The Financial Review
EFA Eastern Finance Association

Early Movers Advantage? Evidence from Short Selling during After Hours on Earnings Announcement Days

Journal:	*The Financial Review*
Manuscript ID	FIRE-2018-01-012.R1
Manuscript Type:	Paper Submitted for Accelerated Review
Keywords:	Short selling, After-hours trading, Earnings announcements

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Abstract

We examine short sellers' after-hours trading (AHT) following quarterly earnings announcements released outside of the normal trading hours. Our innovation is to use the actual short trades immediately after the announcements. We find that on these earnings announcement days, there is significant shorting activity in AHT relative to shorting activity both during AHT on non-announcements days as well as during regular trading sessions around announcements. Short sellers who trade after-hours on announcement days earn an excess return of 0.82 percent and 1.40 percent during before-market-open (BMO) and after-market-close sessions (AMC), respectively. The magnitude of these returns increases to 1.48 (3.92) percent for BMO (AMC) earnings announcements with negative surprise. We find that the reactive short selling during AHT has information in predicting future returns. Short-sellers' trades have no predictive power if they wait for the market to open to trade during regular hours. In addition, we find that the weighted price contribution during AHT increases with an increase in after-hours short selling. Overall, our results suggest that short sellers in AHT are informed. Our findings remain robust using alternative holding periods and after controlling for macroeconomic news announcements during BMO sessions.

Keywords: Short selling; After-hours trading; Earnings announcements;

1. Introduction

Several studies have examined short selling behavior around earnings announcements (Berkman and McKenzie (2012); Blau and Pinegar (2010); Christophe, Ferri, and Angel (2004); Daske, Richardson, and Tuna (2005); Engelberg, Reed, and Ringgenberg (2012)). Interestingly, the existing literature provides mixed evidence on the role of short sellers around earnings announcements. While Christophe, Ferri, and Angel (2004) find that short sellers have private information and trade prior to earnings announcements, Daske et al. (2005) find no evidence to support this conclusion. Studying a large sample of news events (including earnings), the more recent work of Engelberg et al. (2012) finds that short sellers' trading advantages come mainly from their ability to analyze publicly available information. Alexander, Peterson, and Beardsley (2014) examine predictive and reactive short sellers who short, respectively, on the day before and the day after quarterly earnings announcements and report that reactive short sellers earn significantly greater profits than predictive short sellers do. Since short sellers are generally considered informed agents (Boehmer, Jones, and Zhang (2008)) and their trades made after news releases are more profitable, we expect short sellers to be interested in short selling immediately after the news releases. Is there an early movers advantage and does it pay to skip happy hours or get up early to short immediately after earnings releases? Thus far, this is a relatively unexplored area as all aforementioned studies on short selling around earnings announcements have only examined short selling during normal trading hours.

Since 2005, over 90 percent of earnings announcements occurred during the pre-market and after-market periods (Michaely, Rubin, and Vedrashko (2014)). After hours trading (AHT) is the trading of listed securities outside an exchange's specified regular trading hours (RTH), which in the U.S. are 9:30am-4:00pm (U.S. Eastern Time). Currently, all investors can trade in

either one of the two AHT sessions; before-market-open (BMO) and after-market-close (AMC). Therefore, an important question is how short sellers react to earnings announcements made during after-hours trading (AHT) sessions. Although many studies have shown that short sellers are informed, some focus on informed short on average days, such as Boehmer et al (2008), some focus on event days' regular hour trading, such as Christophe et al (2004), and some focus on news, such as Engelberg et al (2012). Trading during after-hours period involves many risks such as lack of liquidity, larger quoted spreads, and uncertain prices.[1] Thus, trading in after-hours is dominated by professional traders who are well-informed. Less-informed traders may mimic these informed trades at a later time and/or take longer to process this newly information around earnings announcement. Thus, these later trades would be less likely to make money / predict future returns.[2] Our paper's innovation is to use the after hour trading as the arena to show short-sellers' informativeness. This is an interesting approach as we are able to show how quickly short sellers start to process public information and whether their ability leads to profitable trades.

A few specific questions naturally follow: Do short sellers trade immediately? How important is after hour short selling, compared to regular trading hours short selling? How different are the predictive power of short selling during AHT versus those of short selling during RTH? Are the short trades profitable and what drives the profits of short selling in AHT, if any?

Jiang, Likitapiwat, and McInish (2012) focus their study on AHT around earnings announcement days. They find that on days of earnings announcement, significant portion of the price change and price discovery occurs immediately after the earnings releases during BMO or AMC sessions. Volume during after-hours is event driven as noted by Jiang, Likitapiwat, and

[1] https://www.sec.gov/investor/alerts/afterhourtrading.pdf
[2] We thank the editor for this useful insight.

McInish (2012). For example, on January 31, 2006, when Google posted a profit that missed Wall Street targets for the first time, its shares went down 19 percent during AHT, a $15 billion drop in market value. On this day, 2,386 short sell trades, totaling $162 million of trading volume, were executed for Google stock during AHT after the earnings announcement.

In this paper, we look at short selling activity immediately after the earnings announcements made during BMO or AMC sessions. Our paper provides a much more timely picture of short sellers' reaction to the earnings announcements compared to the existing literature, which focuses on the daily level short selling activity during normal trading hours.

We collect data for earnings announcements made outside RTH along with the exact time-stamp for all exchange-listed firms from January 2011 to October 2016. For our sample of stocks, more than 90 percent of earnings announcements are made outside of RTH, which is comparable to the results of Michaely et al. (2014) and substantially higher than that reported by Bagnoli, Clement, and Watts (2006).

We address four aspects of short selling following after-hours earnings announcements. First, we present fresh evidence concerning short selling activity on earnings announcement days during AHT. We believe that we are the first to study short selling activity during AHT on earnings announcement days. Our results show that there is a significant amount of short selling activity following earnings announcements. Short selling activity during AMC session occurred on 32 percent of AMC announcement days; during BMO sessions, short-selling occurred on 31 percent of BMO announcement days. These numbers increase to 83 percent and 71 percent for the top 250 stocks by trading volume. For these active stocks during AMC, the average short volume is about 20 percent of the short volume during regular hours trading, and the number of short trades is 10.27 percent of the trades during the regular trading hours. On a per unit basis,

given that there are 6 ½ hours of RTH, and less than 2 ½ hours of AHT, the average short volume and trades relative to those of RHT are substantially higher than the numbers reported above. Overall, we show that short selling in AHT is a lot more active on announcement days than non-announcements days. In addition, short selling in the AHT sessions immediately after the announcements is quite sizable and important even when benchmarked against short-selling during the two extremely active trading days of the stock (the day before and the day after the announcement). Short selling volume during AMC session is 16.11 (7.81) percent of short selling during regular trading hours on the day of (day after) the announcement.

Second, we provide evidence on profitability of short trades during AHT. Engelberg et al. (2012) find that the trading advantage of short sellers comes from their ability to analyze public information. We analyze the profitability of short trades that take place immediately after the earnings announcement. While the past literature often measures profitability of short sellers based on the change in prices at the daily level, we use the actual price of each short sale trade to compute the profitability of short sellers. Profitability measures of short selling prompt researchers to make a reasonable assumption about when the short sale is closed, as we do not observe the closing trades directly. Many short selling studies measure profitability over holding period of varying lengths, from the day the trade is initiated. Comerton-Forde, Jones, and Putnins (2016) argue that many short sellers employ high-frequency trading strategies, and it is important to gain an understanding of the behavior of short sellers at intraday horizons. Thus, we use prices at market open and market close in our baseline analysis. If short sales in AHT were covered at the market open, short trades in AHT on announcement days earn an excess return of 0.27 percent and 0.87 percent during BMO and AMC sessions, respectively. If the short sellers close their positions at the next market close after the announcement, returns rise to 0.82 percent

for BMO and 1.40 percent for AMC. On announcement days with negative surprise, the magnitude of these returns for positions covered at the market open (market close) increases to 0.48 percent (1.48 percent) and 3.14 percent (3.92 percent) during BMO and AMC sessions, respectively.

To alleviate the concern that these returns are short-term and prices may reverse, we extend the return computation to 2 and 5 days after the short position is initiated. Reed (2007) finds that in the late 90s, the median duration of a position in the equity lending market is three days and that the mode is only one day. Diether et al. (2009) estimate an average days-to-cover ratio of four to five days for a shorted stock in 2005. These findings indicate that a large portion of recent short-selling activity is short-term. Our results show that there is no reversal in returns during 2- and 5-day periods, and the bulk of the returns are earned when the short position is closed at the market closing price.

Third, we compare return strategies based on predictive and reactive short selling following Alexandar et al (2014). Traditionally, reactive short selling has been studied during RTH after the announcement. As short sellers have the ability to trade in AHT, a time period immediately after the announcements, we include a return strategy based on reactive short selling during AHT. Our results show that a strategy based on reactive trading in AHT yields positive and significant returns. Specifically, for AMC announcements, a strategy of simultaneously buying the quintile portfolio with the lowest short activity and selling the one with the highest short activity during AHT has a one-day return of 0.75 percent. Reactive short-selling in the RTH after the announcements is not profitable at all. These findings are new and important as they shed additional light on the performance of predictive and reactive short sellers who take relatively large short positions immediately before and after quarterly earnings announcements.

