.79**	0.024	**3.65**	0.004
	11	1.53	0.122	**2.49**	0.010	**3.13**	0.014	**3.89**	0.000
	12	1.12	0.232	**2.15**	0.050	**3.50**	0.004	**4.19**	0.000
	13	0.32	0.796	1.18	0.312	1.99	0.116	**2.83**	0.030
	14	-0.22	0.794	0.41	0.684	1.49	0.206	1.81	0.148
	15	-0.44	0.634	-0.14	0.908	2.11	0.074	2.29	0.056
	16	0.75	0.434	1.61	0.152	1.72	0.124	1.94	0.120
	17	-0.13	0.906	1.08	0.342	2.02	0.094	1.94	0.116
	18	1.12	0.248	**2.81**	0.004	0.41	0.720	0.43	0.730
	19	0.50	0.576	1.60	0.116	1.63	0.178	1.88	0.138
+2	20	0.05	0.888	0.88	0.394	2.11	0.086	2.57	0.034
	21	1.23	0.226	1.68	0.132	1.13	0.326	2.26	0.082
	22	0.29	0.760	1.25	0.224	1.68	0.190	2.04	0.108
	23	-0.39	0.644	0.57	0.598	**2.27**	0.046	2.19	0.084
	24	0.06	0.954	1.17	0.266	1.56	0.202	1.09	0.368
	25	0.68	0.496	1.90	0.068	0.31	0.772	0.81	0.530
	26	-0.02	0.998	0.97	0.338	1.84	0.124	**2.47**	0.046

Table 4. Downgrades - Differences in Proportion of Time at Inside Quotes Between Recommending Market Maker and Control Groups: Raw Deviations From Control Period

We compute the difference between the proportion of time at inside quotes during the event period and during the control period for all market makers. We then calculate the difference in the quoting behavior changes between recommending market makers and the mean of all other market makers and peer market makers, respectively. The other market maker sample contains 411 upgrades and 433 downgrades. Due to a lack of peers, there are 393 observations for upgrades and 403 observations for downgrades in the peer market maker sample. The means are calculated across all recommendations and p-values are obtained from empirical distributions created by Monte Carlo simulations. Boldface indicates significance at the 5% level.

		Differences in Proportion of Time at Inside Ask				Differences in Proportion of Time at Inside Bid			
	Half-Hour	Other Market Makers		Peer Market Makers		Other Market Makers		Peer Market Makers	
Day	Interval	Mean (%)	p-value	Mean (%)	p-value	Mean (%)	p-value	Mean (%)	p-value
	-13	**2.30**	0.024	2.16	0.052	0.62	0.568	0.42	0.700
	-12	1.24	0.250	1.51	0.198	-0.64	0.554	-1.59	0.210
	-11	0.57	0.594	0.88	0.454	-0.60	0.572	-1.28	0.330
	-10	1.60	0.136	1.57	0.188	0.35	0.742	-0.33	0.772
	- 9	0.44	0.696	0.13	0.866	-0.51	0.656	-0.57	0.636
	- 8	-0.41	0.666	0.59	0.576	-1.31	0.236	-1.93	0.140
-1	- 7	0.80	0.454	1.70	0.174	0.42	0.666	-0.78	0.542
	- 6	**3.01**	0.004	**3.23**	0.010	0.08	0.958	0.10	0.956
	- 5	**3.10**	0.000	**3.08**	0.002	0.95	0.380	1.93	0.140
	- 4	**3.07**	0.000	**2.60**	0.032	0.72	0.516	2.39	0.066
	- 3	**2.70**	0.016	2.25	0.056	-1.20	0.288	0.14	0.880
	- 2	**3.36**	0.004	**3.72**	0.002	-0.78	0.490	0.09	0.924
	- 1	**4.53**	0.000	**4.90**	0.000	-1.11	0.346	0.26	0.828
Event	0	**4.02**	0.002	**5.37**	0.000	**-2.49**	0.024	0.11	0.980
	1	**2.96**	0.008	**4.25**	0.000	**-2.01**	0.048	-0.57	0.642
	2	**2.39**	0.016	**3.69**	0.000	-1.32	0.216	-0.41	0.702
	3	**2.72**	0.006	**2.75**	0.018	-0.76	0.554	0.34	0.784
	4	**3.35**	0.004	**3.41**	0.000	-0.81	0.500	-0.20	0.844
	5	**2.62**	0.022	2.35	0.060	**-2.37**	0.026	-2.17	0.072
	6	2.04	0.076	0.98	0.408	-1.78	0.096	-1.29	0.316
+1	7	**4.01**	0.000	2.22	0.062	-2.15	0.052	-1.65	0.190
	8	**3.29**	0.006	2.64	0.040	**-3.11**	0.008	-1.98	0.088
	9	**3.04**	0.008	1.97	0.124	-1.87	0.088	-0.01	0.992
	10	1.78	0.104	1.92	0.106	**-2.63**	0.010	-1.15	0.286
	11	**2.70**	0.014	**3.44**	0.002	**-3.12**	0.008	-1.05	0.426
	12	1.33	0.228	**2.54**	0.036	-1.45	0.190	-0.43	0.768
	13	1.63	0.128	1.74	0.140	-0.97	0.370	0.75	0.566
	14	0.87	0.430	1.16	0.358	-1.34	0.246	0.41	0.736
	15	1.10	0.312	1.80	0.150	-1.84	0.076	-0.04	0.966
	16	0.82	0.372	0.75	0.464	-0.21	0.878	1.48	0.228
	17	1.16	0.276	**2.40**	0.050	-1.34	0.232	-0.10	0.994
	18	0.63	0.578	1.50	0.196	**-2.20**	0.044	-1.58	0.210
	19	-0.52	0.636	-0.50	0.718	-1.73	0.154	-1.02	0.444
+2	20	-1.18	0.276	-1.02	0.354	-1.81	0.144	-1.50	0.254
	21	-0.36	0.764	0.12	0.872	-1.08	0.328	-1.73	0.170
	22	-0.70	0.536	0.10	0.898	-0.47	0.656	-0.95	0.418
	23	0.34	0.698	1.20	0.332	-1.07	0.332	-1.25	0.356
	24	0.66	0.552	1.09	0.328	-0.15	0.958	0.59	0.618
	25	0.96	0.382	0.31	0.792	-0.92	0.342	0.68	0.638
	26	-0.18	0.922	-1.58	0.204	-0.12	0.904	1.57	0.178

