Informed High Frequency Trading with Advance Peek into the Michigan Index of Consumer Sentiment

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Abstract

This paper provides evidence of large profits earned by informed high frequency traders (HFTs) from two seconds of advance peek into the Michigan Index of Consumer Sentiment (ICS). We find that this early advantage, provided by Thomson Reuters to its elite customers, is a pervasive problem in our sample period. While informed HFTs facilitate price discovery and promote market efficiency, their large profits from both speed and informational advantages could erode investors' confidence about the integrity of financial markets. Our results elucidate the debate on regulatory oversight to circumvent the potentially adverse effects from an advance peek into ICS.

JEL Classification: G12; G14; K22; D82

Key words: Informed trading; high frequency traders; advance peek; information efficiency; price discovery

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1. Introduction

Informed trading is a longstanding issue that has been debated extensively. In the absence of market impediments, all investors should receive information pertinent to the value of a stock or index immediately and simultaneously. In practice, however, some agents receive the information before it is disclosed to the general public. The point of contention is that early-informed agents, when combined with an appropriate trading strategy, can generate substantial returns. In this paper we provide evidence on the existence of informed trading from two seconds of advance peek into the Michigan Index of Consumer Sentiment (ICS).

This study is motivated by the report published by the *Wall Street Journal*, which suggested that certain investors, including many high-frequency traders, received the University of Michigan's consumer report two seconds before everyone else in 2013. Given that an early peek into the index, when combined with high frequency trading techniques, can result in windfall profits, the New York Attorney General began scrutinizing whether the advance release to some customers violates the Martin Act, New York's securities law in April, 2013.[2] As part of an agreement with the N.Y. Attorney General's office, Thomson Reuters announced on July 8, 2013 that it was suspending its early release practice. The initiation and suspension of early release practice provides not only a natural experiment on the impact of informed trading, but

[2] Former Securities and Exchange Commission Chairman Harvey Pitt indicates that this episode posed a fairness issue and destroyed confidence in the market by the public (Javers, Eamon (12 June 2013). "Thomson Reuters Gives Elite Traders Early Advantage". *CNBC*. Retrieved 12 June 2013.)

also sheds new light on the profitability of high frequency informed traders who receive ICS news earlier.

We focus our empirical investigation on NASDAQ high frequency dataset because it explicitly identifies HFTs from non-HFTs. This feature gives us a unique opportunity to provide direct evidence, compared to the contemporaneous work by Hu et al. (2013), on the impact of informed high frequency trading on ICS data[3]. Given the extremely short time window of two seconds to access this tiered information, it is likely that this information release will bring significant benefits to liquidity demanding HFTs. We show that informed trading by HFTs during the two-second advance peek is prevalent even prior to this service being advertised by Reuters in September 2009. By focusing on 120 listed stocks listed in NASDAQ and NYSE, we also find that informed liquidity demanding HFTs tend to trade more frequently yet in modest size during the advance peek, implying their attempt to conceal their identity as informed traders. This trading behavior is synonymous with informed traders who may have a longer time horizon to utilize private or insider information to trade (Fishe and Robe, 2004).

On the basis that liquidity demanding HFTs have an informational advantage during the advance peek, we estimate their profit from exploiting the two-second window period prior to the ICS announcements. We assume that informed HFTs open their trading positions during the advance peek before closing them out two or several seconds later. The maximum cumulative profit of an informed liquidity demanding HFT is $40,245 compared to $31,944 for a non-informed trader[4]. Furthermore, there is evidence of a first-mover advantage in that the earlier the

[33] Hu et al. (2013) addresses the issue on the early peek advantage of the ICS and focus on the trading and price behavior in E-mini S&P 500 futures without distinguishing HFTs from non-HFTs.

[4] This estimate is considered to be conservative given that our profit calculation also includes HFTs who may not have access to an early peek and therefore could have opened their trade position wrongly or in the direction that contradicts the news in that two-second window period.

informed traders exploit information obtained during the advance peek, the bigger their profit will be.

This study contributes to the existing literature in three important ways. First, the impact of informed trading on individual stock prices is shown to be relevant in the order of seconds and milliseconds. Past studies look at an informed trading period of a longer duration ranging from several minutes (Bernile et al., 2014), to several hours (Chakravarty and McConnell, 1999; Fishe and Robe, 2004), to several days and months (Meulbroek, 1992; Cornell and Sirri, 1992, Seyhun, 1986, 1992). For example, Fishe and Robe (2004) study five stockbrokers who acquire information on 116 publicly traded companies from Business Weeks' "Inside Wall Street" (IWS) column at least four hours before it is released to the public.[5] Our results provide stark contrast in the duration (two seconds versus four hours) for which information that moves market is acquired before it becomes public. The magnitude of the price changes that occur on this shorter trading duration indicates that informed trading is widespread[6]. This is especially true in today's financial markets that are increasingly characterized by the use of computer algorithms to exploit short-lived trading opportunities.

The second contribution relates to the information content of insider trading. The early informed trading literature has focused on the ability of corporate insiders in exploiting non-public information content to their advantage. The information content of insider trading

[5] Fishe and Robe (2004) state that the broker obtained information about the publicly traded firms "in the early afternoon on Thursdays, before the public release of portions of the magazine over news wire (at 5:15 p.m.) and electronic distribution on America Online (at 7:00 p.m.)" (pp. 466-467).

[6] The role of market intervention to ensure a level playing field by all traders remains a highly controversial issue. Although the University of Michigan spokesperson claims that the ICS information is produced with private funds and the university does not violate any regulation, its action has been criticized by Senator Grassley, a former chairman of the Senate Finance Committee, as being out of line with a publicly funded university that should operate for public benefit and not act like a private business that is contrary to taxpayers' expectations. Legal and moral arguments aside, there remain challenges with monitoring and regulating the market, which may be extremely costly and impractical, and the benefits from market regulation may not outweigh the costs.

includes Hirschey and Zaima (1989) for selloffs, Seyhun (1990) for takeovers, John and Lang (1991) for dividend policy, Lee et al. (1992) for share repurchase, and Irvine et al. (2007) for the release of analysts' initial buy recommendations. In all cases, they clearly demonstrate that corporate insiders possess valuable information regarding the future price of their firms' securities. In this paper the information content of insider trading is on ICS, which is a blind spot in U.S. law[7].

Finally, this paper contributes to the literature on price discovery using public information. While many previous studies have documented the effects of public news releases on asset prices (Ederington and Lee, 1993; Fleming and Remolona 1999; Flannery and Protopapadakis, 2001; Balduzzi, Elton, and Green, 2001; Andersen, Bollerslev, Diebold, and Vega, 2003; Erenburg et al., 2006; Tetlock, 2010), we examine how informed HFT affects price discovery of individual stocks before public news releases (Bernile et al., 2014). Bernile et al. (2014) show evidence of informed trading in equity index futures during the lockup period before salient macroeconomic news announcements. However, they only implicitly infer about the role played by informed HFTs from their data, while not explicitly identifying the roles of HFTs. The nature of the information structure of ICS is also different from other macroeconomic news because we can identify the exact time when high frequency traders received material information through the selective disclosure process by Thomson Reuters.

The paper proceeds as follows. Section 2 presents the background to the practice of an advance peek into ICS and discusses the testable hypotheses. Section 3 describes NASDAQ high frequency trade data and the classification of positive and negative ICS news. Section 4 provides

[7] There is no law that prevents investors from trading on nonpublic information they have legally purchased from other private entities.

empirical results. Section 5 offers some robustness analyses. Section 6 concludes with some policy implications.

2. Advance Peek into the Index of Consumer Sentiment and Testable Hypotheses

2.1 The History of Surveys on Consumer Sentiment and the Two-Second Advance Peek

The University of Michigan (UM) started conducting surveys of consumer sentiment in 1946. The Surveys of Consumers are influential both in public policy and business circles, providing a gauge of consumer anticipation of changes in the economic environment. One part of the surveys, the Index of Consumer Expectations, is an official component of the U.S. Index of Leading Economic Indicators, which is a key element for understanding and forecasting changes in the national economy. The UM signed an agreement with Thomson Reuters in 2006, which gave the international news organization the exclusive right to distribute the highly regarded surveys of consumers. The survey was renamed the Thomson Reuters/University of Michigan Surveys of Consumers. Under this agreement, effective January 1, 2007 and for the six months after their release, Thomson Reuters has the exclusive right to distribute the headline survey index numbers through its news and media services. Thomson Reuters also provides a more in-depth view of this important consumer opinion data exclusively to its customers, building on the strong base of current subscribers. Thomson Reuters' paying clients receive the data comprising certain headline survey indices through a conference call at five minutes (i.e. 9.55 a.m.) prior to the data release for the general public, which is posted on the web at 10 a.m. on the days it is released.

It was reported that starting September 2009 the contract permits a more elite group of Thomson Reuters' clients, who subscribe to its high-speed data feed, to receive the information

in a specialized format tailor-made for computer-drive algorithmic trading at 9:54:58.000 (i.e. two seconds) prior to the data release to Thomson Reuters' non-elite paying clients. Although the arrangement for an early peek into ICS was formally announced to the finance community in September 2009, our results in fact show that the two-second early releases may have occurred as early as January 2008. On occasion, the elite clients could get the data even earlier—the contract allows for a plus or minus 500-millisecond margin of error. In exchange for this exclusive access to the data, the contract stipulates that Thomson Reuters pays the University of Michigan $1 million per year, in addition to a "contingent fee" that is based on the revenue generated by Thomson Reuters. As to the advantage of a two-second advance peek, Thomson Reuters provides in its marketing materials[8] that there is a two-second lead time, which is illustrated through the major market move on August 12, 2011 when U.S stocks slipped after consumer sentiment data were released. More importantly, Thomson Reuters News Feed Direct customers were able to benefit from the two-second advance and the fastest delivery in the market.

It was not until June 12 of 2013 when this two-second advance peek practice caught the attention of the media and was reported by the CNBC and the Wall Street Journal (WSJ), respectively. Both news reports highlighted virtually instantaneous (i.e. within milliseconds) response of the market when Thomson Reuters transmitted the data to its elite group of traders on May 17, 2013, for which trading volume sky-rocketed in the Spider exchange traded fund (ETF) at precisely 9:54:57.975. In addition, according to the analysis reported by the firm Nanex more than 100,000 shares traded hands in the first 10 milliseconds of the burst of activity while

[8] http://thomsonreuters.com/products/financial-risk/01_255/NewsFeedDirect_UOM.pdf

the price of SPY jumped from $165.90 to $166.06 within 100 milliseconds.[9] Furthermore, in the first half second of the trading burst, Nanex indicates that more than $40 million changed hands in the Spider ETF. Such anecdotal evidence is indicative of the work of high frequency traders who are likely to have access to the two-second advance release of Thomson Reuters' consumer survey data. Given the importance of distinguishing ordinary traders from high frequency traders, our study employs the NASDAQ high frequency dataset that explicitly identifies HFTs from non-HFTs, and thus our results provide *direct* evidence, compared to the use of equity index futures and exchange traded funds. Our results imply that there is a legitimate and serious concern about the pernicious effect of an early peek into ICS and its use with high frequency trading programs on the integrity of financial markets.

Since July 2013, Thomson Reuters has suspended the two-second early release of its ICS report to their elite subscribers at the behest of the New York Attorney General, whose office is currently reviewing the arrangement. The New York Attorney General is investigating whether this tiered system constitutes a violation of insider trading regulations, despite UM spokesperson Rick Fitzgerald maintaining that the UM's arrangement with Thomson Reuters complied with regulations and that the index is produced with private funds.

2.2 Empirical Hypotheses

2.2.1 Trading Characteristics of Informed HFTs

We hypothesize that other things being equal, informed HFTs will (1) trade in bigger volume, (2) trade more frequently, and (3) trade in the direction of stock price movement as

[9] SPY is the ticker symbol for an ETF that tracks the S&P 500.

predicted by ICS news in the two-second advance peek. These predictions are well substantiated by the literature on HFTs' trading behavior and characteristics.

The model of Foucault et al. (2013) predicts that informed HFTs are prone to trade aggressively when they have access to news faster than other traders. In other words, the speed with which a trader obtains news increases the degree of responsiveness by the trader's optimal trading strategy to news. Using a dynamic version of Kyle's (1985) model that incorporates new information (or "news") about the payoff of a risky security, Foucault et al. (2013) demonstrate that the speed advantage to accessing news affects a trader's optimal strategy insofar as it affects the forecast of the asset payoff. HFTs are known to have speed advantage through their use of computer algorithms and by placing their computers in stock exchange data centers so that they can trade faster. The two-second advance peek clearly provides not only informational advantage, but further enhances the speed advantage that HFTs already possess over ordinary traders. Consequently, it is predicted by the Foucault et al. (2013) model that informed HFTs will trade in bigger volume and more frequently during the two-second advance peek.

Brogaard et al. (2014) find that HFTs facilitate price efficiency by trading in the direction of permanent price changes and in the opposite direction of transitory price errors. In the context of their state space model, stock price movements are decomposed into permanent and transitory components such that the permanent component is associated with information impounded into prices while the transitory component relates to pricing errors or noise caused by transitory price movements that impede unsophisticated traders from deciphering the true price. In the two-second window when ICS is released to HFTs, this information provides HFTs with a better prediction of the predicted change in stock price movements. This early release of information facilitates HFTs to trade in the direction of stock price movements ahead of other investors. If

HFTs are trading in the direction of a permanent price change as demonstrated by Brogaard et al. (2014) who employ the same dataset used in our study, we believe that HFTs will trade in the direction of stock price movements as predicted by ICS news in the two-second advance peek.

Hypothesis 1 (*H1*): Informed HFTs with early access to the Thomson Reuters/UM consumer sentiment survey tend to trade aggressively in bigger volume and more frequently, and their trade imbalance increases (decreases) with positive (negative) ICS news.