Finally, we find evidence that short selling during AHT contributes significantly to price discovery. Barclay and Hendershott (2003) show that the probability of informed trading is generally higher during AHT than during normal market hours. Further, price discovery is greater during after-hours. Focusing on a sample of earnings releases outside of regular trading hours, Jiang et al. (2012) also report a significant portion of price discovery immediately after the earnings releases. We are interested in understanding the effect of short-selling in AHT on price discovery. To investigate the informativeness of short-selling during AHT, we follow the literature and use weighted price contribution (WPC), which measures how much of a stock's cumulative price change or return change is attributable to trades in particular time periods (Barclay and Warner, 1993). If short sellers are skilled at analyzing information after public releases of earnings announcement outside of regular trading hours, stocks with short selling activity during AHT should have a higher percentage of WPC compared to those without short selling during AHT. To this end, our results show that WPC for stocks with no AHT short-selling is significantly lower compared to those with AHT short selling. In addition, price discovery increases with an increase in short selling volume in AHT.

Our results are robust after accounting for the impact of macroeconomic news releases in the BMO sessions. Our results also hold for alternative samples of top 250 stocks and top 250 Nasdaq stocks by trading volume. Collectively, our results suggest that AHT short trades are informed and profitable which is highly consistent with the finding of Engelberg et al. (2012).

In contrast to prior studies of short-selling activities (typically at horizons of days, weeks, or months), our study contributes to the literature by focusing on short selling at the transaction level on earnings announcement days. Comerton-Forde et al. (2014) highlight the importance of using trade-level information in studying short-selling in today's world. Our findings of the

profitability of immediate short selling following earnings announcements also relate to the results reported by Diether et al. (2009). Because earnings announcements are fundamental sources of firm-specific information, evidence of short sellers exploiting misvaluations to correct temporary deviations from fundamentals indicates that short-sellers are informed. Such evidence is also consistent with the findings of Engelberg et al. (2012) that short sellers have superior abilities to process public information. Through examining the immediate trading of short sellers in reaction to earnings releases, our study also contributes to the extensive literature on post-earnings announcement drift (PEAD) (Ball and Brown (1968), Foster, Olsen, and Shevlin (1984)). Our study enables us to incorporate the timing of the short trades as well as whether the trade is in the same direction as the earnings surprise in examining the relation between short trading behavior and subsequent returns. Future studies of market reaction to announcements need to incorporate short selling in AHT and the impact of their trading on price discovery.

2. Related literature

Our paper relates to two distinct branches of literature. First, our study is connected to an extensive literature on the informativeness of short sellers and their trading behavior around news events. Second, our paper contributes to a growing literature on after-hours trading.

2.1. Short selling and information

Boehmer et al. (2008) find that short sellers possess important information and are important contributors to efficient stock prices. Dechow, Hutton, Meulbroek, and Sloan (2001) also find that short sellers target companies that are overpriced, based on fundamental ratios such as price-to-earnings ratios and market-to-book ratios.

Several papers find that short sellers can anticipate negative news and trade before announcement of the news. Karpoff and Lou (2010) examine short sellers' positions in firms that are investigated for financial misconduct and find that short sellers generally anticipate public announcements of investigations. Christophe, Ferri, and Angel (2004) and Christophe, Ferri, and Hsieh (2010) focus on short sellers' trades around earnings announcements and analyst downgrades, respectively. They find evidence that short sellers are informed traders who can profit from these events. Boehmer, Jones, and Zhang (2015) look at short selling around management forecast announcements and earnings announcements and find some evidence that short sellers anticipate these announcements and that a significant fraction of their information advantage comes from trading around these events. Senchack and Starks (1993) find that an announcement of increase in short interest results in some significant negative reaction in stock prices. They find this result to be stronger for non-optioned stocks, while the reaction for optioned stocks is still negative but insignificant.

Another stream of literature finds that short sellers do not possess private information and their information advantage comes from analyzing public information such as news announcements (Engelberg et al. (2012)). Daske et al. (2005) find no evidence that short sale transactions concentrate prior to bad news events. Berkman and McKenzie (2010) also find that short sellers decrease their positions prior to earnings announcements and increase their positions in the post-announcement period. The aggressive trading by short sellers in reaction to earnings releases enhances immediate price discovery. Boehmer and Wu (2013) find that short sellers contribute to price discovery after negative surprise earnings announcements and with more shorting post-earnings announcement drift vanishes. Blau and Pinegar (2010) and Zheng (2009) also find that short sellers react to rather than anticipate the news in earnings announcements and

short selling activity increases following both negative and positive earnings surprises. Alexander, Peterson, and Beardsley (2014) study the performance of 'predictive' and 'reactive' short sellers who take large positions before and after quarterly earnings announcement, respectively. They find that the subsequent returns of reactive short sellers are significantly greater than those of predictive short sellers for S&P 500 stocks.

2.2. After-hours trading

Barclay and Hendershott (2003) find that even though trading volume is lower during after hours, it can generate significant price discovery. Barclay and Hendershott (2008) find that as Nasdaq pre-open trading volume increased, the opening price became more efficient and price discovery shifted from the opening trade to the pre-opening period. Cao, Ghysels, and Hatheway (2000) study preopening quotes as signaling for price discovery on the Nasdaq. They find that the contribution of the pre-opening period, as measured on a relative unit time basis, is as large as that of the trading period.

Jiang et al. (2012) study AHT following earnings announcements outside of the normal trading hours. They find that a significant portion of price discovery happens during the BMO and AMC sessions. Thus, trading outside normal trading hours plays an important role for price discovery in stock markets. McInish, Van Ness, and Van Ness (2002) study the AHT of NYSE-listed stocks on regional exchanges. They find that the stocks that are traded most actively during RTH are also traded actively during AHT. Francis, Pagach, and Stephan (1992) investigate market responses to overnight (OVR) and daytime announcements of U.S. firms and focus on volume and price reaction at the open of the market following OVR announcements. They find

that investors who submit orders before the market open based on the sign of forecast error can earn excess returns at the market close. Greene and Watts (1996) report that stocks react differently to earnings announcements made during different time periods. For the announcements that are made during non-trading periods, price changes occur immediately when the market opens. Berkman and Truong (2009) note that event studies of announcements typically assign the Compustat or I/B/E/S earnings announcement date as event day 0, which is incorrect when announcements are made during after hours.

In a study closely related to ours, Alldredge, Blau, and Brough (2012) find that short sellers are less contrarian during the after-hours period. They also find that return predictability contained in short sales is nearly five times less during after-hours as compared to regular trading hours. However, they focus their study on the overall after-hours period, while we focus our paper on earnings announcement days. We are the first to study after-hours short selling following announcements made outside of RTH. Previous studies focus on short selling activity on days prior to the earnings announcement, on day of earnings announcement, and on days following earnings announcement. Our research design allows us to study the immediate behavior of short sellers in AHT.

3. Data/descriptive statistics

We use transaction-level short volume data for the period January 2011 to October 2016. We obtain the short volume data from NYSE and Nasdaq stock exchanges. For each stock day, we sum the intraday short selling volume for both the exchanges and calculate the total short volume during the BMO session, RTH session, and AMC session. We also use I/B/E/S dataset to identify the quarterly earnings announcements. I/B/E/S provides the date and time of earnings

releases, earnings estimates by each analyst, and actual earnings. For BMO and AMC session on earnings announcement days, we only use short trades that execute after the actual time of the announcement. We download trading volume, opening price, closing price, number of shares outstanding, dividend amount, factor to adjust price, and primary exchange for each stock from CRSP.

Table 1 presents the distribution of announcements by time of release during our sample period. In Panel A, we present the number of announcements by time and by surprise for all stocks in our sample. Surprise is the difference of the actual earnings and the median analysts forecast for each stock-quarter. In column 2 and column 3, we present the number of earnings announcements with a positive earnings surprise and number of announcements with a negative earnings surprise, respectively. More than 90 percent of the quarterly announcements are made outside of RTH (9:30am – 4:00pm); with about 31 percent in the BMO session (7:00am - 9:30am) and 46 percent in the AMC session (4:00pm – 6:30pm), and 14 percent in the OVR session (6:30pm – 7:00am). Overall, about 65 percent of earnings announcement in our sample have a positive earnings surprise and the remaining 35 percent have a negative earnings surprise. In Panel B, we present these numbers for a subset of top 250 stocks by trading volume during our sample period. We separately analyze these high volume stocks as after-hours trading is shown to be quite thin (Barclay and Hendershott, 2003).[3] For these stocks, we find that about 97 percent of the earnings announcements take place outside of RTH. About 45 percent of earnings announcement take place in the BMO session and 33 percent of earnings announcement take place in the AMC session. In Panel C, we also include a subset of top 250 Nasdaq-listed stocks by trading volume. Barclay and Hendershott (2008) use the 250 most active Nasdaq stocks in

[3] Three separate samples are considered in our study to minimize the potential for drawing improper inferences from thinly traded stocks.

their study, as these stocks have seen tremendous growth in pre-open trading. Jiang, Likitapiwat, and McInish (2012) also show that Nasdaq stocks trade actively during the AMC session. For these stocks, about 91 percent of the earnings announcements take place outside RTH sessions. About 22 percent of earnings announcements take place in the BMO session and about 56 percent of earnings announcements take place in the AMC session.

