Do Short Sellers Front-Run Insider Sales?

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ABSTRACT: We study the behavior of short sellers as informed market participants and examine potential sources of their information. Using a newly available dataset with high-frequency short sales data, we find evidence of significant increases in short sales immediately prior to large insider sales, but not prior to small insider sales. We examine a number of explanations that the increase in short sales is driven by public information, either about the firm or about the impending insider sale. The evidence is inconsistent with these explanations, but is consistent with front-running facilitated by leaked information. The front-running appears to be concentrated in firms with poor accounting quality, suggesting that information about a large insider sale reinforces short sellers' adverse opinion about firm value when accounting quality is poor.

Keywords: Short Selling; Insider Sales; Front Running; Information Leakage.

JEL Classifications: G14, G18, G30, M41

The Accounting Review, forthcoming.

I. INTRODUCTION

A large prior literature studies the trades of informed market participants such as firm insiders (Ke et al. 2003; Piotroski and Roulstone 2005; Jagolinzer 2009), short sellers (Desai et al. 2006; Drake et al. 2011), analysts, institutional investors, and others. Insiders are generally considered the most informed because they have access to non-public information. Short sellers are considered particularly well-informed and sophisticated investors (Diamond and Verrecchia 1987; Boehmer et al. 2008; Desai et al. 2006; Drake et al. 2011). In this study we examine: (1) how informed short sellers are, relative to insiders; and (2) whether short sellers' information is likely from public or non-public sources. Specifically, we examine whether short sellers trade ahead of, or following, insider sales.

Our study is facilitated by newly available high frequency short sales data. The intra-day transaction data, disclosed (monthly, not in real time) by NYSE pursuant to Regulation SHO, are publicly available from January 2005 to May 2007. In contrast, the prior literature has generally used *monthly* short interest data (total short interest at one point in time, not transaction data for the month), or in very few instances has used proprietary transaction data. By combining daily short selling with daily insider sales data, we are able to take advantage of the higher frequency data to conduct an event study of short sales around insider sales.

We document significantly positive abnormal short sales in the days leading up to large insider sales, peaking sharply on the day of the large insider sale. We define a large insider sale as the top 30 percent of all insider sales as a proportion of firm value. For small insider sales (the bottom 30 percent of insider sales), we do not observe abnormal short sales prior to the insider sale, but rather, we observe abnormal short sales two days after the insider sale.

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Insiders are required to disclose their trades to the SEC on Form 4 within two business days of the trade in the post-Sarbanes Oxley period covered by our sample (e.g., Brochet 2010), and the SEC makes Form 4 publicly available online in real time. We expect the SEC filing date is when the general public first becomes aware of the insider trade. When we examine short sales around the Form 4 filing date, we find significantly positive abnormal short sales peaking the day before the filing date for large insider sales, but after the filing date for small insider sales.

Collectively, the evidence is consistent with short sellers front-running insider sales. Front-running refers to trading by some parties in advance of large trades by other parties, in anticipation of profiting from the price movement that follows the large trades. The price impact is expected to occur if the insider sale carries information about the firm's future fundamental performance. The price impact could also occur mechanically from price pressure resulting from short-run liquidity effects generated by the large trade or long-run downward sloping demand for the stock.

Front-running can occur when, for example, some parties are tipped off about an impending large sale or a brokerage trades on its own account prior to executing a client's large trade. Large (or block) trades face a latent demand problem in that large orders are not easily filled and therefore have to be shopped in order to discover demand. However, traders risk exposing the order in the course of shopping it. Order exposure is risky because it allows information about the order to be leaked, thereby creating an opportunity for front-running (Harris 2003).

The existence of front-running has long been suspected on Wall Street, with allegations that bank or brokerage employees were leaking information about large upcoming trades to

favored clients such as hedge funds. The SEC opened a sweeping investigation in 2007 by requesting detailed data from a number of major Wall Street banks about stock trades made on their own accounts or client accounts (Anderson 2007; Scannell and Smith 2007). Numerous regulatory enforcement actions suggest how front-running is facilitated. For example, in 2008, the SEC began looking at whether several Merrill Lynch employees "improperly placed trades for the brokerage house's own account ahead of client orders" in a practice "known as front-running" (Scannell 2008, C1). In addition, the SEC recently charged Merrill Lynch with improper control of access to institutional customer order flow (SEC 2009, 1):

> According to the SEC's order instituting proceedings, Merrill Lynch utilizes institutional equities "squawk boxes," which are internal intercom systems used by broker-dealers to broadcast institutional customer order information to traders and sales traders at the broker-dealer. From 2002 to 2004, several Merrill Lynch retail brokers at three branch offices permitted day traders at other firms to listen to confidential information on large unexecuted block orders of Merrill Lynch's institutional customers. The Merrill Lynch brokers put their telephones next to the squawk boxes and let the day traders listen to the squawk box, often for the entire trading day. The day traders used the broadcasts to trade ahead of the orders placed by Merrill Lynch's customers.

As another example, the Ontario Securities Commission and the Alberta Securities Commission in Canada recently charged information technology staff at two companies with snooping on confidential emails of corporate insiders and trading on this information (McFarland 2009). Finally, a former director and head of the New York Mercantile Exchange's Compliance Committee recently pleaded guilty to delaying his clients' orders so that he could trade ahead of them (Hargreaves 2008), while an analyst was dismissed for surreptitiously distributing research to hedge fund clients before his report was published (Schecter 2008). In these examples, the information is not leaked by the investor making the trade. Rather, the leakage appears to occur when the information about the upcoming trade is intercepted in the course of trade execution.

We further examine the role of accounting quality in front-running. Holthausen and Verrecchia (1988) suggest that, when a firm's prior accounting information quality is poor (good), investors revise their beliefs relatively more (less) in response to new information. Empirically, Veenman (2012) finds that insider trades trigger stronger stock market reaction when a firm's prior accounting information quality is poor, suggesting that insider trades reinforce or disconfirm investors' beliefs more for such firms. In addition, Desai et al. (2006) show that short sellers target firms that subsequently restate earnings, suggesting that short sellers consider accounting information quality in their decision process.

We therefore examine whether short sellers' response to intercepted information about an upcoming large insider sale is conditioned on the firm's accounting information quality. In particular, firms with poor accounting information quality are likely associated with greater information asymmetry between insiders and outsiders (e.g., Baiman and Verrecchia 1996), and greater divergence of opinion among investors about the firms' equity value. If information about an upcoming large insider sale reinforces short sellers' adverse priors about a firm with poor accounting information quality, we expect heightened front-running of large insider sales for such firms.

We use a number of different measures of a firm's accounting information quality, including accrual quality (the AQ measure of Dechow and Dichev 2002), the presence of R&D (Aboody and Lev 2000), the magnitude of stock market reaction to past quarterly earnings announcements (Huddart and Ke 2007) and the relative frequency of past quarterly losses (Huddart and Ke 2007). Across all four measures, front-running is generally stronger when accounting information quality is poor (i.e., when information asymmetry is high), suggesting short sellers consider accounting information quality in their investment decision, and that news

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of an upcoming insider sale reinforces short sellers' adverse opinion of equity value when accounting quality is poor.

In order to examine whether front-running is profitable, we test for abnormal returns in the short window after large insider sales. We find two signals that help to identify large insider sales that can be profitably front-run: (1) large sales by insiders at firms with poor AQ (Dechow and Dichev 2002) are followed by negative abnormal returns of about 3 percent in the subsequent twenty trading days, and (2) large insider sales identified as opportunistic (or non-routine) by the Cohen et al (2012) algorithm are followed by negative abnormal returns of about 1.5 percent in the subsequent twenty trading days.

Because our data do not allow us to establish directly the source of the front-runners' information, we examine an array of alternative explanations for short sales leading insider sales, as described in detail in Section VIII. In particular, one set of potential explanations includes the presence of adverse public information, or other confounding news events such as dividend, acquisition, or litigation announcements (among others), in the short window preceding the insider sales. Accordingly, we conduct a detailed Factiva search and hand-collect information about news events in the week prior to the insider sale for half our sample. After dropping observations with news events, we continue to find front-running of large insider sales in the selected sample. Overall, we find that the evidence is inconsistent with all the alternative explanations we examine.

Front-running facilitated by inappropriately acquired information distorts the playing field for market participants and can create adverse selection problems that limit market participation and inhibit efficient capital allocation (Harris 2003). Information leakage can be curtailed by regulatory enforcement action, or by "shining light" through more timely disclosure

of short sales by exchanges. Exchanges disclose the level of short interest once a month in our sample period,[1] which only provides a snapshot. This is a topical issue, as the SEC has recently considered requiring more timely disclosures (SEC 2008). However, regulators must also consider the costs of higher frequency disclosures by exchanges, on which we provide no evidence.