Table 5. Market Maker Quoting Behavior and Stock Returns

Table 5 reports the estimation results of a five-variable vector autoregressive (VAR) system,

$$X_t = a_0 + a_{t-1} X_{t-1} + e_t ,$$

where X_t is a (5 x 1) vector that includes stock returns based on midpoints (Return), the proportion of time at the inside bid of recommending market makers (Bid – Recommending) and of peer market makers (Bid – Peer), and the proportion of time at the inside ask of recommending market makers (Ask – Recommending) and of peer market makers (Ask – Peer). We estimate the VAR system for the periods [-39, -14], [-39, -1], and [0, 39], and for upgrades and downgrades. The variables of the VAR system are computed as follows. First, we compute the raw deviation of the variable of interest during the event period from the time-of-day-matched mean during the control period. Second, we calculate the cross-sectional means of the raw deviations across recommendation sample, the "event-period means." Third, we standardize the event-period means by subtracting the mean of the event-period means during the estimation period, e.g., period [-39, -14], and by dividing by the standard deviation of the event-period means during the same estimation period. In Panel A, we report the variance decomposition results for the stock return equation. The numbers represent the proportion of variance in stock returns that can be explained by innovations in the respective independent variable. We use the Choleski decomposition method to diagonalize the covariance matrix of innovations. We estimate all of the 120 possible orderings for the five-variable VAR system. For each independent variable, we report the mean, median, maximum, and minimum estimates. In Panel B, we report coefficient estimates and t-statistics for the independent variables in the stock return equation of the VAR system. The t-tests are Granger causality tests. Because we have standardized the variables, the reported coefficient estimate for an independent variable is the change in the stock return, measured in standard deviations, when there is a one standard deviation change in the independent variable in the prior period. There are 393 observations for upgrades and 403 observations for downgrades in the peer market maker sample. In Panel B, boldface indicates significance at the 1% level.

Panel A. Variance Decomposition

	Upgrades				**Downgrades**			
Variable	**Mean**	**Median**	**Max**	**Min**	**Mean**	**Median**	**Max**	**Min**
					Variance Decomposition for Period [-39, -14]			
Return	0.758	0.741	0.874	0.659	0.845	0.840	0.883	0.813
Bid – Recommending	0.078	0.076	0.092	0.070	0.057	0.057	0.068	0.049
Bid – Peer	0.047	0.026	0.095	0.017	0.029	0.026	0.053	0.004
Ask – Recommending	0.097	0.077	0.220	0.001	0.031	0.027	0.053	0.011
Ask – Peer	0.021	0.025	0.021	0.018	0.038	0.052	0.036	0.027
					Variance Decomposition for Period [-39, -1]			
Return	0.492	0.481	0.703	0.334	0.494	0.483	0.669	0.394
Bid – Recommending	0.324	0.294	0.459	0.225	0.032	0.020	0.112	0.013
Bid – Peer	0.106	0.079	0.220	0.024	0.006	0.004	0.023	0.000
Ask – Recommending	0.030	0.012	0.092	0.001	0.425	0.448	0.561	0.274
Ask – Peer	0.049	0.112	0.030	0.013	0.042	0.078	0.029	0.014
					Variance Decomposition for Period [0, 39]			
Return	0.494	0.459	0.639	0.374	0.699	0.698	0.859	0.540
Bid – Recommending	0.195	0.204	0.244	0.159	0.064	0.061	0.074	0.055
Bid – Peer	0.176	0.165	0.296	0.045	0.198	0.200	0.346	0.048
Ask – Recommending	0.017	0.013	0.054	0.000	0.022	0.024	0.044	0.003
Ask – Peer	0.118	0.197	0.118	0.017	0.016	0.023	0.017	0.005