[Insert Table 1 here]

Next, we merge the short volume data and I/B/E/S data and look at the after-hours short selling activity on earnings announcement and non-announcement days. To keep our sample of non-announcement days clean, we exclude stocks-days immediately following an AMC announcement in forming our non-announcement sample. We exclude stock-days when short selling during the BMO or AMC session is higher than the short selling during the following RTH session to remove outliers. We also exclude stock-split days and ex-dividend days from our sample. We drop announcements made during RTH and OVR. Our final sample comprises of 4,171 stocks and 48,447 earnings announcements during AHT. In Table 2 Panel A, we report the results for all stocks in our sample, and separately for BMO and AMC sessions on earnings announcement days and non-announcement days. Only earnings announcement days and non-announcement days with short selling are reported. In column 3 and column 4, we report the mean dollar short selling volume and mean number of short trades. In column 5, we report DollarVol% relative to predictive short selling, calculated as dollar short selling during BMO (AMC) session divided by dollar short selling volume during RTH session on day *t-1* (*t*). We also report the mean proportional dollar short selling volume (DollarVol%), relative to reactive short selling volume, calculated as average dollar short selling during BMO (AMC) session

divided by average dollar short selling volume during RTH session on day *t* (*t+1*).[4] In column 6, we also report the mean proportional short selling trades (Trades%), relative to both reactive and predictive short selling, calculated in similar fashion as the DollarVol%. In Table 2 Panel B, we report similar results for top 250 stocks by trading volume. In Table 2 Panel C, we report the results for top 250 Nasdaq-listed stocks by trading volume.

In Table 2 Panel A, we see a significant amount of short selling outside the regular trading hours on earnings announcement days. Short selling activity occurred during the BMO session on 31 percent of BMO announcement days. Similarly, short selling activity occurred during the AMC session on 32.2 percent of AMC announcement days. On earnings announcement days with short selling, average short selling is $455,000 and $2,009,000 during BMO and AMC sessions, respectively. On earnings announcement days with short selling, the average number of short trades is 39 and 98 during BMO and AMC sessions, respectively. DollarVol% during BMO and AMC sessions is 2.27 percent and 16.11 percent, respectively, of RTH short selling volume. For Trade%, AMC trades is 6.78 percent of the short trades in RHT. Since there are many more trading hours in RTH (6 ½ hrs) versus AMC and BMO (2 ½ hrs at most), on a per unit basis, the average short volume and trades relative to those of RHT (either predictive or reactive) are substantially higher than the numbers reported above.

For the top 250 stocks by trading volume, short selling activity occurred during the BMO session on 71.2 percent of BMO announcement days. Short sellers were more active during the AMC session, trading occurred on 83.1 percent of AMC announcement days. The average short selling volume for these stocks is $1,212,000 and $10,388,000 during BMO and AMC sessions on these earnings announcement days, respectively. On earnings announcement days with short

[4] Following Barclay and Hendershott (2003), we report ratio of the averages. Taking the ratio of the averages or the average of the ratios yield slightly different results.

selling, the average number of short trades is 92 and 448 during BMO and AMC sessions, respectively. DollarVol% during BMO and AMC sessions is 2.28 percent and 19.66 percent of RTH short selling. Trades% during BMO and AMC sessions is 1.93 percent and 10.27 percent of RTH short trades.

For the top 250 Nasdaq stocks by trading volume, there was short selling activity during the BMO session on 61 percent of BMO announcement days. Similarly, we find evidence of short selling activity during the AMC session on 79.6 percent of AMC announcement days. The average short selling volume for these stocks is $719,000 and $6,478,000 during BMO and AMC sessions on earnings announcement days, respectively. On earnings announcement days with short selling, the average numbers of short trades are 52 and 294 during BMO and AMC sessions, respectively. DollarVol% during BMO and AMC sessions is 4.95 percent and 24.99 percent of RTH short selling. Trades% during BMO and AMC sessions is 3.02 percent and 12.87 percent of RTH short trades. On a per unit basis (using 6 ½ hrs for RTH, and 2 ½ hrs for AMC), the average dollar short volume is $2,591,000 during AMC vs. $3,988,000 during RHT. Similarly, the average short trades is 118 during AMC vs. 351 during RHT on a per unit basis.

In sum, these statistics show that AHT short trades, especially AMC short trades, is a substantial portion of the RTH short trades. Since there are many more trading hours in RTH (6 ½ hrs) versus AMC and BMO (2 ½ hrs), there is very significant short selling during AMC and BMO sessions on a per unit basis.

In addition, the comparison between short trades on announcement days versus non-announcement days suggest that short trades are far less active and trade less often on days with no earnings announcements. Given the lack of liquidity and the many impediments of short

selling outside of regular trading hours, the presence of short trades suggests that they are likely informed and are able to make profits from AHT.

[Insert Table 2 here]

4. Methodology and Results

In this section, we provide research methodology, our results, and their interpretation.

4.1. Do short sellers profit from after-hours short selling?

In this subsection, we test if short sellers have early movers advantage and profit by short selling during BMO and AMC sessions. The difficulty of computing returns of short selling trades is that we cannot observe the actual covering transactions. We do not know the exact holding period for which short sellers keep their positions open. Thus, instead we evaluate if short sellers can potentially make money, if they were to close out their position within a certain time period. Comerton-Forde et al (2014) suggest that many short sellers employ high-frequency trading strategies and that short selling is often limited to intraday horizons. Since the immediacy of the trading is the focus of our paper, our benchmark computation of profitability of each after-hours short sell trade (r_{ss}) uses the short sale price and opening price as follows:[5]

$$r_{ss} = \left(Price_{Short\ sell} - Price_{open}\right) \Big/ Price_{open} \; X\; 100 \qquad (2)$$

For BMO sessions, $Price_{open}$ is the opening price of the same day. For AMC sessions, $Price_{open}$ is the opening price of the next day. To make sure that our results are not being driven by a few trades with extreme returns, we exclude short sale trades that yield a return greater than

[5] Returns are not computed for closing trades in the same AHT session or next morning's BMO session as spreads are large and volatility considerably higher in AHT (Barclay and Hendershott, 2004).

50 percent or less than -50 percent.[6] Next, we only keep BMO/AMC announcements with at least 10 short trades during BMO/AMC session. We also exclude stocks with price less than $1 on day *t-1* and day *t* for BMO and AMC sessions, respectively. For both BMO and AMC sessions, we compute the average return for each stock-day by weighing the return of each short sale trade by the size of the trade.[7] Then, we calculate excess return by subtracting the close to open value-weighted market return where value-weighted market return is calculated using all stocks from CRSP. Next, we take the average of return separately across all earnings announcement days and across all non-announcement days. We also calculate the closing return for each after-hours short sell trade (r_{ss}) uses the short sale price and closing price as follows:

$$r_{ss} = {(Price_{Short\ sell} - Price_{close})}/{Price_{close}}\ X\ 100 \quad (2)$$

In Table 3, we report these results for all stocks in our sample. In columns 3 through 5, we report the mean, median, and standard deviation of excess opening returns. In columns 6 through 8, we report the mean, median, and standard deviation of the excess closing returns. [8]

[Insert Table 3 here]

We find that short sellers make an opening return of 0.27 percent and 0.87 percent on BMO and AMC earnings announcement days, respectively. The difference in returns on announcements and non-announcements days are statistically significant for AMC announcements. The magnitude of closing returns is higher than opening returns. The return to short sellers for the BMO sample increases to 0.82 percent and the return for the AMC sample increases to 1.40 percent. Thus, using both opening and closing price to calculate returns of short

[6] Our main results in the paper are robust when we include short sales trades with returns greater than 50 percent or less than -50 percent.

[7] Li (2016) computes profitability of all after-hour trades by using 8pm closing price. This is problematic as trading is very thin after 6pm. See Jiang et al (2012) for further details of after-hour volume distribution.

[8] We also use 3-month T-bill rate to compute excess returns and find qualitatively similar results.

sellers, we find that short sellers make a positive return from after-hours short selling. The fact that returns using closing prices are higher than returns earned over a shorter holding period (until market-open) indicates that adjustment to information extends beyond AHT and is at least ongoing during the first regular trading period subsequent to announcements. This is consistent with the well-documented post-earnings announcement drift anomaly in that significant abnormal returns of the same sign exist on the announcement day and over the next several weeks following significant earnings surprises.

If short sellers react quickly to the negative news and bring the prices close to fundamental values, then they should make higher profits on days of negative surprise compared to days of positive surprise. To test this, we separate earnings announcement days by positive surprise and negative surprise. We report trading returns of short sellers on earnings announcement days of positive and negative surprise. We find that short sellers make a positive and significant opening (closing) return of 0.48 (1.48) percent and 3.14 (3.92) percent for negative surprise announcements during BMO and AMC sessions, respectively. These returns are significantly higher than the return on the days of positive surprise announcements. Thus, short sellers make higher returns when there is a negative surprise in earnings announcement. These results indicate that short sellers react quickly to negative news and are able to profit when their trades bring the prices closer to their fundamental value.