While our evidence is more consistent with information leakage than with any of the alternative explanations we examine, providing definitive proof is beyond the scope of our data. This challenge of conclusive proof is similar to that faced in Christie and Schultz (1994), who find that odd-eighths quotes on NASDAQ appeared more infrequently than statistically expected. They interpret this evidence as suggestive of price fixing or collusion by NASDAQ dealers but were constrained by the scope of their data from providing definitive proof. Similarly, Lie (2005) finds that options awards occur at the lowest price in the period around options grant dates and interprets this as suggesting options were backdated *ex post*.

Section II discusses our motivation and related literature. Section III describes our data and sample. Section IV describes our event studies of short sales around insider sales. Section V describes regression-based tests. Section VI describes tests examining whether short-sellers front-run large insider sales when the firm's (accounting-based) information environment is poor. Section VII examines the profitability of front-running. Section VIII discusses alternative explanations, and Section IX concludes.

II. MOTIVATION AND RELATED LITERATURE

Short sellers (including hedge funds) are considered particularly well-informed and sophisticated investors, and corporate insiders are generally considered the most informed due to

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[1] NYSE now reports twice a month.

their access to non-public information. Examining the lead-lag relation between the trades of the two groups is thus a powerful setting to study whether short sellers' information is from public or non-public sources.

Examining front-running of insider sales has a number of advantages. First, insiders' Form 4 filings allow us to identify the exact date of sale and thereby to conduct an event study of short sales around the insider sale date. Second, because insiders are likely the most informed of traders, trading in advance of insiders is unlikely to be due to superior information. This rules out attribution of the front-running to superior information. Below, we briefly discuss related literature to place our study in context.

Front-Running

Front-running is frequently alleged in practitioner circles, and was widely believed to have occurred around the Long Term Capital Management debacle of 1998. The empirical literature on front-running is relatively small, likely due to the difficulty of directly testing for front-running and the absence of relevant and publicly available data. Chen et al. (2008) present indirect evidence consistent with hedge funds front-running fire sales by distressed mutual funds, although they do not examine what mechanisms facilitate the front-running. Chakravarty and Li (2003) use proprietary audit trail transaction data, and suggest that dual traders at the Chicago Mercantile Exchange do not engage in front-running.

Short Selling

A number of studies suggest that short sellers are informed traders, by showing that short sales predict returns (Desai et al. 2002; Asquith et al. 2005; Boehmer et al. 2008; Diether et al. 2009). Other studies suggest short sellers exploit predictable mean-reversion in valuation multiples (Dechow et al. 2001), anticipate adverse news in earnings announcements (Christophe

et al. 2004) and earnings restatements (Desai et al. 2006), and are relatively more informed than analysts (Drake et al. 2011), consistent with short sellers being sophisticated or informed investors. However, Daske et al. (2005) assert that short sellers do not anticipate bad news events and are therefore unlikely to be informed traders.

Evidence on whether short sellers are informed is important because it bears on: (1) a potential cost, through loss of value-relevant information, of restricting short sales (Diamond and Verrecchia 1987; Ofek and Richardson 2003); and (2) a potential benefit of higher frequency disclosures of short sales, such as outstanding daily or weekly short interest (Aitken et al. 1998; Christophe et al. 2004).

Insider Trading

There is an extensive literature on insider trading. One related branch is the literature on return predictability of insider sales. The evidence in Seyhun (1986, 1998), Damodaran and Liu (1993), Jagolinzer (2009) and Cohen et al. (2012) suggests that insider sales predict negative abnormal returns,[2] and the evidence in Ke et al. (2003) and Piotroski and Roulstone (2005) suggests that insider trades predict the firm's future earnings performance.

If large insider sales carry more information, front-running or information leakage is more likely for large insider sales. Seyhun (1986, 1998) shows that larger insider sales (as a proportion of firm value) result in more negative abnormal stock returns, while Datta and Iskandar-Datta (1996) show that the size of the insider sale is a signal used by bond traders in identifying information-motivated insider sales.

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[2] However, Lakonishok and Lee (2001) and Jeng et al. (2003) do not find evidence that insider sales predict negative returns.

III. DATA AND SAMPLE

Data and Variable Definitions

We obtain daily returns, prices and shares outstanding from CRSP, and annual accounting data from Compustat. We obtain intra-day short sales transactions data from the NYSE TAQ database that reports short sales on NYSE from January 2005 through May 2007, pursuant to Regulation SHO. We aggregate intraday data to obtain daily short sales data. Insider trading data are from the Thomson Financial Insider database. All variable definitions are presented in the notes to Table 2.

Sample

Table 1 describes the sample selection procedure. We start with all open market insider sales as reported to the SEC in Table 1 of Form 4 (Seyhun 1998; Ke et al. 2003), where the insider is the CEO. We then delete insider trading records assigned a cleansing code of "A" or "S" by Thomson Financial (Narayanan and Seyhun 2008).[3] After merging the different datasets, ensuring that we have an estimation window for all insider sales events, eliminating insider sales events that have earnings announcements within 15 trading days, and eliminating insider sales that do not fall on the first day of the sale, we are left with a final sample of 2,030 insider sales events. Some insider sales are executed over multiple days. In such cases, we measure the size of the insider sale based on first day sales, but the results are robust when we measure size based on sales summed over up to five consecutive days.[4]

[Insert Table 1 about here]

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[3] According to Thomson Financial, these cleansing codes identify observations for which: (1) collection requirements were not met; (2) numerous data elements were missing or invalid; or (3) reasonable assumptions could not be made.

[4] The correlation between the size of the insider sale measured based on first day or multiple consecutive day sales is large (over 0.9).

Table 2, Panel A reports descriptive statistics for the full sample. The mean firm *size* of 7.84 implies a mean market value of about $2.5b, so the firms in our sample are large firms on average. The mean *market/book* is 3.85, suggesting the presence of some growth firms. The mean of *Average Daily Short Sales* is 0.19 percent, while the mean *Event Date Short Sales* is 0.20 percent. This suggests short sales are higher on the insider sale date than on other days by about 0.01 percent of shares outstanding in the full sample. The mean of *Average Daily Short Transactions* is 449, while the mean *Event Date Short Transactions* is 538, indicating that the number of short sale transactions increases by about 20 percent on average on insider sale dates. The mean *Insider Sales* is 0.06 percent of shares outstanding, but 8.13 percent of trading volume. Finally, the mean *Frequency of Insider Sales* is 3.2 distinct sales events per firm over the entire sample period.

Panel B (C) of Table 2 shows descriptive statistics for large (small) insider sales, where we define large (small) sales as the top (bottom) 30 percent of insider sales as a percent of firm market value. Mean insider sales are 19.38 percent of normal daily trading volume for large sales but 1.24 percent of daily trading volume for small sales. Firm size and shares outstanding are smaller and market/book ratios are larger for the large insider sale sample than for the small insider sample, suggesting firms in the large insider sale sample are relatively smaller and have higher expected growth than firms in the small insider sale sample. The mean of *Event Date Short Sales* is 0.27 percent (0.18 percent) for the large (small) insider sale sample, while the *Average Daily Short Sales* is 0.21 percent (0.18 percent) for the large (small) insider sale sample. This implies that short sales increase by 0.06 percent of shares outstanding on large insider sales dates, but do not increase on small insider sales dates. Finally, the mean *Frequency of Insider*

Sales is 1.8 (2.7) for the large (small) insider sales sample, indicating that CEOs at firms in the large insider sale sample trade less frequently than those in the small insider sale sample.

[Insert Table 2 about here]

In untabulated results we find that neither short sales nor insider sales appear concentrated in any month, which is inconsistent with any calendar time-based explanation (e.g., tax) for the pattern of shorts leading insiders that we document in the next section. In addition, the sample is not dominated by any particular industry.

IV. EVENT STUDIES

Short Sales around the Insider Sale Date

We conduct an event study of short sales around insider sales using the methodology described in MacKinlay (1997) and Campbell et al. (1997, Ch. 4). The event is the insider sale, and day 0 is the day the insider sale is executed. If the insider sale is executed over multiple days, we take the first day of execution as day 0. The particular insider we consider is the CEO. Our test window is the [-10, +10] trading day window around the insider sale. The estimation window, used to estimate the normal or expected level of daily short sales, is the [-60, -11] trading day window.

We ensure that the test window is free from events that are known to affect short sales. In particular, we exclude from our sample events with earnings announcements in the [-15, +15] trading day window for two reasons: (1) Bettis et al. (2000) report that many firms restrict insiders to trading three to twelve trading days after earnings announcements, such that insider trades in this period are predictable once earnings are announced; (2) Christophe et al. (2004) show that short sales increase prior to negative earnings announcement, so it is important to

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ensure that the increasing short sales we observe are in anticipation of the insider sale rather than in anticipation of the earnings announcement. We also exclude the earnings announcement week from the estimation window, since this window is used to calculate "normal" daily short sales.

