Singapore Management University

Institutional Knowledge at Singapore Management University

Research Collection School Of Accountancy | School of Accountancy

5-2022

# Short sellers and insider trading profitability: A natural experiment

Xia CHEN
*Singapore Management University*, xchen@smu.edu.sg

Qiang CHENG
*Singapore Management University*, qcheng@smu.edu.sg

Ting LUO
*Tsinghua University*

Heng YUE
*Singapore Management University*, hyue@smu.edu.sg

Follow this and additional works at: https://ink.library.smu.edu.sg/soa_research

 Part of the Accounting Commons, and the Portfolio and Security Analysis Commons

## Citation

CHEN, Xia; CHENG, Qiang; LUO, Ting; and YUE, Heng. Short sellers and insider trading profitability: A natural experiment. (2022). *Journal of Accounting and Public Policy*. 41, (3), 1-19.
**Available at:** https://ink.library.smu.edu.sg/soa_research/1936

This Journal Article is brought to you for free and open access by the School of Accountancy at Institutional Knowledge at Singapore Management University. It has been accepted for inclusion in Research Collection School Of Accountancy by an authorized administrator of Institutional Knowledge at Singapore Management University. For more information, please email cherylds@smu.edu.sg.

ARTICLE IN PRESS

J. Account. Public Policy xxx (xxxx) xxx

Contents lists available at ScienceDirect

J. Account. Public Policy

journal homepage: www.elsevier.com/locate/jaccpubpol

# Short sellers and insider trading profitability: A natural experiment

Xia Chen [a], Qiang Cheng [a], Ting Luo [b,*], Heng Yue [a]

[a] School of Accountancy, Singapore Management University, Singapore 178900, Singapore
[b] School of Economics and Management, Tsinghua University, Beijing 100084, China

ARTICLE INFO

*Article history:*
Available online xxxx

*JEL classifications:*
M41
G14
G18

*Keywords:*
Short sellers
Insider trading
Government regulation

ABSTRACT

We examine the impact of short sellers on insider trading profitability using a natural experiment of a pilot program which relaxed short-selling constraints for randomly selected pilot stocks. We find that pilot firms experienced a significant decrease in insider trading profitability during the pilot program. The results are more pronounced for the pilot firms with poor information quality, and for the pilot firms without corporate restrictions on insider trading. Our evidence suggests that short sellers serve an important market disciplinary role by reducing insider trading profitability.

© 2021 Published by Elsevier Inc.

## 1. Introduction

Corporate insiders enjoy an information advantage over outside investors. An agency problem arising from this information advantage is insiders trading on their private information. Consistent with this notion, prior research shows that insider trading is significantly associated with future abnormal stock returns.[1] Expecting to trade against more informed insiders, outside investors require higher rate of return, leading to higher cost of capital and, in the worst case, market breakdown. Opportunistic insider trading can also lead to corporate under-investment (e.g., Manove 1989). Because of its adverse consequences, how to restrict opportunistic insider trading is an important issue. While government regulations and corporate policies are useful mechanisms, in this paper, we examine whether an important group of market participants – short sellers – plays a market disciplinary role and helps reduce insider trading profitability.

Short sellers can reduce insider trading profitability through at least two channels. First, prior studies document that short sellers are informed and sophisticated market participants and their trading helps improve the information environment. For example, Boehmer et al. (2010) show that short sellers have expertise in collecting and processing information. They are successful in identifying overvalued stocks to short and identifying (and avoiding) undervalued stocks. Therefore short interest, or a lack of it, conveys valuable information to the market. They find that higher short interest is indicative of bad news whereas lower short interest conveys good news. Because short sellers' trading can convey news to the capital markets, it can reduce information asymmetry and insider trading profitability. Second, recent studies find that short sellers

* Corresponding author.
*E-mail addresses:* xchen@smu.edu.sg (X. Chen), qcheng@smu.edu.sg (Q. Cheng), luot@sem.tsinghua.edu.cn (T. Luo), hyue@smu.edu.sg (H. Yue).

[1] See, for example, Allen and Ramanan (1995), Jagolinzer (2009), Lakonishok and Lee (2001), and Ravina and Sapienza (2010).

https://doi.org/10.1016/j.jaccpubpol.2021.106936
0278-4254/© 2021 Published by Elsevier Inc.

Please cite this article as: X. Chen, Q. Cheng, T. Luo et al., Short sellers and insider trading profitability: A natural experiment, J. Account. Public Policy, https://doi.org/10.1016/j.jaccpubpol.2021.106936

can constrain earnings management (Fang et al. 2016) and induce managers to voluntarily disclose more information to the capital markets (Chen et al. 2020). Both the reduction in earnings management and the increase in disclosures can reduce information asymmetry and insider trading profitability.

At the same time, when facing short-selling threat, insiders are concerned with losing their information advantage and as a result, can strategically change their trading patterns to exploit their private information. Massa et al. (2015a) argue that when the short-selling threat is higher, insiders will sell more aggressively based on their private information: they will sell faster and in larger amounts in order to maintain their trading profits. Using lendable shares as a proxy for the short-selling threat, Massa et al.'s results on insider trading patterns are consistent with their arguments.

As such, whether short sellers can reduce insider trading profitability is an empirical question. To examine the effect of short sellers on insider trading profitability, we utilize a natural experiment that helps address potential endogeneity issues.[2] On June 23, 2004, the SEC announced a pilot program under Regulation SHO to temporarily suspend the tick test for short-selling for a group of randomly selected firms (i.e., the pilot firms). During the pilot program (from May 2, 2005 to July 6, 2007), short-selling constraints were lower for the pilot firms, and it was easier and less costly to take short positions in the pilot firms than in the other firms (referred to as the control firms hereafter). While pilot and control firms have similar firm fundamentals because of the randomization, prior studies provide consistent evidence that short sellers are more active and short-selling increased significantly for the pilot firms compared to the control firms during the pilot program (e.g., Boehmer et al. 2008; Diether et al. 2009; Grullon et al. 2015). The combination of an exogenous shock to the short-selling constraints and the randomization of the treatment group provides us with an ideal setting to examine how short sellers affect insider trading profitability.