A short seller will make money if the price is too high. The price could be too high after a good news event or after a bad news event. In general, there exists a notion that if the news is positive (e.g., positive earnings surprises), then the stock must be moving up and the longs are making money. But, in the short-run, the price could easily overreact, providing profit opportunities possible on either side of the news. In the case of positive surprises, short-sellers

can profit if price overshoot after the announcement to a level even after incorporating the positive surprises. Our findings of significant short returns on positive surprises support this conjecture. However, our analysis is consistent with the notion that short sellers make profits mainly through exploiting information related to bad news or negative earnings surprises.

The results in Table 3 show the profitability of short selling during AHT at the univariate level. In the next subsection, we perform a regression analysis to control for other confounding factors.

4.2. Regression analysis of return to short sellers

In this subsection, we run a regression analysis of return to short sellers. Following Engelberg et al. (2012), we estimate the following OLS regression and report the results in Table 4:

$$Opening\ (Closing)\ excess\ return\ to\ short\ sellers = \alpha + \beta_1 Negative\ surprise + \beta_2 Short\ volume\ ratio + \beta_3\ Return_{t-1} + \beta_4\ Return_{t-2} + \beta_5 \log Market\ capitalization + \varepsilon \quad (3)$$

where β_1-β_5 are parameters to be estimated and ε is a random error term. Our dependent variable is excess return to short sellers, which is computed by subtracting value-weighted market opening (closing) return from *Opening* (*Closing) return to short sellers*. *Opening return to short sellers* is calculated as ($Price_{short\ sell}$- $Price_{open}$)/$Price_{open}$ for each trade. *Closing return to short sellers* is calculated as ($Price_{short\ sell}$- $Price_{close}$)/$Price_{close}$ for each trade. Then these returns are aggregated for each stock-day by weighing the return of each short sale trade by the size of the trade. *Negative surprise* is a dummy variable that takes a value of 1 for negative surprise

stock-days, and 0 otherwise. *Short volume ratio* is BMO/AMC short volume scaled by short volume during RTH. $Return_{t-1}$ and $Return_{t-2}$ are the stock returns on day *t–1* and day *t–2*, respectively. We report the coefficients from three alternate specifications based on all or a subset of the above variables.

In Panel A, we report the results for opening returns. For AMC announcements, the coefficient of *negative surprise* is positive and significant in all three models. Thus, short sellers make a positive return on days of AMC announcements with negative surprise. In models 2 and 3, the coefficient of short volume is positive, implying that higher short volume during AMC session results in a higher return to short sellers. In model 3, the coefficient of $Return_{t-2}$ is positive and significant indicating that short sellers are contrarian and make higher returns for stocks that have positive returns on day t-2. The coefficient for *log (Market cap)* is negative in model 3, indicating lower returns for larger stocks.

For the BMO announcements regression for all stocks, the coefficient for *negative surprise* is positive and significant in model 4, indicating positive return on days of negative surprise. In model 5 and model 6, the coefficients of *short volume ratio* is positive, implying that returns to short sellers increases with increase in short volume. The coefficient on *log (Market cap)* is negative and significant in model 6, indicating short sellers make lower returns for higher market capitalization firms.

In Panel B, we report the results for closing returns. The coefficient of *negative surprise* is positive and significant in all six models. Thus, short sellers make a positive return on days of announcements with negative surprise. In models 2, 3, 5, and 6, the coefficient of short volume is positive, implying that higher short volume results in a higher return to short sellers. The coefficient for *log (Market cap)* is negative in model 3 and model 6, indicating lower returns for

larger stocks. Thus, our results are qualitatively similar when we use closing return instead of opening returns.

[Insert Table 4 here]

4.3. Reactive vs. predictive short selling

Alexandar et al (2014) study reactive short selling during RTH after the announcement. Short sellers have the ability to trade in AHT and we have shown in our earlier sections that they do take advantages of the window of opportunity to short before regular sessions start. We include return from a long-short strategy, which is long in stocks with low short selling and short in stocks with high short selling. We include return of this strategy based on reactive short selling during AHT and our results show that reactive short selling in AHT yield positive and significant returns.

In Table 5 Panel A, for BMO announcements, we create quintiles of announcements days based on predictive short selling during RTH (RTH short selling on day *t-1),* reactive short selling during BMO, and reactive short selling during RTH (RTH short selling on day *t)*. We use short selling as a % of shares outstanding following Alexandar, Peterson, Beardsley (2014)). We report the future returns for these quintiles in columns 2 through 6. In column 7, we report the difference between returns of quintile 1 and quintile 5. We find the results for sorting based on predictive short selling to be insignificant. Next, we find that a strategy based on reactive short selling during BMO yields a positive and significant return of 0.81 percent by the close of day *t+1*. A strategy based on reactive short selling during RTH fails to yield a significant return.

We report similar results for AMC announcements in Panel B of Table 5. We form quintiles of announcements days based on predictive short selling during RTH (RTH short selling on day *t),* reactive short selling during AMC, and reactive short selling during RTH (RTH

short selling on day *t+1)*, .We find that the strategy based on a sorting by predictive short selling provides insignificant return by the close of day *t+1* and *t+2,* respectively. This strategy yields a negative and significant return by the end of day *t+5*. Strategy based on reactive short selling during AMC after the announcements yields a positive return by the close of day *t+1*, *t+2*, and *t+5*. Strategy based on reactive short selling in the RTH after the announcements yields a negative return by the close of day *t+1*, *t+2*, and *t+5*. These findings are new and important as they shed additional light on the performance of 'predictive' and 'reactive' short sellers who take relatively large short positions immediately before and after quarterly earnings announcements.

[Insert Table 5 here]

4.4. Price discovery of short trades in AHT

Prior literature suggests that trading contributes to price discovery. Barclay and Hendershott (2008) find that as Nasdaq pre-opening trading volume increases, the opening price becomes more efficient and price discovery shifts from the opening trade to the pre-opening period. Their results suggest that pre-opening trading contributes to price discovery and efficiency of the opening price. In this subsection, we study the informativeness of after-hours short selling when short-sellers are present. To quantify price discovery during after-hours trading, following Barclay and Warner (1993), we compute the weighted price contribution (WPC) of the close period to the open period on earnings announcement days as:

$$WPC_{co} = \sum_{s=1}^{S} \left[\left(\frac{|ret_s|}{\sum_{s=1}^{s} |ret_s|} \right) \left(\frac{ret_{co,s}}{ret_s} \right) \right] \quad (4)$$

where $ret_{co,s}$ for BMO (AMC) sessions is based on the closing price of the previous day (earnings announcement day) and the opening price of the earnings announcement day (next day). Ret_s for BMO (AMC) sessions is based on the closing price of the previous day (earnings announcement day) and the closing price of the earnings announcement day (next day).

We calculate WPC_{co} separately for days with short selling activity and days without short selling activity, for both BMO and AMC sessions, and report these numbers in columns 2 and 3 of Table 6 Panel A. In column 4, we report the difference between these two numbers. We find that for BMO announcements, WPC_{co} for days with short selling (no short selling) is 0.59 (0.33). For AMC announcements, WPC_{co} for days with short selling (no short selling) is 0.69 (0.43). The difference in WPC_{co} measure for days with short selling and WPC_{co} measure for days without short selling is statistically significant for both BMO and AMC sessions.

In Table 6 Panel B, we only keep BMO/AMC announcements with at least 10 short trades during BMO/AMC session. We divide these BMO (AMC) earnings announcement days with short selling into quintiles using the BMO (AMC) short selling volume ratio. We calculate WPC_{co} by taking the average across stock-days in each quintile. We report the numbers for each short selling quintile in columns 2 through 6. We report the difference between the lowest and highest short selling quintile in column 7. We find that the quintile with the highest BMO short selling volume ratio has a WPC_{co} measure of 0.91, which is significantly higher than WPC_{co} measure of 0.54 for the quintile with the lowest BMO short selling volume. We find similar results for AMC announcements. The WPC_{co} measure for the highest AMC short selling quintile is 0.86, which is significantly higher than the WPC_{co} measure of 0.71 for the quintile with the lowest AMC short selling volume. These results in Table 6 indicate that a higher level of short selling on the announcement days results in a more efficient opening price.

[Insert Table 6]

Next, we run a regression analysis of WPC_{co} to control for factors that are important determinants of the level of price discovery. We estimate the following OLS regression and report the results in Table 7:

$$WPC_{co} = \alpha + \beta_1 \, Negative\ surprise + \ \beta_2 \, Short\ volume\ ratio + \beta_3 \, Return_{t-1} + \beta_4 \, Return_{t-2} + \beta_5 \log Market\ cap + \ \varepsilon \quad (5)$$

where β_1-β_5 are parameters to be estimated and ε is a random error term. Our dependent variable $WPC_{co,}$ is defined previously. In column 2, we report the results for model 1 for the AMC sample. In column 3, we add other explanatory variables and control variables such as lagged returns and market capitalization. We report similar results for the BMO period in column 4 and column 5.