For a given firm-event, denote short sales on any day in the event window as $Sh_{i,n}$, where i indexes the day and takes any value in [-10, +10] and n indexes the firm-event. Denote short sales on any day in the estimation window as $Sh_{j,n}$, where j indexes the day and takes any value in [-60, -11]. The normal or expected level of daily short sales for any firm-event, $E(Sh_n)$, is calculated as the mean daily short sales in the estimation window:

$$E(Sh_n) = \frac{1}{J} \sum_{j=-60}^{j=-11} Sh_{j,n} \,, \tag{1}$$

where J is the number of days in the estimation window. The variance of abnormal short sales for a given firm-event is:

$$\sigma^2(e_n) = \frac{1}{J-1} \sum_{j=-60}^{j=-11} \{Sh_{j,n} - E(Sh_n)\}^2 \,. \tag{2}$$

Using these estimates from the estimation window, the abnormal short sales for a given firm-event on any day in the event window is:

$$e_{i,n} = Sh_{i,n} - E(Sh_n). \qquad i \in [-10, +10] \tag{3}$$

For statistical inference, we aggregate abnormal short sales across all firm-events for each day in the estimation window:

$$E_N(e_i) = \frac{1}{N} \sum_{n=1}^{N} e_{i,n} \,, \qquad i \in [-10, +10] \tag{4}$$

where N is the number of firm-events (=2,030 insider sales events in the case of the full sample) and $E_N(e_i)$ is the average abnormal short sales on event day i. The variance of the average abnormal short sale for day i is:

$$\sigma^2[E_N(e_i)] = (1/N^2) \sum_{n=1}^{N} \sigma^2(e_n) . \tag{5}$$

Figure 1, Panel A shows average abnormal short sales, $E_N(e_i)$, for trading days i=-10 to i=+10. Abnormal short sales increase before the insider sale and peak on the day of the sale, suggesting advance knowledge of the insider sale.

[Insert Figure 1 about here]

Short Sales around the Form 4 Filing Date

During our sample period from January 2005 to May 2007, insiders are required under the Sarbanes-Oxley Act of 2002 to report sales electronically on Form 4 within two business days of the sale, and the SEC makes Form 4 available online (through EDGAR) on the day of filing. We expect the filing date is when the sale becomes known publicly, so we examine abnormal short sales around the Form 4 filing date. The methodology is the same as described above, except that the event is the Form 4 filing date (the filing date is day 0).

Figure 1, Panel B shows average abnormal short sales, $E_N(e_i)$, for trading days i=-10 to i=+10 around the Form 4 filing date. Abnormal short sales rise sharply two days before, and peak one day before, day 0, suggesting advance knowledge of the insider sale.

Front-Running and Insider Sale Size

Large sales are likely to have larger price impact or more information content than small sales (Seyhun 1986, 1998; Datta and Iskandar-Datta 1996). If short sellers have advance knowledge of insider sales, we expect the front-running to be more pronounced for large insider sales. We therefore conduct an event study of abnormal short sales around large insider sales and around small insider sales, using the methodology described above. We split the sample into large and small insider sales, where we define large (small) sales as the top (bottom) 30 percent of insider sales as a percent of firm market value.

It is possible that large insider sales are not informative for prices if informed insiders fragment their sale in order to mask its information content (Barclay and Warner 1993) or to price discriminate (Harris 2003). We expect this is unlikely to be an issue because we use the total sale, rather than transaction size, to identify large sales.

Table 3 shows daily abnormal short sales, $E_N(e_i)$, in the [-10, +10] day window around large and small insider sales. The t-statistics are calculated using equations (4) and (5). Figure 2, Panel A provides a graphical depiction, showing that abnormal short sales are positive before a large insider sale, and have a pronounced peak on the day of the large insider sale. In contrast, there does not appear to be a relation between abnormal short sales and small insider sales in the pre-event window, but abnormal short sales on day +2 following a small insider sale are significantly positive.

[Insert Table 3 about here]

[Insert Figure 2 about here]

We repeat the analysis by examining abnormal short sales around the Form 4 filing date for large versus small insider sales. In Figure 2, Panel B, day 0 is the SEC Form 4 filing date. Panel B of Figure 2 shows the same pattern as Panel A, except that abnormal short sales show a pronounced increase two days before the SEC filing date, and peak one day before the SEC filing date, for large insider sales.

The pattern of abnormal short sales around large insider sales, contrasted with abnormal short sales around small insider sales in both panels of Figure 2, is consistent with advance knowledge of the impending insider sale.

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In our main tests described above, the number of shares sold by the insider is scaled by total shares outstanding (Seyhun 1986; Brochet 2010). We examine whether results are robust to:

(1) Scaling insider sales by normal daily trading volume (average daily trading volume in the estimation window). The correlation between insider sales scaled by shares outstanding and insider sales scaled by trading volume is large (0.84), and results remain robust;

(2) Using unscaled insider sales (i.e., the dollar amount) to identify large and small sales. In untabulated results [5] we find that abnormal short sales are significantly positive in the seven trading days before large (top 30%), but not before small (bottom 30%), unscaled insider sales. In contrast, abnormal short sales are significantly positive in the days subsequent to small, but not large, insider sales. This suggests short sellers respond to all insider sales as they find out about them. When information about large insider sales is leaked ahead of time, short sellers front-run. When information about small insider sales is discovered through the SEC filing by day +2, short sellers respond on day +3 to +7. Thus, the result is consistent with our main results and their interpretation.

Further, while our main tests identify large (small) insider sales as the top (bottom) 30% by insider sale size, the results are robust to defining large (small) insider sales as the top (bottom) quintile or decile of insider sale size.

Cross-Sectional Clustering

If insider sale events are clustered in calendar time, the t-statistics reported in Table 4 should be adjusted for cross-sectional dependence. Following MacKinlay (1997) and Campbell et al. (1997, Ch.4), we adjust standard errors for cross-sectional dependence using a portfolio

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[5] Available upon request.

approach, whereby abnormal short sales are aggregated into a portfolio if they share the same event date in calendar time.

To implement the portfolio approach, we calculate the portfolio abnormal short sales for each event day i=-10 to i=+10 as follows:

$$e_{i,p} = \frac{1}{N(i,t)} \sum_n \{e_{i,n} \mid n \in p\},$$ (6)

where p denotes a portfolio-event. In other words, p is a portfolio consisting of all firm-events that share the same event date in calendar time, and N(i,t) is the number of firm-events on calendar day t that have the same event day i. For example, if two firms x and y both have event day i=-5 on June 1, then the portfolio abnormal short sales for day i=-5 on June 1 is $\frac{1}{2}$ ($e_{-5,x}$ + $e_{-5,y}$). We then repeat this procedure for each calendar day t and each event day i. The median of N(i,t) for the large insider sale sample is 1, the mean is 2 and the standard deviation is 1.57. This evidence suggests that cross-sectional dependence is unlikely to be an issue in the results reported earlier, as we confirm next.

We use two approaches to calculate the t-statistics. For the first approach, it is useful to note that the procedure above yields a time series of portfolio abnormal short sales for each event day i. In other words, we have 21 time series of portfolio abnormal short sales, one for each event day i=-10 to i=+10. We use the time series mean and standard error to calculate the mean abnormal short sales and associated t-statistic for each event day i, in the spirit of Fama and MacBeth (1973). We find that the results in Table 3 are virtually unchanged, suggesting cross-sectional dependence is not an issue in our event studies.

Under the second approach, we estimate the average abnormal short sales on event day i and the variance of abnormal short sales using estimation window parameters (Campbell et al.

1997). In other words, we apply the firm-event-level method outlined earlier to portfolio-events. The easiest way to see this is to replace the subscript "n" in equations (1) to (5) with "p." We find the Table 3 results are robust to this approach as well. Overall, the results suggest cross-sectional clustering is not an issue in our sample and our inferences are robust.

Alternative Normal Short Sales Model

For robustness, we consider the effect of using an alternative model of the expected or normal level of daily short sales. The normal level was previously given by equation (1). We begin by estimating the following regression in the estimation window for each firm-event:

$$Sh_{j,n} = \beta_{1,n} + \beta_{2,n}Ret_{j,n} + \beta_{3,n}Ret_{j-1,n} + \beta_{4,n}HILO_{j,n} + \beta_{5,n}HILO_{j-1,n}$$

$$+ \beta_{6,n}VOL_{j,n} + \beta_{7,n}VOL_{j-1,n} + u_{j,n} . \tag{7}$$

Ret is the firm's daily stock return, HILO is the firm's intraday stock price volatility, and VOL is the stock's daily trading volume. These control variables adjust for short sales that are driven by speculation that the stock is temporarily overpriced (if daily returns are high), by heightened intraday price volatility that affords greater opportunity for profit, or by higher trading volume that affords an opportunity to earn a liquidity premium. We do not control for firm-level characteristics such as size in equation (7) because the equation is estimated for each firm-event, and hence, each firm is its own control when we calculate abnormal short sales.