We use a difference-in-differences design to examine the impact of reduced short-selling constraints on insider trading profitability. To capture insider trading profitability, we focus on the extent to which insider trading predicts future stock returns. Since prior literature suggests that insiders' routine trades do not reflect private information (Cohen et al. 2012), we exclude routine trades and focus on only "informed" insider trading. The main tests indicate that compared to the control firms, the pilot firms experience a significant decline in insider trading profitability from the pre period (the period prior to the pilot program) to the during period (the period during the pilot program). Further, in the post period (the period after the pilot program) when short-selling constraints are removed for all public firms, there are no longer any significant differences in insider trading profitability between the pilot firms and the control firms.[3] The results are robust to a series of sensitivity checks, including using an alternative measure of insider trading profitability, controlling for option trading, and controlling for potential changes in the pilot firms' operations during the pilot program (such as investment and financing).

We perform several cross-sectional analyses to strengthen our main inference. First, when accounting information quality is high, outside investors can better assess firm value, reducing the information advantage of insiders (Frankel and Li 2004). Because insiders are more likely to exploit their private information when accounting information quality is poor, we predict and find that the effect of reduced short-selling constraints on insider trading profitability is stronger for the pilot firms with low accounting information quality than for the other pilot firms.

Second, prior studies, such as Bettis et al. (2000), find that corporate restrictions on insider trading can reduce the likelihood of insiders exploiting their information advantage and lower insider trading profitability. As such, we expect the effect of reduced short-selling constraints on insider trading profitability to be more pronounced for the pilot firms without insider trading restrictions than for the other pilot firms. Using insider trading patterns to identify firms with insider trading restrictions as in prior studies (e.g., Roulstone 2003), we find results consistent with this expectation.

We conduct several additional analyses to provide more insights. First, we explore the channels through which the reduction in short-selling constraints affects insider trading profitability. We find that both the increase in short-selling activities and the increase in corporate disclosures contribute to the reduction in insider trading profitability experienced by the pilot firms during the pilot program. Second, when we split insider trades into purchases and sales, we find that the results hold for both purchases and sales. Third, we validate the parallel trend assumption underlying the difference-and-differences analysis by documenting that there is no significant difference regarding insider trading profitability between the pilot firms and the control firms before the pilot program. Fourth, we find that, during the pilot program, the pilot firms' insider trades on average become smaller compared to the control firms'. This result is consistent with the reduced likelihood of pilot firms' insiders to trade on private information. Lastly, we confirm that our results are not affected by the possibility of short sellers front-running insider trades.

Our paper contributes to the literature in the following important ways. First, in the past decade short sellers have become an important group of traders in the equity market, and there is increasing interest in the economic consequences of short-selling. While the majority of prior studies focus on the impact of short sellers on price discovery, recent studies start to examine their effect on earnings management (Fang et al. 2016), corporate investment and financing decisions (Grullon et al. 2015), and corporate disclosures (Li and Zhang 2015; Chen et al. 2020). Our study contributes to the literature

[2] The potential endogeneity issues arise because both short interest and insider trading profitability can be related to some underlying factors, such as information asymmetry and mispricing. For example, for an overvalued stock, both short interest and the profitability of insider sales are likely high; whereas for an undervalued stock, the short interest is low and the profitability of insider purchases is high. In addition, short-selling may be affected by insider trading. For example, Bushman et al. (2005) document an increase in analyst following after the restriction of insider trading, which suggests that insider trading can crowd out information acquisition efforts, including those by short sellers.

[3] Our inferences are the same if we include the routine trades in our analyses.

by investigating the effect of short sellers on insider trading profitability. Our findings suggest that short sellers keep insider trading in check and thus serve a disciplinary role.

As mentioned above, Massa et al. (2015a) also examine the interplay between short-selling and insider trading. They find that insiders respond to the short-selling threat by strategically changing their selling behavior. Unlike Massa et al., we focus on a related but different question: do short sellers reduce insider trading profitability through their effect on the market's information discovery and firms' reporting and disclosures? Whether insiders' strategic behavior, as documented in Massa et al., can fully offset short sellers' impact on inside trading profitability is an empirical question. Exploiting the exogenous shock of REG SHO to short-selling constraints, we provide evidence that short sellers significantly reduce insider trading profitability. While Massa et al.'s evidence is consistent with insiders changing trading patterns in order to maintain their trading profits, our evidence suggests that the negative effect of short sellers on inside trading profitability prevails.

In an additional test, Massa et al. use the REG SHO setting to address endogeneity and examine the magnitude and timing of insider sales in the three months after the *announcement* of the list of pilot firms but before the pilot program became effective. This test captures managers' one-time reaction to the announcement of the pilot program. In contrast, we focus on short sellers' effect on insider trading profitability *during* the pilot program with the implementation of REG SHO – how the relaxation of short-selling constraints affects insider trading profitability.[4] Taken together, the two studies' results lead to a more comprehensive understanding of the interplay between insider trading and short-selling – while insiders try to compete with short sellers for trading profits, short sellers nonetheless reduce insiders' trading advantage.

Second, insider trading for private gains is generally regarded as detrimental to the capital markets (e.g., Kyle 1985). The regulators have spent significant amounts of resources on restricting and monitoring opportunistic insider trading. Firms have also implemented various policies to restrict insider trading (Bettis et al. 2000). This paper provides evidence on a market mechanism that helps constrain insiders' exploitation of their information advantage – short-selling, and sheds light on one channel through which the external market disciplines insider trading.

The remainder of the paper is organized as follows. Section 2 discusses the institutional background and related literature and develops the hypotheses. Section 3 describes the research design and sample selection. Section 4 presents the main empirical analyses and Section 5 the additional analyses. Section 6 concludes.

## 2. Institutional background, prior research, and hypothesis development

### *2.1. Institutional background on the pilot program*

In 1938, the SEC adopted Rule 10a-1, often referred to as the uptick rule. According to the SEC, "Rule 10a-1(a)(1) provided that, subject to certain exceptions, a listed security may be sold short (A) at a price above the price at which the immediately preceding sale was effected (plus tick), or (B) at the last sale price if it is higher than the last different price (zero-plus tick). Short sales were not permitted on minus ticks or zero-minus ticks, subject to narrow exceptions." Consequently, a short sale is only allowed on a plus tick or on a zero tick when the last trade is a plus tick. In 1994, the Nasdaq adopted a bid price test to determine whether short sales are allowed for shares traded on Nasdaq (Nasdaq Rule 3350). Short sales on Nasdaq are not allowed at or below the best bid when the current best bid is at or below the previous best bid. These rules and tests, referred to as the tick test for convenience, impose significant constraints on short-selling. For example, Jones and Lamont (2002) examine NYSE-listed stocks and find that stocks are more difficult to short after the introduction of short-selling restrictions.

