Trading Aggressiveness and Market Breadth Around Earnings Announcements

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Abstract:

In a single market, liquidity supply has two dimensions--price measured by the quoted spread, and quantity measured by the quoted depth. A third liquidity dimension, market breath, should be added when multiple markets quote the same security and there are enforceable regulatory penalties for a violation of price priority. We define the breadth of the market as the number of quoting market centers matching the best prices, by side of the market. Regulation NMS introduced a price priority rule mandating that orders be routed to the exchange with the best prices, which, in turn, led to the establishment of high speed communications connections between markets. We study liquidity around earnings announcements for NYSE firms. We find that liquidity suppliers significantly decrease market breath prior to earnings announcements, and that large uninformed liquidity demanders significantly increase their use of Intermarket Sweep Orders (ISOs). ISOs are a more aggressive and expensive trading strategy. In post Regulation NMS markets, we show that market breadth is an important measure of liquidity and significantly affects the level of aggressive trading in the market.

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1. Introduction

In a single market, liquidity supply has two dimensions--price as measured by the quoted spread and quantity as measured by the quoted depth. A third dimension, market breadth, is added when multiple markets quote the same security. Market Breadth is the number of market centers quoting liquidity that matches best prices. The implementation of Reg NMS has increased the importance of market breadth. Reg NMS required market centers to install and maintain high speed communications links, allowing market participants to quickly execute against posted liquidity across all market center. Reg NMS also introduced Rule 611, the order protection rule. This rule establishes a price priority between market centers with enforceable penalties for trade throughs of better market prices. These two changes significantly alter the market environment evaluated in previous studies of market breadth.

Prior to the implementation of Regulation National Market System (Reg NMS), intermarket trading was conducted over the Intermarket Trading System (ITS), which was slow and cumbersome to use.[1] In this context market breath was analyzed under the framework of quote competitiveness (see Bessembinder (2003) and Blume and Goldstein (1997)). It is an open question as to whether findings under the older and much different market architecture apply in the current trading environment.

Market breath is an important measure of liquidity for several reasons. First, the liquidity supplier faces execution risk. Although Reg NMS only specifies a price priority requirement, different SRO have different order priority rules. By fragmenting liquidity supply across different market centers, liquidity suppliers may be able to improve the probability of execution by bypassing priority rules on individual exchanges and competing only on the price priority requirement of reg NMS. Second, from a liquidity demand standpoint, liquidity supply on multiple markets allows traders to parallel process demand through multiple market centers simultaneously, obtaining faster execution of trades. We call this the

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[1] Under the old ITS system, trades could take 30 seconds or more to execute. Under the current high speed communications systems, trade times are measured in tens of milliseconds. For additional information on the ITS system see Lee (1993).

'highway affect'; identical to the increase in speed at which drivers move as more lanes are opened. Conversely, as more lanes close, due to construction or other factors, the more aggressive drivers become in order to maintain speed.

We address two questions with this study. First, we investigate when and why liquidity suppliers chose to widen markets by placing liquidity supply on more markets and when and why markets narrow. Second, we investigate how changes in market breadth impact the trading and trade aggressiveness of liquidity demanders. We examine liquidity supply around the NYSE firm earnings announcements. We are the first to investigate market breadth around earnings announcements in the post Reg NMS period.

Our primary findings are:

Market breadth is significantly reduced prior to earnings announcements. We believe that liquidity suppliers reduce market breadth in order to induce more aggressive trading by both informed and uninformed traders. As the number of reliable trading lanes decrease, traders of all types become more aggressive in trading. Aggressive trading comes at a cost, specifically in the form of higher effective spreads for trades.

We find that effective spreads increase by a statistically significant 0.08 cents per share for Intermarket Sweep Orders (ISOs) and 0.06 cents for non-ISO (NSO) trades on the trading day just before the earnings announcement, even though relative spreads narrow and realized spreads remain unchanged. Our findings indicate that market breadth is a statistically significant new dimension of liquidity in the post Reg NMS market.

In this study, we define market breadth as the time weighted average number of markets offering depth (ask or bid) at the best price in the market.[2] Our analysis shows that market breadth continually declines leading up to the earnings announcement. This decline is independent of the subsequent level of earnings surprise. Our analysis, based on daily averages, indicates that there are roughly 0.22 fewer markets to trade in on the last trading day prior to the earnings announcement, compared to our base

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[2] Section 2.0 of this paper reviews several key features of Rule 611, including the definition of best price in the market. We adopt the Rule 611 definition of best price in evaluating market breadth. Specifically, the best price in the market is the least aggressive NBBO ask and bid prices over the previous one (1) second of quotes.

period. After the earnings announcement, breath increases slightly, but remains below base period levels. We find that the magnitude of the reduction in market breath is independent of changes in relative spread and quoted depth around the earnings announcement, but, rather, is related to firm size and trading volume. We find that breadth decreases more for larger firms, but less when trade volumes increase relative to the base period on the last trading day before the announcement. After the announcement, breadth increases less for larger firms and is negatively related to relative spreads, but positively related to quoted depths.

Concurrent with our analysis of market breadth, we also evaluate changes in the traditional measures of quote based liquidity, depth and relative spreads. Similar to the findings of Lee, Mucklow, and Ready (1993), we find the quoted depths, measured as the total posted depth from all market centers posting quotes at best prices, decreases prior to the earnings announcements and then increases after the announcement. We find that depth decreases by an average of roughly 400 shares between the reference period and the last trading day before the announcement. Depth then increases by roughly 300 shares on the first trading day after the announcement, relative to the level on the day before the announcement. However, we find that relative spreads, measured by the difference between the NBBO ask and bid prices divided by the NBBO mid-point, tighten prior to the earnings announcement and then increase after the announcement has been made. Our finding show that while breadth and depth decrease, indicating a reduction of liquidity in the market prior to earnings announcements, spreads also decrease, indicating an increase in liquidity prior to earnings announcements. In the post announcement period, breadth and depth increase, increasing liquidity, however; spreads also increase, decreasing liquidity.

We show that in response to the narrowing of markets around earnings announcements, trade aggressiveness increases. Our proxy for trade aggressiveness is the use of ISOs. Chakravarty, Jain, Upson, and Wood (2011) show that ISO trades are widely used in the market and are primarily used by informed institutional traders.[3] ISO trades represent the most aggressive trade type in the post Reg NMS market. We find that both the percentage and amount of volume traded using ISOs rises significantly

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[3] Additional information on ISO trades is provided in section 2.

starting three days prior to the earnings announcement. On the trading day just before the announcement the percentage of ISO volume increase by roughly 2% and this increase, like the decrease in breadth, is independent of the subsequent level of earnings surprise. ISO use increases again after the earnings announcement by an additional 3.5%, roughly. However, the information content of ISO trades, as measured by the information shares method of Hasbrouck (1995) decreases as ISO use increases. We interpret this finding as follows. As markets narrow both informed and uninformed trades must become more aggressive in their trading in order to fill large positions. The increased use of ISO trades by uninformed traders decreases the information content of this order flow. Through regression analysis we show that the reduction of information content of ISO order flow is positively related to the narrowing of markets. In other words, our findings indicate that as markets narrow, uninformed traders turn to more aggressive ISO trades to fill positions.

While the information content of type ISO trades decreases, the costs of aggressive trading increase both before and after the earnings announcement. We find that on the day just prior to the earnings announcement, when breadth is narrowest, effective spreads of both ISO and NSO trades are significantly higher, but realized spreads remain unchanged. In the first trading period after the earnings announcement, effective spreads for ISO trades again increase, however realized spreads remain unchanged. We examine the determinates of effective spreads on ISO trades on the day before (the Pre announcement day) and the day after (the Post announcement day) the earnings announcement. Our cross sectional regression indicates that market breadth is a significant factor in the size of effective spreads on both the Pre and Post announcement day. The results indicate that narrower markets lead to higher effective spreads of type ISO trades. Overall our findings indicate that market breadth is a new and important measure of liquidity in the post Reg NMS market. As other markets in other economic zones such as Europe and Asia become more integrated, the concept of market breadth is likely to become an important measure of liquidity outside of the US.

2.0 Reg NMS Rule 611 Overview

Rule 611, the order protection rule has several properties that we wish to highlight before continuing the exposition of our findings. The order protection rule requires all market centers to route orders to the market center(s) posting the best prices for the equity. For example, if market center A receives an order to buy an equity, but market center B is posting the best ask price for the equity, market center A is required to route the order to market center B for execution. However, if market centers A and B are both posting the best ask price for the market, then market center A can execute the trade. In short, the order protection rule guarantees that any standard trade submitted to any market center will be executed at the best price available in the market.

One critical change that Rule 611 brings to the post Reg NMS market is that it changes the definition of 'best price'. Prior to Reg NMS, the best price in the market was defined as the instantaneous National Best Bid and Offer or NBBO. However, the Securities and Exchange Commission (SEC) recognized that in today's millisecond speed markets, quotes within a market center can change faster than these quote updates can be disseminated to other market centers, for the evaluation of a market wide best price. The SEC therefore adopted the 'flicker quotes' exception, set forth in paragraph (b)(8) of Rule 611.[4] Specifically, a market center can only claim a trade through violation if the trade is outside of the least aggressive ask and bid quotation over the previous one (1) second of quotes from the market center. Implicitly, the flickering quotes exception defines the 'best price' in the market as the least aggressive NBBO ask and bid prices over the previous one (1) second of NBBO quotes. We denote the least aggressive NBBO ask and bid quote over the previous one (1) second as the Flicker Quote. Any trades that execute at or within the flicker quote are not trade throughs, while any trades that execute outside of the flicker quote are trade throughs. In other words, any order routed to a market center displaying a price at or inside the flicker quote is available for immediate execution, while any order routed to a market center displaying a price outside the flicker quote is subject to the order protection rule and must be re-routed to the market center displaying a best price. Figure 1 shows a stylized representation of the flicker

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[4] In SEC release 34-51808 discusses the flicker quotes exception on page 152.

quote and the flickering quotes exception. Prices shown in bold on the market center table are at or inside

the flicker quote and can be traded against without violation of the order protection rule of Reg NMS,

Rule 611. If prices outside the flicker quote are accessed, without the use of an Intermarket Sweep Order

(discussed next), the resulting trade is a violation of the order protection rule.