For AMC announcements, we find a positive and significant coefficient for *negative surprise*, indicating a higher price discovery during after-hours on negative surprise days. The coefficient on *short volume ratio* is positive and significant. This indicates that higher short selling results in a higher efficiency of the opening price. The coefficient on *Log (Market cap)* is negative and significant. This result indicates that WPC_{co} is lower for higher market capitalization firms, consistent with Jiang et al. (2012). For BMO announcement regressions, our results are similar except the coefficient on $Return_{t-2}$, which is negative and significant, indicating that short selling contributes less to price discovery if the stock price had fallen on day *t-2*. This result indicates that WPC_{co} is lower for higher market capitalization firms, consistent with Jiang et al. (2012).

[Insert Table 7]

5. Alternative Explanations and Robustness Checks

5.1. Profitability over varying-lengths of holding period

Our main analysis of profitability is performed with short sellers closing their trades either at the market open or the next market close. Prior works show that in the late 90's, the median duration of a position in the equity lending market is three days, and the mode is only

one day (Reed, 2007), and that in 2005, the estimated average days-to-cover ratio is four to five days for a shorted stock (Diether et al., 2009). These findings indicate that a large portion of recent short-selling activity is short-term (if not intraday, given the rise of high frequency trading). Thus, for a robustness check, we also calculate 2-day and 5-day return to short sellers to verify if the profitability of short trades continues in the longer term. In addition, because of the slow response to earnings (Li, 2014) and the persistence of the much documented post-earnings announcement drift (PEAD) (Ball and Brown (1968), Foster et al. (1984)), we are interested in observing the return patterns of short trade in AHT over periods extended beyond 24 hours. We report the results for the all stocks sample in Table 8. For BMO announcements and the all stocks sample, we find that the magnitude of the return to short sellers increases from 0.82 percent for the 1-day period to 1.27 for the 5-day period. The magnitude of return for AMC announcements increases from 1.40 percent for the 1-day period to 1.51 percent and 1.84 percent for the 2-day and 5-day period, respectively. For AMC period, the magnitude of non-announcement day returns to short sellers is significantly lower than those of announcement days for all holding periods. Overall, we show that the information advantage of the short-sellers who trade in AHT is not limited to a time frame of 24 hrs. The profitability of their trades does not show a reversal over the 5-day period after the trades. However, a significant portion of the returns is in the early part of the 5-day period. For example, during AMC announcements, 76 percent of the 5-day return (1.40 percent out of 1.84 percent) is realized on the first day.

[Insert Table 8 here]

In Table 8, we also present the 2-day and 5-day return during BMO and AMC earnings announcements for negative surprise and positive surprise separately. We find that short sellers make a 1-day return of 1.48 percent for negative surprise announcements during BMO sessions,

and this number increases to 2.00 percent and 2.69 percent for the 2-day period and 5-day period, respectively. For AMC announcements, we find that short sellers make a 1-day return of 3.92 percent for negative surprise announcements, and this number increases to 4.32 percent and 4.59 percent for the 2-day period and 5-day period, respectively. This suggests that the return to short sellers' trade during AHT period on earnings announcements continues to be positive in longer term. Though, a large portion of the returns is in the early part of the 5-day period. For stock with negative surprise during AMC announcements, 85 percent of the 5-day return (3.92 percent out of 4.59 percent) is realized on the first day. Our results indicate higher profits can be made by being more patient. For both BMO and AMC announcements, return on negative surprise days is significantly higher than the return on positive surprise days.

5.2. Return for top 250 stocks and top 250 Nasdaq stocks by trading volume

In this section, we test the robustness of our results by using top 250 stocks and top 250 Nasdaq stocks to replicate our findings of Table 3. In Panel A, we find that for top 250 stocks and AMC announcements, short sellers make a significant opening and closing return of 0.31 percent and 0.39 percent, respectively. For AMC announcements with negative surprise, short sellers make a positive and significant return of 1.41 percent and 1.52 percent, respectively.

In Panel B, we find that for top 250 Nasdaq stocks and BMO announcements, short sellers make a significant opening and closing return of 0.34 percent and 0.57 percent, respectively. For AMC announcements with negative surprise, the opening and closing returns are 2.07 percent and 2.04 percent, respectively. Thus, we find that the return to short sellers remain positive and significant irrespective of the stock samples.

[Insert Table 9 here]

We plot these returns of short sellers in Figure 1. The first three bars present the returns during BMO sessions on announcement days for all stocks, top 250 stocks by volume, and top 250 Nasdaq listed stocks by volume, respectively. The next three bars are for returns during BMO sessions on non-announcement days. The next six bars are for similar returns during the AMC session. It is evident from the figure that the returns on announcement days are higher than the returns on non-announcement days.

[Insert Figure 1 here]

We also plot the returns by surprise in Figure 2. The first three bars present the return during the BMO session on negative surprise days for all stocks, top 250 stocks by volume, and top 250 Nasdaq listed stocks by volume, respectively. The next three bars are for returns during the BMO session on positive surprise days. The next six bars are for similar returns during the AMC session. We find that returns to short sellers are higher on negative surprise days compared to returns on positive surprise days. We also find that for negative surprise days, the returns during the AMC session are much higher than returns during the BMO session for all stocks.

[Insert Figure 2 here]

5.3. Macroeconomic news and BMO announcements

BMO earnings announcements sometimes coincide with macroeconomic announcements such as GDP and unemployment news. Following Jiang, Likitapiwat, and McInish (2012), we consider GDP, CPI, and unemployment announcements in our analysis.[9] GDP data are usually released on the last Friday of January, April, July and October. With the initial release plus two revisions for each quarter, there are 12 event dates each year. Unemployment data is usually released on the first Friday of the month. The CPI is usually released on the 11th business day of

[9] We collect macroeconomic announcements from www.econoday.com.

the month, respectively. Employment and inflation data are released monthly. All news is scheduled to be released at 8:30 am (EST). Thus, we match each macroeconomic announcement with BMO announcements in our samples. Following their methodology, we investigate if macroeconomic announcements are driving our results by adding a macroeconomic dummy in our regressions. We find that the macro dummy is insignificant. Thus, these macroeconomic announcements do not materially affect our findings (results not reported for brevity).

6. Conclusion

The existing literature on behavior of short sellers around earnings announcements focuses only on short selling during regular trading hours aggregated at the daily level. We provide a microscopic look at the short selling activity immediately after the earnings announcements made during BMO or AMC sessions. For our sample of stocks, more than 90 percent of earnings announcements are made outside of RTH. We address several aspects of short selling following after-hours earnings announcements.

First, we document short selling activity during AHT on earnings announcement days to be much higher than short selling activity during AHT on non-announcement days, consistent with the results reported for all trades (not limited to short trades) in Jiang et al (2012). Short selling in the AHT sessions immediately after the announcements is quite sizable and important even when benchmarked against short-selling during the two extremely active trading days of the stock (the day before and the day after the announcement). Short-sellers do skip happy hours or get up early to trade on these scheduled earnings announcement days.

Second, we provide evidence on profitability of short trades during AHT. We find that short sellers who trade after-hours on earnings announcement days earn positive excess returns

during both BMO and AMC sessions. On announcement days with a negative surprise, the magnitude of the returns is 1.48 percent and 3.92 percent during BMO and AMC sessions, respectively. When we compare return strategies using predictive and reactive short selling during RTH with reactive short selling during AHT, we find that reactive trading in AHT yields positive and significant returns. Specifically, for AMC announcements, a strategy of simultaneously buying the quintile portfolio with the lowest short activity and selling the one with the highest short activity during AHT has a one-day return of 0.75 percent, significantly higher than the return earned based on the reactive portfolio during RTH. Reactive short-selling in the RTH after the announcements is not profitable at all. These findings are new and important as they shed additional light on the performance of predictive and reactive short sellers who take relatively large short positions immediately before and after quarterly earnings announcements.

Lastly, we find that short selling contributes to more efficient opening prices. We find that opening prices are more efficient when there is short selling during AHT. We also find that for earnings announcement days with short selling, the opening prices become more efficient with the increase in short selling volume.

These findings combined together indicate that short sellers react quickly to earnings surprises during AHT and that they are able to profit from these news events. They also help keep the prices in line with their fundamental value, as the magnitude of weighted price contribution during AHT increases in the magnitude of after-hours short selling. Our results are consistent with Boehmer, Jones, and Zhang (2008), that show short sellers are informed as heavily shorted stocks underperform lightly shorted stocks. We contribute by showing that short sellers are informed using the earlier trades in reaction to the most important routinely scheduled firm events, earnings releases by firms. Our findings remain robust after controlling for macroeconomic news

announcements during BMO, for alternative sample of stocks with the highest trading volume, and for longer holding periods of the AHT short positions.

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Table 1
Number of earnings announcements, by time of day.