On June 23, 2004, the SEC adopted Regulation SHO (REG SHO), which will temporarily suspend the tick test for a group of randomly selected firms, so that the SEC can evaluate the effectiveness and necessity of short-selling restrictions. On July 28, 2004, about 1000 U.S. stocks were selected as the pilot firms. Specifically, the SEC separated the U.S. firms in the 2004 Russell 3000 index into three groups based on the exchange on which the stocks were traded (NYSE, AMEX, or Nasdaq) and ranked the firms by average trading volume within each group. The SEC then selected every third stock from each group, beginning from the second stock. Starting from May 2, 2005, the pilot firms were exempt from the tick test. The temporary suspension expired on July 6, 2007 when the SEC permanently suspended the tick test for all the publicly-traded U.S. firms. The permanent suspension of the tick test drew criticisms from firms and former regulators, including former SEC chairman Christopher Cox. The criticism intensified with the financial crisis in 2008–2009 due to the concern that financial stocks may be subject to market manipulations via short-selling. On February 24, 2010, the SEC reinstated the uptick rule, but only when a security's price drops by 10% or more from the last day's closing price.

Because of the random selection of the pilot firms, the pilot firms do not differ from the rest of the Russell 3000 firms (referred to as the control firms) in firm characteristics, as confirmed by Diether et al. (2009) and others. Compared to the control firms, the pilot firms experienced a decrease in short-selling constraints during the pilot program. Consistent with the importance of REG SHO, prior studies find that the pilot program leads to a significant increase in short-selling for the pilot firms as well as significantly impacts the pilot firms' operations. For example, Grullon et al. (2015) estimate that as a result of REG SHO, short-selling in the pilot firms increases by about 19% relative to the control firms, after taking into account the effect upon the announcement of the pilot firms and the implementation of the pilot program. Several recent

[4] To address the possibility that some insiders move their trades from the early period of the pilot program to the period right after the announcement of the pilot firms, we exclude the first three or six months of the pilot program from the sample period in a sensitivity test and obtain the same inferences.

studies provide evidence that REG SHO significantly influences the pilot firms' executive compensation, investment, and disclosures (e.g., De Angelis et al. 2017; Fang et al. 2016; Grullon et al. 2015; Li and Zhang 2015; Chen et al. 2020). In this paper, we take advantage of the pilot program to examine how short sellers influence insider trading profitability.

### 2.2. Prior research

#### 2.2.1. Prior research on insider trading

Prior studies document that insider trades are systematically related to firms' future stock performance. Researchers have attributed insider trading profitability to insiders' foreknowledge of corporate events and future financial performance.[5]

Although information-based insider trading can accelerate the incorporation of information into stock prices and thus improve information efficiency (e.g., Manne 1966; Carlton and Fischel 1983), it has been widely criticized for several reasons. First, insiders' trading gain is at the expense of other investors. This goes against the spirit of fairness in the capital markets (Fried 1998; Kolasinski and Li 2010). Second, insider trading can be detrimental to the firm. Expecting more informed trading counterparts, outside investors will require higher rate of return to compensate for the risk (e.g., Kyle 1985), and in the extreme case, the market can break down. Consistent with this argument, Bhattacharya and Daouk (2002) find that the cost of equity decreases after the initial enforcement of insider trading laws in a country. Insider trading can also lead to suboptimal investment decisions (Seligman 1985; Manove 1989; Ausubel 1990). For example, Manove (1989) show that when insiders trade, investors are less willing to finance firms' investment projects, since insider trading reduces the investment returns to outside investors. Third, insiders can use their discretion in financial reporting and disclosures to further increase their information advantage, leading to greater opacity. For example, prior studies find that managers have incentives to manage earnings for trading purposes (Ronen et al. 2006; Zhang and Zhang 2018). Cheng et al. (2013) have also provided evidence that managers use corporate disclosures strategically to increase their trading profits.

Given the adverse consequences of information-based insider trading, how to constrain such behavior is an important issue. Many countries have implemented insider trading legislations (Bhattacharya and Daouk 2002). Firms have also put into place policies and procedures to restrict insider trading. For example, Bettis et al. (2000) find that 78% of their sample firms have explicit blackout periods for insider trading, and the bid-ask spread is narrower during the blackout periods. Jagolinzer et al. (2011) find that 80% of their sample firms require general counsel to approve insider trading and insider trading profitability is lower for such firms. In addition, prior studies find that internal mechanisms such as effective internal control are associated with lower insider trading profitability (Skaife et al. 2013).

Different from the above studies, we examine a market mechanism – the disciplinary role of short-sellers. Our inquiry is thus related to Frankel and Li (2004) who examine the monitoring role of financial analysts and media in reducing insider trading profitability. Collectively these studies enhance our understanding of how market mechanisms affect insider trading profitability beyond regulatory and internal mechanisms.

#### 2.2.2. Prior research on short-selling

Most of the prior research on short-selling focuses on the information role of short sellers in the capital markets. Theoretical studies argue that short sellers are informed market participants who act to keep prices in line (e.g., Diamond and Verrecchia 1987; Boehmer et al. 2008). Consistent with the theoretical arguments, empirical studies find that short sellers as a whole are well-informed; they unearth over-valued stocks and abnormal short interest is negatively associated with future stock returns.[6] Prior findings suggest that short sellers' information advantage comes from private information acquisition and skilled processing of public information (e.g., Engelberg et al. 2012).[7]

In recent years, short sellers are becoming an increasingly important group of traders in the capital markets. For example, Boehmer and Wu (2013) find that short sales account for more than 20% of the trading volume over the period 2000–2004. Motivated by the increasing importance of short sellers, recent studies examine the influence of short sellers beyond the capital markets using the setting of REG SHO. For example, De Angelis et al. (2017) find that pilot firms change executive compensation structure (by granting more options and fewer stocks) and adopt anti-takeover provisions in order to reduce managers' exposure to downside risk. Grullon et al. (2015) find that short-selling leads to a reduction in equity issuance and investments for financially constrained firms. Fang et al. (2016) find that short sellers constrain earnings management. Li and Zhang (2015) find that short sellers lead to a decrease in management forecast precision of bad news, and Chen et al. (2020) find that short sellers induce managers to increase voluntary disclosures. We extend this line of inquiry by investigating the role of short sellers in curbing the agency problem of opportunistic insider trading.

[5] See, for example, Seyhun (1986), Karpoff and Lee (1991), Damodaran and Liu (1993), Bebchuk and Fershtman (1994), Lakonishok and Lee (2001), Huddart and Louis (2010), and Ravina and Sapienza (2010).