2.2.2 Informed HFTs Facilitate Price Discovery

The speed at which prices incorporate public or private information has been extensively investigated in a number of studies (Lee et al., 1993; Kim and Verrecchia, 1994; Busse and Green, 2002). Lee et al. (1993) find that liquidity providers are sensitive to changes in information asymmetry risk around earnings management. Kim and Verrecchia (1994) show that earnings announcements provide information that allows certain traders to make judgments about a firm's performance that are superior to the judgments of other traders. Their model predicts that informed opinions resulting from public disclosure may lead to an increase in trading volume, despite the reduction in liquidity that accompanies announcements. Busse and Green (2002) show that stock prices respond to reports within seconds of initial mention of analysts' views presented in Morning Call segments on CNBC TV. Trading intensity doubles in the first minute, with a significant increase in buyer- (seller-) initiated trades after positive (negative) reports. Traders who execute within 15 seconds of the initial mention make significant profits by trading on positive reports during the Midday Call. Vega (2006) note that the arrival rate of informed or uninformed traders matters for market efficiency and that stocks with high private information-based trading have higher post-announcement drift.

Like all traders, HFTs rely on macroeconomic news as a source of market-wide information (Andersen et al., 2003; Brogaard et al., 2014). When ICS announcements occur, market consensus about the value of a stock or index will change. When unexpected positive ICS news is released, prices usually rise. Likewise, prices usually fall when unexpected negative ICS news is released. The adjustment from the old price to the new price takes place through trading. Informed HFTs who process the information in ICS announcements during an advance peek are part of the information processing in markets that determines prices. These informed HFTs employ a news-reaction strategy by using computers to scan news feeds for relevant information so as to make and implement trading decisions. As ***H1*** predicts that informed HFTs will trade in the anticipated direction of stock price movements, which is indicated by the sign of ICS news in an advance peek, we hypothesize that informed HFTs' trade imbalance in the advance peek predicts future price changes or future stock returns over horizons of a couple of seconds. Brogaard et al. (2014) also document that HFTS' liquidity demanding trades help incorporate information into prices.

Hypothesis 2 (*H2*): Informed HFTs with access to the two-second advance peek into ICS display large trade imbalances, which have predictive power on future returns over a short-term horizon.

2.2.3 Informed HFTs' Profits

HFT plays an important role in U.S. equity trading. Brogaard (2010) reports that HFTs in his sample were responsible for 68.5% of trading volume. Even though HFTs trade in large quantity, their profit margins are generally very thin. Brogaard (2010) shows that they earned approximately one tenth of a penny per share traded. Given the thin profit margin made by HFTs

in the U.S. equity market, it is necessary that they trade with high volume turnover and very rapidly to cover fixed costs (Narang, 2010). It is envisaged that the information advantage obtained during the two-second advance peek will improve the profit margin of informed HFTs through their precision in discerning the direction of stock price movements as well as their speed advantage over other investors.

Theory also predicts that HFTs exploit their speed advantage by trading with less informed traders. Foucault et al. (2013) find that shares of HFT trading volume are much higher when they have a speed advantage over other investors. Hirshleifer et al. (1994) show that in a partially revealing rational expectations equilibrium, traders with early access to information trade aggressively in the initial period and then partially reverse their trades in the next trading round, when the information is released to less informed investors. This reversal occurs, because risk-averse, early-informed investors wish to reduce the long-term risk associated with price movements that arise from future events they cannot predict. Their model predicts that early informed investors appear to be short-term "profit takers", because of their position reversal. In the context of the two-second advance peek, early access to ICS announcements provides HFTs with much needed informational and speed advantages, and thus informed HFTs are able to make substantially larger profits than uninformed non-HFTs.

Hypothesis 3 (*H3*): Informed HFTs' trade imbalance before and after ICS news release has predictive power for subsequent stock returns, which generate substantial positive profits for them.

3. Data and News Classification

3.1 The Data

Our empirical analyses make use of data on NASDAQ high frequency traders. The data are obtained from NASDAQ under a non-disclosure agreement.[10] The data consist of a stratified sample of 120 randomly selected stocks listed on NASDAQ and NYSE spanning a 2-year period from 2008 to 2009. In addition, the data include observations from the 22nd to 26th of February 2010, which we also utilize in our analysis. It was reported that commencing September 2009, Thomson Reuters began to permit an elite group of clients to receive Thomson Reuters/University of Michigan Surveys of Consumers information at 9:54:58.000 (i.e. 2 seconds) prior to the data release to Thomson Reuters' non-elite paying clients. Although the exact date of this reporting is not known, for the purpose of our analysis we divide our total sample into pre- and post-September 2009 samples to examine whether the practice of this advance peek is prevalent prior to this reporting. The pre-September 2009 sample comprises the period 1 January 2008 to 31 August 2009, while the post-September 2009 sample comprises the period 1 September 2009 to 31 December 2009 and the period 22 to 26 February 2010.[11] Based on the sample results for pre-September 2009, there is evidence to suggest that the two-second advance peek on ICS may have occurred as early as January 2008.

All trades are time-stamped to the millisecond and the demanders and suppliers of liquidity are identified either as a high frequency trader (HFT) or non-high frequency trader (non-HFT). This is the advantage of using the NASDAQ HFT data as the status of each trader, whether a liquidity demander or supplier, is explicitly provided. NASDAQ uses its knowledge of its customers and analyzes the firms' trading patterns, such as the frequency for which their net trading exceeds zero in a day, their order duration, and their order to trade ratio, to categorize

[10] We are thankful to NASDAQ OMX for providing data on HFTs.

[11] Results based on the data for the post-September 2009 sample are not reported for brevity, but they are available upon request.

whether a firm is a HFT. Although the data identify HFTs, they suffer from a drawback in that not all HFTs are identified (Brogaard et al., 2014). Some large integrated firms that function as brokers for customers and are involved in proprietary lower-frequency trading strategies are not included in the data. In addition, HFTs that direct their orders through these large integrated firms are also not included in the sample. The 26 HFT firms in the NASDAQ data can be regarded as independent proprietary trading firms.[12]

The data also come with the following information: the NASDAQ trading symbol for a stock, the date and time (in milliseconds) for which trading occurred, the number of shares traded and the associated price, and a buy/sell indicator that informs whether the trade was buyer- or seller-initiated. There is also the type of traders who are involved in the transaction, which are denoted by two alphabets: H or N. The first (second) alphabet denotes the liquidity demanding (supplying) participant in a transaction. Accordingly, a transaction can fall into one of the four combinations of trading type. The HH (HN) combination denotes a transaction in which a HFT demands liquidity and another HFT (non-HFT) supplies that liquidity. The NN (NH) combination denotes a transaction in which a non-HFT demands liquidity and another non-HFT (HFT) supplies that liquidity. The total trading activity of HFTs (non-HFTs) is the sum of the volume of both HFT (non-HFT) liquidity supply and demand. The HFT (non-HFT) trade imbalance is defined as the net trading volume, which is the HFT (non-HFT) buyer-initiated volume minus HFT (non-HFT) seller-initiated volume.

Along with the NASDAQ HFT data, we also use supplementary data to retrieve the national best bid and best offer (NBBO) from the NYSE Trade and Quoting (TAQ) database and

[12] These 26 firms represent a significant amount of trading activity for which NASDAQ believes they fit the characteristics of HFTs. Nonetheless, it is difficult to determine whether these 26 firms provide adequate representativeness of total HFT activity.

the NASDAQ best bid and best offer (NASDAQ BBO). The NBBO data provide best prices that prevail in all markets over 2008 and 2009, thus permitting a study on market-wide price discovery. NASDAQ BBO, however, only provides the best available prices on NASDAQ for the first week of every quarter in 2008 and 2009, and thus this dataset is less informative than NBBO. Market capitalization data are based on the end-of-2009 data obtained from S&P Compustat. We use the NBBO data to compute stock returns and volatility. Following Brogaard et al. (2014), we drop two stocks, Boise Inc. (BZ) and MAKO Surgical Corp. (MAKO), because they do not appear in the TAQ database for part of our sample period.

3.2 Classification of Early Release of the Survey Data as Positive and Negative News

Our hypotheses focus on the information content associated with the early release of Thomson Reuters/UM survey data on the behaviour of HFTs' trading activity, stock returns, and volatility. To test these hypotheses, news surprises that market prices should impound upon the ICS announcements are measured by the difference between market expectations and the announced values of ICS. This measure is consistent with the convention of computing news surprises in the literature of macroeconomic announcements.[13] To establish whether there are asymmetric effects, we classify an early release of survey data as positive or negative news, using the announcement surprises based on the Thomson Reuters survey of economists. Every two weeks Thomson Reuters contacts a cross-section of economists for the purpose of collecting their forecasts of the consumer sentiment index. The median of collected forecasts serves as an estimate for the market expectations of the upcoming releases. The unexpected component *Sc* for the survey of consumer data is estimated by computing the difference between the early released

[13] See, for example, Adams et al. (2004) and Boyd et al. (2005).

value for the Thomson Reuters/UM Index of Consumer Sentiment (MAc) and the median forecast from the Thomson Reuters Survey of Economists (Ec). For Sc>0 (<0) - that is, when the early released value for the Thomson Reuters/UM ICS is higher (lower) than the median forecast from the Thomson Reuters Survey of Economists - the early release of the consumer survey data is regarded as positive (negative) news.

4. Empirical Results

4.1 Preliminary Data Analysis

Figure 1 shows the intraday patterns of trading volume (Figures 1a and 1b), trade imbalance (Figures 1c and 1d), trade size (Figures 1e and 1f), trading frequency (Figures 1g and 1h), stock returns (Figures 1i and 1j), and volatility of returns (Figures 1k and 1l) on days with and without ICS announcements for the first sample. In each figure, the solid (dotted) line depicts characteristics of the variable in question on the event (pseudo-event) days, which are the days when early releases of the consumer surveys are (not) reported.[14] The pseudo-event days are used as a control sample to compare and contrast the effect of ICS announcements and, in particular, the effect of a two-second advance peek on consumer survey data on trading characteristics, stock returns, and volatility. Note that we utilize data only from the pre-September 2009 sample given that we intend to document that the practice of ICS advance peek

[14] Preliminary (Final) announcements occur on the second (last) Fridays of the month. Pseudo-event days are the same day when no announcements are made. However, in the event of a holiday on these non-announcement days, we use the prior day.

did occur prior to the September 2009 reporting, and that the results for the post-September 2009 sample are qualitatively the same as those of the pre-September 2009 sample.[15]

- Figure 1 about here -

The trading volume in Figures 1a and 1b, which is measured by the number of shares, displays a significant jump at 9:54:58.000, or two seconds prior to the release of the consumer survey data to non-elite subscriber clients. This sharp hike in trading volume would be associated with HFTs' trading activity. It is seen in the case of positive news that the trade volume falls to about half its level at 9:55 a.m., albeit the volume persists at a level that is higher than the trading volume of pseudo-event days. This observation can be rationalized by the fact that when there is positive news of consumer sentiment, traders are bullish and tend to engage in more trading, giving rise to higher volume. The higher trading volume appears to last to a minute after 9:55 a.m. In contrast, the response of trade volume to the release of negative consumer survey data suggests that trade volume falls rapidly in about 5 seconds to a level that is comparable to that of the pseudo-event days. Nevertheless, it is interesting to note that there is also a sharp jump in trading volume in the two seconds prior to the data release at 9:55 a.m. In fact, the trading volume at 9:54:58.000 is higher than that for good news, suggesting that HFTs may have more incentive in exploiting the two-second early release of negative consumer sentiment news to their advantage. There is also evidence that the level of trading volume 58 seconds prior to the early release (from 9:54:00 to 9:54:58) of negative consumer survey data is marginally lower than that of pseudo-event days. This pattern contrasts that of positive news on consumer survey data, suggesting that traders may have prior knowledge of general economic pessimism. Given

[15] Utilizing the total sample does not permit a clear inference that the practice of ICS advance peek has occurred as early as January 2008 as the post-September 2009 sample could skew results from the pre-September 2009 sample.

that part of the sample falls in the period during the global financial crisis when traders were more cautious in a bear market, it is not surprising that we find the response to trading volume is higher and the reversal to the pseudo-event level is faster for bad news than for good news during the early release of ICS.

Figures 1c and 1d depict the response of trade imbalance, which is defined as the per second cumulative difference between buyer-initiated volume and seller-initiated volume to the advance peek on ICS. The figure shows a sharp hike (drop) with buy (sell) orders significantly exceeding sell (buy) orders at 9:54:58.000, or two seconds prior to the release of positive (negative) news in consumer survey data to non-elite subscriber clients. In contrast, no trade imbalance jump is observed on pseudo-event days. The response of trade imbalance to the early release of consumer survey news suggests that traders with access to this information are able to exploit it to their advantage by placing greater buy (sell) orders in anticipation of market reaction to positive (negative) news.

Figures 1e and 1f depict a jump in the level of trade size at 9:54:58.000 for both positive and negative news of the early release of consumer survey data. The jumps are not as apparent as in the cases of trading volume and trade imbalances. This seems to be consistent with the stealth trading hypothesis (e.g., Barclay and Warner, 1993; Chakravarty, 2001). In the case of negative consumer survey news, the peak in trade size occurs after the release of consumer survey data at 9:55 a.m. In contrast, for positive news we observe that the level of trade size remains higher than that of pseudo-event days more than a minute after the early release of consumer survey data.

Figures 1g and 1h show that the effect of positive (negative) news on the early release of consumer survey data increases trading frequency by about six- (seven-) fold relative to that of

pseudo-event days. However, positive (negative) news of consumer survey has persistent (short-lived) effects on trading frequency.

Figures 1i and 1j (Figures 1k and 1l) show the response of stock return (return volatility) to the early release of consumer survey data. Stock return is computed as the first difference of the logarithmic price across one second while volatility of stock return is the absolute return. It can be seen that returns jumped (dropped) to an all high (low) of 1.75% (-1.2%) at two seconds prior to the consumer survey data release at 9:55 a.m. The significant burst in trading activities arising from the early release of consumer survey is associated with information being impounded in stock prices, and the returns reflect the nature of consumer survey news. Return volatility also increases sharply at the instant the advance peek into consumer survey data takes place, although the persistence in the effect on return volatility is longer lasting for good news than for bad news. Return volatility is lower prior to the early release of negative news on consumer survey data. However, the volatility level adjusts rapidly to the level of pseudo-event days once consumer survey data are released.