We estimate the normal or expected level of daily short sales on any event day i by fitting regression equation (7) using values of the independent variables on event day i and parameter estimates from the estimation window regression. The abnormal short sales on event day i equals the short sales on day i minus the expected short sales. The variance of abnormal short sales is estimated as the variance of $u_{j,n}$. We then proceed using the firm-event-level methodology outlined earlier, applied to the portfolio-level to control for cross-sectional

clustering. The results suggest abnormal short sales are significantly positive on event days 0, -1 and -4 for large insider sales, but there is no evidence of front-running in the small insider sales sample.

We also use the Fama and MacBeth (1973) approach to control for cross-sectional correlation in calculating the t-statistics, as described in Section IV ("first approach"), and find significantly positive abnormal short sales on days -1 and -4 for large insider sales. Overall, these results suggest our inferences are robust.

V. REGRESSION-BASED TESTS

As an alternative to the event study methodology, we use a regression-based approach. We estimate event-specific regressions as given in equation (7), but we add an event indicator variable that is 1 in the [-5, 0] trading day window before the insider sale, and 0 in the [-60, -11] day estimation window. Therefore, each regression has 56 observations (6 days from the event window and 50 days from the estimation window). The variable of interest is the event indicator.

Table 4 reports mean coefficients from these regressions, and t-statistics based on the standard error of the mean coefficient across the regressions. The table shows a significant event effect for the large insider sales sample, but not for the small insider sales sample. This finding indicates that, for large insider sales, short sales are significantly higher in the [-5, 0] day window than in the [-60, -11] day estimation window, where day 0 is the insider sale date. To address potential cross-sectional dependence concerns with the t-statistics reported in Table 4, we note that the regression-based test is very similar to the test described in Section IV. Since the test in Section IV was implemented at the portfolio level and yielded robust inferences, we

expect the significance levels in Table 4 are robust. However, we conduct randomization tests described below to test robustness.

[Insert Table 4 about here]

We conduct randomization tests as follows: (1) recall that for a given insider sale event, we have 56 days associated with the event, 50 days in the estimation window and six days in the event window. We start by *redefining* the event indicator as 1 for six randomly selected days out of the original estimation window of 50 days, and 0 for all other days (including the true event days); (2) we do the same for all insider sale events, and then run 608 regressions, one for each of the 608 large insider sale events; (3) we compute the mean of the 608 event indicator coefficients, and the t-statistic based on the standard error of the 608 coefficients. This yields one t-statistic that we can compare to the t-statistic of 2.82 reported in Table 4; (4) we repeat this procedure 1000 times, to obtain 1000 t-statistics.

In the 1000 trials, we find that a t-statistic of 2.82 has a probability less than 0.001, and the probability of obtaining a t-statistic greater than 1.64 is 0.015. This suggests the significant mean event indicator coefficient reported in Table 4 is due to a strong "treatment effect" rather than simply chance.

We verify that the Table 4 result is robust to excluding day 0 and defining the event indicator as 1 in the [-5, -1] day window, in order to ensure that the significant event indicator for large insider sales is not driven by the heightened short sales on day 0. The event indicator coefficient in this case is 0.008 with a t-statistic of 2.23 (one-tailed $p<0.05$). We also define the event indicator as 1 in the [-3, -1] day window. The event indicator coefficient in this case is 0.006 with a t-statistic of 1.45 (one-tailed $p<0.10$). Finally, when we define the event indicator

as 1 in the window [-10, 6], we obtain an insignificant coefficient of 0.002 (t = 0.64), suggesting short sales on days -6 to -10 are not abnormally high.

Overall, the regression result is consistent with the event studies of Section IV, and suggests advance knowledge of insider sales.

VI. EFFECT OF THE FIRM'S ACCOUNTING INFORMATION QUALITY

Poor quality accounting information is likely associated with greater information asymmetry between the firm and outsiders (Baiman and Verrecchia 1996; Skaife et al. 2012) and greater divergence of opinion among investors about the firm's equity value. If intercepted information about an upcoming large insider sale reinforces short sellers' adverse opinion of firms with poor accounting quality, we expect heightened front-running of large insider sales for such firms.

Several studies suggest the importance of a firm's accounting information quality in interpreting newly arriving information that is potentially value-relevant. For example, theoretical work by Holthausen and Verrecchia (1988) shows that, when the prior information set is of poor quality, new information allows greater revision of investors' prior cash flow expectations (see also Verrecchia 1980). Empirically, Veenman (2012) shows that insider purchase filings trigger greater market reactions for firms with poor earnings quality, suggesting greater revision of beliefs when the accounting information environment is of poor quality (Teoh and Wong 1993; Francis et al. 2007). In addition, Desai et al. (2006) show that short sellers target firms that subsequently restate earnings, suggesting that short sellers consider accounting information quality in their decision process.

The quality of publicly available accounting information is likely negatively associated

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with information asymmetry between insiders and outsiders, and when information asymmetry is high, the insider sale is likely perceived by front-runners to be informative with respect to future firm performance (e.g., Veenman 2012). We use the following measures of information asymmetry between the firm and outsiders:

(1) the Dechow and Dichev (2002) measure of accounting quality (AQ), where a poor accrual – cash flow mapping indicates poor accounting quality. We expect poor accounting quality to be associated with higher information asymmetry;

(2) Research and Development expenses (R&D), where positive (zero) R&D expense indicates high (low) information asymmetry (Aboody and Lev 2000);

(3) the median magnitude of short-window abnormal returns around quarterly earnings announcements in the past five years (Mag_AR), where higher abnormal returns indicate higher information asymmetry (Huddart and Ke 2007);

(4) the relative frequency of quarterly losses in the last five years (Loss Freq), where higher loss frequency indicates higher information asymmetry (Huddart and Ke 2007).

For each information asymmetry measure (except R&D which is an indicator variable), we split the large insider sales sample into the top and bottom 30 percent and middle 40 percent of information asymmetry. We then examine abnormal short sales around the insider sale when information asymmetry is high versus low, and expect front-running when information asymmetry is high.

Panel A (Panel B) of Table 5 shows abnormal short sales around large insider sales when information asymmetry is high (low). Abnormal short sales are generally significantly positive in the days before a large insider sale for all high information asymmetry measures, but not for all low information asymmetry measures. This evidence suggests that short sellers respond to

information about a large insider sale by front-running more when information asymmetry is high than when it is low. In untabulated tests, we find no front-running of small insider sales for either high or low information asymmetry firms.

Overall, these results suggest the importance of accounting quality in interpreting newly arriving information. When accounting quality is poor, information asymmetry is likely high and the insider sale is perceived by some short sellers to be informative, thereby triggering front-running.

[Insert Table 5 about here]

In additional untabulated tests, we examine whether short sellers appear to anticipate changes in the firm's future fundamental performance as measured by future earnings (EPS and ROA) changes. In particular, we partition the large insider sale sample into quintiles of future earnings change (t+1 relative to t-1), and examine abnormal short sales around large insider sales for the bottom quintile of future earnings change. If future earnings changes are anticipated by front-runners, we expect front-running in the bottom quintile of future earnings changes. The results do not support such anticipation, consistent with short sellers reacting (and more strongly so when the firm's accounting quality is poor) to information that an insider is about to make a large sale without knowing the motive for the insider sale.

VII. PROFITABILITY OF FRONT-RUNNING

In this section we examine abnormal stock returns following insider sales, in order to assess whether front-running is profitable. Abnormal returns are defined as size-adjusted returns (Sloan 1996; Bradshaw et al. 2006; Veenman 2012). Table 6 shows average cumulative abnormal returns (CAR), and their t-statistics, in the [-10, -1], [0, +10] and [0, +20] trading day

windows around large and small insider sales. CAR is significantly positive in the [-10, -1] window for both large and small insider sales. This evidence suggests that (1) short selling before large insider sales does not appear to be a response to adverse public information about the firm; and (2) the similar CAR pattern prior to both large and small insider sales can not explain why short sellers front-run large, but not small, insider sales.

Table 6 also shows that CAR in the [0, +10] and [0, +20] trading day windows is insignificant. We therefore examine whether short sellers profitably condition front-running of large insider sales on additional signals. In particular, Table 5 showed that front-running of large insider sales occurs in poor accounting quality firms, so we examine whether such front-running is profitable. Table 7 shows that front-running in firms with poor AQ is profitable in both the [0, +10] and [0, +20] trading day windows following a large insider sale, yielding about 3 percent abnormal returns in the latter window. Therefore, short sellers conditioning their front-running on poor accounting information quality as measured by AQ appear to profit from front-running.