[6] For examples, see Senchack and Starks (1993), Dechow et al. (2001), Jones and Lamont (2002), Ofek and Richardson (2003), Boehme et al. (2006), Boehmer et al. (2008), Hirshleifer et al. (2011), and Boehmer and Wu (2013). Recent studies also examine the effect of short selling on price discovery in corporate bonds (e.g. Hendershott et al. 2020).

[7] Some studies suggest that short sellers also benefit from front-running or tipping (Christophe et al. 2010; Khan and Lu 2013).

### 2.3. Hypothesis development

#### 2.3.1. Main hypothesis – H1

Insider trading profitability arises from insiders' information advantage. We argue that the relaxation of short-selling constraints during the pilot program can reduce insider trading profitability by reducing insiders' information advantage, as elaborated below.

Diamond and Verrecchia (1987) model the impact of short-selling constraints on asset prices. They show that with short-selling constraints, the speed of price adjustment to private information, particularly to bad news, is slower. In equilibrium, stock prices are correct on average; not knowing which firms have bad news, investors rationally discount all firms. Hence, individual stocks can be overvalued or undervalued because of short-selling constraints. The mispricing increases insider trading profitability. It thus follows that when short-selling constraints are relaxed, mispricing (over- or under-valuation) is reduced and the profits of insider trades (sales and purchases) will decrease.

As discussed above, prior studies provide supportive evidence that short sellers help accelerate the incorporation of information into prices and improve price efficiency. For example, Cohen et al. (2007) find that short-selling conveys private information to the market. Hirshleifer et al. (2011) find that short-selling reduces the post-earnings announcement drift. Boehmer and Wu (2013) find that the relaxation of short-selling constraints is associated with a reduction in information asymmetry.

Note that short sellers' role in informing markets is applicable to both bad news and good news. Short sellers are successful in identifying overvalued stocks to short and identifying (and avoiding) undervalued stocks. While higher short interest indicates bad news, lower short interest indicates good news, *ceteris paribus*. For example, Boehmer et al. (2010) find that a low level of short interest is associated with positive abnormal returns in the future. Further, the positive returns associated with low short interest are even bigger (in absolute value) than the negative returns associated with high short interest. When short-selling constraints are relaxed during the pilot period, the level of short interest reveals more of short sellers' information (bad or good news), compared to when short-selling constraints are binding. For example, before the pilot program, a firm with no short interest may indicate (1) short sellers believe the firm is undervalued, or (2) the firm is overvalued but short sellers do not short due to high short-selling costs. During the pilot program, since the short-selling costs are reduced, a firm with no short interest more likely represents the first situation, i.e., the firm is more likely undervalued. Thus, assuming that the capital markets incorporate the information revealed by the level of short interest, both over-valuation and under-valuation will be reduced and insider trades (both sales and purchases) will thus become less profitable.

Short sellers can also reduce information asymmetry indirectly through their impact on financial reporting and disclosures. As discussed above, Fang et al. (2016) find that short sellers constrain earnings management because increased short-selling can better reveal earnings management, leading to higher litigation risk for managers. Massa et al. (2015b) also find consistent evidence using data from 33 countries that short-selling has a disciplining role on reducing earnings manipulation. Along this line, Karpoff and Lou (2010) document that short sellers help uncover misconduct and keep prices closer to fundamental values. Chen et al. (2019) find that firms that are eligible for short-selling significantly improve their internal control. In addition, Chen et al. (2020) find that the relaxation of short-selling constraints induces managers to disclose information in a more timely fashion to discourage short sellers from taking positions. Deng et al. (2020) document that short sales decrease pilot firms' crash risk by reducing firms' ability to hoard bad news. Consistent with Deng et al. (2020), Clinch et al. (2019) document that pilot firms are more likely to disclose bad news forecasts during REG SHO. Both the reduction in earnings management and the more timely disclosures can reduce information asymmetry.

Note that Chen et al. (2020) find that the pilot firms disclose more good news during REG SHO. If managers can time their purchases before the good news disclosure, they can still earn the same trading profits. However, the literature suggests that managers may be deterred from doing so because of the litigation risk concern. Specifically, NOE (1999) suggests that insider purchases followed by good news releases may lead to investigations by the SEC, as this sequence of actions potentially contravene the "disclose or abstain" rule. Consistent with this argument, both NOE (1999) and Cheng and Lo (2006) show that insider purchase prior to good news disclosure is not significantly different from that prior to bad news disclosure, indicating that managers do not time purchases before good news disclosure due to litigation risk. Thus, during the pilot period when managers need to timely disclose good news, information asymmetry is reduced which leads to the decrease of insider purchase profitability.

In sum, the relaxation of short-selling constraints for the pilot firms will increase information efficiency and reduce mispricing. This is reinforced by short sellers' role in constraining earnings management and inducing disclosures. Hence, we predict that during the pilot program, pilot firms' insider trading profitability will decrease relative to the control firms. To test this prediction, we adopt a difference-in-differences design and use insider trades' ability to predict future stock returns to proxy for insider trading profitability. We compare insider trades' ability to predict future stock returns between the period prior to the pilot program (i.e., the pre period) and the period when the pilot program was in place (i.e., the during period) and between the pilot and control firms. Our first hypothesis is thus stated as follows:

**H1.** Ceteris paribus, insider trades' ability to predict future stock returns in pilot firms decreases from the pre period to the during period, relative to control firms.

We might not find results consistent with H1 for at least two reasons. First, as argued in Massa et al. (2015a), when facing higher short-selling threat, insiders can change their selling behavior in order to exploit their information advantage and maintain insider trading profitability. Massa et al. find that insiders tend to sell more aggressively in such cases. Insiders' strategic trading behavior in response to short-selling threat can preempt short sellers so that short-selling has no detectable effect on insider trading profitability. Second, prior research suggests that short sellers can increase stock price volatility and lead to disorderly market (e.g., Savor and Gamboa-Cavazos 2011; Hong et al. 2012; Liu 2015), which can potentially create more opportunities for opportunistic insider trading. Thus whether we can find results consistent with H1 is an empirical question.