To summarize, it can be seen that the early release of consumer survey data has significant effects on trading activity, stock returns, and volatility; traders behave very differently on event days (two seconds prior to 9:55 a.m.) compared to pseudo-event days (when there is no release of consumer survey data). Furthermore, the persistence of the responses in trade volume, size, trade imbalance and frequency, and return volatility is contingent on the news about whether the consumer survey is positive or negative. There is also evidence that the two-second early release of consumer survey data leads to some degree of price discovery as reflected by the sharp difference in the level of stock returns at 9:54:58.000 a.m. and its variability thereafter.

4.2 Trading Characteristics At and Around ICS Announcement Time

Table 1 reports summary statistics of trading activities around the release of Thomson Reuters' consumer survey data for the period from 1 January 2008 to 31 August 2009. This period is associated with the release of consumer sentiment announcements at 9:55 a.m., before the practice of the two-second advance peek on consumer survey data was advertised to Reuters' subscribers. We also compute summary statistics of trading activities for the post-September 2009 sample after the two-second advance peek on ICS data is reported. The results are qualitatively similar to the first sample for which the results are reported in Table 1, and hence they are not reported here for brevity. We compute the one-second interval trade volume, trade imbalance, trade size, trade frequency, stock return, and volatility on ICS announcement days.

Panel A shows the results for both HFT^D and non-HFT^D with the superscript D denoting liquidity demanders when there are positive and negative ICS announcements. On average, the one-second interval trade volume, trade imbalance, and trade frequency are higher on days with positive, rather than negative, ICS announcements. The one-second stock return volatility is also higher on days with positive ICS announcements, although the mean return is lower. However, the number of shares in each transaction per second is higher on days with negative ICS announcements, versus positive ones. The amount of trade imbalance is negative on days with positive ICS announcements as the impact of positive ICS announcements on trade imbalance is expected to be short lived. Given that the reported value for trade imbalance is for the average one-second interval on all positive announcement days, it is possible that the trade imbalance on positive announcement days is negative.

- Table 1 about here -

Panels B and C show the summary statistics for HFT^D and non-HFT^D, respectively. It can be seen that on days with positive ICS announcement, the average one-second interval trading volume, size, and frequency are higher than that from negative news. In contrast, the average trade imbalance is higher for days with negative ICS announcements than for positive announcements. The pattern is different for non-HFT^D in which only the mean value of trading volume is higher on days with positive, versus negative, ICS announcements. There are two observations of trading characteristics worth highlighting: (1) the one-second average trade imbalance for HFT^D is substantially smaller than non-HFT^D, and (2) HFT^D tend to trade more frequently, but with a lower trade size compared to non-HFT^D. The former observation can be rationalized by the fact that HFTs often rely on fast and sophisticated computer algorithms to submit and cancel orders rapidly, and to that effect the average one-second trade imbalance for liquidity demanding high frequency traders is expected to be significantly smaller than that of non-HFT^D. The latter observation supports the widely held view that informed traders, in their attempts to allay suspicion on their informational advantages, engage in strategic order splitting, which is trading more frequently but without larger size orders (Barclay and Warner, 1993; Chakravarty, 2001; Fishe and Robe, 2004; Anand and Chakravarty, 2007; Chou and Wang, 2009). Note that we do not report the stock return and return volatility for HFT^D and non-HFT^D as it is not possible to compute continuous returns when all traders only trade intermittently and not at each second. Although there are some insights from the summary statistics of data on days with ICS announcements, more insights about informed trading can be obtained by focusing on the period close to the timing of announcements.

- Table 2 about here -

Table 2 reports the mean trading activities of both HFT^D and non-HFT^D surrounding the timing of ICS announcements. Panels A and B report the one-second mean results for the various time intervals on days with and without ICS announcements, respectively. To determine the impact of the two-second advance peek into ICS on trade activities and stock returns, we examine the time interval two seconds before (i.e. (-2,0)) and after (i.e. (0,2)) the ICS announcements to wider subscribers at 9:55 a.m. In addition, we evaluate the mean results for the five-second time interval prior to the starting time of the advance peek (i.e. (-7,-2)), and a symmetric time interval two seconds after the announcement of ICS at 9:55 a.m. (i.e. (2,7)). To determine the statistical significance of mean across two corresponding symmetric time intervals, and across event and pseudo-event days, we perform difference-in-mean tests between them. Panel C reports the difference-in-mean across event and pseudo-event days.

Comparing the mean trading volume under the column headings (-2,0) and (0,2) for negative (positive) ICS announcements, we find that trade volume is higher by as much as 200 (130) shares during the two-second advance peek. In other words, early informed traders who demand liquidity on average trade in greater volume than traders who receive the same information two seconds later. This evidence that the two-second advance peek granted informed traders informational advantages is further supported by the result that we do not observe a similar pattern in the mean trade volume between (-7,-2) and (2,7). In fact, prior to advance peek knowledge, trade volume is lower amongst liquidity demanding traders than after ICS announcements were made. There is also an economically and statistically significant difference in the magnitude of trade imbalance between traders who receive positive (or negative) ICS news two seconds earlier; early informed traders utilize information about ICS negative news and place higher marketable sell orders than marketable buy orders, and the reverse is true for ICS

positive news. It is also interesting to note that conditioned on accessing the ICS news two seconds earlier, early informed traders have a propensity to trade more frequently, but in smaller trade size. This trading characteristic is reminiscent of Fishe and Robe's (2004) argument that informed traders tend to engage in such trading behavior in order to conceal their status as insiders. Our results are further corroborated by the pattern observed in the mean trade size and frequency for the time intervals (-7,-2) and (2,7) in which we do not find that the average trade frequency increases prior to the two-second advance peek. Moreover, the average trade size increases during the time interval (2,7) relative to (-7,-2) as a result of a wider group of traders having access to the same information set from the ICS announcements.

The notion that there are informed traders due to the two-second advance peek is also supported by the mean stock returns, which exhibit a statistically significant bigger fall during the two-second interval when negative ICS news are released before being announced to more subscribers. Although mean stock returns continue to fall two seconds after negative ICS announcements, the magnitude is statistically smaller than that during the advance peek. The same, but reverse, pattern holds for positive ICS news. There is also evidence from returns volatility that the two-second advance peek leads to greater volatility than in the two-second interval after ICS announcement, albeit the difference is only statistically significant for positive news.

With respect to Panel C, we find that the mean-difference tests of all variables for event and pseudo-event days are, by and large, statistically significant in the time interval two seconds before and after the ICS announcements (i.e. (-2,0) and (0,2), respectively) and in the five-second interval two seconds after the announcement (i.e. (2,7)). The fact that the majority of the mean-difference test results is not statistically significant for the five-second interval prior to the

advance peek (i.e. (-7,-2)), which contrasts other results, suggests that informed traders are pervasive as a result of Thomson Reuters/UM elite subscribers having access to ICS announcements two seconds before it is released to general subscribers.[16]

Taken together, it can be seen from Table 2 that the results based on the mean-difference tests suggest the presence of informed traders during the two-second advance peek, to the extent that they are able to utilize information from early access to ICS announcements in order to influence market trade characteristics. The next section further analyzes these trade characteristics between high and non-high frequency traders who demand liquidity.

4.3 Trading Characteristics of HFT^D and Non-HFT^D around ICS Announcement Time

Table 3 reports the results by distinguishing the trade characteristics of HFT^D and non-HFT^D around ICS announcement time. Here, we focus on trade imbalance, size, and frequency, which supplement the preliminary analysis reported in Panels B and C of Table 1.

- Table 3 about here -

The finding that early informed traders have a tendency to trade more frequently, but in smaller trade size, is also demonstrated in Table 3. For both positive and negative ICS news, the average size of liquidity demanding trade by high frequency traders during the advance peek is smaller than that of non-HFT^D during the two seconds post-advance peek. On average, HFT^D trade more frequently than non-HFT^D during the advance peek. These results are statistically significant, except for the average trade frequency under positive consumer sentiment news. One possible explanation is that there is a number of HFTs in the non-HFT classification, such that the higher trading frequency of HFT^D classified under non-HFT^D could bias the difference in the

[16] Results for the second sample period, post-September 2009, are qualitatively unchanged and are not reported for brevity. They are available from the authors upon request.

two types of traders' average trade frequency. No such patterns exist in the pseudo-event days for average trade size and frequency, suggesting that the differences between HFT^D and non-HFT^D on event days imply the presence of informed HFT^D who possess trading characteristics that set them apart from non-HFT^D.

It can also been seen that the average trade imbalance of informed HFT^D is larger during the advance peek relative to non-HFT^D, even though this result is only statistically significant in the case of positive consumer sentiment news. The average trade imbalance also has an opposite sign for positive and negative consumer sentiment news; HFT^D buy on positive and sell on negative ICS news, and the effects can be seen in the intervals before and after the announcements. This finding is consistent with that of Brogaard et al. (2014), but we further demonstrate that informed HFT^D buy (sell) more shares in the two seconds prior to the announcement of positive (negative) ICS news, thus supporting the view that they engage more aggressively in trade by using this information. A similar pattern in the substantial difference of trade imbalance is observed for non-HFT^D, but we err on the side of caution as this result could be due to the misclassification of some HFTs as non-HFTs, thus magnifying the difference in the average trade imbalance between HFT^D and non-HFT^D during the advance peek and two seconds post-announcements. Again, in general, we find no statistically significant difference for the average trade imbalance between HFT^D and non-HFT^D in the control sample (i.e. pseudo-event days).

The results in Table 3 support Hypothesis 1 - that is, informed HFTs (in particular, liquidity demanding HFTs) trade aggressively, which manifest through higher trading volume, smaller trade size, and higher trade frequency, in the two seconds prior to the ICS releases. In

addition, their trade imbalance is higher than non-HFT^{D}, but it is of opposite sign for both positive and negative ICS news.

4.4 Determinants of Trade Imbalance Dynamics Surrounding ICS Announcements

Table 4 reports the pooled regression results of per second trade imbalance of HFT^{D} and non-HFT^{D} as a dependent variable for the data sample comprising transaction data in the fifteen-minute intervals before and after ICS announcements at 9:55 a.m. The determinants are: a dummy called *Final* that equals one for end-of-month ICS announcements and zero for middle-of-month ICS announcements; time interval dummy variables, with *W1* denoting the five-second interval before the start of the advance peek (9:54:53 to 9:54:57), *W2* denoting the two-second advance peek duration (9:54:58 to 9:54:59), *W3* denoting the two-second interval inclusive of the time ICS is announced to wider subscribers (9:55:00 to 9:55:01), *W4* denoting the five-second interval two seconds after the announcements (9:55:02 to 9:55:06), *W5* denoting the last five-second interval before the announcements have lapsed for five minutes (9:59:55-9:59:59), and *W6* denoting the first five-second interval after the announcements have lapsed for five minutes (10:00:00-10:00:04); the dummy *Nasdaq* equals one if the stock is listed in NASDAQ and zero if it is listed in NYSE.

The *Final* dummy variable determines whether the mid-month or final month ICS announcements are more informative to speed traders to the extent that they influence trade imbalance. The time interval dummy provides a conditional means of measuring the degree of responsiveness of trade imbalance to the early release of ICS news and evaluates the extent by which the timing of information dissemination in the two-second interval before and after the announcement affects trade imbalance. The *Nasdaq* dummy determines whether there is a

differential impact on trade imbalance arising from the location the stock is listed. The interactive dummies between the timing interval and *Nasdaq*, and the timing interval and *Final*, establish whether the timing of information dissemination conditional on the type of ICS reports (i.e. mid-month versus final) and the location of stock listing affects the dynamics of trade imbalance. Each type of trader's trade imbalance is standardized to have a mean of zero and a standard deviation of one for each stock on each announcement day.

- Table 4 about here –

Regarding the statistical significance of time interval dummy coefficients, we find that the coefficient of *W2* is statistically significant in all cases (for both HFT^D and non-HFT^D and for both positive and negative news), implying that the two-second advance peek has an impact on trade imbalance. The coefficient of *W2* is also dependent on the sign of news; negative (positive) news decreases (increases) trade imbalance, which purports our finding in Table 3 that liquidity demanding high frequency traders sell (buy) more with the early release of negative (positive) ICS news. Although we find that the coefficient of *W2* is also statistically significant for non-HFT^D, the difference in the magnitude of this coefficient from the coefficient of HFT^D (-0.98 versus -0.53 for negative news and 0.76 versus 0.27 for positive news) is indicative of liquidity demanding HFTs' role as informed traders during the advance peek.[17] There is little evidence to suggest that there is ICS information leakage in the five-second interval prior to the advance peek, because the coefficient of *W1* is not statistically significant in most cases but one (positive news and non-HFT^D). Following the announcements of ICS, news about consumer sentiment continues to exert an influence on trade imbalance for two seconds. However, the degree of

[17] Some HFTs are classified as non-HFTs, and as a result it is no surprise that the coefficient of W2 for non-HFT^D regression is overstated, while that of HFT^D regression is understated.

responsiveness of trade imbalance to news of ICS at this point is lower than that of the advance peek as judged by the magnitude of the coefficients, implying that informed high frequency traders would have responded to news of ICS and traded more aggressively than after the announced news. Again, this result supports Hypothesis 1, which pertains to HFT^D's trading imbalance. Last but not least, we find that the effect of positive ICS news on trade imbalance lasts longer than negative news. About five minutes after the announcements, ICS news continues to exert a positive influence on trade imbalance for both HFT^D and non-HFT^D.