Table 5. ***Continued***

Panel B. Granger Causality Tests

	Upgrades		Downgrades	
Variable	**Estimate**	**t-stat**	**Estimate**	**t-stat**
	Granger Causality Test for Period [-39, -14]			
Return	0.090	0.382	-0.183	-0.810
Bid – Recommending	0.316	1.347	-0.257	-1.103
Bid – Peer	0.101	0.421	0.091	0.382
Ask – Recommending	-0.150	-0.647	0.039	0.147
Ask – Peer	0.051	0.198	0.261	1.128
	Granger Causality Test for Period [-39, -1]			
Return	**0.793**	4.758	**0.730**	4.014
Bid – Recommending	**0.432**	2.960	0.011	0.103
Bid – Peer	0.043	0.317	-0.031	-0.284
Ask – Recommending	-0.066	-0.590	**-0.350**	-2.233
Ask – Peer	-0.105	-0.879	-0.142	-1.377
	Granger Causality Test for Period [0, 39]			
Return	0.075	1.031	**0.087**	2.915
Bid – Recommending	**0.189**	2.446	0.056	1.846
Bid – Peer	**0.175**	2.701	-0.050	-1.681
Ask – Recommending	0.055	0.903	0.028	0.913
Ask – Peer	0.164	1.875	-0.018	-0.580