Cohen et al. (2012) develop an algorithm to identify opportunistic insider sales and show that such sales have return predictability. In this study we focus on large versus small insider sales as a front-running signal, rather than opportunistic versus routine insider sales, for two reasons. First, the large versus small insider sale classification is readily observable to any market participant, while the opportunistic versus routine classification relies on a fairly involved algorithm. Second, the opportunistic versus routine classification is new, at least to academics, and therefore it is unclear that the classification was exploited by market participants in our sample period of 2005-2007.

In order to examine whether front-runners appear to distinguish between opportunistic and routine insider sales, we sort large and small insider sales further into opportunistic and

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routine insider sales.[6] In untabulated results[7] we find that short sellers front-run large opportunistic insider sales, and do not front-run either small opportunistic or small routine inside sales, consistent with our prediction. However, inconsistent with our prediction, we find that short sellers front-run large routine insider sales. Next we examine whether opportunistic and routine large insider sales are followed by negative abnormal returns. As Table 8 shows, opportunistic insider sales in our large insider sale sample yield significant negative CAR of about 1.5 percent in the 20 trading days following the insider sale. Routine insider sales in the same sample are not followed by significantly negative CAR. We interpret the evidence as suggesting that the average front-runner does not appear to be aware of the distinction between opportunistic and routine insider sales as identified by the Cohen et al. (2012) algorithm, but front-runners who do distinguish between opportunistic and routine large insider sales can use the signal to front-run profitably. Alternatively, if short sellers are aware of the distinction between opportunistic and large insider sales, and can distinguish between them, then the result above is inconsistent with our front-running hypothesis.

Overall, the results suggest that front-running is a risky strategy, but that sophisticated short sellers who condition their front-running on poor AQ and opportunistic insider sales can gain abnormal returns.

[Insert Table 6 about here]

[Insert Table 7 about here]

[Insert Table 8 about here]

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[6] Details are available upon request. We are grateful to Cohen, Malloy, and Pomorski for sharing their opportunistic trade data.

[7] Available upon request.

VIII. ALTERNATIVE EXPLANATIONS

In this section we describe robustness tests and examine a number of competing explanations (to the explanation that front-running is facilitated by non-public information) for the pattern of short sales leading large insider sales. We test these explanations using event studies at the portfolio-level to control for cross-sectional clustering.

Confounding News Events in the Pre-Insider Sale Window

As noted earlier, our tests exclude earnings announcements from the pre-insider sale window. In order to further ensure a clean test window and rule out potential attribution of our results to confounding events, we hand-collect data by conducting a detailed Factiva search for news events in the week prior to the insider sale. In order to keep the data collection manageable, we conduct the search for our sample firms from November 2005 through November 2006 (about half the length of our full sample of 27 months). The search revealed 82 (75) news events in the week prior to the 312 large (313 small) insider sales during this period. The events are dividend announcements, M&A announcements, share repurchases, litigation, earnings restatements, options exercise by insiders, credit rating changes, asset divestitures, executive turnover, and conference calls.

Two features of the results are of note. First, there is generally no substantial difference in the frequency of any of these news events within the large insider sale sample relative to the small insider sale sample. If the pattern of short sales front-running large, but not small, insider sales were due to these confounding news events, we would expect substantially more news events in the large insider sale sample.

Second and more importantly, we exclude from our tests all observations with confounding events, and continue to find robust evidence of short sales front-running large, but

not small, insider sales in the November 2005 to November 2006 sample.[8] Overall, we conclude that confounding news events are unlikely to explain our results.

Liquidity Provision or Speculation by Contrarian Short Sellers

Table 5 shows positive cumulative abnormal returns prior to all insider sales, especially for large insider sales. Therefore, it is possible that short sellers are speculating that the stock is temporarily overpriced, or are attempting to earn a premium for providing liquidity if there is temporary buying pressure on the stock. The entirety of the evidence is inconsistent with these hypotheses for two reasons: (1) these hypotheses do not explain why insiders sell a few days later, since insiders are unlikely to trade to exploit temporary mispricing or to provide temporary liquidity (Seyhun 1998); (2) these hypotheses do not explain the differential response of short sales to the size of the insider sale. That is, they do not explain why short sales do not lead small insider sales even though abnormal returns are increasing and positive before small insider sales, nor why short sales increase two days after small insider sales when abnormal returns are non-positive and there is presumably less buying pressure.

In addition, the event study of Section IV and the regression test of Section V suggest that, in the large insider sale sample, short sales are significantly higher in the pre-insider sale window after controlling for contemporaneous and lagged stock returns, trading volume, and price volatility (proxies for the speculation and liquidity provision motives). Therefore, the contrarian short sale (for large insider sales) in the pre-insider sale window is inconsistent with liquidity provision and speculation explanations.

Inventory Management by Market Makers

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[8] Given both the low frequency of news events in the insider sales sample we examine, as well as robustness of results to dropping the relevant observations, we do not hand-collect news events for the other half of our sample.

Under this hypothesis, market makers short sell in advance of an insider sale in order to hedge their purchase from the insider. To examine this possibility, we identify short sales by market makers (labeled "exempt" in the Reg SHO data) and exclude these from our large insider sale sample.[9] We continue to find robust evidence of front-running.

Advance Information from Form 144

Under this hypothesis, short sellers legally acquire information about upcoming insider sales from insiders' Form 144 filings. We believe it is unlikely that this hypothesis explains our evidence for the following reasons. First, Form 144 identifies a proposed sale date but the insider does not have to sell on this date. The insider can sell anytime within three months of filing, or can re-file if the window expires prior to sale. This suggests the sale date can not be predicted in advance by others. Second, Form 144 identifies the number of shares expected to be sold but the insider does not have to sell this many shares, and also can sell those shares in smaller blocks on different days within three months. Thus, the amount to be sold on a particular date likely cannot be predicted by others in advance, which is required for front-running. Third, Form 144 does not have to be filed prior to every insider sale (for example, if the shares to be sold have previously been registered with the SEC), suggesting that it is not a consistent source of information.

To empirically examine this hypothesis, we use the Thomson Financial database and identify five Form 144s with proposed sales dates falling within one week before the actual sale date. Results are robust to excluding these five insider sales.

Advance Information from 10b5-1Plan Disclosures

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[9] Pilot securities under Reg SHO were excluded from the requirement to label market-maker shorts as "exempt." Therefore, market-maker shorting activity in Pilot securities is unobservable in our data. We expect this is unlikely to alter our inferences for the combined reasons that Pilot securities comprise one-third of NYSE securities and market-maker short sale activity is economically insignificant compared to non-market-maker short sale activity (e.g., Boehmer and Wu 2012).

Some corporate insiders may set up a 10b5-1 plan to sell a specified number of shares over a specified future period, according to a specified algorithm. The plan cedes execution authority to a third party, usually a broker. Such a plan provides insiders with affirmative defense against possible insider trading allegations. Public disclosure of 10b5-1 plans is not mandated, but voluntary advance disclosure is allowed in Form 8-K. Voluntary disclosures may simply disclose the existence of the plan, or may provide more details about the plan.

In a comprehensive search of all corporate 8-K filings between 2000 and 2006, Henderson et al. (2012) find only 773 disclosures. They find an additional 894 disclosures in Form 4s, but these are not relevant in our study since the Form 4 is filed after the insider sale. Of the 1,667 disclosures (i.e., 773+894) they find, more than 94 percent do not disclose sufficient details about the plan to allow front-running. Of the disclosures that provide more plan details, a sample plan in Henderson et al. (2012) does not disclose the precise date the shares are to be sold (it only specifies the number to be sold in a given month over the next twelve months). Given this evidence, we expect 10b5-1 disclosures are unlikely to be an explanation for the pattern of short sales leading large insider sales.

Further Robustness Tests

Definition of Insider

Our main tests define the CEO as the insider. To test robustness with respect to this definition, we examine large and small sales by the President, CFO and COO, and continue to find strong evidence of short sellers front-running large, but not small, sales by these insiders (the results are stronger for the President and CFO).

Sales by Other Insiders

To ensure that short sales are not responding to sales by insiders other than the CEO, who

sell just before the CEO, we exclude the 148 large CEO sales events with sales by other insiders (the top 5 executives) in the previous five trading days. Results remain robust.