*2.3.2. Cross-sectional predictions*

*2.3.2.1. Accounting information quality.* Accounting information is one of the most important sources of information for outside investors. Poor accounting information quality is associated with greater information asymmetry between insiders and outsiders (Baiman and Verrecchia 1996). This can lead to greater insider trading profitability. Consistent with this argument, Frankel and Li (2004) find that low financial statement informativeness and poor earnings quality are associated with greater insider trading profitability. Similarly, Veenman (2012) finds that insider trades in firms with poor accounting quality are associated with greater market reaction upon disclosure of the trades. Since poor accounting information quality is associated with greater insider trading profitability, the effect of reduced short-selling constraints is expected to be greater for the pilot firms with poor accounting information quality. Thus, our second hypothesis is:

**H2.** The reduction in insider trading profitability experienced by pilot firms from the pre to the during period, as hypothesized in H1, is larger for the pilot firms with poor accounting information quality than for other pilot firms.

*2.3.2.2. Corporate restrictions on insider trading.* Previous studies find that many firms adopt policies and procedures to restrict insider trading (Bettis et al. 2000). One common policy is to specify blackout periods during which insiders are not allowed to trade, usually in the month before earnings announcements when insiders presumably possess private information. Bettis et al. (2000) find that insider trades are less profitable in firms with blackout periods than in other firms. Given that insider trading is more profitable for firms without insider trading restrictions, we expect that the effect of reduced short-selling constraints is stronger for the pilot firms without insider trading restrictions. Thus, our third hypothesis is:

**H3.** The reduction in insider trading profitability experienced by pilot firms from the pre to the during period, as hypothesized in H1, is larger for the pilot firms without insider trading restrictions than for other pilot firms.

## 3. Sample

### *3.1. Sample selection*

To construct our sample, we start with the Russell 3000 index firms in 2004, the set of firms from which the SEC selected the pilot firms. Panel A of Table 1 summarizes the sample selection process. Following Diether et al. (2009), we exclude firms that are not in the Russell 3000 index in 2005.[8] We also exclude stocks that change tickers during the pilot program. We follow the SEC's selection criteria and exclude the stocks that were not listed on NYSE, AMEX, and Nasdaq, or went public after April 30, 2004.

We obtain data on insiders' open market transactions from Thomson Financial, which defines insiders as officers. Following prior studies (e.g., Khan and Lu 2013), we delete insider trading records assigned a cleansing code of "A" or "S" by Thomson Financial. We delete trades with missing transaction date, with the number of transaction shares more than the trading volume on the transaction day, or with transaction price outside the price range on the transaction day as recorded by CRSP; these cases likely indicate data errors.

Fig. 1 presents the timeline. The during period is for the duration of the pilot program; the pre period is about the same length and ends on July 28, 2004, when the SEC announced the pilot firms; the post period is about the same length within the permanent removal period and starts from August 2007[9]. We do not examine transactions between July 28, 2004 and May 2, 2005, the transition period, because our predictions rely on the implementation of the pilot program and the actual relaxation of short-selling constraints for the pilot firms.[10] Huddart and Ke (2007) argue that six months is a reasonable length to measure insider trading profit. Hence, we focus on the trades executed before January 31, 2004 in the pre period, the trades executed before December 31, 2006 in the during period, and the trades executed before March 31, 2009 in the post period, so that there

[8] According to the Russell index manual, firms that dropped out of the Russell index usually are involved in mergers and acquisitions or have other significant events, which can potentially confound our analyses. Including these firms in our analyses leads to quantitatively similar results.

[9] July 2007 is excluded to ensure the same length of the first month as those in the pre and during period, because short-selling constraints were removed for all public firms on July 6, 2007. Including July 2007 does not change the results.

[10] In an additional analysis, we examine the transition period and find that compared to the control firms, the pilot firms' insider trading profitability does not change significantly from the pre period to the transition period.

**Table 1**
Sample Selection and Comparison of the Pilot and Control Firms.

*Panel A: Sample selection*

| | | The number of firms |
|---|---|---|
| Firms included in the Russell 3000 index in 2004 | | 3,000 |
| Less: | | |
| Firms not in the Russell 3000 index in 2005 | 408 | |
| Firms with change in tickers during the pilot program, or not listed on NYSE, AMEX or Nasdaq, or with IPOs after April 30, 2004 | 190 | |
| Firms having required financial or stock price data only in one period | 457 | |
| Firms not covered by Thomson Financial | 168 | |
| Firms having insider trades only in one period | 245 | |
| Final sample | | 1532 |
| Pilot firms | | 527 |
| Control firms | | 1005 |

*Panel B: Comparison of the pilot and control firms' key firm characteristics before the pilot program*

| | Pilot firms | | | | Control firms | | | | P-value of the test for differences | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | Median | Std. Dev. | N | Mean | Median | Std. Dev. | Mean | Median |
| Firm characteristics | | | | | | | | | | |
| *Size* | 527 | 6432 | 1140 | 18328 | 1005 | 7918 | 1387 | 24,801 | 0.18 | 0.33 |
| *M/B* | 527 | 3.26 | 2.33 | 2.60 | 1005 | 3.08 | 2.40 | 2.27 | 0.18 | 0.63 |
| *Leverage* | 527 | 0.21 | 0.19 | 0.19 | 1005 | 0.21 | 0.18 | 0.18 | 0.99 | 0.89 |
| *ROE* | 527 | 0.00 | 0.11 | 1.50 | 1005 | 0.05 | 0.11 | 1.32 | 0.48 | 0.82 |
| *Ret* | 527 | 0.19 | 0.14 | 0.18 | 1005 | 0.20 | 0.15 | 0.17 | 0.55 | 0.17 |
| *Trading Volume* | 527 | 253,545 | 75,409 | 511,626 | 1005 | 245,277 | 73,257 | 480,043 | 0.75 | 0.91 |
| *Analyst Following* | 527 | 11 | 8 | 9 | 1005 | 11 | 8 | 9 | 0.99 | 0.55 |
| Insider trading | | | | | | | | | | |
| *Shares* | 527 | 277,077 | 60,147 | 603,821 | 1005 | 309,612 | 57,050 | 713,101 | 0.34 | 0.88 |
| *Frequency* | 527 | 8 | 4 | 11 | 1005 | 8 | 4 | 11 | 0.35 | 0.41 |
| *Volume* | 527 | 6,415,374 | 1,129,638 | 15,200,000 | 1005 | 6,293,767 | 1,066,473 | 14,500,000 | 0.87 | 0.98 |