Rule 611 also specifies several trade type exemptions to the order protection rule, of which the

most important is the Intermarket Sweep Order (ISO) exemption, specified in paragraphs (b)(5) and (b)(6)

of the rule. An ISO order can trade through the best prices posted in the market but not violate the order

protection rule. Specifically, an ISO is a limit order designated for quick and automatic execution in a

specific market center. It can be executed at the target market even when another market center is

publishing a better quotation. When submitting an ISO, the submitting trader also needs to fulfill Reg.

NMS order-protection obligations by concurrently sending orders to other market centers with better

prices. Each order in the package must be marked as an ISO and the orders sent to the market(s) posting

better prices must be of sufficient quantity to match their displayed depth at the top of the book.

Importantly, ISO orders are not subject to auto-routing. Chakravarty, *et al.* (2011) investigate the

properties of ISO trades and find that they are widely used in the market and predominantly used by

informed institutional traders. In the context of this study we use ISO trades as a proxy for trade

aggressiveness and to investigate the interaction between market breadth and the aggressiveness of

trading.

To illustrate the use of ISO trades we present a brief example. Suppose a trader wants to purchase

1,000 shares of an equity as soon as possible. Three exchanges are posting prices and depth as follows:

Exchange A 20.05 x 100, Exchange B 20.07 x 300, and Exchange C 20.10 x 500. The trader can meet the

requirements of Rule 611 by submitting a trade to A for 100 shares, 300 shares to B, and 500 shares to C

to fill the order. These are not trade throughs because the order initiator 'took out' all posted liquidity at

better prices as they accessed liquidity at inferior prices. If the trader had submitted a NSO trade to

exchange A, only 100 shares would have been executed. The remaining 900 shares would be rerouted to

exchange B for execution, however, routing takes time, and by the time the order arrives at exchange B it

might no longer have price priority or significantly lower depth. The benefit of ISO trades are faster execution and capture of counter party depth, however this comes at the cost of potentially higher trade prices.

3. Hypothesis development

Trade aggressiveness is an important choice variable for both informed and liquidity traders. We consider that the least aggressive trades are limit orders supplying liquidity, followed by NSO orders (that can be a marketable limit or market order). The most aggressive orders are ISO orders. Prior to the announcement of earnings, informed traders select their level of aggressiveness so as to maximize profits from their information. Griffiths, Smith, Turnbull, and White (2000) investigate order and trade aggressiveness on the Toronto Stock Exchange and find that aggressive trading creates a higher price impact, but lower opportunity costs relative to less aggressive order and trade paradigms. Their findings indicate that there is a tradeoff between the price impact of aggressive trading and the opportunity loss associated with implementation shortfall. The informed trading model of Adimati *et al.* (1988) allows for competitive informed traders, trading aggressively, to obtain profits. Easly *et al.* show that PIN increases before earnings announcements and Cho (2007) shows that the number of informed traders increases as the announcement day approaches. These papers imply that trade aggressiveness will increase as the earnings announcement date arrives, which should increase the use of type ISO trades, leading to our first hypothesis:[5]

Hypothesis 1a: *Prior to earnings announcements, the trade aggressiveness increases.*

Hypothesis 1b: *Trade aggressiveness prior to the earnings announcements is increasing in the level of earnings surprise.*

Trading aggressiveness in the post announcement period can also exhibit an increase or decrease. Dey *et al.* (2007) explain the increase in aggressive institutional trading after earnings announcement as a portfolio rebalancing effort, although their findings are based on TORQ data, which may not be

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[5] Informed traders can also profit from their information in the options market, which is not considered in our analysis. See Cao and Ou-Yang (2010) and Roll, Schwarz, and Subrahmanyam (2010).

representative of the post reg NMS market. Institutions can use aggressive ISO trades to accomplish portfolio rebalancing as quickly as possible or use the slower, less aggressive NSO trades (Chakravarty *et al.* 2011). Given the competitive nature of institutions and the findings of Dey *et al.* (2007), we believe that aggressive trading will increase after the earnings announcement.

Hypothesis 2a: *After earnings announcements, the trade aggressiveness increases.*

Hypothesis 2b: *The increase in trade aggressiveness after earnings announcements is increasing in the level of earnings surprise.*

The information content of ISO trades should also change as the earnings announcement date arrives. To assess the information content of aggressive trading in the pre- and post-announcement period, estimate information shares based on Hasbrouck (1995). Chakravarty *et al.* (2011) show that the ratio of information share to trade volume (*InfoRatio*) is higher for ISO trades relative to NSO trades.[6] For ISO and NSO trades, Chakravarty *et al.* (2011) define the information ratio as:

$$InfoRatio_{i,t} = \frac{TradeTypeInfoShare_{i,t}}{TradeTypeVolume_{i,t}} \qquad (1)$$

where *TradeTypeInfoShare*$_{i,t}$ refers to the information share of the trade type (ISO or NSO) and *TradeTypeVolume*$_{i,t}$ refers to the volume of each trade type of stock *i* on day *t*. The *InfoRatio* is a measure of informativeness. If informed traders turn to aggressive ISO trades prior to the earnings announcement, then the information content of ISO order flow should increase. If the post-announcement period is dominated by liquidity based portfolio rebalancing, the information content of the order flow should decrease. To analyze the impact of trade aggressiveness around the earnings announcement, we test the following hypothesis:

Hypothesis 3a: *ISO trades in the pre-announcement period have higher informativeness than ISO trades in the base period.*

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[6] The information share has been used in a number of other research papers. See for example Hasbrouck (2003), Anand and Chakravarty (2007), Goldstein, Shkilko, Van Ness, and Van Ness (2008)

Hypothesis 3b: *The relative informativeness in the post-announcement period relative to the pre-announcement period is increasing in the degree of earnings surprise.*

The choice of trading aggressiveness will also depend on the liquidity environment present in the market. Traditional measures of liquidity such as spreads and depth are likely to have an impact; however with the current level of market integration, created by high speed communication networks, smart routers, and advanced trading algorithms, we feel that the breadth of the market is a new and important measure of liquidity. We define Basic Market Breadth (BMB) as the time weighted number of market centers offering liquidity at or inside the flicker quote:

$$BMB = \left[\sum_{t=0}^{T} \Delta t \sum_{k=1}^{K} k(I_k) \right] \Big/ T \tag{2}$$

where t is the time in seconds, T equals the full time interval, K is the number of market centers in the Daily Trade and Quote (DTAQ) database, and I_k is an indicator variable that equals 1 if the market center quote is within the flicker quote and 0 otherwise.

Based on the previous literature we obtain differing predictions about how market breadth will change around earnings announcements:

Market breath increases around earnings announcements: Suominen (2001) develops a model showing (see proposition 1 on page 551) that liquidity traders submit more limit orders when there is a high probability of private information in the market, such as around earnings announcements. These liquidity traders may choose to post liquidity on exchanges that offer a higher liquidity rebate rate for posted liquidity to maximize profits, thereby increasing market breadth.[7] Based on NYSE quotes, Lee, Mucklow, and Ready (1993) find that spreads widen and quoted depths fall prior to earnings announcements. If these findings still hold, the wider spreads could allow for more market centers to offer liquidity inside the flicker quote, thereby increasing market breadth. These authors focus only on the NYSE while our study focuses on multiple market centers.

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[7] The rebate rate represents the value, per share, paid to the initiator of a limit order that supplies liquidity on a market center. Shkilko, Van Ness, and Van Ness (2008) find that this rebate rate is significant in attracting liquidity to market centers.

Market breath decreases around earnings announcements: The models of Admati and Pfleiderer (1988) and Foster and Viswanathan (1990) allow for discretionary liquidity traders to withdraw from the market during periods of high information asymmetry, leaving a higher proportion of informed traders left in the market. A higher proportion of informed investors in the market can lead to a reduction in market breadth for two reasons. First, the adverse selection problem created by a higher percentage of informed investors can lead to a reduction in posted liquidity (Copeland and Galai, 1983). Second, the competition between informed traders can lead to aggressive trading, quickly depleting small posted liquidity reserves on some markets (Cho, 2007).

Easley, Engle, O'Hara, and Wu (2008) find that prior to earnings announcements the probability of informed trading increases. Krinsky and Lee (1996) who find the adverse selection component of the bid-ask spread increase prior to earning announcements. Campbell, Ramadorai, and Schwartz (2009) find that institutions buy stocks prior to positive earnings surprises and sell prior to negative earnings surprises. Knowing that informed traders are in the market, liquidity traders are likely to reduce market breath.

Madureira and Underwood (2008) investigate the relationship between a bank's market making and research activities. They find that banks provide liquidity to firms that are also covered by the bank's research. National Association of Securities Dealers regulations prohibit market makers from trading prior to research report releases; however, a more general sharing of information away from these releases is not prohibited.[8] Knowing that there is going to be an earnings surprise, the banks may withdraw liquidity. If the banks do not expect an earnings surprise, we expect no change in market breath.