Other Tests

We examine a number of other potential ways short sellers could have foreknowledge of insider sales. For example, the insider sale might occur on IPO lockup expiration dates that are publicly known, or the insider sale might occur on option vesting dates that are publicly known. We find robust results after controlling for these alternative explanations.[10]

IX. CONCLUSION

We examine short sales around insider sales and find significantly positive abnormal short sales in the days leading up to large insider sales, with the short sales peaking on the day of large insider sales. In addition, abnormal short sales are significantly positive and peak one day before the large insider sale is reported to the SEC (and therefore before the insider sale becomes publicly known). In contrast, this front-running result does not hold for small insider sales.

Further tests indicate that the front-running of large insider sales is stronger when the firm's accounting information quality is poor, suggesting that information about an upcoming insider sale reinforces some short sellers' adverse priors about firm value, likely triggering the front-running. This result is consistent with accounting information quality being useful in interpreting newly arriving information (in this case, information about the upcoming insider sale). We find that large insider sales at firms with poor accounting quality are followed by negative abnormal returns, suggesting short sellers profit from front-running such sales.

We also examine whether front-runners appear to distinguish between opportunistic versus routine insider sales as identified by the Cohen et al. (2012) algorithm, and find front-

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[10] Details are available upon request.

running of both opportunistic and routine large insider sales. Only the large opportunistic, but not routine, insider sales are followed by negative abnormal returns. We interpret this result as suggesting that the average front-runner does not appear to be aware of the opportunistic versus routine distinction as identified by the Cohen et al. (2012) algorithm. Alternatively, if short sellers are able to identify opportunistic versus routine insider sales, then the foregoing result is inconsistent with our front-running hypothesis.

We identify and test several explanations that the pattern of short sales leading insider sales is driven by public information about the impending insider sale or by public information about the firm, but the evidence is inconsistent with these explanations. This, combined with the finding that short sales lead large, but not small, insider sales, is consistent with information leakage.

A novel feature of our evidence is that we use newly public high frequency data on short sales transactions. Prior studies have used monthly short interest data, or proprietary high frequency data in a very few cases, to explore the return predictability of short sales, although, to our knowledge, no prior study has studied whether short sales front-run insider sales.

Our results have implications for the enforcement of insider information regulations. Information leakage undermines market integrity, and can lead to adverse selection problems that limit market participation and inhibit efficient capital allocation. Information leakage can be curtailed through regulatory enforcement action, or through more timely disclosure of short sales.

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TABLE 1
Sample Selection Procedure

	Number of Observations
(1) # of CEO stock sales transactions in Thomson Financial Insider database from Jan 1, 2005 to May 31, 2007	212,050
(2) Excluding cleansing code "A' and "S" and eliminating observations with missing ticker symbol	210,503
(3) Aggregating transactions by day	23,301
(4) Merging with NYSE SHO short sales data by ticker symbol and calendar time	7,836
(5) Merging with CRSP by CUSIP and calendar time	7,743
(6) Keeping transaction dates in the window March 1, 2005 to May 15, 2007	7,100
(7) Excluding earnings announcements within 15 days of insider sale	3,642
(8) Keeping only the first day of insider sales as a distinct sale	2,030
Final Sample:	2,030

TABLE 2
Descriptive Statistics

Panel A: All Insider Sale Events

	Mean	Q1	Median	Q3	StdDev
Event Date Short Transactions	538	169	351	697	590
Event Date Short Sales (%)	0.20	0.07	0.13	0.25	0.23
Insider Sales/Shares Outstanding (%)	0.06	0.01	0.03	0.06	0.20
Insider Sales/Trading Volume (%)	8.13	1.44	3.94	9.33	12.59
Firm Size	7.84	6.89	7.67	8.64	1.32
Shares Outstanding	157,787	31,999	60,691	134,121	374,194
Market/Book	3.85	1.82	2.53	3.78	6.72
Days between Transaction and Filing	3.09	1.00	2.00	2.00	17.26
Average Daily Short Transactions	449	142	295	582	476
Average Daily Short Sales (%)	0.19	0.06	0.12	0.23	0.22
Frequency of Insider Sales	3.2	1	2	4	3.94

Panel B: Large Insider Sales Events

	Mean	Q1	Median	Q3	StdDev
Event Date Short Transactions	473	171	308	613	506
Event Date Short Sales (%)	0.27	0.10	0.18	0.32	0.27
Insider Sales/Shares Outstanding (%)	0.17	0.08	0.11	0.17	0.35
Insider Sales/Trading Volume (%)	19.38	7.89	13.35	22.81	17.93
Firm Size	7.29	6.64	7.14	7.84	1.04
Shares Outstanding	71,276	29,205	45,115	70,740	96,291
Market/Book	4.11	1.82	2.55	3.50	8.00
Days between Transaction and Filing	3.90	1.00	2.00	3.00	19.29
Average Daily Short Transactions	364	118	242	452	395
Average Daily Short Sales (%)	0.21	0.08	0.14	0.26	0.24
Frequency of Insider Sales	1.8	1	1	2	1.59

Panel C: Small Insider Sales Events

	Mean	Q1	Median	Q3	StdDev
Event Date Short Transactions	737	249	531	985	728
Event Date Short Sales (%)	0.18	0.06	0.11	0.23	0.20
Insider Sales/Shares Outstanding (%)	0.01	0.00	0.01	0.01	0.00
Insider Sales/Trading Volume (%)	1.24	0.39	0.84	1.59	1.44
Firm Size	8.55	7.57	8.34	9.56	1.38
Shares Outstanding	297,870	54,699	101,636	375,620	574,280
Market/Book	3.54	1.81	2.47	3.84	5.29
Days between Transaction and Filing	3.60	1.00	1.00	2.00	24.30
Average Daily Short Transactions	639	230	454	858	590
Average Daily Short Sales (%)	0.18	0.06	0.11	0.22	0.22
Frequency of Insider Sales	2.7	1	1	2	4.68

Panel A reports descriptive statistics for the full sample of 2,030 insider sales events; Panel B (C) reports descriptive statistics for Large (Small) insider sales, defined as the top (bottom) 30% of *Insider Sales*. *Event Date Short Transactions* is the number of short sale transactions on the insider sale date. *Event*

Date Short Sales is the number of shorted shares as a percent of shares outstanding, on the insider sale date. *Insider Sales* are the shares sold by the CEO as a percent of the firm's shares outstanding (/Shares Outstanding) or as a percent of normal daily trading volume (/Trading Volume). *Firm Size* is the logarithm of firm market value at the last fiscal year-end prior to the insider sale. *Shares Outstanding* is the number of shares outstanding, in thousands. *Market/Book* is the ratio of market value divided by book value of equity at the end of the last fiscal year prior to the insider sale. *Days between Transaction and Filing* is the number of days from the first day of the insider sale to the SEC Form 4 filing date. *Average Daily Short Transactions* is the average number of daily short sale transactions in the [-60,-11] trading day window before the insider sale. *Average Daily Short Sales* is the average daily number of shares shorted as a percentage of shares outstanding, in the [-60,-11] trading day window before the insider sale. *Frequency of Insider Sales* is the number of distinct Insider Sales in the sample period.

TABLE 3
TABLE 3
Event Study of Short Sales around Insider Sales

Event Day	Large Insider Sales Sample		Small Insider Sales Sample	
	Abnormal Short Sales	t-stat	Abnormal Short Sales	t-stat
-10	0.0065	0.97	0.0042	0.82
-9	0.0031	0.46	0.0022	0.43
-8	-0.0003	-0.05	-0.0019	-0.38
-7	0.0193***	2.88	0.0026	0.52
-6	0.0166**	2.48	-0.0029	-0.57
-5	0.0177***	2.65	-0.0064	-1.26
-4	0.0220***	3.28	0.0063	1.24
-3	0.0186***	2.77	0.0012	0.24
-2	0.0133**	1.99	-0.0036	-0.70
-1	0.0280***	4.19	-0.0010	-0.19
0	0.0564***	8.41	0.0056	1.09
1	0.0295***	4.40	-0.0003	-0.07
2	0.0154**	2.30	0.0137***	2.69
3	0.0178***	2.65	0.0014	0.28
4	0.0108	1.61	0.0004	0.08
5	0.0119*	1.77	-0.0016	-0.32
6	0.0137**	2.04	0.0029	0.57
7	0.0147**	2.20	0.0081	1.58
8	0.0082	1.23	0.0104**	2.03
9	0.0156**	2.32	0.0058	1.14
10	0.0181***	2.69	0.0099*	1.92
Number of observations	608		609	

The table reports abnormal daily short sales, as a percent of shares outstanding, in the [-10, +10] day window around the insider sale (day 0). Abnormal daily short sales are the daily short sales minus the expected daily short sales. Expected daily short sales is the mean daily short sales in the [-60, -11] day window excluding the earnings announcement week. *, **, *** denotes two-tailed statistical significance of difference from 0 at 10%, 5%, and 1%, respectively. Number of observations is the number of insider sales events for the category of insider sales. Insider Sales are the shares sold by the insider as a percent of the firm's shares outstanding. Large (Small) insider sales are the top (bottom) three deciles of insider sales in the full sample.