There is little evidence to suggest that the location of stock listing determines trade imbalance dynamics, although for positive ICS news there is some evidence to suggest its effect is more appreciably felt on trade imbalance of stocks listed in NASDAQ than in NYSE. Interestingly, only the coefficients of interactive dummy variables *W2* and *Final* and those of *W3* and *Final* are statistically significant and have the opposite sign from those of *W2* and *W3*. These results suggest that final reports of ICS news are less informative than mid-month reports to the extent that the former tends to have a smaller effect on trade imbalance. For instance, conditional on the advance peek into positive ICS news, informed HFT^D's trading imbalance increases by (0.7162-0.3993=0.3169), resulting from final reports, compared to 0.7162 for mid-month reports. This result is not surprising as information about the state of the economy is contained in the mid-month ICS report, while the final report tends to reflect minor data revisions of the mid-month ICS report.

4.5 The Price Discovery Process of Trading on Information Obtained Through the Advance Peek into ICS

Table 5 shows the results of pooled regressions of one-second interval stock returns on trade imbalance for transaction data in 15-minute intervals pre- and post-announcements and for the sample covering pre-September 2009 (i.e. 1 January 2008 to 31 August 2009). The purpose of this regression is to determine whether trade imbalances, particularly during the two-second duration of the advance peek, have predictive power on stock returns. This is also used to test the validity of Hypothesis 2: Informed HFTs, who have access to the two-second advance peek into ICS, display large trade imbalances, which have predictive power on returns.

- Table 5 about here –

It can be seen in Model 1 for both negative and positive consumer sentiment news that current and past trade imbalances of both HFT^Ds and non-HFT^Ds have predictive power on current second-by-second stock returns. To establish whether trade imbalances during the two-second advance peek into ICS possess predictive power on stock returns, we define a dummy variable *D* that equals one at event time 9:55:00 a.m. and one second after the ICS announcement (i.e. 9:55:01 a.m.). This dummy variable interacts with various lagged trade imbalances of HFT^D and non-HFT^D. Model 2 repeats the regression of Model 1, but includes interactive variables between the dummy variable and lagged trade imbalances. It is interesting to note that the coefficients of the interactive dummy variable *D* with trade imbalance of liquidity demanding HFTs are statistically significant for the time period *t* until *t-3*. By definition of dummy variable *D*, the interactive dummy variable between *D* and the lagged trade imbalances of *t-2* and *t-3* can be interpreted as the information that is contained in ICS announcements when released two seconds before 9:55:00 a.m. The statistically significant and positive coefficients of these variables suggest that the trade imbalances two seconds before the ICS announcements contain information content that strongly predicts current stock returns. For example, for ICS positive

news released at 9:54:58 a.m. and 9:54:59 a.m., informed HFTs incorporate this information to formulate the direction of their trade, which gives rise to greater trade imbalances. In this situation, they will buy in anticipation of a further rise in stock prices when ICS news is announced at 9:55:00 a.m. The increase in demand for stocks leads to greater trade imbalances, which in turn leads to an increase in stock returns. An increase in trade imbalance by one standard deviation at 9:54:58 a.m. (9:54:59 a.m.) increases returns by 0.0515% (0.0747%). The impact on returns due to an increase in trade imbalance is positive during the advance peek, implying that informed HFTs stand to gain from higher stock returns as a result of early access to ICS news. The significance in the coefficient of the interactive terms for the periods *t-2* and *t-3* is only observed for HFT^D, suggesting that it is the increase in trade imbalance of liquidity demanding HFTs that facilitates the price discovery process. It is also evident that the advance peek into ICS provides HFT^D with informational advantages that promote market efficiency. Taken together, our results clearly support Hypothesis 2.

4.6 Profits of Informed HFT^D from Trading on Information Obtained from the Advance Peek into ICS

Table 6 reports aggregate profits across all stocks on announcement days. We analyze second-by-second transaction data on event announcement days for the pre-September 2009 sample (i.e. 1 January 2008 to 31 August 2009, totaling 40 announcement days). We assume that traders buy or sell during the two-second advance peek before 9:55:00 a.m. This could be two seconds prior to 9:55:00 a.m. denoted by "-2", one second prior denoted by "-1", or at both two seconds and one second prior, which is denoted by "Both". For a conservative estimate of the profits earned by informed traders who utilize pre-release ICS news during the early peek, we

consider two scenarios: (a) traders' open position is consistent with the sign of news; buy (sell) for positive (negative) news, and (b) traders' open position contradicts the sign of news; sell (buy) for positive (negative) news. We further assume that these positions are closed at different points in time, measured in seconds, after the ICS announcements at 9:55:00 a.m. Here, "0" second denotes 9:55:00 a.m. and "300" seconds denotes 10:00 a.m. The settlement price for closing out a position is represented by the average price at that time. If no price exists at that time, then we employ the last observable price for that stock. Finally, we compute profits with respect to the duration of traders' open-close position.

- Table 6 about here –

It can be seen that liquidity demanding informed traders who exploit ICS announcements two seconds before they are announced make more profits than those who exploit the information one second later. The difference in profits is substantial; when HFT^D close their position between 9:55:00 and 9:55:10 a.m., the difference in profits is more than $20,000. It can be inferred that early access to ICS, coupled with a first-mover advantage, can give rise to windfall profits. This amount of profits is considered to be a conservative estimate since it includes the profits of HFT^D who may not have access to the early peek, and therefore they could have opened their position wrongly.[18] Our results also suggest that informed HFT^D will earn the most if they close out their position four seconds after the ICS announcement (i.e. 9:55:04 a.m.).

Comparing the profits earned by HFT^D and non-HFT^D who open their position two seconds prior to ICS announcements in the pre-September 2009 sample, there is a difference in the range of around $5000 to $8000 in the first 10 seconds of closing out a position, suggesting

[18] We compute the profit for HFT^D who open their position correctly (i.e. their position is consistent with ICS news) and their lowest (highest) profit is $7,552 ($44,356) between 9:55:00 and 9:55:10 a.m. compared to $6,610 ($40,245) in Table 6.

that informed HFT^D, in general, can make more profit than non-HFT^D. Given that there are non-identified HFT^D in the classification of non-HFT^Ds, the difference in their profits could in fact be higher. If we consider their open position at two seconds and one second prior to 9:55:00 a.m. (i.e. "Both"), the difference between HFT^D and non-HFT^D profits is even more substantial. It can be inferred from these results that the claim made in Hypothesis 3 is well supported by the data - that is, informed HFTs' trade imbalance arising from the advance peek into ICS generates substantial positive profits.

5. Robustness Analyses

5.1 Trade Imbalance of HFTs and Market Capitalization of Stocks

The data sample categorizes the 118 stocks into three groups of market capitalization – namely, high, medium, and low - with each group containing 40 stocks. Our categorization is consistent with Brogaard et al. (2014). Within each size category, half of the firms are NASDAQ-listed and the other half are NYSE-listed. To examine whether trade imbalances are driven by traders' propensity to invest in stocks with higher market capitalization, we regress the trade imbalance of liquidity demanding HFTs and non-HFTs on the time dummies *W1* to *W6* defined in the same way as in Table 4 (see subsection 4.4), with the stock market capitalization dummies of Large (Medium) taking the value one when stocks are in the category of large (medium) market capitalization and zero otherwise, and the interaction is between time and stock market capitalization dummies. Table 7 reports the pooled regression results.

- Table 7 about here –

Similar to results in Table 4, only the coefficients of the time dummy variables *W2*, *W3*, *W5*, and *W6* are statistically significant. None of the coefficients of the *Large* and *Medium*

dummy variables are statistically significant. However, the coefficients of the interactive dummy variables between time and size of market capitalization are all statistically significant at the 1% level for regressions involving HFT^D in both negative and positive consumer sentiment news. The impact of the advance peek on trade imbalance of liquidity demanding HFTs for small stocks is -0.1153 (0.1041) for negative (positive) news. For stocks with large market capitalization, the impact on the HFT^D trade imbalance is -1.0738 (0.8959) for negative (positive) news, which is substantially larger, implying that HFTs tend to trade in stocks with larger market capitalization. This is also supported by the magnitude of the coefficient of the interactive dummy coefficients for medium and large sized stocks.

Another interesting finding is in the contrasting coefficients of the interactive dummies *W2*×*Large* and *W3*×*Large*, and likewise for *W2*×*Medium* and *W3*× *Medium* for both negative and positive news. The effect on trade imbalance in the two-second interval arising from the advance peek is always larger than the announcement effects, again pointing to the presence of informed HFTs who by accessing pre-announcement ICS news are engaging in greater trades in the direction that are in line with the predicted direction of stock price movements.

5.2 Trade Imbalance of Liquidity Demanding and Supplying HFTs

To ensure that our results are robust to the inclusion of liquidity supplying HFTs, we repeat the analyses in subsection 4.4 using the data for all HFTs, which we denote as HFT_All. Table 8 shows that our results remain unchanged, with evidence showing greater trade imbalance arising from the advance peek of mid-month reports and to a much lesser extent with final reports. There is also no distinction in the response of trade imbalance to the advance peek for stocks listed in NASDAQ and NYSE.

- Table 8 about here –

5.3 Price Discovery, Stock Returns and Trade Imbalance of all HFTs

We also repeat the analysis reported in Table 5 of subsection 4.5 by including liquidity supplying HFTs in our sample. Note that unlike Table 5, we cannot include the trade imbalance of all non-HFTs together with the trade imbalance of all HFTs in the same regression, because the total trade imbalance for both types of traders sum to zero, and thus if we were to do so we would run into the perfect multicollinearity problem. Consequently, we only include the trade imbalance of traders that pertains to the regression type. The results reported in Table 9 do not differ from those in Table 5 - that is, information contained in ICS announcements during the two-second advance peek has predictive power on current stock returns. This result is robust to both positive and negative news. By paying to receive ICS news two seconds before its announcements, HFTs are able to influence the direction of their trade imbalance in a manner that grants them positive and higher stock returns. In contrast, the coefficients on the trade imbalances of all non-HFTs have the wrong sign.

- Table 9 about here –

6. Conclusions

High frequency traders have recently been in the limelight with controversial debates over their roles on price quality in the market by politicians and regulators. When Thomson Reuters/UM provided the two-second advance peek into ICS to its elite group of subscribers, this short split-second window of opportunity to utilize the early release of ICS clearly benefits speed traders. For this reason, HFTs' speed advantage through the use of rapid computer algorithms coupled with information advantage through the advance peek, which could improve their

precision in deciphering the direction of stock price movements and earn them windfall profits, has drawn public outcry and scrutiny by the U.S. Securities and Exchange Commission. It is in this context that we have studied the trading behavior of informed high frequency traders and their market microstructure implications so as to inform market regulators on the appropriate policy action for the practice of advance peek.

Our key contribution is that we identify HFTs, as a group, are among the ones who benefit from the early-access service in addition to other fast traders who could also benefit from it. Our empirical results demonstrate that liquidity demanding HFTs stand to benefit the most from the early release of ICS. During the advance peek, the intraday data of 118 NASDAQ and NYSE stocks show that trading volume increases sharply and is largely influenced by informed HFTs who trade more frequently with modest trade size. Although there is only a two-second window of information release, we find that the behavior of informed HFTs is akin to informed traders who have access to private information over a longer time horizon; their trading strategy attempts to hide their informational advantage. As informed HFTs tend to be better informed about the direction of stock price movements, they exhibit larger trade imbalance with the volume of buyer (seller)-initiated transactions exceeding the volume of seller (buyer)-initiated transactions for positive (negative) ICS news. Stock returns are found to react with a two-second lag to informed HFTs' trade imbalance, thus confirming their role as facilitators in the price discovery process. Finally, we provide an estimate of the profit made by informed HFTs, which is substantially larger than that of non-informed traders, thus confirming concerns raised by the SEC.

While the advance peek gives HFTs an informational advantage that may be deemed as a violation of a level playing field for equal information, one can easily provide a counter

argument to that. From the perspective of procedural fairness, or equal application of the rules, the advance peek does not appear to contravene this criterion. To the extent that any trader is able to generate a competitive advantage through investment in computer algorithms for a speed advantage and invest in the co-location of HFT computers in exchange data centers so as to gain access to data faster, the two-second advance peek is a service that is made available to all financial practitioners who subscribe to Thomson Reuters' financial data services and is not exclusively offered to HFTs. There is nothing particularly unfair about the advance peek, just as high frequency trading is not procedurally unfair. However, given that the advance peek is designed for traders who are equipped with high-speed technology, this practice grants HFTs an added advantage that sets them procedurally ahead of ordinary traders. On that basis, the advance peek may be regarded as an "unfair" practice in favor of those with faster and closer access to financial markets, and if this practice continues it may lead to speculation about the integrity of financial markets. Moreover, given that HFTs are thought to trade based on market data, regulators will try to ensure that all market participants are on a level playing field in obtaining up-to-date market data. It is possible on these grounds that the New York Attorney General has requested Thomson Reuters to suspend the two-second early release of its sentiment report to their elite subscribers in July 2013.