Irvine, Lipson, and Puckett (2007) investigate buying activity prior to the release of analyst buy recommendations and find results that are consistent with institutions being 'tipped' prior to the release of the report. If analysts are willing to tip institutional clientele, it would seem reasonable to suspect that

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[8] In October of 2000 the SEC implemented regulation Fair Disclosure that prohibits companies from disclosing different information to different analysts. We assume that any superior information generated by analyst is from fundamental analysis rather than specific insider knowledge. The impact of regulation Fair Discloser on trading is studied in Collver (2007) and Eleswarapu, Thompson, and Venkataraman (2004).

information is transferred to the market making function of the analysts' bank, even around earnings announcements. If this knowledge helps mitigate the information asymmetry around earnings announcements, even to a limited degree, then we could see a lower reduction in market breadth, prior to earnings announcements, for firms that have little or no subsequent earnings surprise, and a greater reduction for firms with a large earnings surprise. Again, knowing that there is going to be an earnings surprise, the clients may withdraw liquidity; otherwise liquidity will be unchanged.

Hypothesis 4a: *Prior to an earnings announcement the breadth of the market decreases.*

Hypothesis 4b: *The magnitude of the decrease in market breath prior to earnings surprises is increasing in the earnings surprise of the announcing firm.*

Market breath during the post earnings announcement period is also of interest. Madureira and Underwood (2008) show that research/market maker banks offer more depth at lower spreads than other market makers that do not have research coverage of the announcing firm, leaving the impact on market breadth uncertain. There is a potential increase in market breadth from the research/market maker banks and a potential decrease from market makers without a research affiliation. Easley, Engle, O'Hara, and Wu (2008) find a decrease in PIN after earnings announcements while Dey and Radhakrishna (2007) find that institutions are the most active traders in the post announcement period and that institutional trades are aggressive. While Easley *et al.* imply that market breadth will increase because of lower informational asymmetries, Dey *et al.* indicates that market breadth will remain lower because of the aggressive taking of liquidity. If the earnings surprise is small or nonexistent, the breadth should expand quickly, while markets might remain narrow for high earnings surprise stocks. The trading models of Kyle (1985) and Glosten and Milgrom (1985) indicate that after the information has been released to the market, liquidity should quickly return to the level prior to the introduction of information asymmetry, also indicating an increase in market breadth. Based on these considerations, we investigate the following hypothesis:

Hypothesis 5a: *After an earnings announcement the breadth of the market increases.*

Hypothesis 5b: *After an earnings announcement the breadth of the market increases is decreasing in the earnings surprise of the announcing firm.*

4. Data, Sample, and Methods

Our stock sample comprises all NYSE stocks with a minimum price of $10 on the last trading day

of 2007 that are also included in the I/B/E/S, DTAQ (detailed later), and CRSP data sets. We limit our

analysis to NYSE stocks because of the inherent difference in market breadth between NASDAQ and

NYSE securities. Specifically, while NASDAQ quotes NYSE listed stocks, the NYSE does not quote

NASDAQ stocks. Our analysis is based on data for the last quarter of 2007 and the first quarter of 2008.

Earnings surprise is defined as the difference between the median earnings estimate from I/B/E/S and the

actual earnings level.

The DTAQ (Daily Trade and Quote) database is similar to the Monthly Trade and Quote

(MTAQ) database used in market microstructure studies. There are a number of significant differences

between the DTAQ and MTAQ databases. DTAQ has trade and quote time stamps to the millisecond and

contains the exchange calculated National Best Bid and Offer (NBBO) along with additional condition

codes for trades and quotes. Following the basic method of McInish and Upson (2011), we use the

millisecond time stamps of the NBBO and trade file to construct an improved alignment between trades

and quotes that supports the trade direction inference. Specifically, for each stock day in the sample we

test lag times between the NBBO quote and the trade time stamp in increments of 25 milliseconds starting

from 0 through 1500 milliseconds. The lag selected for each stock day is the lag that maximizes the

number of trades that execute at the NBBO quote. We select this lag for the simple reason that the

majority of trade executions occur inside the matching engines of each exchange, indicating that the

majority of trades will in fact execute at the NBBO.[9]

All of the earnings announcements in our study occur either after the market close or before the

market opens. We label the first trading day after the earnings announcement as day 0. If the

announcement is before the market open, day 0 is the same day. If the announcement is after hours, day 0

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[9] Additional justifications and details of the alignment method are presented in McInish and Upson (2011). A
similar method is applied in Chakravarty et el (2011).

is the next day. Day 0 is the first Post-period day and day -1 is the last Pre-period day. The Base period comprises day -25 through day -6, inclusive.

Table 1 shows descriptive statistics for market capitalization and trade volume for our sample equities based on deciles of earnings surprise and also grouped into Extreme (deciles 1, 2, 9, 10) and Center earnings surprise groups. Market capitalization is based on the number of shares outstanding and the closing share price on the last trading day of 2007. Trade volume is the daily average volume for the 25 days prior to the earnings announcement, i.e., including both the Base period and the Pre period. Market capitalization and trade volume (shown in thousands of shares per day) are roughly comparable across the deciles. We test whether the market capitalization and trading volume of the Extreme and Center deciles are significantly different.

There are 789 firms in the Extreme earnings surprise deciles and 1,209 stocks in the Center deciles. Since we perform a separate analysis for each quarter, a given stock can be in the Extreme group one quarter and Center group the next quarter. Our results indicate that there is no significant difference in market capitalization between the Extreme deciles and the Center deciles. However, we do find that the Extreme deciles have significantly higher trading volume than the Center deciles. Since firm size is not statistically different between the Center group and the Extreme group, we feel the firm characteristics are less likely to drive our results, which we turn to next.

5.0 Results

5.1 Trade aggressiveness

In Table 2 we investigate the use of ISO trades by deciles of earnings surprise and by Extreme and Center earnings surprise groups. The first column presents changes in ISO volume as a percentage of total volume. We find that ISO use increase for all deciles on the day prior to the earnings announcement. The increase is highest for the stocks that have the most negative earnings surprise, but is significant at the 1% level for 7 of the deciles and at the 5% level for the remaining deciles. In the post announcement

period, ISO use again significantly increases for each earnings decile. These results support hypotheses 1A and 2A; trading aggressiveness increase both before and after an earnings announcement.

Hypotheses 1B and 2B state that trading aggressiveness will be higher for the firms reporting the larger earnings surprises compared to the with small earnings surprises. To test this implication we find the average increase in ISO volume for the extreme earning surprise firms and compare it with firms with low earnings surprise. Prior to the earnings announcement extreme firms show a 1.9% increase in ISO volume while center firms have a 1.8% increase in ISO volume. The difference is insignificant. However, after the earnings announcement, extreme firms have a significantly higher increase in ISO use compared to center firms, with a difference of 1.0% , significant at the 1% level. The results reject hypothesis 1B, the trading aggressiveness prior to the earnings announcement will be higher for large earning surprise firms, but support hypothesis 2B, that trade aggressiveness is higher for firms posting large earnings surprises relative to firms with small earnings surprises.

We also test whether the number of ISO trades increases. In the Pre announcement period all of the changes are positive, but some of the changes are not statistically significant. The largest increases in ISO trades occur for the most negative earnings surprises. Our results are equivalent from both ISO volume and the percentage of ISO trades. The number of ISO trades in the Post announcement period does increase significantly for all deciles and is higher for the extreme earnings group compared to the center group.

Since the percentage of ISO volume depends both on the numerator and denominator, we also explicitly test whether ISO volume increases. It is possible that ISO volume remains unchanged but total volume decreases, creating an increase in the percentage of ISO volume. Our results indicate that ISO volume increases for all deciles for both the Pre- and Post-announcement periods, but that the increase is greater in the Post period.

The results of Table 2 indicate that trade aggressiveness increases substantially for all deciles of earnings surprise. A significant question raised by these findings is Why does trading aggressiveness increase, prior to the earnings announcement, for firms with low magnitudes of earnings surprise? One

explanation could be that ISO trades have lower execution costs than NSO trades in this period. Alternatively, the market wide increase in trade aggressiveness could result from a market wide change in liquidity conditions. We explore both of these potential explanations.

5.2 Transaction costs.

Table 3 presents the results of the transaction cost analysis. Our discussion focuses on the change in these spread measures presented at the bottom of the table. Prior to the earnings announcement, effective half spreads for ISO trades increases by 0.08 cents per share, which is significant at the 1% level. However, the realized spreads for the Pre period are not statistically different from those in the Base period. Effective spreads for NSO trades also significantly increase for the Pre period versus the Base period, but realized spreads are not statistically different. In addition, the effective spreads of ISO trades are significantly higher than for NSO trades, consistent with the findings of Chakravarty *et el* (2011), for all periods. Our results indicate that, prior to the earnings announcement, ISO trades carry higher transaction costs than NSO trades.

In the Post announcement period, effective spreads for both trade types also increase. Realized spreads for ISO trades remain unchanged in the post announcement period relative to realized spreads of ISO trades in the pre period, but realized spreads for NSO trades are significantly higher relative to the pre period. NSO realized spreads are also significantly higher than ISO trades in post announcement trading. These results indicate that in the post announcement period informed traders select the ISO trade type for faster trade execution, at a higher effective spread, to quickly capture counterparty depth. This finding explains the higher use of ISO trades in the post announcement period but does not explain why ISO use increases prior to earnings announcements market wide.

5.3 Liquidity changes around earnings announcements

The second explanation for the increase in trade aggressiveness prior to earnings announcements is because of changes in market wide liquidity. We examine spreads, depths, and Market Breadth. Market breath, as we calculate it, is new, so we first characterize the change to quote based liquidity for our sample. In Figure 2, we present a time series plot of the average market breadth for the Extreme and

Center deciles of earnings surprises. First, note that the Extreme decile group has a markedly lower breadth than the Center group. For example on day -25, there are roughly 5.6 market channels on average available to for the Center deciles of earnings surprises compared to 5.4 market channels for the Extreme deciles. Since we find no statistically significant difference in firm size between these two groups, we do not believe that size affects our results.