Figure 1. Proportional Inside Spreads

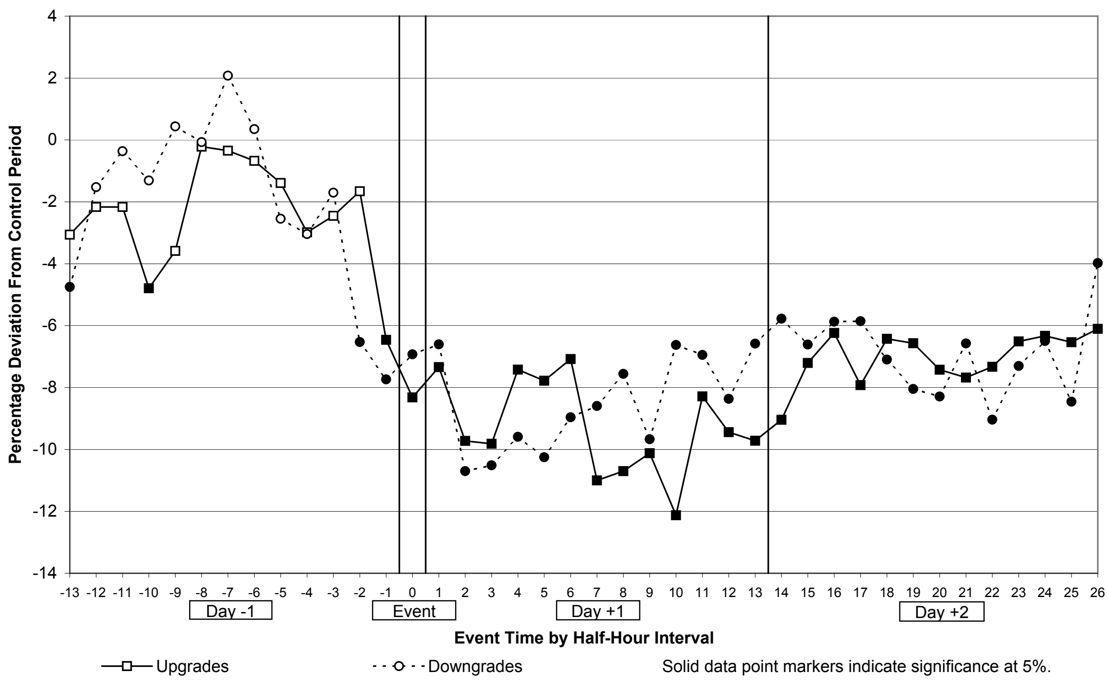

Figure 2. Share Volume

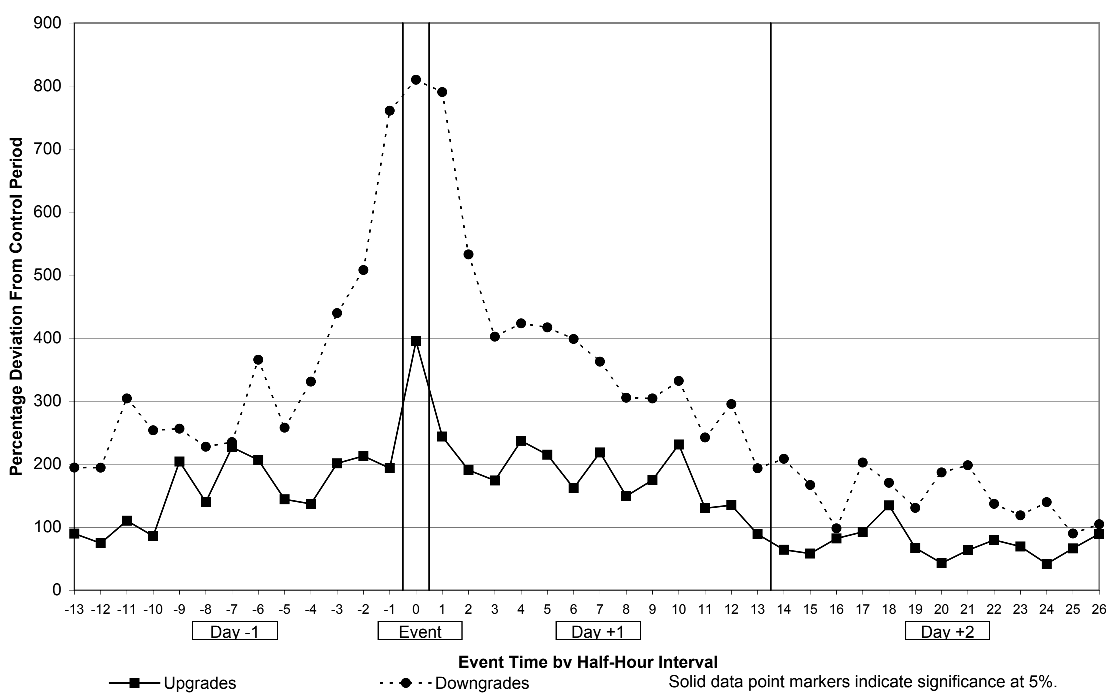

Figure 3. Abnormal Returns

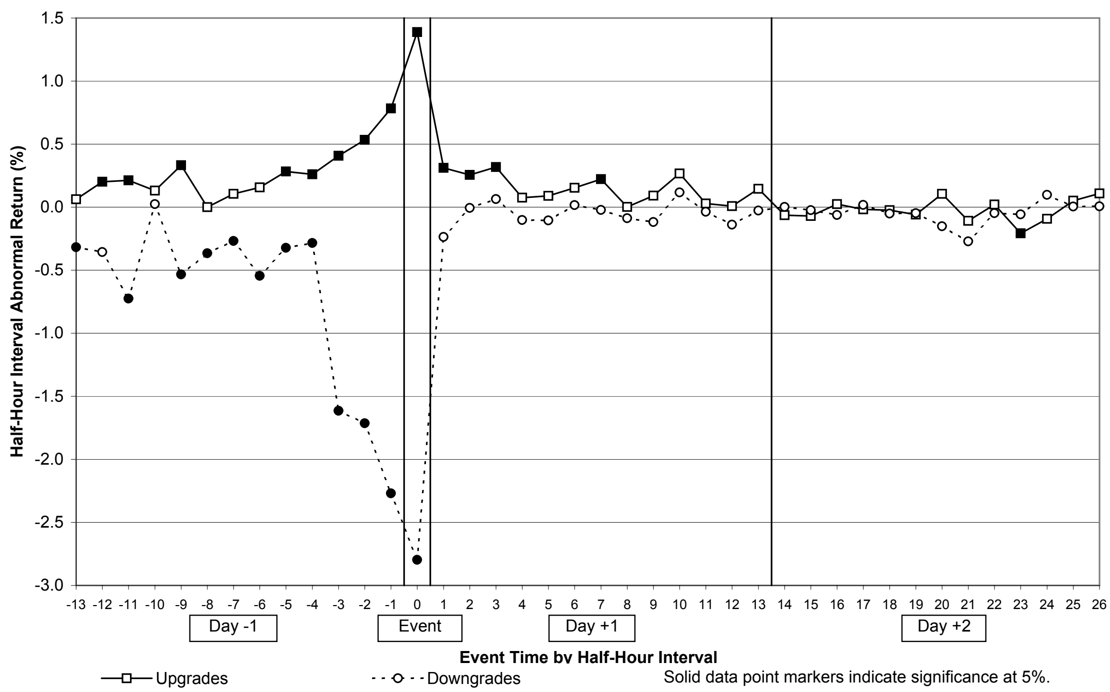

Figure 4. Upgrades - Proportion of Time at Inside Ask

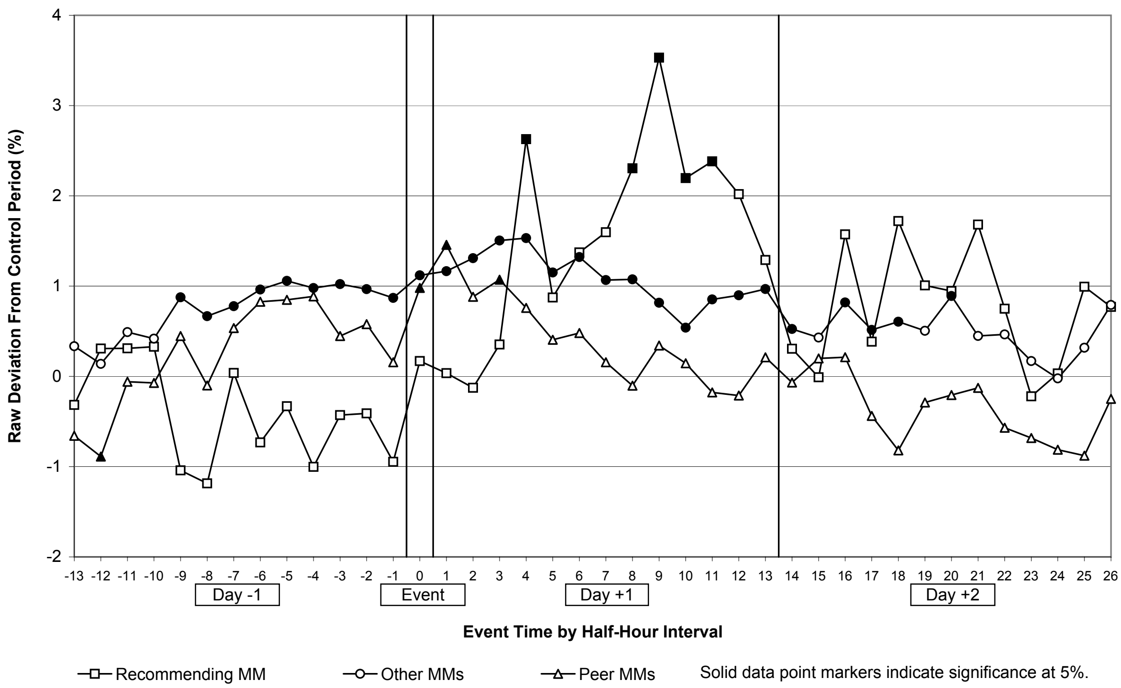