For all exchange listed stocks, we present the distribution of quarterly earnings announcements by time of the day from January 2011 to October 2016. We report four time periods: before market open (BMO), 7:00am – 9:30am; regular trading hours (RTH), 9:30am – 4:00pm; after market close (AMC), 4:00pm – 6:30pm; and overnight (OVR), 6:30pm – 7:00am. We also divide each earnings announcement into positive and negative surprise category. Surprise is the difference between the actual earnings and the median analysts forecast for each quarter normalized by the stock price. In Panel B, we report a similar analysis for the top 250 stocks by volume. In Panel C, we report a similar analysis for the top 250 Nasdaq stocks by volume.

Time of announcement	Positive	Negative	Total
Panel A: All stocks			
7:00am - 9:30am BMO	13,438	7083	20,521
9:30am - 4:00pm RTH	4028	2364	6,392
4:00pm - 6:30pm AMC	20,239	10,301	30,540
6:30pm - 7:00am OVR	6,061	3362	9,423
Total	43,766	23,110	66,876
Panel B: Top 250 stocks by volume			
7:00am - 9:30am BMO	1,920	582	2,502
9:30am - 4:00pm RTH	147	46	193
4:00pm - 6:30pm AMC	1,418	403	1,821
6:30pm - 7:00am OVR	846	222	1,068
Total	4,331	1,253	5,584
Panel C: Top 250 Nasdaq listed stocks by volume			
7:00am - 9:30am BMO	807	306	1,113
9:30am - 4:00pm RTH	381	123	504
164:00pm - 6:30pm AMC	2,278	592	2,870
186:30pm - 7:00am OVR	440	158	598
Total	3,906	1,179	5,085

Table 2
Descriptive statistics.

For the BMO and AMC sessions, we report statistics for earnings-announcement days when short selling occurs and non-earnings-announcement days when short selling occurs. We report the mean dollar short selling volume, numbers of short trades, DollarVol% and Trades% in columns 3 through 6, respectively. DollarVol% is the ratio of dollar short selling during the BMO/AMC sessions divided by dollar short selling volume during the RTH session multiplied by 100. Trades% is the ratio of short selling trades during the BMO/AMC sessions divided by short selling trades during the RTH session multiplied by 100. In Panel B, we report a similar analysis for the top 250 stocks by volume. In Panel C, we report a similar analysis for top 250 Nasdaq stocks by volume.

	N	Short volume ('000)	Short trades	DollarVol% using RTH predictive shorts (RTH reactive shorts)	Trades% using RTH predictive shorts (RTH reactive shorts)
Panel A: All stocks					
BMO (Total Ann. Days: 19,709)					
Ann. days with short selling	6,112	455	39	2.27 (1.30)	0.99 (1.78)
Non-ann. days with short selling	334,143	122	9	0.50	0.37
RTH short selling (t-1) on ann. days	6,112	20,001	2,192		
RTH short selling (t) on ann. days	6,112	34,984	3,924		
RTH short selling on non-ann. days	334,143	24,276	2,293		
AMC (Total Ann. Days: 28,738)					
Ann. days with short selling	9,257	2,009	98	16.11 (7.81)	6.78 (3.52)
Non-ann. days with short selling	1,816,461	1,187	2	11.30	0.13
RTH short selling (t) on ann. days	9,257	12,475	1,452		
RTH short selling (t+1) on ann. days	9,257	25,715	2,798		
RTH short selling on non-ann. days	1,816,461	10,497	1,277		

	N	Short volume ('000)	Short trades	DollarVol% using RTH predictive shorts (RTH reactive shorts)	Trades% using RTH predictive shorts (RTH reactive shorts)
Panel B: Top 250 stocks by volume					
BMO (Total Ann. Days: 2,483)					
Ann. days with short selling	1,768	1,212	92	2.28 (1.37)	1.93 (1.16)
Non-ann. days with short selling	117,453	259	13	0.44	0.29
RTH short selling (t-1)	1,768	53,197	4,777		
RTH short selling (t)	1,768	88,127	7,916		
RTH short selling on non-ann. days	117,453	58,262	4,633		
AMC (Total Ann. Days: 1,780)					
Ann. days with short selling	1,479	10,388	448	19.66 (9.71)	10.27 (5.69)
Non-ann. days with short selling	285,512	4,789	3	11.00	0.08
RTH short selling (t) on ann. days	1,479	52,852	4,363		
RTH short selling (t+1) on ann. days	1,479	107,019	7,881		
RTH short selling on non-ann. days	285,512	43,551	3865		
Panel C: Top 250 Nasdaq listed stocks by volume					
BMO (Total Ann. Days: 1,062)					
Ann. days with short selling	648	719	52	4.95 (2.74)	3.02 (1.68)
Non-ann. days with short selling	98,829	245	10	0.83	0.48
RTH short selling (t-1)	648	14,538	1,727		
RTH short selling (t)	648	26,212	3,106		
RTH short selling on non-ann. days	98,829	29,621	2,156		
AMC (Total Ann. Days: 2,741)					
Ann. days with short selling	2,183	6,478	294	24.99 (11.62)	12.87 (6.51)
Non-ann. days with short selling	81,488	445	4	1.42	0.18
RTH short selling (t) on ann. days	2,183	25,920	2,284		
RTH short selling (t+1) on ann. days	2,183	55,733	4,511		
RTH short selling on non-ann. days	81,488	30,485	2345		

Table 3

Excess returns to short sellers during BMO and AMC periods using opening and closing price.

For each stock-day during RegSHO period from January 2011 to October 2016, we compute the return of each short sell trade that occurred during after-hours using the short sale price and the opening (closing) price as follows:

$$r_{ss} = \left(Price_{Short\ sell} - Price_{open(close)}\right) \Big/ Price_{open(close)} \ X\ 100$$

For BMO (AMC) session, $price_{open}$ is the opening price of the same day (next day). For BMO (AMC) session, $price_{close}$ is the closing price of the same day (next day). For both BMO and AMC sessions, we compute the average return for each stock-day by weighing the return of each short sale trade by the size of the trade. We keep only those announcement days with at least 10 short trades during the BMO/AMC session. We calculate excess return as r_{ss} minus the value-weighted market return. Next, we take average of returns across all earnings announcement days and across all non-announcement days. We report these numbers in column 3. In column 6, we present the closing returns. We also report these numbers separately for announcements with negative surprise and for announcements with positive surprise.

		Opening excess return in %			Closing excess return in %		
	N	Mean	Median	Std	Mean	Median	Std
BMO							
Ann.	1,963	0.27***	-0.01	2.94	0.82***	0.33	5.99
Non-ann.	36,796	0.24***	0.05	3.20	0.60***	0.10	5.76
Difference		0.05			0.22		
Negative surprise	562	0.48***	0.05	3.80	1.48***	0.49	6.97
Positive surprise	1,401	0.19***	-0.02	2.51	0.55***	0.23	5.53
Difference		0.29*			0.93***		
AMC							
Ann.	3,397	0.87***	0.05	6.71	1.40***	0.38	9.18
Non-ann.	12,959	0.05	-0.10	4.78	0.26***	-0.06	6.09
Difference		0.82***			1.14***		
Negative surprise	823	3.14***	1.71	7.60	3.92***	2.19	10.41
Positive surprise	2,574	0.15	-0.38	6.23	0.59***	-0.25	8.60
Difference		2.99***			3.33***		

***, **, and * represent significance at 1%, 5% and 10% respectively.

Table 4

Return regression

In this table, return for each after-hour short sell trade is computed using opening price and closing price. For both BMO and AMC sessions, we compute the average return for each stock-day by weighing the return of each short sale trade by the size of the trade. We keep only those announcement days with at least 10 short trades during the BMO/AMC session. We calculate excess return as r_{ss} minus the value-weighted market return. We use the average excess return as the dependent variable in the following regression:

$$Opening\ (Closing)\ excess\ return\ to\ short\ sellers(r_{ss})\% = \alpha + \beta_1 Negative\ surprise + \beta_2 Short\ volume\ ratio + \beta_3\ Return_{t-1} + \beta_4\ Return_{t-2} + \beta_5 \log Market\ capitalization + \varepsilon$$

Negative surprise is a dummy variable that takes a value for negative surprise stock-days, and 0 otherwise. *Short volume ratio* is BMO/AMC short volume scaled by short volume during RTH in Panel A. $Return_{t-1}$ and $Return_{t-2}$ are the stock returns on day *t-1* and day *t-2*, respectively. In Panel A, we use the opening return as the dependent variable. In Panel B, we use closing return as the dependent variable.