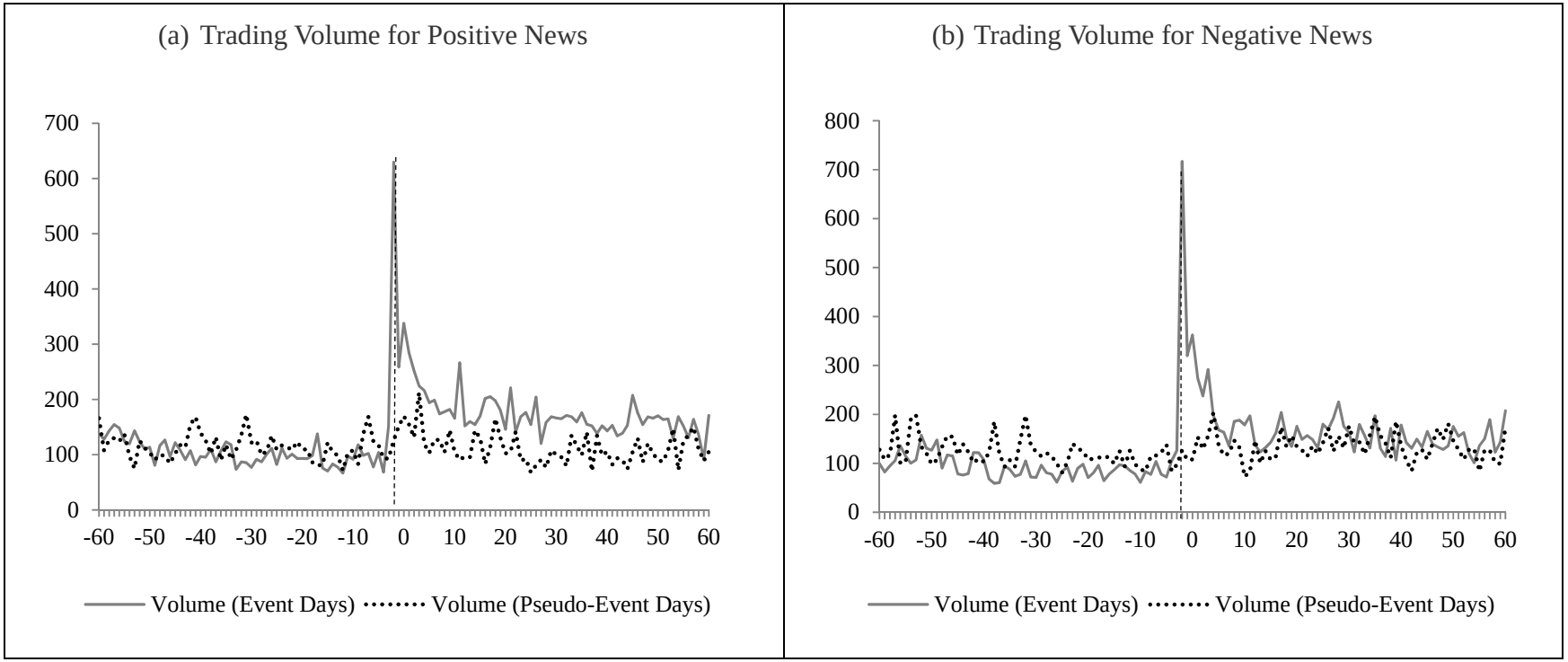
As to whether HFTs' gain an advantage in terms of windfall profits by imposing equivalent losses on other traders during the two-second advance peek, we do not find any evidence to support this claim.[19] Apart from assisting in the price discovery process during periods of informed trading, we do not find that HFTs disrupt the market in a manner disproportionate to the benefits they provide. For instance, we find that stock returns generally

[19] The notion of simple fairness, whereby one person should not achieve a gain by simply imposing an equivalent loss on another, originates from the work of Pava et al. (1999).

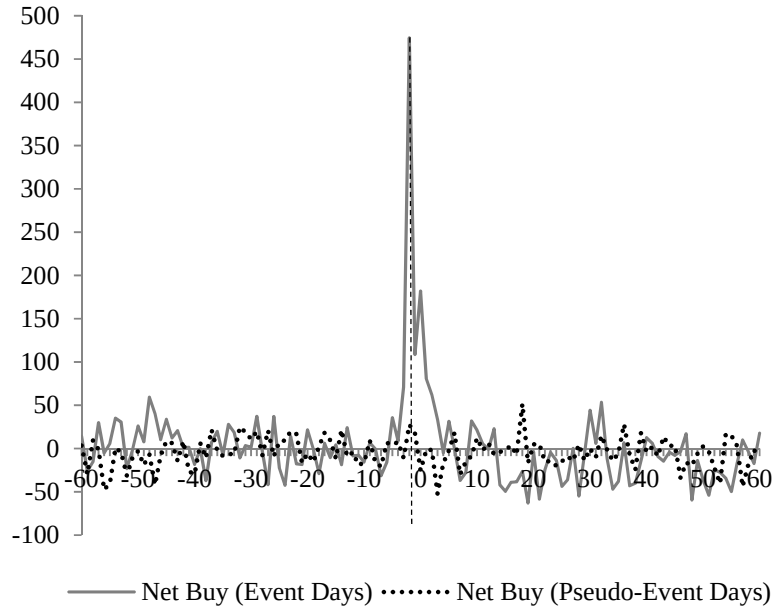
increase in the two-second window in response to informed HFTs' reactions through changes in their trade imbalance, independent of positive or negative news. Much of the market microstructure effect, like an increase in return volatility caused by informed HFTs' trading behavior, also dissipates very rapidly at the very moment ICS is announced to general subscribers. These findings are consistent with Hu et al. (2013), who find that the scope of the advance peek occurs within the time window, whereas outside of this window general investors are not disadvantaged by informed HFTs and are able to trade at fully adjusted prices.

Figure 1. Intraday Patterns on Announcement and Non-announcement Days

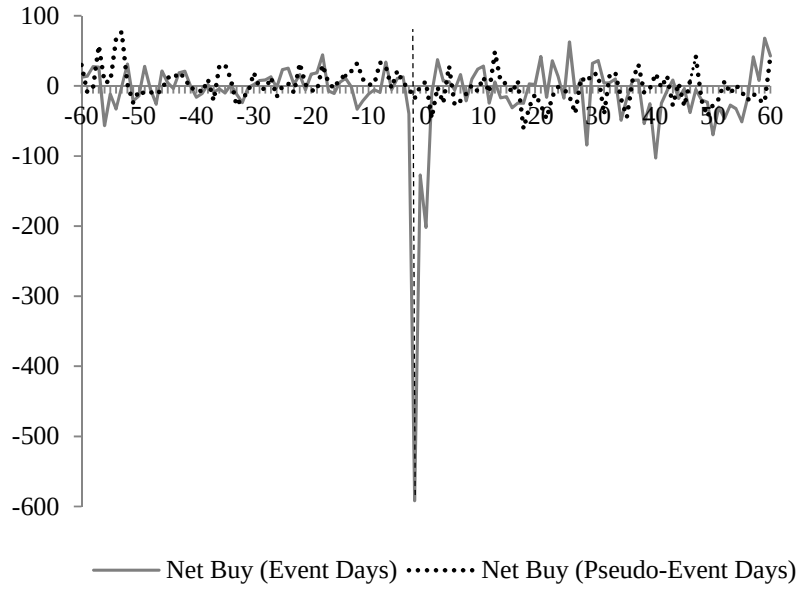
The figures below show intraday patterns for HFT stock returns spanning two minutes (one minute before and one minute after the ICS announcement) on days with or without ICS announcements. ICS announcements are further classified as positive or negative news. The solid (dashed) lines are for days with (without) announcements. The sample covers the period 1 January 2008 to 31 August 2009, which comprises 40 announcements days. Figures on the left-hand (right-hand) column are for positive (negative) ICS announcements. Positive (negative) ICS announcements are for announced ICS that are higher (lower) than analysts' forecast average. The x-axis denotes time in seconds such that t = 0 is associated with the ICS announcement at 9:55 a.m. The vertical dot-lines are for t = -2, indicating the exact time for the two-second advance peek into ICS. Trading volume (Figures 1a and 1b) is measured by the number of shares, trade imbalance (Figures 1c and 1d) is defined as the number of shares in buyer-initiated transactions minus seller-initiated transactions, trade size (Figures 1e and 1f) is defined as the number of shares in each transaction, trade frequency (Figures 1g and 1h) is measured by the number of transactions in one second, returns (Figures 1i and 1j) are defined as the first difference of the log of stock price calculated from NBBO quotes, and returns volatility (Figures 1k and 1l) is defined as absolute returns.