Figure 5. Upgrades - Proportion of Time at Inside Bid

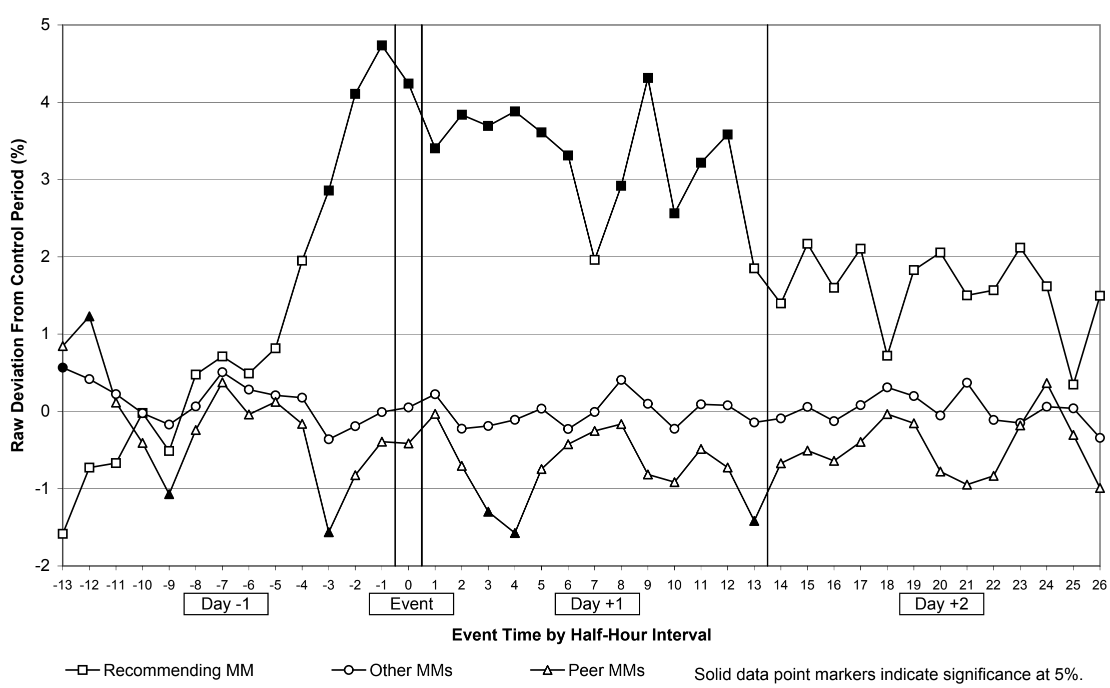

Figure 6. Downgrades - Proportion of Time at Inside Ask

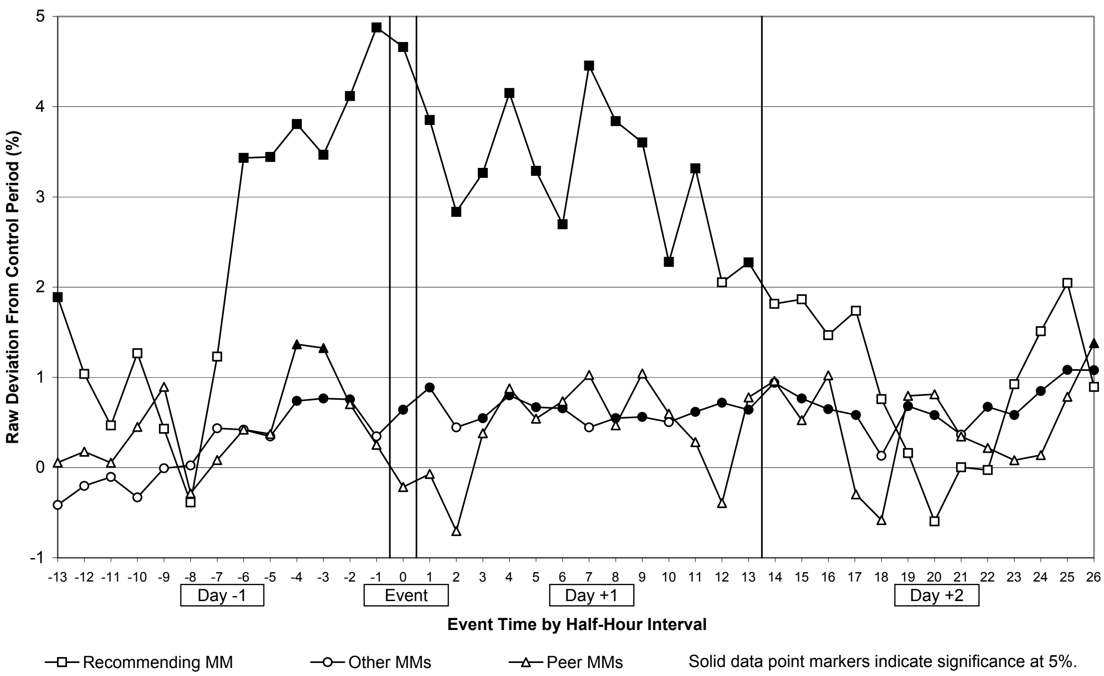

Figure 7. Downgrades - Proportion of Time at Inside Bid

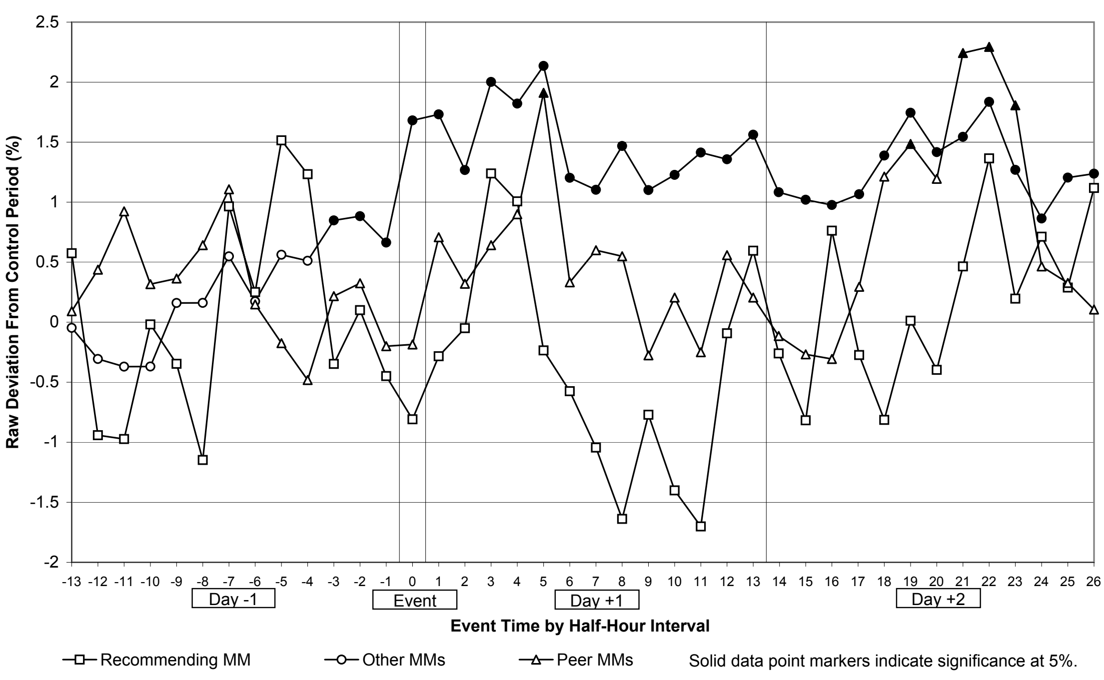