Graphically, supporting hypotheses 4A and 5A, market breadth clearly narrows as the earnings announcement approaches for all firms in our sample, and then increases after the announcment. In the majority of microstructure trading models, such as Kyle (1985), Glosten and Milgrom (1985), and their many derivatives, market makers, dealers, and liquidity providers are generally considered to be uninformed about the future value of the firm. They must discern this value from the noisy trading of informed and uninformed liquidity demanders. If market breadth is a general property of market based liquidity, then the rate of change of breadth should be consistent for all firms in our sample, as this figure indicates. If the rate of change for the Extreme deciles group is larger than for the Center group, then one can infer that liquidity suppliers are informed about the level of earnings surprise prior to the announcement. But in that case why would they supply liquidity? After the earnings announcement, market breadth increases, though it does not recover to the levels that existed 10 days before the announcement. Overall, Figure 2 indicates that market breadth has the general characteristics of an important choice variable of liquidity suppliers.

In Table 4 we present tests focused on changes in market breadth as well in the traditional liquidity measures of quoted depth and relative spreads around earnings announcements. For each measure, we find the average daily level for each firm in the Base period. We then conduct paired t-tests for each liquidity measure shown in the difference column of the table for the Pre period. We also conduct paired t-tests for the difference between the Pre and Post periods. Table 4, Panel A, shows the results for market breath. For the Extreme group Base period, the mean number of channels available for trading is 5.30, which drops to 5.08 channels on the day prior to the announcement. The difference of

-0.22 is statistically significant at the 1% level. The relative change for the Center group between the Base and Pre period (-0.26 channels) is also statistically significant. After the announcement we find that breadth again increases significantly, though the level is quite low.

Table 4, Panels B and C, show the results for depth and relative spread. As in Lee *et al.* (1993) paper, we find that depth decreases prior to earnings announcements. Depths presented are in round lots of 100 shares. We find that for the Extreme group there are roughly 400 fewer shares, and that this change is significant at the 5% level. The change for the Center group is similar at -4.15 round lots. After the earnings announcement, quoted depth available for immediate execution also increases significantly for both groups. Our relative spread findings are different from those of Lee *et al.* (1993). Rather than showing that spreads increase, we find that relative spreads decrease and that this decrease is significant. Recall, our relative spread evaluation is based on the NBBO, and not from a single exchange as in Lee. For the Extreme group, relative spreads in the Base period is 0.157% of the stock's price, but decreases to 0.132% on the day -1. Spreads then increase to 0.198% after the announcement. Later, we present evidence that in the multiple integrated market of the post Reg NMS world, quote based liquidity is best defined by depth and breadth, rather than depth and spread.

5.4 The breadth mechanism.

The preceding results indicate that market breadth is a relevant measure of liquidity in the Reg NMS market. In this section we examine how liquidity suppliers increase and decrease the number of markets offering liquidity. For each active market center, in Figure 3 we plot the time series of the percent of the day that the center offers depth at or inside the flicker quote. This is depth that is available for immediate execution of all trade types. Figure 3 clearly shows that the reduction in available breadth that occurs as the earnings announcement day approaches is due to reduced participation from the National Stock Exchange. The Automated Display Facility (ADF) makes a smaller contribution to the reduction in available breadth, dropping from roughly 12% to 10%. The NYSE and NASDAQ also experience declines in the time quotes are at the flicker just prior to the announcement. Chicago, Arca, and the

International Stock Exchange (ISE) all experience increases in participation prior to the earnings announcements. Although breadth reduction is focused on the National Stock Exchange, other exchanges also experience a reduction in participation at market competitive prices.

How do liquidity providers change the concentration of quoted depth as breadth changes? We introduce a new measure, Market Depth Concentration (MDC), calculated as follows:

$$MDC = \left[\sum_{t=0}^{T} \Delta t \sum_{k=1}^{K} \left(\frac{I_k(Dpth_k)}{DpthTot_t} \right)^2 \right] \Big/ T \qquad (3)$$

where t is the time in seconds, T equals the full time interval, K is the number of market centers contained in the DTAQ database, and I_k is an indicator variable that is 1 if the market center quote is within the flicker quote of the market and 0 otherwise. $Dpth_k$ is the quoted depth for the market center and $DpthTot_t$ is the total depth in all market centers at or better than the flicker quote.

Table 5 shows the results of the analysis of MDC for our earnings surprise groups. MDC of the Center deciles group is small, less concentrated, than for the Extreme group in all three periods--Base, Pre, and Post. Both groups show a reduction in MDC in the Pre period. Not only is the breadth of the market reduced as shown in Table 4, but as the change in the Herfindahl index indicates, depth is more evenly distributed over the remaining trading channels. In the Post period, concentration increases to levels representative of the Base period. In the difference column of the table we test to see if the changes in MDC are significant, which they are at the 1% level, though the magnitude of these differences is low. In short, liquidity providers reduce market breadth primarily by withdrawing quote from the National Stock Exchange, and at the same time, distribute the remain quoted depth more evenly over the remaining trading channels.

5.5 Breadth determinates

Next, we look at the determinates of the changes in market breadth to evaluate hypotheses 4B and 5B. We estimate two cross sectional regressions--one for the Pre period and one for the Post period. The cross sectional regression is of the form:

$$\Delta Brdth_{i,t} = \alpha + \beta_1 AbsSur_i + \beta_2 \Delta RelSprd_{i,t} + \beta_3 \Delta Dpth_{i,t} + \beta_4 LnCap_i + \beta_5 VolRatio_{i,t} + \varepsilon_{i,t} \quad (3)$$

where the t subscript is indexed on either the Pre period or Post period (i.e., t = Pre or t = Post). All variables with a Δ represent the change between the Base and Pre period (Pre minus Base) for the Pre announcement regression while these variable represent the change between the Post and Pre periods (Post minus Pre) for the post announcement regression. $Brdth_{i,t}$ is the change in market breadth. $AbsSur_i$ is the absolute value of the earnings surprise. If liquidity providers are informed about the future results of the earnings announcement, then $AbsSur_i$ should be significant in the Pre regression. $RelSprd_{i,t}$ is the change in the time weighted relative spread and $Dpth_{i,t}$ is the change in quoted depth. If breadth is a simple proxy for these measures of liquidity, $RelSprd$ they and $Dpth$ should be significant in our regressions, but the expected sign is uncertain. As a control variable we add $LnCap_i$, which is the natural log of the market capitalization of the firm. Lee *et al*. find that the majority of liquidity changes are due to volume effects. We therefore include $VolRatio_{i,t}$. For the Pre regression $VolRatio$ is the ratio of volume traded on the Pre day divided by the average volume from the base period. For the Post regression $VolRatio$ represents the ratio of the volume traded on the post day divided by the volume traded on the Pre day. We run two specifications of this regression (S1 and S2) for each cross section.

Table 6 presents our regression results. In specification S1, the coefficient of *AbsSur* is not statistically significant in either the Pre- or Post-announcement periods, which indicates that liquidity suppliers are not changing their supply strategy based on knowledge of the future earnings of the company. For the S2 specification for the Pre period, the coefficients of *AbsSur*, Δ*RelSprd*, and Δ*Dpth* are not statistically significant, indicating that Δ*Brdth* is independent of the changes the other quote based liquidity measures. Since the coefficient of AbsSur is insignificant there is no support for hypothesis 4B, that changes in market breadth are correlated with the magnitude of earnings surprise. However, Δ*Brdth* is increasing in firm size. The negative sign on the coefficient of *LnCap* indicates that there is a negative relationship with larger firms showing a larger reduction in Δ*Brdth*. Our regression indicates that breath

reduction is mitigated to some extend as volume levels increase, relative to the Base period. The coefficient of *VolRatio* is positive and significant at the 0.05 level.

In the S2 specification for the Post period, the coefficients of Δ*RelSprd* and Δ*Dpth* are significantly negative and positive, respectively, at the 0.05 level. An increase in spread decreases breadth and an increase in depth increases breadth. Recall from Table 2 that in the Post announcement period quoted depth increases. Our regression results indicate that rather than simply increase the quoted depth on an existing trading channel, liquidity suppliers open additional channels for trading. As we will show later (Section 5.6), larger spreads and narrow markets impact the price discovery process by increasing the aggressiveness of traders. The coefficient of *LnCap* is negative and significant at the 0.01 level. *VolRatio* is not significant in the Post period. As with the Pre- regression, the impact of the magnitude of the earnings surprise is not significant, leading to the rejection of hypothesis 5B.

5.5 Market liquidity impact of transaction costs

If narrow markets help liquidity suppliers net higher effective spread for ISO trades then in a regression breadth should be a significantly negatively related to effective spreads. In other words, when market breadth is wider, the effective spread should be smaller. We estimate the following cross sectional regression for the effective spread of ISO trades.

$$
\begin{aligned}
EfSpdISO_{i,t} = \alpha &+ \beta_1 Brdth_{i,t} + \beta_2 LnCap_i + \beta_3 AbsSur_i + \beta_4 Dpth_{i,t} \\
&+ \beta_5 RelSprd + \beta_6 VolRatio + \varepsilon_t
\end{aligned}
\tag{4}
$$

As with other regression in this paper, we estimate the Pre period and the Post period separately. *EfSprdISO* is the daily trade weighted effective half spreads for ISO trades and the remaining variables represent the daily levels for the day of the regression. Table 7 presents the results.

We estimate two specifications for each regression, the first containing *Brdth, LnCap*, and *AbsSur* and the second adding *Dpth, RelSprd,* and *VolRatio*. In all of the specifications, for both the Pre and Post periods, *Brdth* is significant at the 1% level and has the expected negative sign. As market breadth narrows, effective spreads for ISO trades increase. This result remains consistent even with controls for firm size, other quote based liquidity measures, and demand based liquidity measures. We believe that

market breadth is a key liquidity consideration in the post Reg NMS markets of the US. Moreover, as other global market centers, such as Europe, integrate their markets, we believe that market breadth will play an increasingly important role as a liquidity measure.