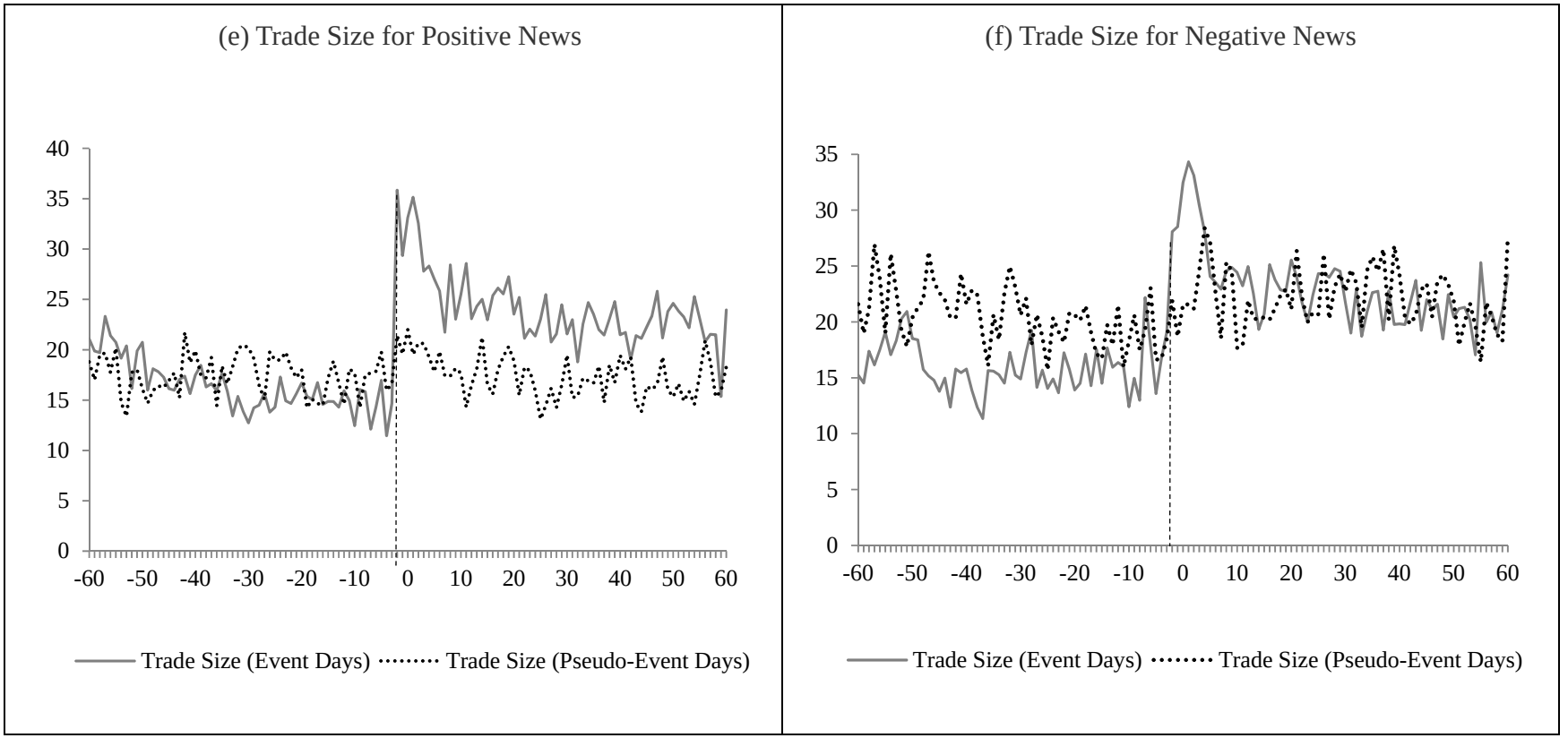


(c) Trade Imbalance for Positive News

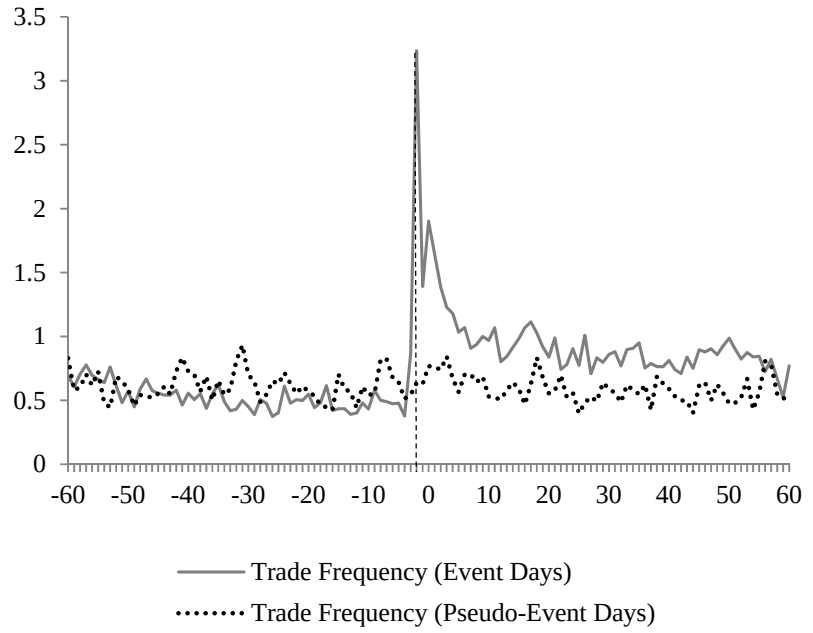


(d) Trade Imbalance for Negative News

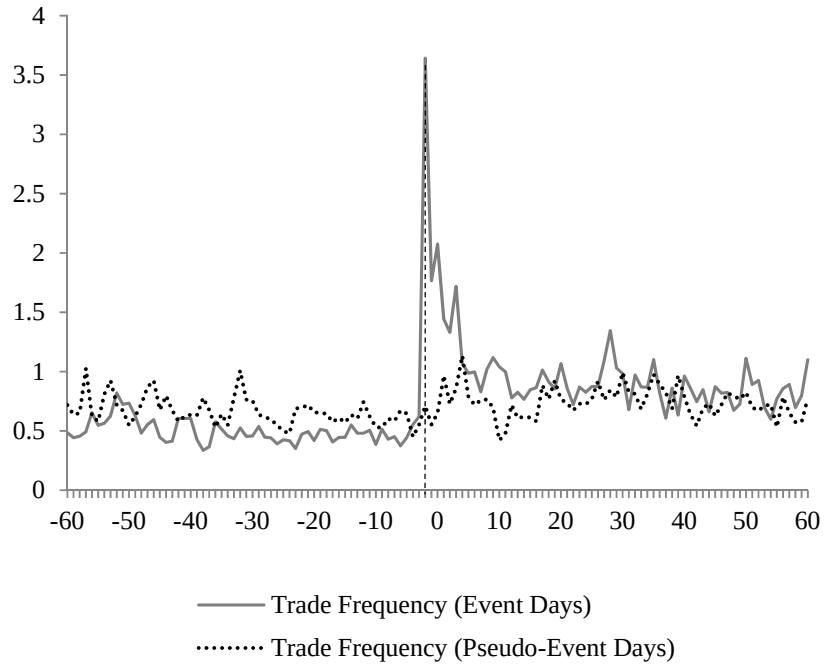


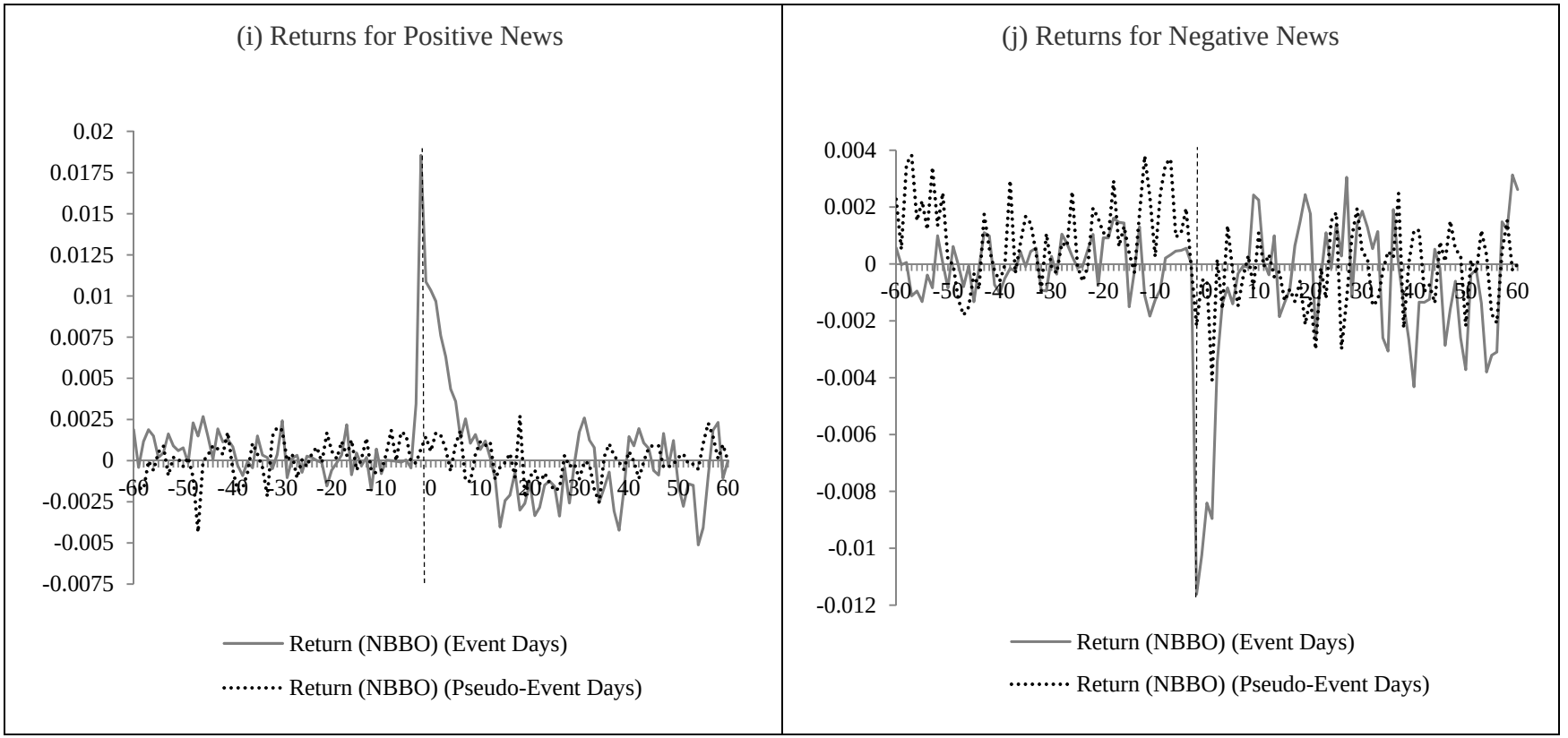

(e) Trade Size for Positive News
40
35
30
25
20
15
10
5
0
-60 -50 -40 -30 -20 -10 0 10 20 30 40 50 60
Trade Size (Event Days)
Trade Size (Pseudo-Event Days)
(f) Trade Size for Negative News
35
30
25
20
15
10
5
0
-60 -50 -40 -30 -20 -10 0 10 20 30 40 50 60
Trade Size (Event Days)
Trade Size (Pseudo-Event Days)

(g) Trade Frequency for Positive News



(h) Trade Frequency for Negative News




(i) Returns for Positive News
0.02
0.0175
0.015
0.0125
0.01
0.0075
0.005
0.0025
0
-0.0025
-0.005
-0.0075
-60 -50 -40 -30 -20 -10 0 10 20 30 40 50 60
Return (NBBO) (Event Days)
Return (NBBO) (Pseudo-Event Days)
(j) Returns for Negative News
0.004
0.002
0
-0.002
-0.004
-0.006
-0.008
-0.01
-0.012
-60 -50 -40 -30 -20 -10 0 10 20 30 40 50 60
Return (NBBO) (Event Days)
Return (NBBO) (Pseudo-Event Days)

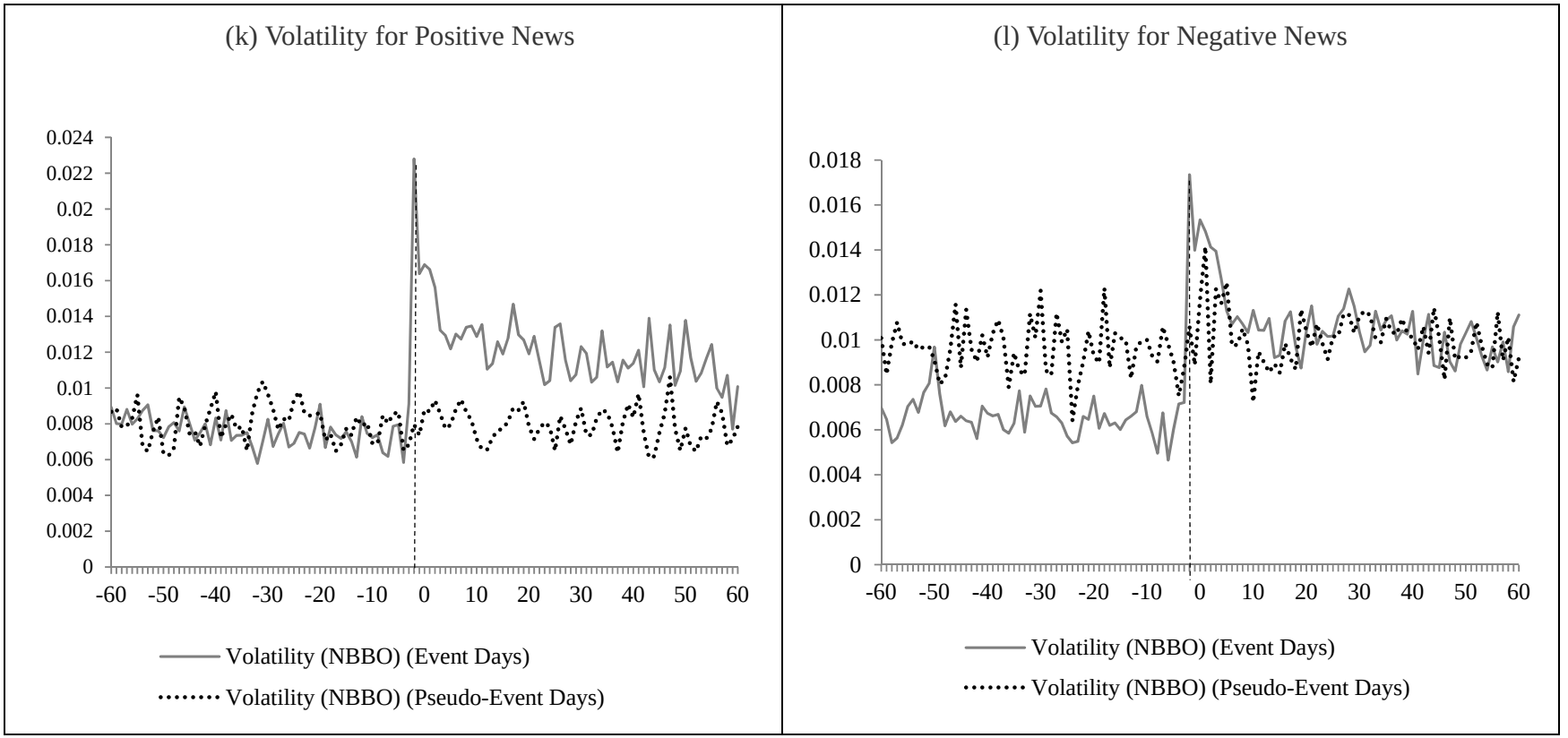

(k) Volatility for Positive News
0.024
0.022
0.02
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
-60 -50 -40 -30 -20 -10 0 10 20 30 40 50 60
Volatility (NBBO) (Event Days)
Volatility (NBBO) (Pseudo-Event Days)
(l) Volatility for Negative News
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
-60 -50 -40 -30 -20 -10 0 10 20 30 40 50 60
Volatility (NBBO) (Event Days)
Volatility (NBBO) (Pseudo-Event Days)

Table 1. Summary Statistics of Trade and Return Characteristics on ICS Announcement Days

This table reports summary statistics of one-second interval trade and return characteristics on the announcement day of ICS for the sample period from 1 January 2008 to 31 August 2009. There are 40 event days in this sample. Trading volume (Figures 1a and 1b) is measured by the number of shares, trade imbalance (Figures 1c and 1d) is defined as the number of shares in buyer-initiated transactions minus seller-initiated transactions, trade size (Figures 1e and 1f) is defined as the number of shares in each transaction, trade frequency (Figures 1g and 1h) is measured by the number of transactions in one second, returns (Figures 1i and 1j) are defined as the first difference of the log of stock price calculated from NBBO quotes, and returns volatility (Figures 1k and 1l) is defined as absolute returns. HFT^D denotes high frequency traders who demand liquidity.

	Negative Consumer Sentiment News				Positive Consumer Sentiment News			
	Mean	S.D.	Min.	Max.	Mean	S.D.	Min.	Max.
Panel A: HFT^D+ Non-HFT^D								
Volume	74.4267	803.3346	0	310,631	77.5993	858.5021	0	438,335
Trade imbalance	-0.5225	693.7824	-297,450	310,631	-0.9207	728.1621	-376,137	282,212
Trade size	13.1497	72.0854	0	56,000	12.8284	66.9868	0	42,500
Trade frequency	0.1670	1.3286	0	330	0.1808	1.4392	0	307
Return (%)	0.000017	0.0846	-351.8732	352.3732	-0.000022	0.0820	-302.6041	345.4606
Volatility (%)	0.0043	0.0845	0	352.3732	0.0046	0.0819	0	345.4606
Panel B: HFT^D								
Volume	27.7001	346.3574	0	142,000	30.2009	386.2822	0	290,812
Trade imbalance	-0.0498	328.5720	-142,000	96,197	-0.1937	363.6468	-137,627	283,212
Trade size	6.1030	44.6238	0	45,222	6.2695	43.7625	0	50,000
Trade frequency	0.3905	2.4565	0	875	0.4038	2.6081	0	1,011
Panel C: Non-HFT^D								
Volume	46.7266	629.5003	0	309,931	47.3984	654.3356	0	411,936
Trade imbalance	-0.4726	559.8299	-296,050	309,931	-0.7270	572.8554	-402,536	270,760
Trade size	10.5244	74.2881	0	64,600	10.0587	71.3365	0	120,050
Trade frequency	0.2235	1.6539	0	850	0.2230	1.7178	0	876

Table 2. Trade and Return Characteristics during Pre- and Post-announcements Periods

The advance peek on ICS, which occurred at 09:54:58 EST, was reported in September 2009. The results are for the pre-September 2009 sample (i.e. 1 January 2008 to 31 August 2009). We compute the average one-second interval trade volume, trade imbalance, trade size, trade frequency, stock return, and volatility before and after announcements. Trading volume is measured by the number of shares, trade imbalance is defined as the number of shares in buyer-initiated transactions minus seller-initiated transactions, trade size is defined as the number of shares in each transaction, trade frequency is measured by the number of transactions in one second, returns are defined as the first difference of the log of stock price calculated from NBBO quotes, and returns volatility is defined as absolute returns. The time intervals of (-7, -2), (2,7), (-2,0) and (0,2). (-2,0) and (0,2) denote the two-second pre- and post-announcement times of 9:55 a.m., respectively. Here, (-7,-2) denotes the five-second interval prior to the timing of the advance peek and (2,7) is the five-second interval following two seconds after the ICS is announced to wider subscribers. Pseudo-event days are the same day, but in the weeks when no announcements are made. If the weekday on a non-announcement day is a non-trading day, then the previous day's data are used. The superscripts a, b, and c denote significance at the 10%, 5%, and 1% levels, respectively.