Figure 8. Upgrades - Differences in Proportion of Time at Inside Ask Between Recommending MM and Control Groups of Market Makers

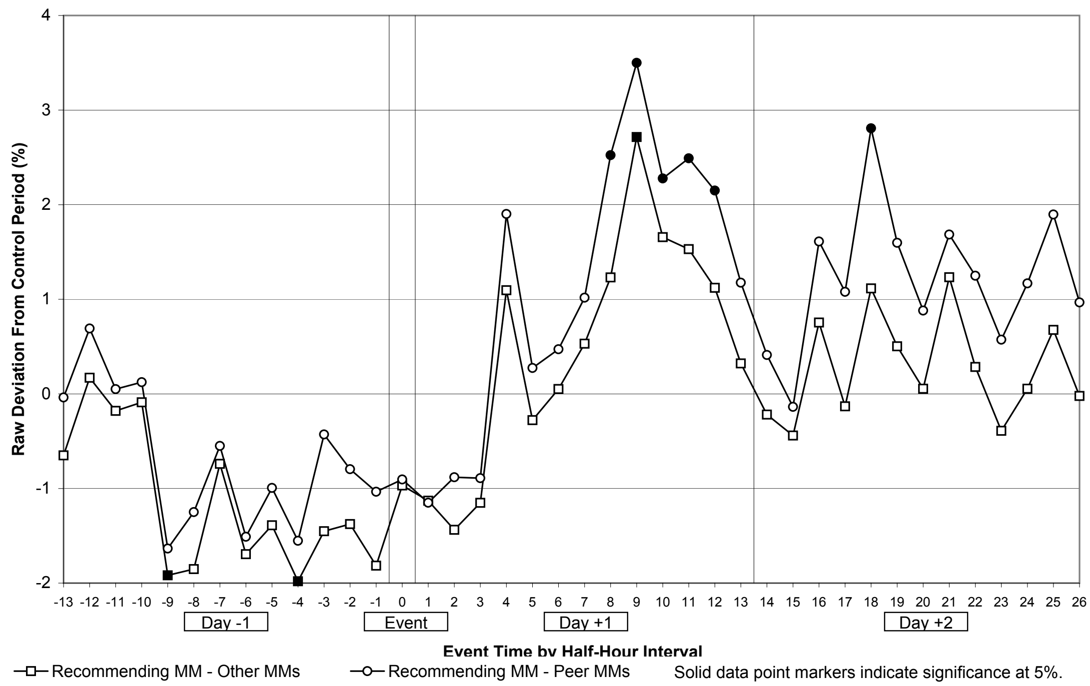

Figure 9. Upgrades - Differences in Proportion of Time at Inside Bid Between Recommending MM and Control Groups of Market Makers