TABLE 4
Regression Analysis of Short Sales around Insider Sales

Indep. Variables	Large Insider Sales Sample		Small Insider Sales Sample	
	Coefficient	t-statistic	Coefficient	t-statistic
Intercept	0.012***	3.18	0.015***	5.55
Event	0.011***	2.82	-0.001	-0.31
RET_t	1.657***	4.31	1.181***	18.83
RET_{t-1}	0.713***	8.73	0.743***	17.10
$HILO_t$	2.440***	7.98	2.574***	23.29
$HILO_{t-1}$	0.468***	6.33	0.299***	4.44
VOL_t	12.69***	30.75	12.43***	36.42
VOL_{t-1}	0.368*	1.87	0.339*	1.90
Number of observations	608		609	

The table reports mean coefficients from event-level regressions of daily short sales (as a percentage of shares outstanding) on the independent variables listed. A separate regression is run for each insider sale event. There are 608 (609) insider sales events in the Large (Small) insider sales sample. Large (Small) insider sales are the top (bottom) three deciles of insider sales in the full sample. Insider Sales are the shares sold by the insider as a percent of the firm's shares outstanding. *Event* is an indicator variable that is "1" if the day is in the event window [-5,0], and "0" if the day is in the [-60,-11] trading day window. Day 0 is the insider trading date. RET_t is the firm's daily stock return, and RET_{t-1} is the one-day-lagged RET. $HILO_t$, or intraday price volatility, is the difference between the highest and lowest intraday price, scaled by the average of the highest and lowest price. $HILO_{t-1}$ is the one-day-lagged HILO. VOL_t is the daily trading volume, excluding short sales. VOL_{t-1} is the one-day-lagged VOL. *, **, *** denotes two-tailed statistical significance of difference from 0 at 10%, 5%, and 1%, respectively. Number of observations is the number of regressions in the sample.

TABLE 5
Accounting Quality and Front-Running

Panel A: High Information Asymmetry

Day	AQ ab_short	t_stat	R&D ab_short	t_stat	Mag_AR ab_short	t_stat	Loss Freq ab_short	t_stat
-10	-0.0100	-0.95	0.0113	0.99	0.0372	2.03**	0.0170	1.15
-9	-0.0071	-0.58	0.0120	0.76	0.0062	0.37	0.0066	0.32
-8	-0.0049	-0.41	0.0059	0.43	0.0026	0.17	0.0022	0.12
-7	-0.0003	-0.02	0.0294	1.77*	0.0549	2.14**	0.0383	1.72*
-6	-0.0027	-0.18	0.0355	1.92*	0.0138	0.64	0.0228	0.93
-5	-0.0077	-0.55	0.0394	2.61***	0.0268	1.39	0.0362	1.70*
-4	0.0072	0.46	0.0192	1.27	0.0399	1.89*	0.0687	2.49**
-3	0.0076	0.62	0.0025	0.20	0.0250	1.28	0.0298	1.64*
-2	0.0223	1.65*	0.0119	0.81	0.0040	0.27	0.0027	0.16
-1	0.0324	2.35**	0.0381	2.36**	0.0326	1.74*	0.0312	1.56
0	0.0171	1.08	0.0500	3.57***	0.0608	3.11***	0.0656	2.93***
1	0.0124	0.92	0.0292	2.37**	0.0495	2.24	0.0679	2.72
2	0.0173	1.16	0.0244	1.68*	0.0214	1.24	0.0204	1.23
3	0.0083	0.67	0.0339	2.01	0.0345	1.71	0.0106	0.58
4	-0.0008	-0.06	0.0082	0.69	-0.0059	-0.44	-0.0035	-0.22
5	0.0125	0.76	0.0077	0.57	0.0023	0.12	0.0020	0.12
6	0.0122	0.63	0.0148	0.93	0.0224	1.05	0.0108	0.58
7	-0.0189	-1.44	0.0086	0.61	0.0077	0.42	0.0133	0.77
8	0.0011	0.08	0.0242	1.31	0.0161	0.69	0.0083	0.37
9	0.0053	0.38	0.0192	1.08	0.0488	1.91	0.0173	0.77
10	-0.0052	-0.4	0.0321	2.03**	0.0193	1.06	0.0510	2.03**

Panel B: Low Information Asymmetry

Day	AQ ab_short	t_stat	R&D ab_short	t_stat	Mag_AR ab_short	t_stat	Loss Freq ab_short	t_stat
-10	0.0101	0.76	0.0052	0.51	-0.0144	-1.30	0.0047	0.36
-9	-0.0006	-0.06	-0.0006	-0.06	-0.0041	-0.51	-0.0010	-0.10

-8	-0.0176	-2.03	-0.0018	-0.19	0.0073	0.66	-0.0170	-1.61
-7	0.0268	1.40	0.0231	1.70*	-0.0059	-0.72	0.0220	1.14
-6	0.0167	0.97	0.0086	0.76	0.0114	0.81	0.0147	1.11
-5	0.0190	1.42	0.0064	0.56	0.0172	1.31	0.0080	0.61
-4	-0.0031	-0.29	0.0177	1.33	0.0088	0.64	-0.0002	-0.02
-3	-0.0044	-0.39	0.0198	1.70*	0.0127	1.20	0.0139	0.90
-2	-0.0068	-0.69	0.0077	0.85	0.0212	1.69*	0.0049	0.45
-1	-0.0016	-0.15	0.0172	1.64*	0.0211	1.61	0.0164	1.34
0	0.0270	2.23**	0.0614	4.15***	0.0489	2.30**	0.0626	3.63***
1	0.0025	0.16	0.0260	1.95*	-0.0009	-0.08	0.0062	0.46
2	-0.0146	-1.40	0.0049	0.46	-0.0064	-0.68	0.0152	0.92
3	0.0090	0.62	0.0038	0.41	-0.0053	-0.52	0.0180	1.26
4	-0.0025	-0.22	0.0038	0.39	0.0073	0.57	0.0019	0.16
5	-0.0150	-1.30	0.0025	0.24	0.0043	0.33	-0.0038	-0.30
6	0.0112	0.76	0.0070	0.63	0.0014	0.15	0.0104	0.66
7	0.0052	0.33	0.0085	0.76	-0.0080	-0.93	-0.0007	-0.05
8	-0.0021	-0.17	-0.0039	-0.42	-0.0075	-0.89	0.0052	0.41
9	0.0206	1.36	0.0234	1.81*	-0.0075	-0.79	0.0347	1.92*
10	0.0196	1.25	0.0144	1.16	-0.0015	-0.18	0.0005	0.04

The table reports abnormal short sales around large insider sales, when information asymmetry is high (Panel A) versus low (Panel B). The insider sale occurs on day 0. Abnormal daily short sales are the daily short sales minus the expected daily short sales, scaled by shares outstanding. Expected daily short sales is the mean daily short sales in the [-60, -11] day window excluding the earnings announcement week. The information asymmetry measures are identified in the column headers. AQ is the accounting quality measure of Dechow and Dichev (2002). R&D is an indicator which equals 1 (0) if R&D is positive (zero). Mag_AR is the median magnitude of short window abnormal returns around quarterly earnings announcements in the previous five years. Loss Freq is the relative frequency of quarterly losses in the previous five years. *, **, *** denotes two-tailed statistical significance of difference from 0 at 10%, 5%, and 1%, respectively.

TABLE 6
Abnormal Stock Returns around Insider Sales

Window	Large Insider Sales Sample		Small Insider Sales Sample	
	CAR	t-stat	CAR	t-stat
[-10,-1]	0.0273	4.51***	0.0101	2.40**
[0,10]	-0.0018	-0.23	0.0007	0.16
[0,20]	0.0004	0.12	-0.0002	-0.09

The table reports cumulative abnormal returns (CAR) in the [-10, +20] day window around the insider sale (day 0). Abnormal returns are size-adjusted returns. *, **, *** denotes two-tailed statistical significance of difference from 0 at 10%, 5%, and 1%, respectively. Large (Small) insider sales are the top (bottom) three deciles of insider sales in the full sample.