	Negative Consumer Sentiment News				**Positive Consumer Sentiment News**			
	(-2,0)	(0,2)	(-7,-2)	(2,7)	(-2,0)	(0,2)	(-7,-2)	(2,7)
Panel A: Event days								
Volume	518.4807	318.2429	97.0734	211.8462	444.1853	311.1733	100.605	216.9831
mean-diff. t-test	*(3.6831^{c})*		*(-5.2082^{c})*		*(3.2732^{c})*		*(-8.0345^{c})*	
Trade imbalance	-359.5716	-106.2387	2.5584	12.1860	291.4680	131.3201	13.5141	24.2200
mean-diff. t-test	*(-5.5144^{c})*		*(-0.9087)*		*(4.4666^{c})*		*(-0.9882)*	
Trade size	28.2957	33.3971	17.904	27.8503	32.5968	34.1266	13.9125	28.3116
mean-diff. t-test	*(-2.7539^{c})*		*(-6.2596^{c})*		*-0.9489*		*(-16.8299^{c})*	
Trade frequency	2.7039	1.7597	0.4889	1.2200	2.3138	1.7720	0.5364	1.1797
mean-diff. t-test	*(4.6847^{c})*		*(-14.3287^{c})*		*(3.6820^{c})*		*(-12.2858^{c})*	
Return (%)	-0.0109	-0.0087	0.0004	-0.0015	0.0147	0.0100	0.0006	0.0046
mean-diff. t-test	*(-2.4961^{b})*		*(4.0301^{c})*		*(5.0374^{c})*		*(-8.8168^{c})*	
Volatility (%)	0.0157	0.0151	0.0064	0.0126	0.0196	0.0168	0.0074	0.0134
mean-diff. t-test	*(0.6783)*		*(-14.1245^{c})*		*(3.1735^{c})*		*(-13.5563^{c})*	
Panel B: Pseudo-event days								
Volume	116.8093	130.6831	111.5879	148.3854	138.8305	161.9965	119.2639	138.7364
mean-diff. t-test	*(-0.8663)*		*(-2.1329^{b})*		*(-0.6919)*		*(-1.1779)*	
Trade imbalance	-9.1803	-19.9991	9.4453	-9.3632	22.5824	-13.1988	-2.629	-11.0243
mean-diff. t-test	*(0.9001)*		*(2.1243^{b})*		*(1.1391)*		*(0.6708)*	
Trade size	20.3090	21.5711	18.8251	24.7679	20.4943	20.7662	17.5828	19.6434
mean-diff. t-test	*(-0.8728)*		*(-5.6157^{c})*		*-0.1671*		*(-2.4471^{b})*	
Trade frequency	0.6321	0.8086	0.5804	0.8460	0.6323	0.7637	0.6411	0.7048
mean-diff. t-test	*(-0.1221)*		*(-0.2509)*		*(-0.0807)*		*(-0.0756)*	
Return (%)	-0.0014	-0.0023	0.0015	-0.0004	0.0011	0.0011	0.0006	0.0009
mean-diff. t-test	*(0.8105)*		*(3.0678^{c})*		*(-0.0853)*		*(-0.6828)*	
Volatility (%)	0.0097	0.0130	0.0091	0.0108	0.0077	0.0087	0.0077	0.0085
mean-diff. t-test	*(-2.7906^{c})*		*(-2.8833^{c})*		*(-1.8239^{a})*		*(-1.9072^{a})*	

Table 2. (continued)

Panel C: *t-tests* for the mean-difference between event days (Panel A) and pseudo-event days (Panel B)

Volume	*(8.0261^{c})*	*(7.0511^{c})*	*(-0.8497)*	*(2.8626^{c})*	*(7.6548^{c})*	*(4.3409^{c})*	*(-1.5153)*	*(4.2978^{c})*
Trade imbalance	*(-8.1227^{c})*	*(-4.3438^{c})*	*(-0.7745)*	*(2.0401^{b})*	*(7.4908^{c})*	*(4.6075^{c})*	*(1.7400^{a})*	*(2.5710^{b})*
Trade size	*(4.7191^{c})*	*(7.2535^{c})*	*(-0.5733)*	*(2.9892^{c})*	*(7.8431^{c})*	*(7.8914^{c})*	*(-4.9711^{c})*	*(9.1580^{c})*
Trade frequency	*(1.8830^{a})*	*(0.9910)*	*(-0.1217)*	*(0.5011)*	*(1.6504^{a})*	*(0.7892)*	*(-0.1847)*	*(0.7606)*
Return (%)	*(-10.9108^{c})*	*(-5.2628^{c})*	*(-2.4979^{b})*	*(-1.8445^{a})*	*(17.5503^{c})*	*(11.1514^{c})*	*(-0.0691)*	*(7.8277^{c})*
Volatility (%)	*(7.0026^{c})*	*(1.7849^{a})*	*(-6.2597^{c})*	*(2.8971^{c})*	*(15.9398^{c})*	*(10.4603^{c})*	*(-0.8705)*	*(10.6630^{c})*

Table 3. Trade Characteristics for HFT^D and Non-HFT^D during Pre- and Post-announcement Periods

This table reports the one-second mean value of trade characteristics on announcement days of ICS for the total sample period from 1 January 2008 to 31 December 2009, and for 21-26 February 2010. There are 49 event days in this sample. We compute the average one-second interval trade imbalance, trade size, and trade frequency before and after announcements. Trade imbalance is defined as the number of shares in buy-initiated transactions minus sell-initiated transactions, trade size is defined as the number of shares, and trade frequency is measured by the number of transactions in one second. HFT^D denotes high frequency traders who demand liquidity. The time intervals of (-7, -2), (2,7), (-2,0) and (0,2). (-2,0) and (0,2) denote the two-second pre- and post-announcement times of 9:55 a.m., respectively. Here, (-7,-2) denotes the five-second interval prior to the timing of the advance peek and (2,7) is the five-second interval following two seconds after the ICS is announced to wider subscribers. Pseudo-event days are the same days, but in the weeks when no announcements are made. If the weekday on a non-announcement day is a non-trading day, then the previous day's data are used. All traders are identified either as a high frequency trader (HFT) or non-high frequency traded (non-HFT) by NASDAQ. The superscripts a, b, and c denote significance at the 10%, 5%, and 1% levels, respectively.

	Negative Consumer Sentiment News				Positive Consumer Sentiment News			
	(-2,0)	(0,2)	(-7,-2)	(2,7)	(-2,0)	(0,2)	(-7,-2)	(2,7)
Panel A: Event days								
Trade imbalance								
HFT^D	-186.6262	-56.8484	0.9085	4.4506	168.9746	101.7594	2.8042	4.9705
Non-HFT^D	-172.9454	-49.3903	1.6499	7.7354	122.4935	29.5607	10.7099	19.2495
mean-diff. t-test	*(-0.4143)*	*(-0.4722)*	*(-0.1204)*	*(-0.4012)*	*(1.8678^a)*	*(4.4194^c)*	*(-1.3995)*	*(-1.8083^a)*
Trade size								
HFT^D	20.2394	22.0004	7.7646	17.1295	23.2753	21.7362	7.3860	16.1027
Non-HFT^D	22.6741	26.3880	14.7791	22.7475	26.9923	26.9817	11.1487	23.2783
mean-diff. t-test	*(-1.7223^a)*	*(-0.1671)*	*(-0.5692)*	*(-1.0949)*	*(-2.6411^c)*	*(-0.3679)*	*(-2.6492^c)*	*(-0.5273)*
Trade frequency								
HFT^D	1.5275	0.6907	0.2048	0.5808	1.2423	0.9235	0.2124	0.4995
Non-HFT^D	1.1763	1.0690	0.2841	0.6392	1.0715	0.8484	0.3240	0.6802
mean-diff. t-test	*(2.1052^b)*	*(-3.1526^c)*	*(-0.3477)*	*(-2.4665^b)*	*(1.0585)*	*(3.0629^c)*	*(-1.4919)*	*(-1.1290)*
Panel B: Pseudo-event days								
Trade imbalance								
HFT^D	-7.7564	-11.2411	2.5320	-8.3103	17.8790	8.3359	-4.6888	4.0935
Non-HFT^D	-1.4240	-8.7580	6.9133	-1.0529	4.7034	-21.5347	2.0598	-15.1179
mean-diff. t-test	*(-0.7215)*	*(-0.3246)*	*(-0.7450)*	*(-1.2644)*	*(0.7830)*	*(1.2789)*	*(-1.1525)*	*(1.7463^a)*
Trade size								
HFT^D	9.4294	10.5952	8.5227	12.1431	9.8047	9.8321	8.8617	10.4922
Non-HFT^D	16.7982	18.5278	15.3183	20.4231	16.4306	18.0361	14.3698	14.8542
mean-diff. t-test	*(-0.3445)*	*(-0.8202)*	*(-0.5915)*	*(-2.3643^b)*	*(-0.2570)*	*(-0.2644)*	*(-0.9891)*	*(-6.2726^a)*
Trade frequency								
HFT^D	0.2453	0.3529	0.2521	0.3668	0.2712	0.3376	0.2989	0.3104
Non-HFT^D	0.3868	0.4557	0.3283	0.4792	0.3611	0.4260	0.3422	0.3944
mean-diff. t-test	*(-0.7588)*	*(0.3222)*	*(-1.8571^a)*	*(-2.1308^b)*	*(-0.6313)*	*(-0.6387)*	*(-0.5723)*	*(-2.4593^b)*

Table 4. Determinants of Trade Imbalance of Liquidity Demanding HFTs and Non-HFTs

Below are pooled regression results with trade imbalance for all stocks as dependent variables. We analyze transaction data in 15-minute intervals pre- and post-announcements for the sample covering pre-September 2009 (i.e. 1 January 2008 to 31 August 2009). TIB denotes one-second interval trade imbalance, which is measured by the number of shares in buy-initiated transactions minus sell-initiated transactions. All dependent variables are standardized relative to the average of each stock on each announcement day. *W1* to *W6* are time interval dummy variables that equal one for the following intervals: (9:54:53, 9:54:57), (9:54:58, 9:54:59), (9:55:00, 9:55:01), (9:55:02, 9:55:06), (9:59:55, 9:59:59), (10:00:00, 10:00:04), and zero otherwise. *Nasdaq* is a dummy variable that equals one for Nasdaq stocks and zero otherwise. *Final* is a dummy that equals one for Thomson Reuters/UM index of consumer sentiment final reports and zero for mid-term reports. The two interaction terms measure the effect of insider trading on Nasdaq stocks and insider trading on University of Michigan index of consumer sentiment final reports. Standard errors are corrected for heteroskedasticity using the White (1980) method. The t-statistics are shown in parentheses next to the coefficients. Here, *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

	Negative Consumer Sentiment News				Positive Consumer Sentiment News			
	$TIB\_HFT^D_t$		$TIB\_non\text{-}HFT^D_t$		$TIB\_HFT^D_t$		$TIB\_non\text{-}HFT^D_t$	
Intercept	0.0019	(2.26)**	0.0012	(1.44)	-0.0016	(-1.91)*	-0.0006	(-0.77)
W1	0.0070	(0.93)	-0.0080	(-0.91)	0.0077	(1.05)	0.0216	(2.59)***
W2	-0.9758	(-12.89)***	-0.5282	(-7.96)***	0.7162	(11.32)***	0.2716	(6.04)***
W3	-0.5110	(-8.41)***	-0.2667	(-6.59)***	0.4001	(7.79)***	0.1037	(2.86)***
W4	0.0002	(0.02)	-0.0036	(-0.31)	0.0953	(7.28)***	0.0623	(5.43)***
W5	-0.0675	(-5.40)***	-0.0292	(-2.57)**	0.0466	(4.77)***	0.0188	(2.17)**
W6	-0.0548	(-3.92)***	-0.0642	(-5.13)***	-0.0450	(-3.01)***	-0.0181	(-1.50)
Nasdaq	0.0003	(0.33)	0.0002	(0.17)	-0.0002	(-0.23)	-0.0001	(-0.16)
Final	-0.0017	(-1.64)	-0.0009	(-0.90)	0.0006	(0.70)	0.0001	(0.07)
W2×Nasdaq	-0.1221	(-1.51)	-0.0474	(-0.77)	0.0031	(0.05)	0.0408	(0.88)
W3×Nasdaq	-0.0682	(-1.04)	-0.0972	(-2.01)**	0.2554	(4.07)***	0.0638	(1.42)
W2×Final	0.9763	(13.16)***	0.5282	(9.42)***	-0.3933	(-6.09)***	-0.1373	(-2.90)***
W3×Final	0.5531	(9.18)***	0.3065	(6.81)***	-0.1987	(-3.04)***	0.0361	(0.82)
Obs.	3,825,324		3,825,324		4,675,396		4,675,396	
Adj. R-sq. (%)	0.09		0.03		0.06		0.01	

Table 5. The Effects of HFT^D and Non-HFT^D Trade Imbalance on Returns

Below are pooled regression results with one-second stock returns as the dependent variable. We analyze transaction data in 15-minute intervals pre- and post-announcements for the sample covering pre-September 2009 (i.e. 1 January 2008 to 31 August 2009). *TIB* denotes the number of shares in buyer-initiated transactions minus seller-initiated transactions. Trade imbalance for each stock is standardized by the type of investors on each day in order to facilitate any inference. The dummy variable D equals one at event time and one second after Thomson Reuters/UM ICS announcements. Standard errors are corrected for heteroskedasticity using the White (1980) method. The t-statistics are shown in parentheses next to the coefficients. Here, *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