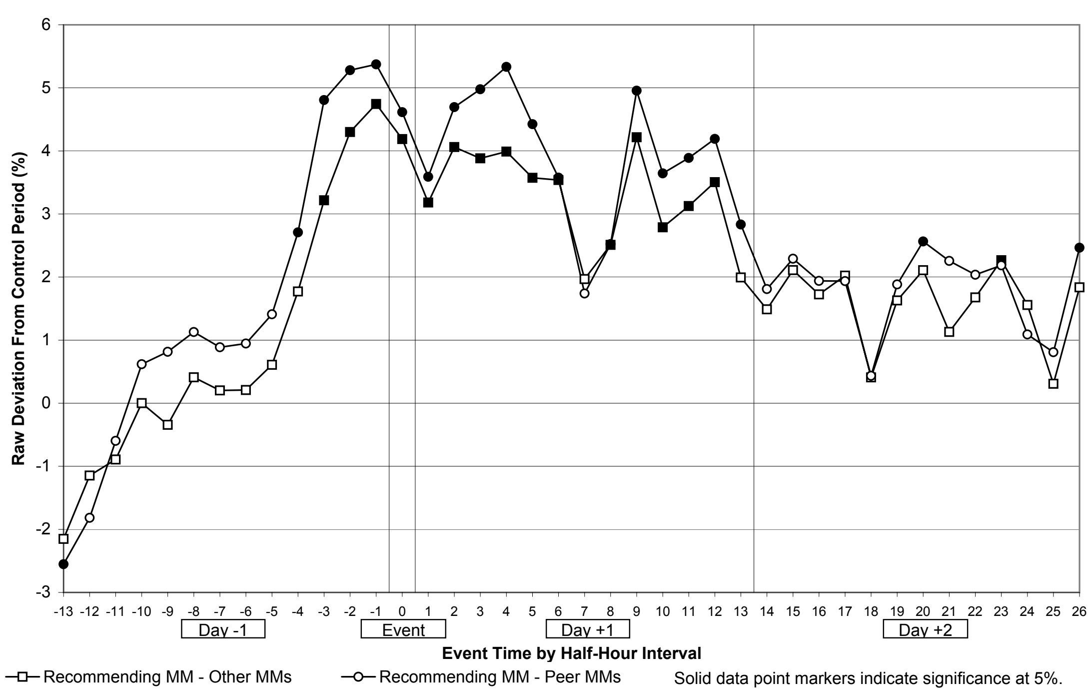

Figure 10. Downgrades - Differences in Proportion of Time at Inside Ask Between Recommending MM and Control Groups of Market Makers

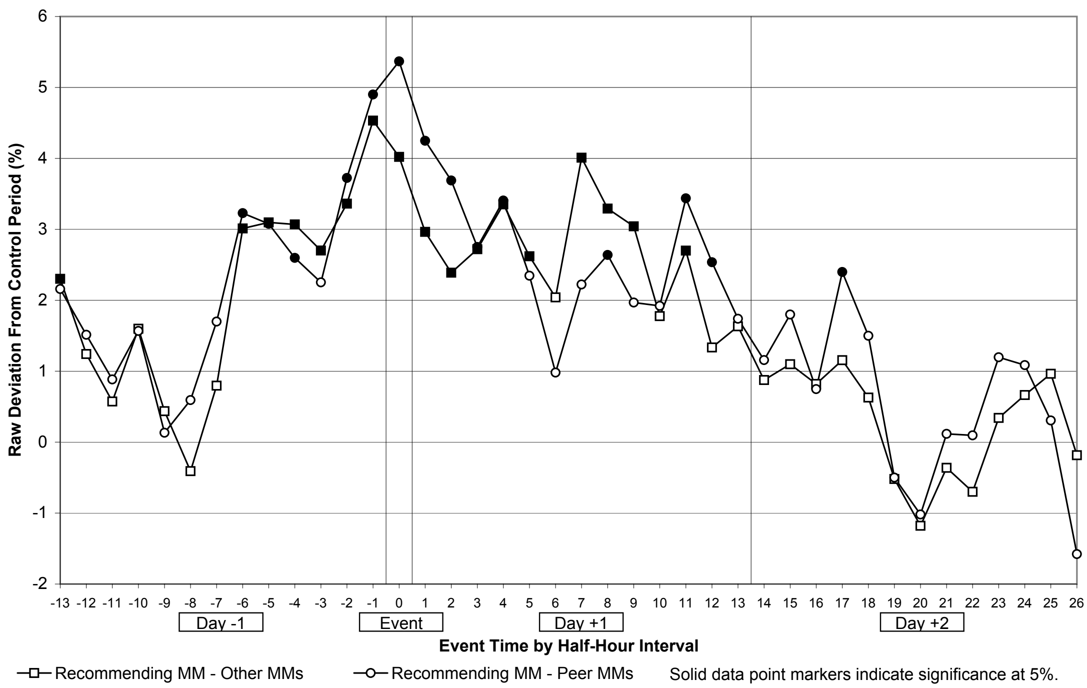

Figure 11. Downgrades - Differences in Proportion of Time at Inside Bid Between Recommending MM and Control Groups of Market Makers