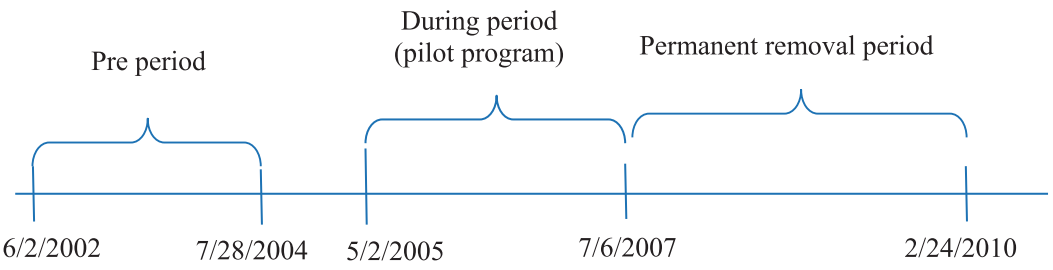
This table describes the sample selection process and compares the pilot and control firms' key firm characteristics.
This panel presents descriptive statistics on firm characteristics and insider trading in fiscal year 2003, the year before the SEC selected the pilot firms. The statistics are presented separately for the pilot and control firms. A sample firm is a pilot firm if its stock is designated as a pilot stock by the SEC and is a control firm otherwise. *Size* is total assets (in millions), *M/B* is the market-to-book ratio, *Leverage* is the ratio of total debt to total assets, *ROE* is the ratio of earnings before extraordinary items to book value of stockholders' equity, *Ret* is raw stock returns, *Trading Volume* is the average monthly trading volume (in number of shares), and *Analyst Following* is the number of analysts following the firm. *Shares* is the total number of shares insiders purchase or sell, *Frequency* is the number of days when insiders buy or sell shares, and *Volume* is the dollar amount of insider transactions.

is a sufficiently long window in each period to calculate the stock returns following insider trades.[11] As a result, insider trades in the pre period include those between June 2, 2002 and January 31, 2004, insider trades in the during period include those between May 2, 2005 and December 31, 2006, and insider trades in the post period include those between August 2, 2007 and March 31, 2009.

We further exclude firms that have financial and stock price data only in one period and firms that are not covered by Thomson Financial. In addition, we exclude firms that have insider trades only in one period. Cohen et al. (2012) show that insiders' routine trades do not reflect private information; therefore, we exclude routine trades from the sample. Our final sample includes 53,964 insider trades in 19,410 firm-months from 1532 unique firms, of which 527 are pilot firms and 1005 are control firms.

Panel B of Table 1 presents the descriptive statistics for the pilot and control firms in 2003, the year before the SEC selected the pilot firms. As reported, there are no significant differences between the pilot and control firms in total assets (*Size*), market-to-book ratio (*M/B*), leverage (*Leverage*), return on equity (*ROE*), raw returns (*Ret*), trading volume (*Trading Volume*), analyst following (*Analyst Following*), and insider trading characteristics (*Shares*, *Frequency*, *Volume*), consistent with the random selection of the pilot firms by the SEC. We also find that the pilot firms do not differ significantly from the control firms in these characteristics during the pilot program, lending further support to using the control firms as the benchmark in the difference-in-differences research design.

[11] This design choice ensures that future stock returns associated with insider trades in each period are not confounded by the events outside the respective period.




Key dates:

| | |
|---|---|
| 6/23/2004 | The SEC adopted Regulation SHO. |
| 7/28/2004 | The SEC announced the list of the pilot firms. |
| 5/2/2005 | The pilot program started. |
| 7/6/2007 | The pilot program ended and the SEC permanently suspended the tick test for all publicly listed US stocks. |
| 2/24/2010 | The SEC reinstated the revised tick test, which is applicable under limited circumstances. |

**Fig. 1.** Timeline Keydates: 6/23/2004, The SEC adopted Regulation SHO. 7/28/2004, The SEC announced the list of the pilot firms. 5/2/2005, The pilot program started. 7/6/2007, The pilot program ended and the SEC permanently suspended the tick test for all publicly listed US stocks. 2/24/2010, The SEC reinstated the revised tick test, which is applicable under limited circumstances.

### 3.2. Research design

Following prior research (e.g., Lakonishok and Lee 2001; Frankel and Li 2004), we use the association between insider trades and future stock returns to measure the ability of insider trades to predict future stock returns.[12] When insiders trade on private information, insider purchases (sales) are expected to be followed by positive (negative) stock returns. As such, we construct a net purchase ratio (*NPR*) for each firm-month to measure the direction and magnitude of insider trades; *NPR* is computed by dividing insiders' net purchases in a given month by the total number of insider transactions in the same month. Net purchases are calculated as the number of purchase transactions minus the number of sale transactions. *NPR* is positive (negative) for months in which there are more (fewer) insider purchase transactions than insider sale transactions. The inferences remain the same if we calculate *NPR* based on the number of transaction shares. For future stock returns, we cumulate daily raw returns (*RET*) or four-factor adjusted abnormal returns (*ARET*) for six months, beginning the day after the last insider transaction for a given firm-month, as is commonly done in prior research (Seyhun 1998; Huddart and Ke 2007; Dai et al. 2015). We obtain the same inferences when using a shorter window, such as three months.

We use the following regression to test the effect of the reduction in short-selling constraints on the predictive ability of insider trades:

$$\begin{aligned} RET(ARET) = {} & \alpha_0 + \alpha_1 NPR + \alpha_2 NPR \times PILOT + \alpha_3 NPR \times DURING + \alpha_4 NPR \times POST + \alpha_5 NPR \times PILOT \times DURING \\ & + \alpha_6 NPR \times PILOT \times POST + \alpha_7 PILOT + \alpha_8 PILOT \times DURING + \alpha_9 PILOT \times POST + \beta Control\_Variable \\ & + \theta NPR \times Control\_Variable + Industry, monthFE + \varepsilon \end{aligned} \quad (1)$$

Firm and month subscripts are omitted for simplicity. *RET* is the 6-month cumulated future raw stock returns; *ARET* is the 6-month cumulated four-factor adjusted abnormal stock returns. *NPR* is the monthly net purchase ratio. If insiders have information advantage over other investors and trade on their superior information, the coefficient on *NPR* is expected to be positive (e.g., Frankel and Li 2004).