5.6 The information content of trade types around earnings announcements

In the hypothesis development section we introduced the *InfoRatio*, defined as the ratio of the information share divided by the volume share. Specifically, we form two price channels from ISO and NSO trades. We retain the last trade price for each second and discard earlier trades during that second. The information share is then estimated for each stock day and divided by the percentage of volume to obtain the *InfoRatio*. Figures 4 and 5 plot the time series of the *InfoRatio* for each trade type for the Extreme and Center groups, respectively. In addition, these figures show the mean proportion of ISO volume for each trading day. ISO and NSO volume bifurcate the trading volume so that the proportion NSO volume is equal to 1-%*ISOvol*.

In both figures, the *InfoRatio* of NSO trades remains relatively constant, with a slight upward trend until the day of the earnings announcement. After the earnings announcement, NSO trade type information content drops sharply. However, the information content of ISO trades shows a downward trend as the earnings announcement approaches and then a high spike in information content after the announcement. ISO volume begins a sharp increase starting at day -4. ISO trades contain higher information that NSO trades through the two quarters. We interpret the drop in the *InfoRatio* of ISO trades as resulting from uninformed traders adopting the aggressive trades to fill large orders.

We formally test hypotheses 3A in Table 8. Panel A shows the results of the information ratio analysis while Panel B reports the raw information share levels. The results are presented by earnings surprise decile. The difference between the information ratio of the base period and the day prior to the earnings announcement is only statistically significant for deciles 6 and Low (10), and negative for those deciles. The change in the level of the information share of ISO trades is also only significant for two deciles though there appears to be a general increase in the information share of ISO trades prior to the earnings announcement. The key point however is that the increase in ISO volume that we show in Table

2 does not carry additional information, beyond the volume contribution of the increase. This result indicates that the increase in ISO use is from uninformed liquidity traders seeking to fill demand, rather than informed traders using ISO trades to capture counterparty depth prior to the earnings announcement.

The change in the information ratio of ISO trades between post announcement trading and pre announcement trading is positive and significant in seven of the ten deciles. In addition, the change in the information share of ISO trades is positive and significant in all deciles. This result indicates that after the earnings information becomes public, informed traders use ISO trades as the vehicle to quickly take positions based on the new information. In other words, the incremental increase in ISO volume after the earnings announcement carries an information content that is greater than the simple volume increase would imply. These results fail to support hypotheses 3A.

To test the impact of market liquidity on the information content of ISO trades we estimate the following regression:

$$
\begin{aligned}
\Delta InfoRiso_{i,t} = \alpha &+ \beta_1 \Delta Brdth_{i,t} + \beta_2 \Delta Dpth_{i,t} + \beta_3 \Delta RelSprd_{i,t} + \beta_4 LnCap_i \\
&+ \beta_5 AbsSur_i + \beta_7 \Delta\%ISO_{i,t} + \varepsilon_t
\end{aligned}
\tag{5}
$$

All variables with a Δ represent the change between the Pre and Base periods (Pre minus Base) for the Pre period cross sectional regression while these variables represent the change between the Post and Pre periods (Post minus Pre) for the Post period cross sectional regression. $\Delta InfoRiso_{i,t}$ is the change in the information ratio of ISO trades, and $\Delta\%ISO_{i,t}$ is the change in the percent of ISO volume. All other variables are as previously defined.

Table 9 presents the results of the estimation of equation 5. In the Pre period regression Δ*Brdth* is positively related to Δ*InfoRatio* with reductions in market breadth correlated with reductions in the information content of ISO volume. The coefficients of Δ*Dpth*, Δ*RelSprd, AbsSur*, and *LnCap* are not statistically significant in either the Pre or Post periods. Since the coefficient of *AbsSur* is not significant, this fails to support hypothesis 3B. *Δ%ISO* is negative and statistically significant at the 0.05 level in both the Pre and Post regressions. We interpret these results as follows. As markets narrow and become

less liquid uninformed traders adopt the more aggressive ISO trades to fill demand. Liquidity suppliers, by narrowing markets, generate higher effective spreads for both ISO and NSO trades. Perhaps as an unintended consequence of the reduction of market breadth, the information content of ISO volume also drops.

6.0 Conclusion

Trading aggressiveness is an important choice variable for liquidity demanders. We investigate how trading aggressiveness changes around earnings announcements. Our findings indicate that there is a significant increase in the level of trade aggressiveness prior to the earnings announcement and after an earnings announcement as proxied by the level of Intermarket Sweep Order (ISO) volume. Our results indicate that the increase in trade aggressiveness prior to the announcement is independent of the subsequent earnings surprise. ISO use after the earnings announcement is also high, but independent of the level of earnings surprise. Our results indicate that market liquidity conditions drive the selection of trade aggressiveness.

We introduce and investigate a new measure of stock market liquidity, market breadth, which we believe captures an important aspect of market liquidity that arose due to the implementation of Regulation NMS. We define market breadth as the time weighted number of market centers offering depth at the best price. Reg NMS made two significant changes to the US market that makes the study of market breadth important. First, a new price priority rule mandated that trades be rerouted to the market(s) with best prices. An exchange that allows execution of a trade at inferior prices can incur significant penalties. Second, the regulation forced market centers to install and maintain high speed communications systems that allow access to posted liquidity by other exchanges. These systems are able to route and execute trades with low latency. The latency of the Intermarket Trading System, which the new system replaced, was much higher.

We analyze market breadth using a sample of NYSE stocks and focus on the impact of breadth around earnings announcements. We show that market breadth narrows significantly prior to earnings

announcements and the narrowing is independent of the subsequent earnings surprise of the firm. Our findings indicate that liquidity suppliers narrow market breadth for all firms to increase the level of aggressive trading through the use of Intermarket Sweep Orders (ISOs). By narrowing market breadth, liquidity suppliers cause large uninformed liquidity traders to switch from lower cost NSO trades to higher cost ISO trades and earn higher effective spreads.   As uninformed traders switch to the ISO trade type, the information content of ISO volume drops significantly.

The theoretical importance of explaining the entry and exit of market centers as suppliers of market liquidity in fast markets is largely unexplored. However, several factors are increasing the need to consider the joint supply of liquidity across market centers. These factors include the introduction of Intermarket Sweep Orders and the remarkable reduction in latency resulting from computer upgrades, co-location of computers and the like. Moreover, as multi-market trading of assets grows in Europe and Asia the relevance of multi-market liquidity is likely to become even more important.

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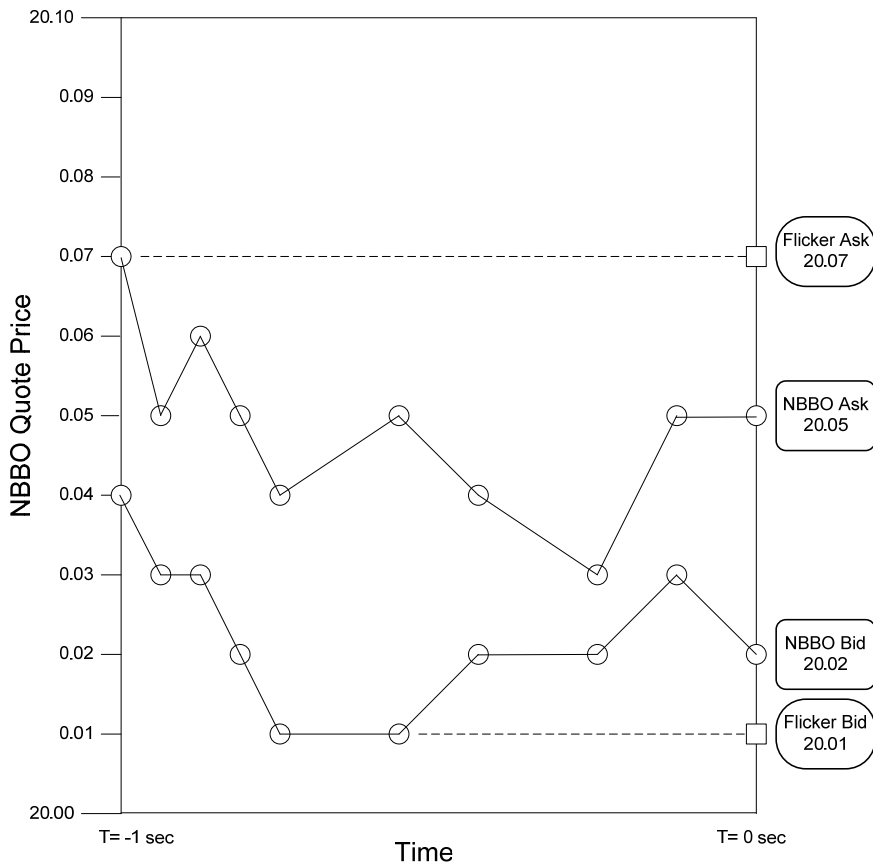
Figure 1: A stylized representation of the Flicker Quote.
Prices shown in bold on the market center table are at or inside the flicker quote and can be traded against without violation of the order protection rule of Reg NMS, Rule 611. If prices outside the flicker quote are hit without using an Intermarket Sweep Order a trade through is recorded.
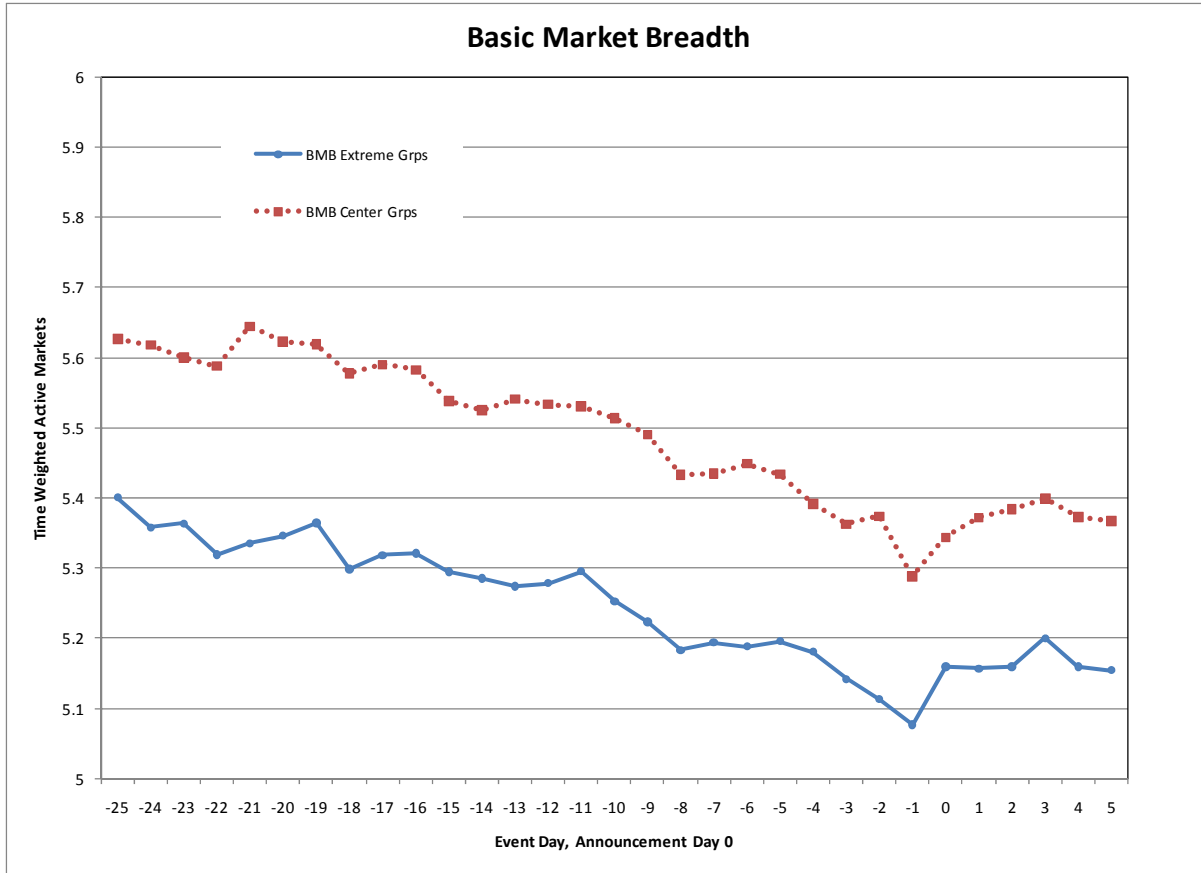
Figure 2: Change in Basic Market Breadth around earnings announcements.
Day 0 is the first trading day after the afterhours or pre-market open earnings announcement. For each quarter, earnings surprises are ranked by deciles according to the size of the surprise. The Extreme group comprises the top and bottom two deciles and the remaining announcements comprise the Center deciles.