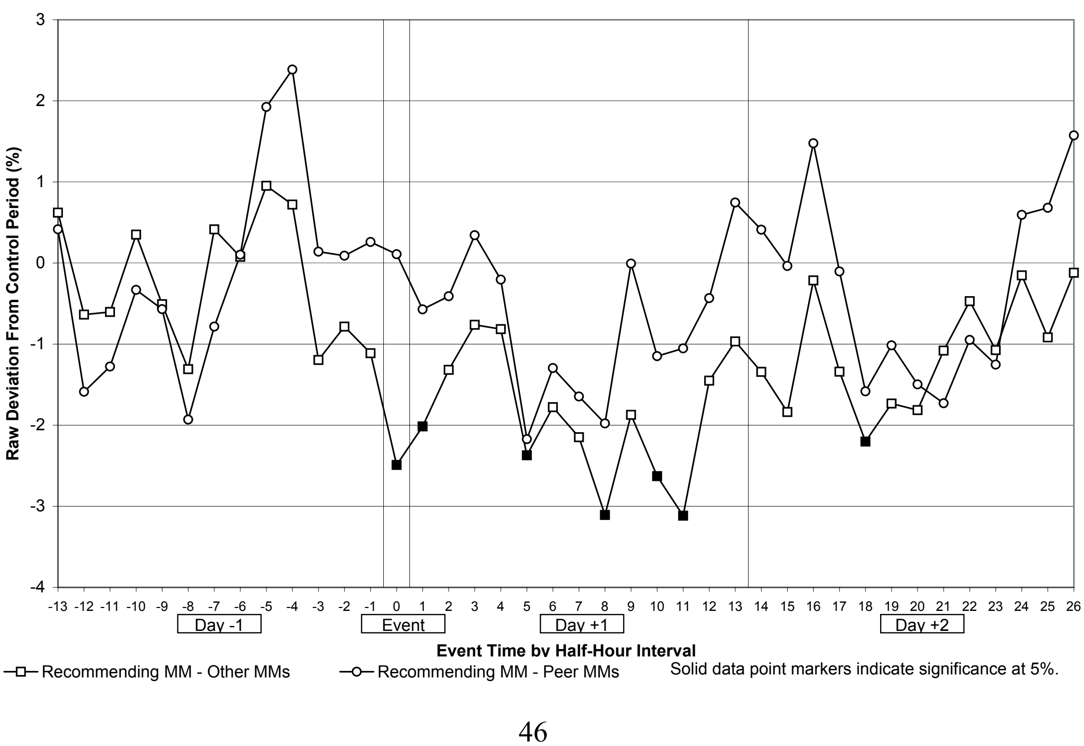

Figure 12. Upgrades - Recommending Market Maker's Rank Scores of Time at Inside Ask and Inside Bid

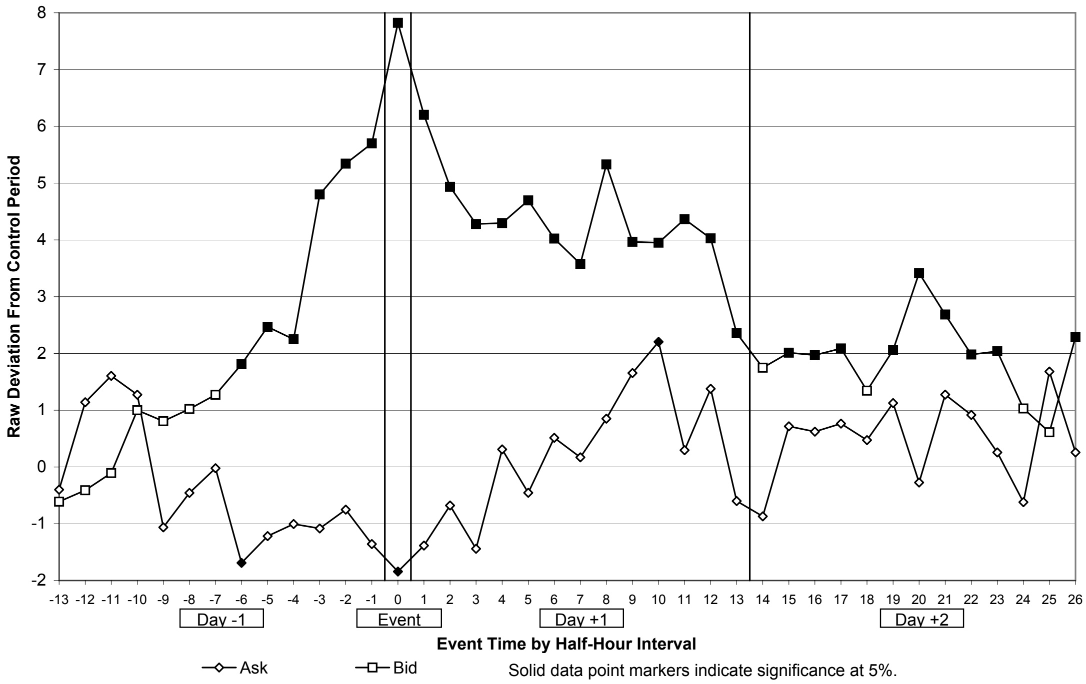

Figure 13. Downgrades - Recommending Market Maker's Rank Scores of Time at Inside Ask and Inside Bid