Panel A: Dependent variable: Opening excess return to after-hours short selling%

	AMC announcements			*BMO announcements*		
	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 5*	*Model 6*
Intercept	0.0015	-0.0031**	0.0545***	0.0019***	-0.0006	0.0262***
Negative surprise	0.0299***	0.0297***	0.0279***	0.0029*	0.0025	0.0016
Short volume ratio		0.0683***	0.0727***		0.0963***	0.0827***
$Return_{t-1}$			0.0761			-0.0540
$Return_{t-2}$			0.0842*			-0.0095
Log (Market cap)			-0.0037***			-0.0016***
Adjusted R Square	0.0362	0.0429	0.0533	0.0015	0.0284	0.0388
No of Observations	3,397	3,397	3,397	1,343	1,343	1,963

Panel B: Dependent variable: Closing excess return to after-hours short selling%

	AMC announcements			*BMO announcements*		
	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 5*	*Model 6*
Intercept	0.0059***	0.0007	0.1078***	0.0055***	0.0019	0.0812***
Negative surprise	0.0333***	0.0330***	0.0294***	0.0094***	0.0087***	0.0062*
Short volume ratio		0.0795***	0.0871***		0.1402***	0.0963***
$Return_{t-1}$			0.0332			0.0891*
$Return_{t-2}$			0.1085			0.0039
Log (Market cap)			-0.0069***			-0.0048***
Adjusted R Square	0.0238	0.0286	0.0454	0.0045	0.0179	0.0408
No of Observations	3,397	3,397	3,397	1,343	1,343	1,963

***, **, and * represent significance at 1%, 5% and 10% respectively.

Table 5

Future returns by predictive/reactive short selling quintiles

We create AHT reactive short selling quintiles based on BMO/AMC short selling (as a % of shares outstanding following Alexandar, Peterson, Beardsley (2014)). We also create quintiles based on reactive and predictive short selling during RTH as a % of shares outstanding. For BMO (AMC) announcements, we use RTH short selling on day *t-1 (t)* for RTH predictive short selling. For RTH reactive short selling, we use RTH short selling on day *t (t+1)* for BMO (AMC) announcements. We report the future returns for these quintiles in columns 2 through 6, and the difference between quintile 1 and quintile 5 in the last column.

Panel A: BMO Announcements						
	Q1	Q2	Q3	Q4	Q5	Q1-Q5
Sorting based on predictive short selling during RTH as a % of shares outstanding						
% short selling (t-1)	0.01%	0.04%	0.08%	0.13%	0.35%	
1-day return	-0.19%	0.17%	0.13%	0.13%	-0.25%	0.06%
2-day return	-0.12%	0.23%	0.21%	0.20%	-0.13%	0.01%
5-day return	-0.60%	0.44%	0.09%	0.66%	-0.06%	-0.54%
Sorting based on reactive short selling during BMO as a % of shares outstanding						
% short selling (t)	0.001%	0.002%	0.004%	0.011%	0.068%	
1-day return	0.03%	-0.23%	-0.48%	-0.44%	-0.78%	0.81%**
2-day return	0.08%	-0.07%	-0.50%	-0.20%	-0.89%	0.97%**
5-day return	0.28%	-0.05%	-0.50%	-0.24%	-1.01%	1.29%**
Sorting based on reactive short selling during RTH as a % of shares outstanding						
% short selling (t)	0.02%	0.07%	0.14%	0.24%	0.67%	
1-day return	0.09%	-0.08%	0.03%	0.10%	0.04%	0.05%
2-day return	0.00%	-0.12%	0.00%	0.07%	0.00%	-0.01%
5-day return	-0.32%	0.07%	0.11%	0.60%	-0.02%	-0.30%
Panel B: AMC Announcements						
Sorting based on predictive short selling during RTH as a % of shares outstanding						
% short selling (t)	0.04%	0.14%	0.17%	0.28%	0.62%	
1-day return	-0.45%	0.18%	0.12%	0.15%	-0.71%	0.26%
2-day return	-0.50%	0.15%	0.30%	0.20%	-0.60%	0.10%
5-day return	-0.84%	0.02%	0.35%	0.21%	-0.39%	-0.45%*
Sorting based on reactive short selling during AMC as a % of shares outstanding						
% short selling (t)	0.00%	0.01%	0.02%	0.04%	0.15%	
1-day return	0.06%	-0.03%	-0.26%	-0.37%	-0.69%	0.75%***
2-day return	0.20%	0.01%	-0.14%	-0.43%	-0.82%	1.02%***
5-day return	0.26%	-0.16%	-0.42%	-0.20%	-0.87%	1.13%***
Sorting based on reactive short selling during RTH as a % of shares outstanding						
% short selling (t+1)	0.02%	0.07%	0.14%	0.26%	0.76%	
1-day return	-0.44%	-0.01%	0.19%	0.03%	0.03%	-0.47%***
2-day return	-0.61%	0.01%	0.14%	0.07%	0.05%	-0.66%***
5-day return	-0.87%	-0.16%	0.31%	0.12%	0.27%	-1.15%***

***, **, and * represent significance at 1%, 5% and 10% respectively.

Table 6

Weighted price contribution with and without after hours short selling.

We compute the WPC for close-to-open period as:

$$WPC_{co} = \sum_{s=1}^{s} \left[\left(\frac{|ret_s|}{\sum_{s=1}^{s} |ret_s|} \right) \left(\frac{ret_{co,s}}{ret_s} \right) \right]$$

where $ret_{co,s}$ for BMO (AMC) is based on closing price of the previous day (earnings announcement day) and opening price of the earnings announcement day (next day). ret_s for BMO (AMC) is based on closing price of the previous day (announcement day) and closing price of the announcement day (next day). In Panel A, we report the WPC_{co} separately for days without short selling activity, for days with short selling activity, and the difference between the two. We report these numbers for both BMO and AMC sessions. In Panel B, we divide BMO (AMC) earnings announcement days with at least 10 short trades during BMO/AMC period in quintiles using BMO (AMC) short selling volume ratio. Short selling volume ratio is defined as the BMO/AMC short volume scaled by short volume during RTH. For our analysis, we calculate WPC_{co} by taking average across stock-days in each quintile. In columns 2 to 6, we report the WPC_{co} for each quintile. In column 7, we report the difference between the quintiles with highest and lowest short volume ratio.

Panel A: BMO/AMC Short selling

	No short selling	Short selling	Difference
The BMO Sub-Sample	0.33	0.59	0.26***
The AMC Sub-Sample	0.43	0.69	0.26***

Panel B: BMO/AMC short selling volume ratio quintile

	Lowest	2	3	4	Highest	Highest-Lowest
The BMO Sub-Sample	0.54	0.64	0.68	0.82	0.91	0.37***
The AMC Sub-Sample	0.71	0.72	0.78	0.83	0.86	0.15***

***, **, and * represent significance at 1%, 5% and 10% respectively.

Table 7

Weighted price contribution regression.

We compute the WPC for close-to-open period as:

$$WPC_{co} = \sum_{s=1}^{s} \left[\left(\frac{|ret_s|}{\sum_{s=1}^{s} |ret_s|} \right) \left(\frac{ret_{co,s}}{ret_s} \right) \right]$$

We estimate the following OLS regression:

$$WPC_{co} = \alpha + \beta_1 Short\ volume\ ratio + \beta_2 Negative\ surprise + \beta_3\ Return_{t-1} + \beta_4\ Return_{t-2} + \beta_5 \log Market\ cap + \varepsilon$$

All the variables have been defined in previous tables.

Dependent variable: Weighted price contribution

	AMC announcements			*BMO announcements*		
	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 5*	*Model 6*
Intercept	0.0627***	0.0514***	0.2904***	0.0440***	0.0310***	0.2733***
Negative surprise	0.0341***	0.0335***	0.0248***	0.0220***	0.0198***	0.0117***
Short volume ratio		0.1698***	0.1868***		0.5057***	0.3757***
$Return_{t-1}$			-0.0124			-0.0310
$Return_{t-2}$			0.0008			-0.0958*
Log (Market cap)			-0.0154***			-0.0147***
Adjusted R Square	0.0289	0.0551	0.1469	0.0174	0.1336	0.2572
No of Observations	3,400	3,400	3,400	1,968	1,968	1,968

***, **, and * represent significance at 1%, 5% and 10% respectively

Table 8

2-day and 5-day returns to short sellers during BMO and AMC periods

For each stock-day during the period from January 2011 to October 2016, we compute the return of each AHT short trade over the next 1-day, 2-day, and 5-day period. For both BMO and AMC sessions, we compute the average return for each stock-day by weighing the return of each short sale trade by the size of the trade. We keep only those announcement days with at least 10 short trades during the BMO/AMC session. We calculate excess return as r_{ss} minus the value-weighted market return. Next, we take average of returns across all earnings announcement days and across all non-announcement days. We report these numbers in column 3. In column 4 and column 5, we present the 2-day and 5-day returns, respectively. We report these numbers separately for announcement days and non-announcement days. For announcement days, we also report these numbers separately for announcements with negative surprise and for announcements with positive surprise.

	N	1-day returns in %	2-day returns in %	5-day returns in %
BMO				
Ann.	1,963	0.82***	0.87***	1.27***
Non-ann.	36,796	0.60***	0.81***	1.26***
Difference		0.22	0.06	0.01
Negative surprise	562	1.48***	2.00***	2.69***
Positive surprise	1,401	0.55***	0.42**	0.70***
Difference		0.93***	1.58***	1.99***
AMC				
Ann.	3,397	1.40***	1.51***	1.84***
Non-ann.	12,959	0.26***	0.48***	0.72***
Difference		1.14***	1.03***	1.12***
Negative surprise	823	3.92***	4.32***	4.59***
Positive surprise	2,574	0.59***	0.62***	0.97***
Difference		3.33***	3.70***	3.62***

***, **, and * represent significance at 1%, 5% and 10% respectively

Table 9

Returns to short sellers during BMO and AMC periods for other subsamples.