*PILOT* is an indicator variable for the pilot firms; it equals 1 for the pilot firms and 0 for the control firms. *DURING* is an indicator variable for the pilot period; it equals 1 for firm-months in the pilot period (i.e., during the pilot program) and 0 for firm-months in other periods. *POST* is an indicator variable for the post period; it equals 1 for firm-months in the post period (i.e., post the pilot program) and 0 for firm-months in other periods. Our variable of interest is the three-way interaction *NPR* × *PILOT* × *DURING*. H1 implies a negative coefficient on *NPR* × *PILOT* × *DURING:* the pilot firms are expected to experience a decrease in the association between insider trades and future stock returns from the pre to the during period, compared to the control firms (i.e., insider trading becomes relatively less profitable for the pilot firms during the pilot program). The three-way interaction *NPR* × *PILOT* × *POST* serves as a robustness check for the effect during the pilot program. H1

[12] The inferences remain the same when we use the association between insider trades and future earnings surprises.

implies an insignificant coefficient on *NPR* × *PILOT* × *POST*: removing short-selling constraints for all public firms can result in no difference in the change of insider trading profitability between the pilot firms and the control firms from the pre to the post period.

We control for other factors that may affect the association between insider trades and future stock returns by including these factors as well as their interactions with *NPR* in the regression. Prior research suggests that insider trades in firms with greater information asymmetry are more predictive of future returns (e.g., Seyhun 1986; Lakonishok and Lee 2001). We include stock return volatility, market-to-book ratio, analyst following, firm size, and an indicator for high-tech industries to capture information asymmetry (Frankel and Li 2004). Managers may trade for liquidity reasons; therefore we include the average number of shares held by the insiders who trade in the month (Frankel and Li 2004). The many interaction terms may cause multicollinearity issue and make the coefficient of *NPR* hard for interpretation; therefore, in the regressions, we mean-adjust all the continuous control variables so that the coefficient on *NPR* captures the association between insider trades and future stock returns for an average firm (Chen et al. 2012; Chen et al. 2020). Lastly, we control for return momentum by including returns in the current month and in the previous eleven months (Cohen et al. 2012). The Appendix describes variable measurements.

As in other studies of insider trading (e.g., Chung et al. 2019), we also control for industry and calendar month fixed effects in the regression. As such, the regression specification does not include the main effect of *DURING* and *POST*. The standard errors are adjusted for firm and calendar month level clustering.

### 3.3. Descriptive statistics

Panel A of Table 2 presents descriptive statistics on the regression variables. The average cumulated 6-month raw and four-factor adjusted stock returns following insider trades is 4.27% and 0.91%, respectively. The mean net purchase ratio is −0. 695, indicating that insiders are more likely to sell than purchase.[13] The pilot firms account for about 34 percent of the observations, the during period accounts for about 41 percent of the observations, and the post period accounts for about 29 percent of the observations. With respect to the control variables, the average return volatility is 2.6%, the average market-to-book ratio is 4.167, the average number of analysts following the sample firms is 12, the average firm size (total assets) is $17,100 million, 19.5 percent of the observations are from the high-tech industries, the average number of shares held by insiders who trade in the month is 829,586, the average stock return in the current month is 2.90%, and the average cumulated stock return in the previous eleven months is 12.62%.

Panel B of Table 2 reports the correlations among the regression variables. Consistent with prior research, the correlation between net purchase ratio and future stock returns is significantly positive. The correlations among the independent variables are usually small.

## 4. Empirical results

### 4.1. Main analysis

Table 3 presents the regression results of Equation (1). As reported, the coefficient on *NPR* is significantly positive, suggesting that insider trades can predict future stock returns – net purchases (sales) are followed by positive (negative) stock returns. More importantly, the coefficient on the variable of interest, *NPR* × *PILOT* × *DURING*, is significantly negative (p = 0.041 for *RET* and 0.02 for *ARET*). This result is consistent with H1; compared to the control firms, the pilot firms experience a decrease in the association between insider trades and future stock returns during the pilot program, implying a decrease in insider trading profitability. The effect is also economically significant. For instance, for the pilot firms, an increase of one standard deviation in *NPR* (0.703) is associated with an abnormal return (*ARET*) of 3.38%[14] in the pre period, while during the pilot period, the change of *NPR* does not generate significant abnormal return.[15] Contrasting to the significant coefficient on *NPR* × *PILOT* × *DURING*, the coefficient on *NPR* × *PILOT* × *POST* is not significant for either *RET* or *ARET*. This suggests that when short-selling constraints were removed for all firms, there is no longer any difference in the change of insider trading profitability between the pilot firms and the control firms from the pre to the post period.

Regarding the control variables, we find that insider trading profitability is lower for larger firms and for growth firms. The coefficients on current and past stock returns are mostly positive, suggesting a continuation in stock returns.

A concurrent study by Wang et al. (2021) documents an increase of total insider sales profits for pilot firms during the pilot period. Their results and ours are not conflicting. The seemingly different results are due to the difference in measuring dependent variables. We examine the profitability of insider sales which is determined by future cumulative abnormal return, while Wang et al. (2021) examine the total profits which are the product of insider sales volume and future cumulative abnormal return, times −1. By reducing non-profitable trades while keeping profitable trades, insiders can increase

[13] *NPR* is 1 for 2719 observations and −1 for 16,145 observations. There are only 206 observations where insiders have conflicting transactions – some buy shares and others sell shares.

[14] The return is calculated as (2.994+1.813) × 0.703.

[15] The abnormal return associated with *NPR* during the pilot program can be calculated as (2.994+1.813–5.360) × 0.703=-0.39%, which is small and insignificant.

**Table 2**
Descriptive Statistics.

*Panel A: Descriptive statistics on the regression variables*

| | | Percentile | | | | | |
|---|---|---|---|---|---|---|---|
| | Mean | 5% | 25% | 50% | 75% | 95% | Std. Dev. |
| *Future raw stock returns (RET, %)* | 4.273 | −45.438 | −7.405 | 6.416 | 18.838 | 44.134 | 27.173 |
| *Future four-factor adjusted returns (ARET, %)* | 0.905 | −49.985 | −15.237 | 1.152 | 17.815 | 51.906 | 31.089 |
| *Net purchase ratio (NPR)* | −0.695 | −1 | −1 | −1 | −1 | 1 | 0.703 |
| *Pilot firm indicator (PILOT)* | 0.337 | 0 | 0 | 0 | 1 | 1 | 0.473 |
| *During period indicator (DURING)* | 0.408 | 0 | 0 | 0 | 1 | 1 | 0.491 |
| *Post period indicator (POST)* | 0.290 | 0 | 0 | 0 | 1 | 1 | 0.454 |
| *Stock return volatility (RetVol, %)* | 2.603 | 0.972 | 1.540 | 2 | 3.085 | 5.692 | 1.722 |
| *Market to book ratio (M/B)* | 4.167 | 0.988 | 1.684 | 2 | 3.848 | 8.508 | 58.339 |
| *Analyst following (Analyst)* | 12 | 2 | 6 | 10 | 17 | 31 | 9 |
| *Firm size (in millions) (Size)* | 17,100 | 158 | 669 | 1957 | 6015 | 46,165 | 94,376 |
| *High-tech indicator (Tech)* | 0.195 | 0 | 0 | 0 | 0 | 1 | 0.396 |
| *Insiders' shareholding (Hold)* | 829,586 | 1368 | 12,000 | 43,309 | 145,561 | 1,245,087 | 23,000,000 |
| *Current stock returns (Ret_Current, %)* | 2.899 | −58.587 | −9.817 | 2.375 | 15.361 | 66.957 | 44.941 |
| *Past stock returns (Ret_Past, %)* | 12.618 | −55.902 | −11.250 | 11.410 | 36.030 | 85.145 | 42.221 |