Percentage of time market center quote is at the flicker quote

Event Day, Day 0 is Announcement

% of day quote is at flicker quote

Legend:
- National
- ADF
- ISE
- Chicago
- NYSE
- Pac/Arca
- NASDAQ
- Phil
- CBOE
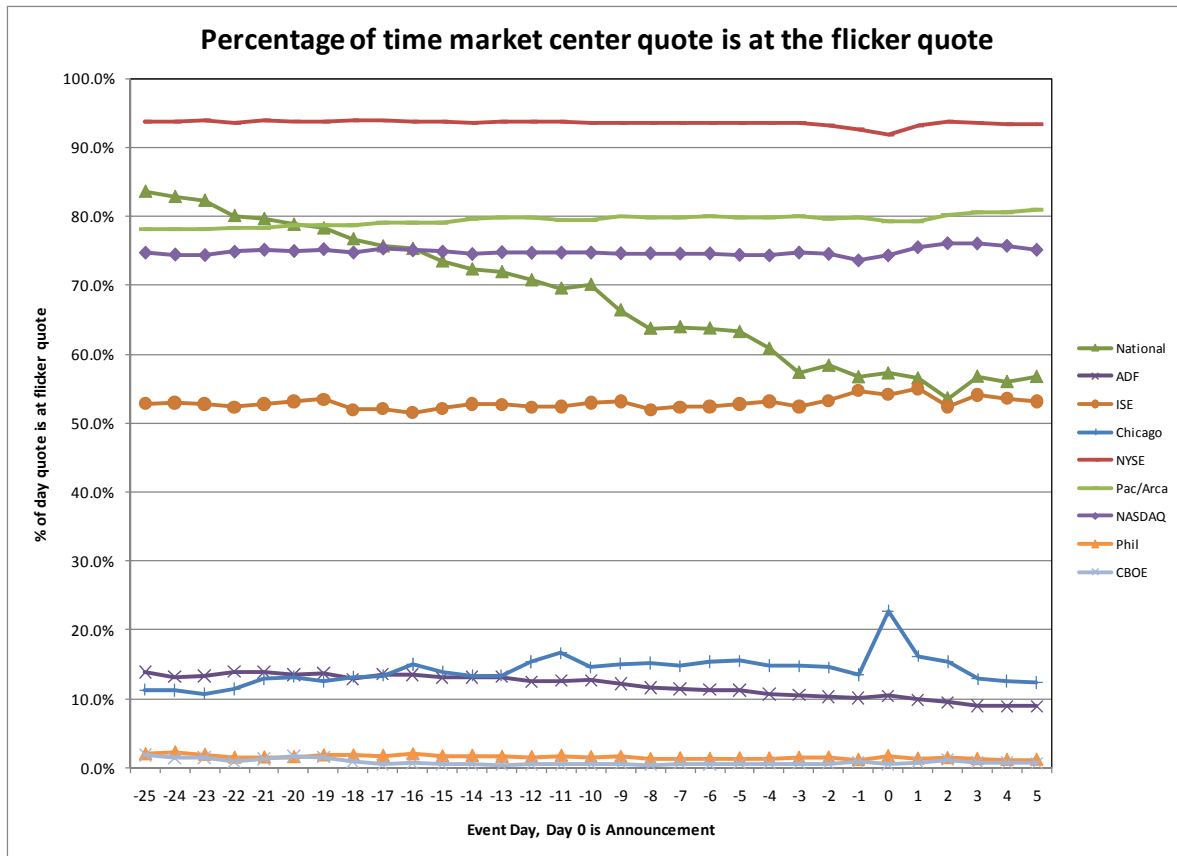
Figure 3: Percentage of day that the quote is at or inside flicker quote, by day and market center. This figure shows the percentage of the trading day that each market center displays a quote that has posted liquidity at a price equal to or inside the flicker quote. The flicker quote is the least aggressive ask and bid NBBO quote over the previous one second. Any liquidity posted within this price is available for immediate execution without violating the order protection rule of Reg NMS. Day 0 is the first trading day after the afterhours or pre-market open earnings announcement.
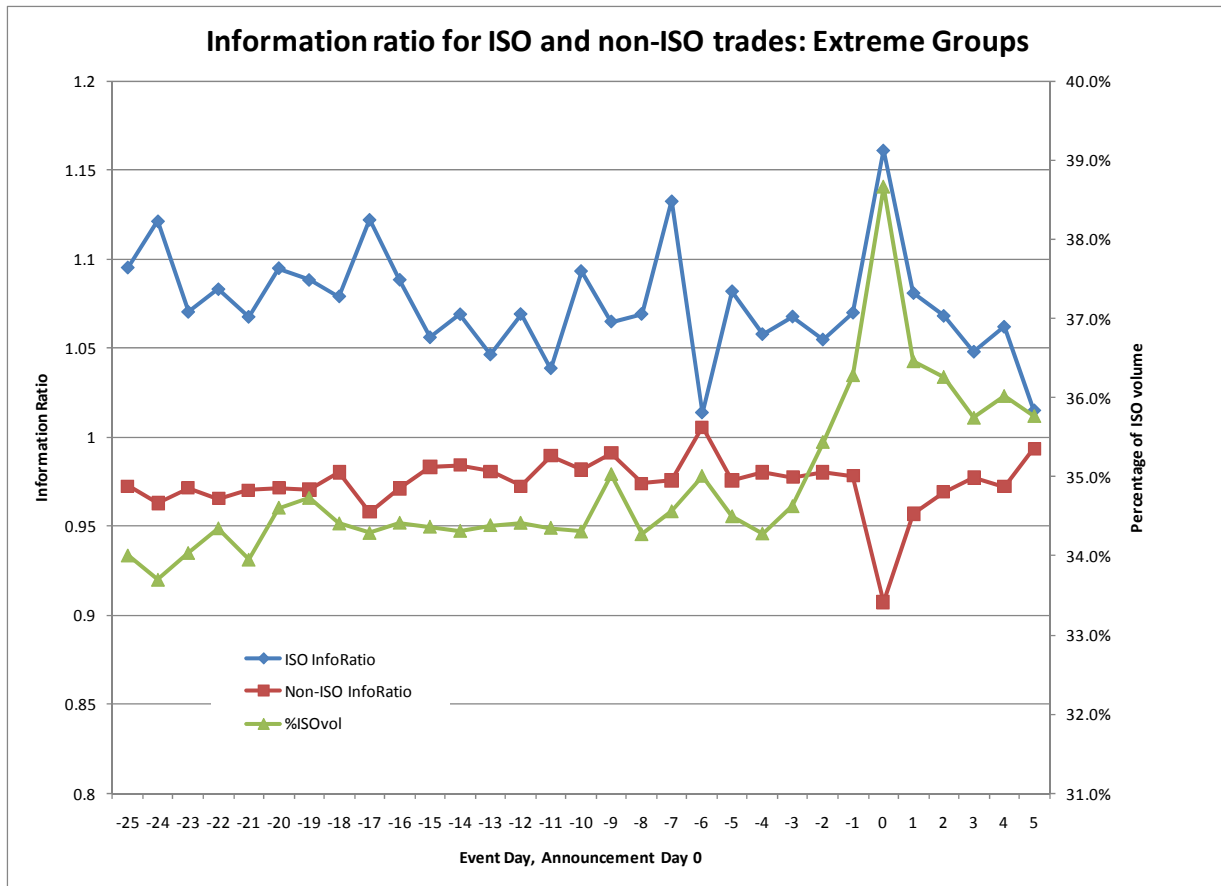
Figure 4: The information ratio of ISO and Non-ISO trades around earnings announcements for Extreme group firms. The *InfoRatio* is the ratio of the Hasbrouck (1995) information share divided by the percent volume. ISO volume is also plotted. Day 0 is the first trading day following the earnings announcement. For each quarter, earnings announcements are ranked by deciles. The Extreme group comprises the top and bottom two deciles; the Center group comprises the remaining firms.
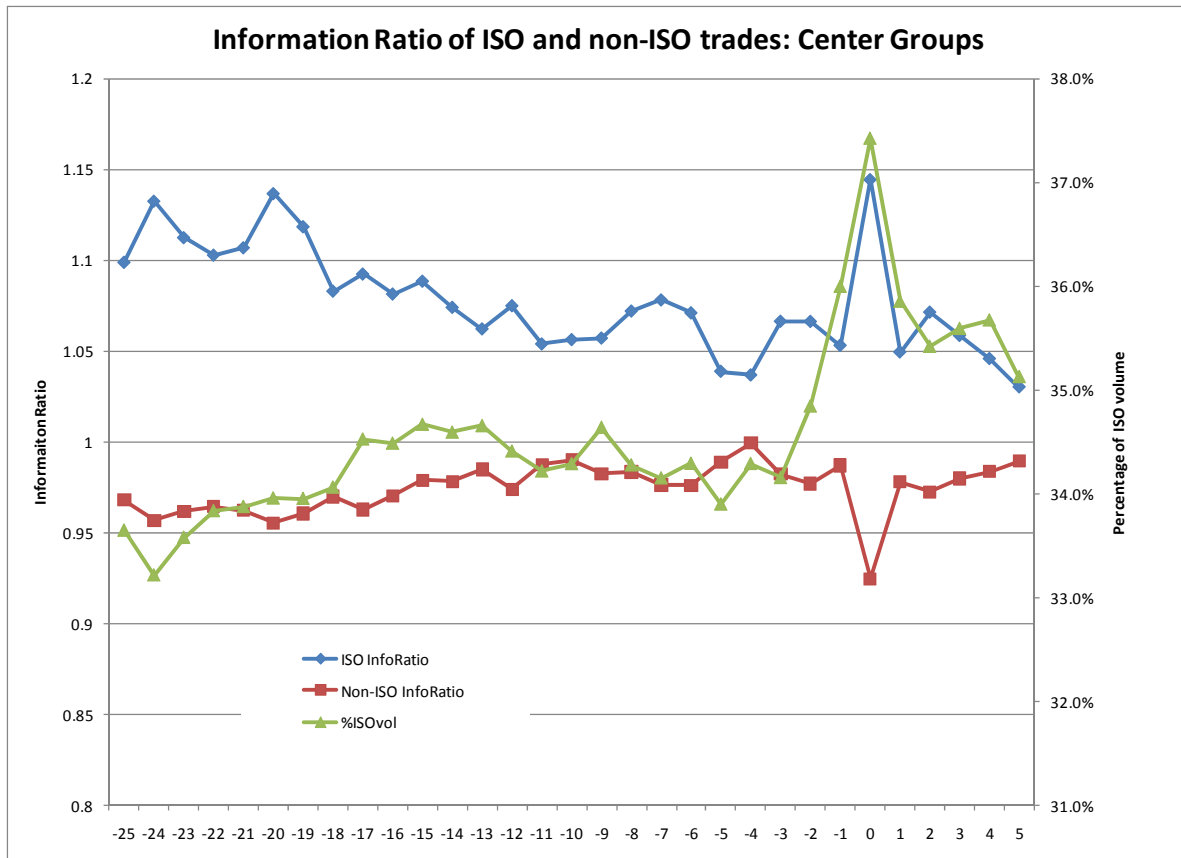
Figure 5: The information ratio of ISO and Non-ISO trades around earnings announcements for Center group firms. The *InfoRatio* is the ratio of the Hasbrouck (1995) Information Share divided by the percent volume. ISO volume is also plotted. Day 0 is the first trading day following the earnings announcement. For each quarter, earnings announcements are ranked by deciles. The Center group comprises all deciles except the top and bottom tw