	Negative Consumer Sentiment News				Positive Consumer Sentiment News			
	Model 1		Model 2		Model 1		Model 2	
Intercept	0.0037	(2.26)***	0.0037	(2.27)**	0.0099	(5.73)***	0.0099	(5.72)***
$TIB\_HFT^D_t$	0.5120	(56.10)***	0.5129	(55.93)***	0.5820	(61.78)***	0.5831	(61.56)***
$TIB\_HFT^D_{t-1}$	0.0952	(25.26)***	0.0947	(25.02)***	0.1030	(26.84)***	0.1028	(26.58)***
$TIB\_HFT^D_{t-2}$	0.0245	(9.12)***	0.0239	(8.84)***	0.0277	(7.77)***	0.0271	(7.58)***
$TIB\_HFT^D_{t-3}$	0.0142	(5.67)***	0.0138	(5.51)***	0.0098	(4.27)***	0.0095	(4.12)***
$TIB\_HFT^D_{t-4}$	0.0086	(3.80)***	0.0087	(3.81)***	0.0078	(3.56)***	0.0079	(3.57)***
$TIB\_HFT^D_{t-5}$	0.0035	(1.34)	0.0035	(1.32)	0.0045	(2.11)**	0.0045	(2.13)**
$D\times TIB\_HFT^D_t$			-0.2011	(-4.15)***			-0.1716	(-2.85)***
$D\times TIB\_HFT^D_{t-1}$			0.0842	(2.11)**			0.1068	(2.67)***
$D\times TIB\_HFT^D_{t-2}$			0.0747	(2.96)***			0.0753	(3.10)***
$D\times TIB\_HFT^D_{t-3}$			0.0515	(2.04)**			0.0704	(2.73)***
$D\times TIB\_HFT^D_{t-4}$			-0.0205	(-0.48)			-0.0201	(-0.31)
$D\times TIB\_HFT^D_{t-5}$			0.0575	(1.15)			-0.0407	(-0.78)
$TIB\_NonHFT^D_t$	0.5380	(71.63)***	0.5386	(71.50)***	0.5690	(71.77)***	0.5693	(71.67)***
$TIB\_NonHFT^D_{t-1}$	0.1060	(25.07)***	0.1063	(25.00)***	0.0955	(24.51)***	0.0953	(24.44)***
$TIB\_NonHFT^D_{t-2}$	0.0238	(7.87)***	0.0238	(7.83)***	0.0227	(7.05)***	0.0227	(7.03)***
$TIB\_NonHFT^D_{t-3}$	0.0081	(3.75)***	0.0080	(3.69)***	0.0116	(3.71)***	0.0116	(3.69)***
$TIB\_NonHFT^D_{t-4}$	0.0028	(1.06)	0.0028	(1.05)	0.0118	(3.99)***	0.0116	(3.93)***
$TIB\_NonHFT^D_{t-5}$	0.0043	(1.72)*	0.0043	(1.75)*	0.0102	(3.81)***	0.0103	(3.81)***
$D\times TIB\_NonHFT^D_t$			-0.1683	(-3.07)***			-0.2283	(-2.71)***
$D\times TIB\_NonHFT^D_{t-1}$			0.0093	(0.24)			0.0995	(1.36)
$D\times TIB\_NonHFT^D_{t-2}$			-0.0103	(-0.25)			-0.0116	(-0.36)
$D\times TIB\_NonHFT^D_{t-3}$			0.0139	(0.55)			-0.0009	(-0.03)
$D\times TIB\_NonHFT^D_{t-4}$			0.0257	(0.47)			0.1491	(1.64)
$D\times TIB\_NonHFT^D_{t-5}$			-0.1301	(-2.55)**			0.0026	(0.05)
Obs.	3,825,324		3,825,324		4,675,396		4,675,396	
Adj. R-sq. (%)	5.72		5.72		5.03		5.03	

Table 6. Trading Profits of HFT^D and Non-HFT^D

We analyze transaction data on event announcement days for the sample covering pre-September 2009 (i.e. 1 January 2008 to 31 August 2009 with 40 announcement days). The column "Open position" denotes the timing of buy or sell transactions during the advance peek on ICS such that -2 (-1) denotes two (one) seconds before the ICS announcements at 9:55:00 a.m. For transactions that occur at two seconds and one second before announcements, we denote this scenario by "Both". We assume traders close out their positions at various times ranging from 9:55:00 a.m. denoted by "0" seconds to 10:00:00 a.m. denoted by "300" seconds from the announcement time. Settlement price for closing out a position is represented by the average price at the time of closing out the position. If no price exists at that time, then we employ the last closing position price for that stock. The figures represent aggregated profits across all stocks and across announcement days in the sample for HFT^D and non-HFT^D.

	Close out time (# of seconds after 9:55:00 a.m.)									
Open position	0	1	2	3	4	5	10	30	60	300
HFT^D										
-2	31,447	33,728	36,322	38,351	40,245	39,867	31,456	18,681	10,719	-28,053
-1	6,610	9,241	10,895	11,661	12,924	11,941	11,870	3,672	4,357	1,287
Both	37,960	42,871	47,119	49,914	53,072	51,711	43,229	22,256	14,978	-26,863
Non-HFT^D										
-2	26,725	28,626	30,592	31,396	31,944	31,924	26,801	13,837	9,789	-27,917
-1	2,129	3,485	4,156	4,536	4,847	5,179	6,054	5,609	2,155	-15,296
Both	28,823	32,081	34,718	35,902	36,761	37,073	32,825	19,416	11,914	-43,244

Table 7. Trade Imbalance, Stock Market Capitalization, and Advance Peek

Below are pooled regression results with trade imbalances for all stocks as dependent variables. We analyze transaction data in 15-minute intervals pre- and post-announcements for the sample covering pre-September 2009 (i.e. 1 January 2008 to 31 August 2009). *TIB* denotes one-second interval trade imbalance, which is measured by the number of shares in buyer-initiated transactions minus seller-initiated transactions. All dependent variables are standardized relative to the average of each stock in each announcement day. *W1* to *W6* are time interval dummy variables that equal one for the following intervals: (9:54:53, 9:54:57), (9:54:58, 9:54:59), (9:55:00, 9:55:01), (9:55:02, 9:55:06), (9:59:55, 9:59:59), (10:00:00, 10:00:04), and zero otherwise. *Large* and *Medium* are dummy variables for stocks with large and medium market capitalization, respectively, such that the dummy takes the value 1 if it fits the definition and 0 otherwise. Standard errors are corrected for heteroskedasticity using the White (1980) method. The t-statistics are shown in parentheses next to the coefficients. Here, *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

	Negative Consumer Sentiment News				Positive Consumer Sentiment News			
	TIB_HFT_t		$TIB\_non\text{-}HFT_t$		TIB_HFT_t		$TIB\_non\text{-}HFT_t$	
Intercept	0.0005	(0.64)	0.0004	(0.48)	-0.0007	(-0.89)	-0.0004	(-0.52)
W1	0.0070	(0.93)	-0.0080	(-0.91)	0.0077	(1.05)	0.0216	(2.59)***
W2	-0.1153	(-3.08)***	-0.0400	(-1.84)*	0.1041	(2.90)***	0.0376	(1.38)
W3	-0.1237	(-2.84)***	-0.0808	(-3.35)***	0.2325	(4.57)***	0.1530	(3.28)***
W4	0.0003	(0.02)	-0.0036	(-0.31)	0.0953	(7.28)***	0.0624	(5.43)***
W5	-0.0674	(-5.39)***	-0.0292	(-2.57)**	0.0466	(4.77)***	0.0188	(2.17)**
W6	-0.0547	(-3.92)***	-0.0641	(-5.13)***	-0.0450	(-3.01)***	-0.0181	(-1.50)
Large	0.0014	(1.15)	0.0012	(0.96)	-0.0013	(-1.22)	-0.0006	(-0.52)
Medium	0.0009	(0.72)	0.0002	(0.17)	-0.0007	(-0.63)	-0.0002	(-0.15)
W2×Large	-0.9585	(-10.25)***	-0.6888	(-8.23)***	0.7918	(11.40)***	0.4898	(8.01)***
W3×Large	-0.2613	(-4.13)***	-0.2407	(-4.28)***	0.3930	(4.84)***	0.0078	(0.13)
W2×Medium	-0.4830	(-5.67)***	-0.1297	(-3.10)***	0.3859	(5.39)***	0.0412	(1.01)
W3×Medium	-0.2585	(-2.95)***	-0.0516	(-1.01)	0.1652	(2.36)**	0.0006	(0.01)
Obs.	3,825,324		3,825,324		4,675,396		4,675,396	
Adj. R-sq. (%)	0.07		0.03		0.07		0.01	

Table 8. Determinants of Trade Imbalance of Total HFTs and Non-HFTs

Below are pooled regression results with trade imbalances for all stocks as dependent variables. We analyze transaction data in 15-minute intervals pre- and post-announcements for the sample covering pre-September 2009 (i.e. 1 January 2008 to 31 August 2009). *TIB* denotes one-second interval trade imbalance, which is measured by the number of shares in buyer-initiated transactions minus seller-initiated transactions. All dependent variables are standardized relative to the average of each stock on each announcement day. HFT_All denotes both liquidity demanding and supplying HFTs. *W1* to *W6* are time interval dummy variables that equal one for the following intervals: (9:54:53, 9:54:57), (9:54:58, 9:54:59), (9:55:00, 9:55:01), (9:55:02, 9:55:06), (9:59:55, 9:59:59), (10:00:00, 10:00:04), and zero otherwise. *Nasdaq* is a dummy variable that equals one for Nasdaq stocks and zero otherwise. *Final* is a dummy that equals one for Thomson Reuters/UM index of consumer sentiment final reports and zero for mid-term reports. The two interaction terms measure the effect of insider trading on Nasdaq stocks and insider trading on University of Michigan index of consumer sentiment final reports. Standard errors are corrected for heteroskedasticity using the White (1980) method. The t-statistics are shown in parentheses next to the coefficients. Here, *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. Since the total net buy is 0, the coefficients for HFT_All and non-HFT_All regressions are symmetric and have the opposite sign.

	Negative Consumer Sentiment News				Positive Consumer Sentiment News			
	$TIB\_HFT\_All_t$		$TIB\_non\text{-}HFT\_All_t$		$TIB\_HFT\_All_t$		$TIB\_non\text{-}HFT\_All_t$	
Interept	0.0012	(1.46)	-0.0012	(-1.46)	-0.0013	(-1.62)	0.0013	(1.62)
W1	0.0015	(0.18)	-0.0015	(-0.18)	-0.0027	(-0.37)	0.0027	(0.37)
W2	-0.5675	(-8.10)***	0.5675	(8.10)***	0.5529	(8.55)***	-0.5529	(-8.55)***
W3	-0.3769	(-6.63)***	0.3769	(6.63)***	0.3419	(7.48)***	-0.3419	(-7.48)***
W4	-0.0243	(-1.95)*	0.0243	(1.95)*	0.0810	(6.28)***	-0.0810	(-6.28)***
W5	-0.0501	(-4.06)***	0.0501	(4.06)***	0.0402	(4.44)***	-0.0402	(-4.44)***
W6	-0.0279	(-2.03)**	0.0279	(2.03)**	-0.0298	(-2.09)**	0.0298	(2.09)**
Nasdaq	0.0002	(0.20)	-0.0002	(-0.20)	-0.0002	(-0.21)	0.0002	(0.21)
Final	-0.0010	(-0.94)	0.0010	(0.94)	0.0007	(0.76)	-0.0007	(-0.76)
W2×Nasdaq	-0.0923	(-1.31)	0.0923	(1.31)	0.0032	(0.05)	-0.0032	(-0.05)
W3×Nasdaq	-0.0204	(-0.35)	0.0204	(0.35)	0.2589	(4.47)***	-0.2589	(-4.47)***
W2×Final	0.5753	(8.91)***	-0.5753	(-8.91)***	-0.3527	(-5.64)***	0.3527	(5.64)***
W3×Final	0.3699	(6.86)***	-0.3699	(-6.86)***	-0.2465	(-4.14)***	0.2465	(4.14)***
Obs.	3,825,324		3,825,324		4,675,396		4,675,396	
Adj. R-sq. (%)	0.03		0.03		0.04		0.04	

Table 9. The Effects of Total Trade Imbalance of HFTs and Non-HFTs on Returns

Below are pooled regression results with one-second stock returns as dependent variables. We analyze transaction data in 15-minute intervals pre- and post-announcements for the sample covering pre-September 2009 (i.e. 1 January 2008 to 31 August 2009). *TIB* denotes the number of shares in buyer-initiated transactions minus seller-initiated transactions specific to the type of trader. Unlike Table 5, we cannot put the trade imbalance for both HFT_All and non-HFT_All in the same regression as the total trade imbalance for both types of traders sums to zero, leading to the perfect multicollinearity problem. Trade imbalance for each stock is standardized by the type of investors on each day in order to facilitate any inference. The dummy variable *D* equals one at event time and one second after Thomson Reuters/UM ICS announcements. Standard errors are corrected for heteroskedasticity using the White (1980) method. The t-statistics are shown in parentheses next to the coefficients. Here, *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

	Negative Consumer Sentiment News				Positive Consumer Sentiment News			
	HFT_All		Non-HFT_All		HFT_All		Non-HFT_All	
Interept	0.0039	(2.31)**	0.0039	(2.31)**	0.0098	(5.52)***	0.0098	(5.52)***
TIB_t	0.2593	(27.49)***	-0.2593	(-27.49)***	0.3069	(33.55)***	-0.3069	(-33.55)***
TIB_{t-1}	0.0393	(8.79)***	-0.0393	(-8.79)***	0.0471	(11.16)***	-0.0471	(-11.16)***
TIB_{t-2}	0.0183	(6.56)***	-0.0183	(-6.56)***	0.0228	(7.14)***	-0.0228	(-7.14)***
TIB_{t-3}	0.0114	(4.64)***	-0.0114	(-4.64)***	0.0105	(4.19)***	-0.0105	(-4.19)***
TIB_{t-4}	0.0087	(3.25)***	-0.0087	(-3.25)***	0.0064	(2.78)***	-0.0064	(-2.78)***
TIB_{t-5}	0.0071	(2.44)**	-0.0071	(-2.44)**	0.0045	(1.91)*	-0.0045	(-1.91)*
$D \times TIB_t$	0.0268	(0.56)	-0.0268	(-0.56)	0.0790	(1.00)	-0.0790	(-1.00)
$D \times TIB_{t-1}$	0.0723	(1.98)**	-0.0723	(-1.98)**	0.1493	(4.32)***	-0.1493	(-4.32)***
$D \times TIB_{t-2}$	0.0836	(2.67)***	-0.0836	(-2.67)***	0.0830	(3.44)***	-0.0830	(-3.44)***
$D \times TIB_{t-3}$	0.0675	(2.55)**	-0.0675	(-2.55)**	0.0566	(2.35)**	-0.0566	(-2.35)**
$D \times TIB_{t-4}$	-0.0346	(-0.70)	0.0346	(0.70)	-0.3806	(-1.00)	0.3806	(1.00)
$D \times TIB_{t-5}$	0.0701	(1.60)	-0.0701	(-1.60)	0.0040	(0.10)	-0.0040	(-0.10)
Obs.	3,825,324		3,825,324		4,675,396		4,675,396	
Adj. R-sq. (%)	0.63		0.63		0.66		0.66	

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