Similar to Table 3, we compute the return of each short trade that occurred during after-hours using the short sale price and the opening (closing) price. For both BMO and AMC sessions, we compute the average return for each stock-day by weighing the return of each short sale trade by the size of the trade. We calculate excess return as r_{ss} minus the value-weighted market return. We take average of returns across all earnings announcement days. We report the mean opening and closing returns in column 3 and column 6. We also report these numbers separately for announcements with negative surprise and for those with positive surprise. In Panel A, we present the results for top 250 stocks and in Panel B, we present the results for top 250 Nasdaq stocks.

		Opening return			Closing return		
	N	Mean	Median	Std	Mean	Median	Std
Panel A: Top 250 stocks by volume							
BMO							
Ann.	1,028	-0.03	-0.05	1.39	0.16	0.11	3.53
Negative surprise	238	-0.06	-0.04	1.33	0.29	0.20	3.45
Positive surprise	790	-0.01	-0.05	1.41	0.12	0.11	3.56
Difference		-0.05			0.17		
AMC							
Ann.	1,181	0.31**	-0.06	4.38	0.39*	-0.22	5.96
Negative surprise	221	1.41***	0.97	4.42	1.52***	0.91	6.38
Positive surprise	960	0.05	-0.28	4.34	0.12	-0.42	5.83
Difference		1.36***			1.40***		
Panel B: Top 250 Nasdaq listed stocks by volume							
BMO							
Ann.	262	0.34*	0.00	2.89	0.57**	-0.18	6.21
Negative surprise	54	0.22	0.09	3.61	1.16	0.48	6.85
Positive surprise	208	0.38**	-0.07	2.69	0.42	-0.35	6.05
Difference		0.15			0.74		
AMC							
Ann.	1,531	0.30	-0.23	5.71	0.42	-0.32	7.56
Negative surprise	289	2.07***	1.47	5.99	2.04***	1.28	7.99
Positive surprise	1,242	-0.11	-0.46	5.56	0.04	-0.65	7.41
Difference		2.18***			2.00***		

***, **, and * represent significance at 1%, 5% and 10% respectively

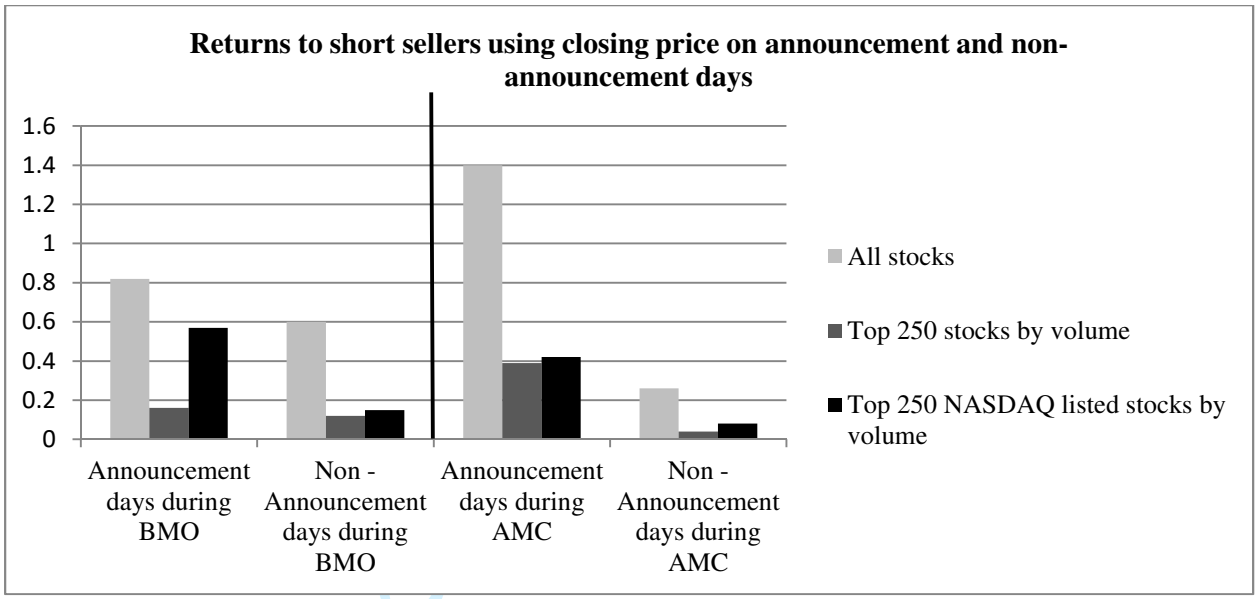

Figure 1: Returns to short sellers during BMO and AMC periods using closing price. For each stock-day during the period from January 2011 to October 2016, we compute the return of each short sell trade that occurred during after-hours using the short sale price and the closing price as follows:

$$r_{ss} = {(Price_{Short\ sell} - Price_{close})}/{Price_{close}}\ X\ 100$$

For BMO (AMC) session, $price_{close}$ is the closing price of the same day (next day). For both BMO and AMC sessions, we compute the average return for each stock-day by weighing the return of each short sale trade by the size of the trade. We calculate excess return as r_{ss} minus the value-weighted market return. Next, we take average of returns across all earnings announcement days and across all non-announcement days. The first three bars present the return during BMO session on announcement days for all stocks, top 250 stocks by volume, and top 250 Nasdaq listed stocks by volume, respectively. The next three bars are for returns during BMO session on non-announcement days. The next six bars are for similar returns during the AMC session.

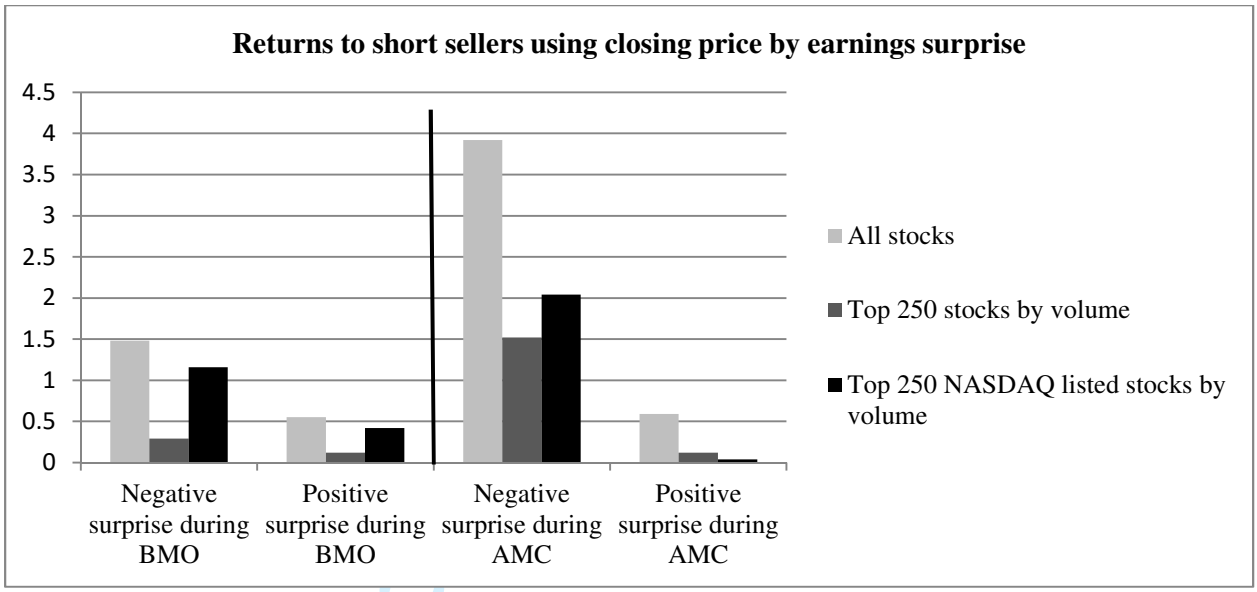

Figure 2: Closing returns to short sellers by earnings surprise. For each stock-day during the period from January 2011 to October 2016, we compute the return of each short sell trade that occurred during after-hours using the short sale price and the closing price as follows:

$$r_{ss} = {(Price_{Short\ sell} - Price_{close})}/{Price_{close}}\ X\ 100$$

For BMO (AMC) session, $price_{close}$ is the closing price of the same day (next day). For both BMO and AMC sessions, we compute the average return for each stock-day by weighing the return of each short sale trade by the size of the trade. We calculate excess return as r_{ss} minus the value-weighted market return. Next, we take average of returns across all earnings announcement days with negative surprise and across all earnings announcement days with positive surprise. The first three bars present the return during BMO session on negative surprise days for all stocks, top 250 stocks by volume, and top 250 Nasdaq listed stocks by volume, respectively. The next three bars are for returns during BMO session on positive surprise days. The next six bars are for similar returns during the AMC session.