Table 1

Descriptive statistics

Descriptive statistics are presented for firm size (market capitalization) and trade volume. The sample consists of all NYSE listed common stocks with a share price greater than $10 and earnings announcement data for the last quarter of 2007 and the first quarter of 2008. Market capitalization data are based on the shares outstanding and closing price on the last trading day of 2007. Trade volume is the mean and standard deviation of the volume traded on the 25 days prior to the earnings announcement. The analysis is presented for each deciles of earnings surprise, where earnings surprise is measured as the difference between the actual earnings level and the median analyst estimate for each firm. Extreme comprises the two highest and lowest earnings surprise deciles (High, 2, 9, Low) and the Center comprises the remaining deciles. We present a means difference test (Diff) comparing the firm size and trade volume of Extreme and Center groups.

| Deciles | N | Market Cap (millions) | | N | Trade Volume (x1,000) | |
		Mean	Std		Mean	Std
High		4,801	9,239		1,768	2,998
2		4,792	9,844		1,501	2,186
3		4,755	9,696		1,433	3,238
4		6,979	16,961		1,836	4,355
5		8,643	24,975		2,536	4,848
6		6,830	18,026		1,870	3,411
7		9,054	33,299		2,274	5,670
8		4,300	10,347		1,374	2,160
9		6,015	18,543		1,828	4,142
low		8,045	32,361		3,158	7,561
Extreme	789	5,921		19,588	2,071	
Center	1,209	6,654		30,045	1,855	
Diff		-733			216**	

**significant at the 1% level
*significant at the 5% level

Table 2

ISO use pre and post announcement

We present the percentage change in ISO volume (ISO % volume) on day -1 (ΔPre) and day 0 (ΔPost), by deciles of earnings surprise. Earnings surprise is measured as the difference between the actual earnings level and the median analyst estimate for each firm. ΔPre represents the change in ISO use between the base period and the Pre period. The Base period is day -25 through day -6 inclusive with day 0 being the first trading day after the earnings announcement. ΔPost represents the difference between the Post (Post) period and the Pre period. Since the percentage of trades and volume can vary based on the numerator and denominator, we also include an analysis of the level of ISO volume use. Tests at the decile level are paired t-tests. Tests between the Extreme and Center portfolios are mean difference. The Extreme portfolio includes deciles High, 2, 9, Low and the Center portfolio represents the remaining deciles.

Decile	ISO % Volume		ISO Trades		ISO Level Volume	
	ΔPre	ΔPst	ΔPre	ΔPst	ΔPre	ΔPst
High	1.3*	3.9**	0.6	4.3**	133,695**	891,471**
2	1.4**	4.2**	0.6	4.2**	139,382**	588,108**
3	2.3**	2.8**	1.5**	3.0**	288,689**	496,066**
4	2.0**	3.7**	1.3**	3.5**	181,509**	886,935**
5	2.4**	3.5**	1.4*	2.9**	348,080**	976,809**
6	1.9**	3.1**	1.4**	3.6**	394,074*	907,899**
7	1.4*	3.3**	0.7	3.2**	458,565**	672,091**
8	1.1*	3.2**	1.0*	3.7**	193,263**	723,172**
9	2.0**	4.5**	1.3**	4.2**	212,893**	881,967**
Low	2.9**	4.4**	2.0**	4.5**	597,738**	1,897,293**
Extreme	1.9	4.3	1.2	4.3		
Center	1.8	3.3	1.2	3.3		
Difference	0.1	1.0**	-0.1	0.9**		

**significant at the 1% level
*significant at the 5% level

Table 3

ISO and Non-ISO spread evaluation

We present a spread analysis of ISO and Non-ISO trades on day -1
(Pre) and day 0 (Post). The Base period is day -25 through day -6,
inclusive, with day 0 being the first day on which trading occurs after
the earnings announcement. Spreads are in cents. Effective spreads are
calculated against the estimated NBBO. Realized spreads are calculated
against the in force NBBO 5 minutes after the trade. The method of
Ellis, Michaely, and O'Hara (2000) is used to infer trade direction. All
spreads are half spreads.

Period	ISO Effective	Realized	Non-ISO Effective	Realized
Base	1.00	0.45	0.92	0.45
Pre	1.09	0.42	0.98	0.43
Post	1.18	0.41	1.06	0.53
Pre-Base	0.08**	-0.04	0.06*	-0.02
Post-Pre	0.09**	0.00	0.08**	0.10**

** statistically significant at the 1% level
* statistically significant at the 5% level

Table 4

Quote based liquidity changes around earnings announcements

Panel A shows Breadth, the time weighted number of market centers offering depth for immediate execution. Traditional measures of quote based liquidity, Depth and Relative spreads, are shown in Panels B and C of this table. The base period is defined as day -25 through day -6 inclusive, where day 0 is the first trading period after the earnings announcement. Pre is day -1 and Post is day 0. The column labeled Difference presents t-statistics for paired tests comparing the liquidity measure between the Pre and Base periods and between the Post and Pre periods. % Change is the percentage change in the indicated liquidity measure. Pre compares the change between the Base and Pre periods while Post compares the change between the Post and Pre periods. The Extreme group comprises the two highest and lowest earnings surprise deciles (High, 2, 9, Low) and the Center group comprises the remaining deciles.