TABLE 7
Accounting Quality and Profitability of Front-Running

Variables	Info Asymmetry	CAR[0,10]	t-stat	CAR[0,20]	t-stat
AQ	High	-0.0147	-1.95 *	-0.0308	-2.56***
	Low	-0.0058	-0.73	-0.0078	-0.75
R&D	High	-0.0047	-0.88	-0.0052	-0.47
	Low	-0.0013	-0.25	-0.0008	-0.10
Mag_AR	High	-0.0040	-0.47	-0.0049	-0.36
	Low	0.0037	0.44	0.0041	0.29
Loss Freq	High	0.0098	1.48	0.0071	0.46
	Low	-0.0084	-1.34	-0.0135	-1.47

The table reports cumulative abnormal returns (CAR) after large insider sales, when information asymmetry is high versus low. Abnormal returns are size-adjusted returns. The insider sale occurs on day 0. CAR [0, 20] is the CAR from trading day 0 to trading day 20. AQ is the accounting quality measure of Dechow and Dichev (2002). R&D is an indicator which equals 1 (0) if R&D is positive (zero). Mag_AR is the median magnitude of short window abnormal returns around quarterly earnings announcements in the previous five years. Loss Freq is the relative frequency of quarterly losses in the previous five years. *, **, *** denotes two-tailed statistical significance of difference from 0 at 10%, 5%, and 1%, respectively.

TABLE 8
Opportunistic Insider Sales and Profitability of Front-Running

Window	Opportunistic		Routine	
	CAR	t-stat	CAR	t-stat
[0,5]	-0.0026	-0.71	0.0050	1.19
[0,10]	-0.0061	-1.09	0.0049	0.88
[0,20]	-0.0152	-2.05[**]	0.0143	1.38
Num of observations	243		360	

The table reports cumulative abnormal returns following large insider sales, when the insider sale is opportunistic versus routine. Abnormal returns are size-adjusted returns. Day 0 is the day on which the insider sale occurs. Opportunistic and routine insider sales are identified using the algorithm in Cohen et al. (2012). *, **, *** denotes two-tailed statistical significance of difference from 0 at 10%, 5%, and 1%, respectively.

FIGURE 1
Daily Abnormal Short Sales around Insider Sales: Full sample

Panel A:Daily Short Sales around Insider Trading Date
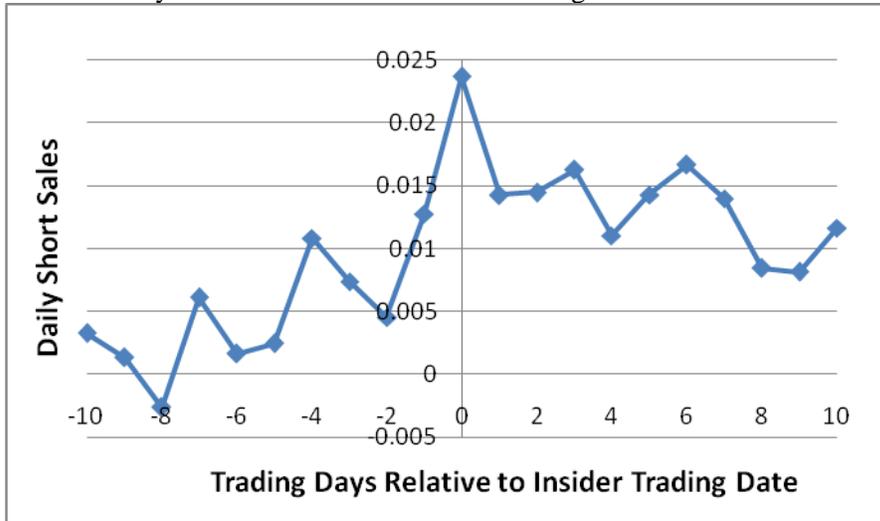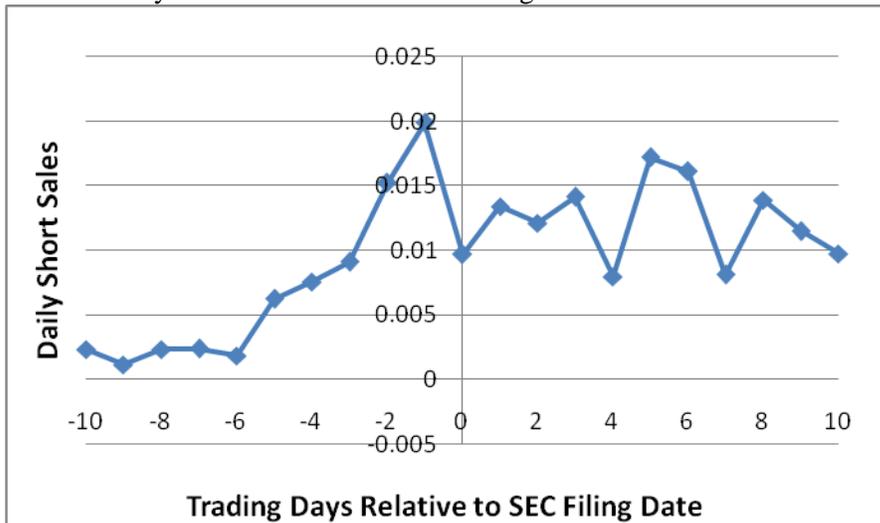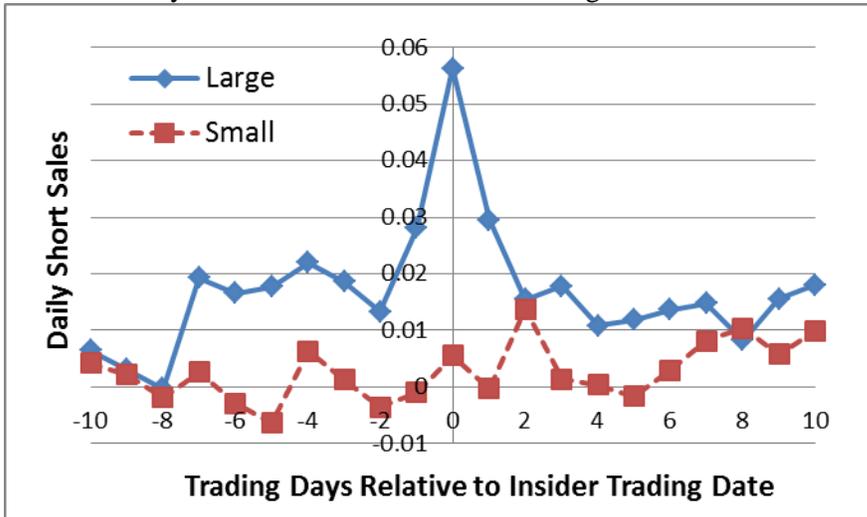

Panel B:Daily Short Sales around SEC Filing Date

Figure 1 shows daily abnormal short sales, as a percent of shares outstanding, for the full sample. Abnormal short sales are short sales in excess of the mean daily short sales in the [-60, -11] trading day window, excluding the week with an earnings announcement. Day 0 is either the insider sale date (Panel A) or the SEC Form filing date (Panel B). For Panel B, we use the 1,998 insider sale observations for which the SEC Form 4 is filed within 10 days after the insider sale.

Panel A: Daily Short Sales around Insider Trading Date

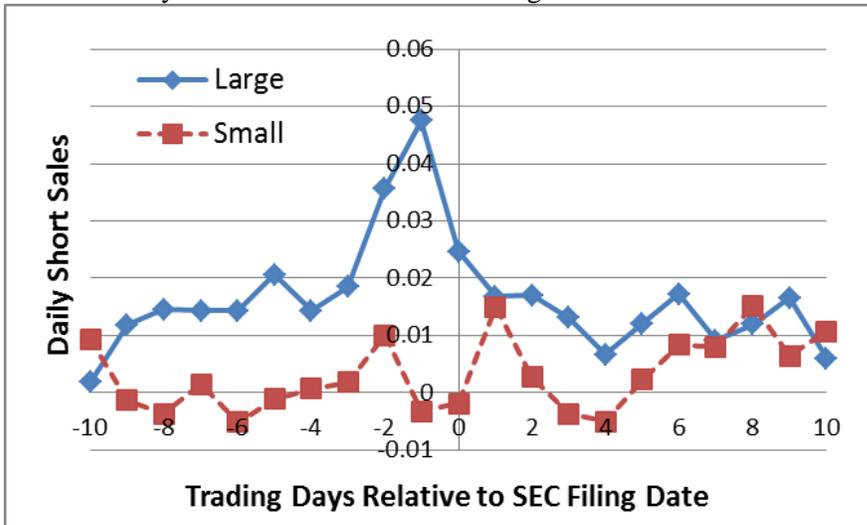Panel B: Daily Short Sales around SEC Filing Date

Figure 2 shows daily abnormal short sales, as a percent of shares outstanding, in the [-10, +10] trading day window. Abnormal short sales are short sales in excess of the mean daily short sales in the [-60, -11] trading day window, excluding the week with an earnings announcement. Day 0 is either the insider sale date (Panel A) or the SEC Form filing date (Panel B). The two panels show daily abnormal short sales around large insider sales and around small insider sales. Insider Sales are the shares sold by the insider as a percent of the firm's shares outstanding. Large (Small) insider sales are the top (bottom) three deciles of insider sales in the full sample.