Portfolio	Measure			Difference		% Change	
	Base	Pre	Post	Pre-Base	Post-Pre	Pre	Post
Panel A: Breadth							
Extreme	5.30	5.08	5.16	-0.22**	0.03**	-4.15	1.57
Center	5.55	5.29	5.34	-0.26**	0.02**	-4.68	0.95
Panel B: Depth							
Extreme	23.4	19.3	22.2	-4.03*	2.85**	-21.24	13.06
Center	30.2	26.0	29.9	-4.15**	3.86**	-16.15	13.04
Panel C: Relative Spread							
Extreme	0.157	0.132	0.198	-0.025**	0.067**	-15.92	50.00
Center	0.139	0.125	0.196	-0.014*	0.071**	-10.07	56.80

** statistically significant at the 1% level
* statistically significant at the 5% level

Table 5

Market Depth Concentration (MDC)

MDC is the time weighted average Herfindahl Index of posted depth >= the flicker quote. The flicker quote is the least aggressive NBBO ask and bid prices over the previous one second. Any depth posted at or inside of the flicker quote can be accessed without violation of the order protection rule of Reg NMS. The base period is day -25 through day -6, inclusive, with day 0 being the first trading day after the earnings announcement. The Difference column is the mean paired difference between either the Pre and Base periods or the Post and Pre periods. The Pre period is day -1 and the post period is day +1. Looking at the % Change, Pre is the change in MDC between the Base and Pre periods and Post is the change between the Post and Pre periods.

Portfolio	MDC			Difference		% Change	
	Base	Pre	Post	Pre-Base	Post-Pre	Pre	Post
Extreme	0.479	0.472	0.479	-0.008**	0.008**	-1.46%	1.48%
Center	0.472	0.463	0.471	-0.009**	0.008**	-1.91%	1.73%

** statistically significant at the 1% level
* statistically significant at the 5% level

Table 6

Breadth regression analysis

We present the results of the following cross sectional regression analysis: :

$$\Delta Brdth_{i,t} = \alpha + \beta_1 AbsSur_i + \beta_2 \Delta RelSprd_{i,t} + \beta_3 \Delta Dpth_{i,t} + \beta_4 LnCap_i + \beta_5 VolRatio_{i,t} + \varepsilon_{i,t}$$

where the t subscript is indexed on either the Pre period or the Post Period. $\Delta Brdth_{i,t}$ is the change in breath. All variables with a Δ represent the change between the Pre and Base period (Pre minus Base) for the Pre announcement trading day regression while these variables represent the change between the Post and Pre periods (Post minus Pre) for the Post announcement trading day regression. The base period is day -25 to day -6 inclusive, where day 0 is the day of the announcement. $AbsSur_i$ is the absolute value of the earnings surprise, where earnings surprise is measured as the difference between the actual earnings level and the median analyst estimate for each firm $\Delta RelSprd$ is the change in relative spread. $\Delta Dpth$ is the change in depth available for immediate execution. $LnCap$ is the natural log of market capitalization of the firm. $VolRatio$ is the ratio of traded volume on the of the Pre day divided by the average volume for the Base period. When the regression is for the Post day, $VolRatio$ is the ratio of traded volume after the announcement divided by the volume on the Pre day. Statistical tests are based on White's standard errors. n = 1,975.

| Variable | Pre | | Post | |
	S1	S2	S1	S2
Intercept	-0.2505**	0.0315	0.0677**	0.3102**
AbsSur	0.0303	0.0325	-0.0232	-0.0243
RelSprd		-3.4287		-14.0686**
Dpth		0.0021		0.0026**
LnCap		-0.0409**		-0.0286*
VolRatio		0.0562**		0.0015
N	1975	1975	1975	1975
Adj R^2	0.017%	2.787%	-0.015%	2.16%

** statistically significant at the 1% level
* statistically significant at the 5% level

Table 7

Effective Spread Regression

We estimate the following cross sectional regression for the Pre period (day -1) and the Post period (day 0):

$$EfSpdISO_{i,t} = \alpha + \beta_1 Brdth_{i,t} + \beta_2 LnCap_i + \beta_3 AbsSur_i + \beta_4 Dpth_{i,t} + \beta_5 RelSprd + \beta_6 VolRatio + \varepsilon_t$$

where the *t* subscript is indexed on either the Pre period or the Post period. $EfSpdISO_{i,t}$ is the effective spread as measured against the NBBO. *Brdth* is the time weighted number of market centers offering depth for immediate execution. *LnCap* is the natural log of the firm's market capitalization. *AbsSur* is the absolute value of the earnings surprise, where earnings surprise is measured as the difference between the actual earnings level and the median analyst estimate for each firm. *Dpth* is the posted depth in round lots/100. *RelSprd* is the time weighted relative spread based on the estimated NBBO. For the Pre day, *VolRatio* is the ratio of the volume on the Pre day divided by the mean volume in the Base period. For the Post day, *VolRatio* is the ratio of the Post day volume divided by the volume on the Pre day. Statistical tests are based on White's standard errors.

Variable	Pre		Post	
	S1	S2	S1	S2
Intercept	0.0438**	0.0213*	0.0520**	0.0520**
Brdth	-0.0021**	-0.0019**	-0.0019**	-0.0025**
LnCap	-0.0026**	-0.0008	-0.0035**	-0.0034**
AbsSur	0.0018	0.0016	0.0026	0.0026
Dpth		0.0019*		0.0020**
RelSprd		4.8044*		0.3087
VolRatio		-0.0001		0.0000
Adj-R^2	4.7%	7.8%	5.9%	6.3%

** statistically significant at the 1% level
* statistically significant at the 5% level

Table 8

Information share analysis

For each decile rank of earnings surprise the information ratio and information share of ISO trades is presented. The information ratio is defined as:

$$InfoRatio_{i,t} = \frac{TradeTypeInfoShare_{i,t}}{TradeTypeVolume_{i,t}}$$

Where $TradeTypeInfoShare_{i,t}$ is the information share of ISO trades for stock i on day t and $TradeTypeVolume_{i,t}$ is the percentage of ISO volume for stock i on day t. The information share method is based on Hasbrouck (1995). We create two price channels using the last trade price of ISO and NSO trades in each second. Panel A presents the information ratio while Panel B presents the information share. The base period is from day -25 to day -6. The pre period is the day prior to the earnings announcement and the post period is the first trading day after the announcement. We conduct a paired t-test to evaluate the difference in each measure for the Pre-Base comparison and the Post-Pre comparison.

Period	Decile of Earnings Surprise									
	High	2	3	4	5	6	7	8	9	Low
Panel A: Information Ratio										
Base	1.09	1.06	1.08	1.09	1.08	1.09	1.11	1.07	1.05	1.11
Pre	1.09	1.11	1.05	1.07	1.04	1.03	1.11	1.02	1.05	1.02
Post	1.22	1.16	1.16	1.12	1.14	1.12	1.15	1.17	1.15	1.11
Pre-Base	0.00	0.05	-0.04	-0.02	-0.04	-0.06*	0.01	-0.05	0.00	-0.09**
Post-Pre	0.13**	0.05	0.12*	0.05	0.10*	0.09*	0.04	0.15**	0.10*	0.08*
Panel B: Information Share										
Base	0.36	0.35	0.35	0.36	0.37	0.37	0.37	0.35	0.35	0.38
Pre	0.38	0.38	0.37	0.38	0.38	0.37	0.39	0.35	0.37	0.39
Post	0.47	0.44	0.42	0.42	0.43	0.42	0.43	0.42	0.44	0.43
Pre-Base	0.01	0.03*	0.01	0.02	0.01	0.01	0.01	0.00	0.02*	0.01
Post-Pre	0.09**	0.06**	0.05**	0.05**	0.05**	0.04**	0.04**	0.07**	0.07**	0.05**

** statistically significant at the 1% level
* statistically significant at the 5% level

Table 9

Information Ratio (*InfoRatio*) regression
We estimate the following cross sectional regression for the Pre period (day -1) and
the Post period (day 0):

$$\Delta InfoRiso_{i,t} = \alpha + \beta_1 \Delta Brdth_{i,t} + \beta_2 \Delta Dpth_{i,t} + \beta_3 \Delta RelSprd_{i,t} + \beta_4 LnCap_i$$
$$+ \beta_5 AbsSur_i + \beta_7 \Delta\%ISO_{i,t} + \varepsilon_t$$

where the *t* subscript is indexed on either the Pre period or the Post period. For the
pre-period regression, all variables with a Δ represent the change between the Pre
and Base period. For the post-period regression, all variables with a Δ represent the
change between the Post and Pre period. $\Delta InfoRatio_{i,t}$ is the change in the *InfoRatio*.
InfoRatio for ISO trades is the information share based on Hasbrouck (1995)
divided by the % of ISO volume. *Brdth* is the market breadth, *Dpth* is the flicker
depth, *RelSprd* is the relative spread, and *AbsSur* is the absolute value of the
earnings surprise, where earnings surprise is measured as the difference between
the actual earnings level and the median analyst estimate for each firm. *%ISO* is the
percentage of ISO volume for each stock in each regression period. Statistical tests
are based on White's standard errors.

Variable	Pre	Post
Intercept	0.0082	0.2155
ΔBrdth	0.0453**	0.0823**
ΔDpth	0.0002	-0.0001
ΔRelSprd	-8.1732	2.7217
LnCap	0.0016	-0.0116
AbsSur	-0.0138	0.0114
Δ%ISO	-1.8179**	-1.8881**
Adj R^2	7.4%	6.6%

** statistically significant at the 1% level
* statistically significant at the 5% level