*Panel B: Correlations among the regression variables*

| | *RET* | *ARET* | *NPR* | *PILOT* | *DURING* | *POST* | *RetVol* | *M/B* | *Analyst* | *Size* | *Tech* | *Hold* | *Ret_Current* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *ARET* | 0.66** | | | | | | | | | | | | |
| *NPR* | 0.09** | 0.02** | | | | | | | | | | | |
| *PILOT* | −0.01 | −0.00 | 0.01 | | | | | | | | | | |
| *DURING* | 0.05** | −0.06** | −0.17** | 0.00 | | | | | | | | | |
| *POST* | −0.28** | 0.02** | 0.17** | −0.00 | −0.53** | | | | | | | | |
| *RetVol* | 0.04** | −0.02** | 0.34** | −0.00 | −0.34** | 0.41** | | | | | | | |
| *M/B* | −0.01 | 0.00 | −0.01 | 0.01* | −0.00 | 0.01 | −0.00 | | | | | | |
| *Analyst* | −0.06** | −0.01* | −0.13** | −0.01 | 0.00 | 0.03** | −0.06** | 0.01 | | | | | |
| *Size* | −0.02** | −0.01 | −0.00 | −0.04** | 0.01* | 0.00 | −0.03** | −0.01 | 0.20** | | | | |
| *Tech* | −0.01** | −0.00 | −0.08** | 0.00 | −0.00 | −0.01 | 0.09** | 0.03** | 0.24** | −0.05** | | | |
| *Hold* | 0.00 | 0.01 | −0.01 | 0.02** | −0.01 | 0.01* | −0.00 | 0.00 | 0.06** | 0.00 | 0.04** | | |
| *Ret_Current* | −0.01* | 0.014 | −0.07** | −0.00 | −0.01 | −0.01 | −0.02** | −0.00 | 0.01 | −0.01 | 0.01* | −0.00 | |
| *Ret_Past* | 0.00 | 0.07** | −0.19** | −0.01 | −0.11** | −0.01 | −0.07** | 0.0065 | −0.02** | −0.02** | −0.00 | 0.00 | 0.02** |

This panel presents descriptive statistics on the regression variables. The sample includes 19,410 firm-months from 1532 firms, including 527 pilot firms and 1005 control firms, in the pre, during and post periods. Please see the Appendix for variable definitions.
This panel presents the correlations among the regression variables. The sample includes 19,410 firm-months from 1532 firms, including 527 pilot firms and 1005 control firms, in the pre, during and post periods. Please see the Appendix for variable definitions. *, ** indicate significance at the 0.05 and 0.01 levels, respectively, based on two-tailed tests.

trading profits even if average trading profitability decreases. In an earlier version of Wang et al. (2021)[16], they have also examined profitability and find similar evidence of declining profitability for the pilot firms in the pilot period compared to the control firms.

We conduct a series of sensitivity tests to ensure the robustness of the results. For the sake of brevity, we do not tabulate the results.

- **Alternative measure of insider trading profitability.** Our measure of insider trading profitability in the main analysis is based on the association between insiders' net purchases and future raw (abnormal) returns. This measure captures the relative profitability of insider purchases versus insider sales and hence is a powerful way to identify the information advantage of insiders. An alternative measure of insider trading profitability is future returns for insider purchases and future returns multiplied by −1 for insider sales. The inferences remain the same when we use this alternative measure.
- **Controlling for option trading.** While conceptually option trading can be a substitute for short-selling, prior research finds that it is not a good substitute, possibly because of transaction costs (e.g., Battalio and Schultz 2011). To control for the potential confounding effect of option trading, we include in the regression an indicator for firms with option trading and its interaction with *NPR*. The results are quantitatively similar.
- **Controlling for changes in the pilot firms' operations.** Prior research finds that the pilot firms experience changes in executive compensation structure, investment, and financing during the pilot program compared to the control firms (e.g., Grullon et al. 2015; De Angelis et al. 2017). To ensure that such changes do not affect our results, we explicitly control for CEO compensation structure, capital expenditures, and financing, and obtain similar results.

[16] The earlier version of the paper can be downloaded at https://www.cicfconf.org/sites/default/files/paper_635.pdf. The title is a little different (Insider Sales under the Threat of Short Sellers: New Theory and New Tests) from the published version.

**Table 3**
Short Sellers and Insider Trading Profitability.

| | *RET* | | *ARET* | |
|---|---|---|---|---|
| | Coef. | t-stat | Coef. | t-stat |
| *NPR* | 2.529 | 0.000 | 2.994 | 0.004 |
| *NPR* × *PILOT* | 0.882 | 0.318 | 1.813 | 0.214 |
| *NPR* × *DURING* | −0.098 | 0.907 | −0.704 | 0.532 |
| *NPR* × *POST* | −1.037 | 0.469 | −1.397 | 0.476 |
| ***NPR* × *PILOT* × *DURING*** | **−3.106** | **0.041** | **−5.360** | **0.020** |
| *NPR* × *PILOT* × *POST* | −1.916 | 0.287 | −2.478 | 0.358 |
| *PILOT* | −0.852 | 0.336 | −0.168 | 0.910 |
| *PILOT* × *DURING* | −0.974 | 0.523 | −2.386 | 0.315 |
| *PILOT* × *POST* | −0.612 | 0.708 | −0.447 | 0.856 |
| *RetVol* | 0.078 | 0.852 | −1.898 | 0.000 |
| *NPR* × *RetVol* | 0.731 | 0.027 | 0.113 | 0.722 |
| *M/B* | −0.389 | 0.023 | −0.341 | 0.236 |
| *NPR* × *M/B* | −0.263 | 0.102 | −0.505 | 0.086 |
| *Analyst* | −0.053 | 0.389 | 0.029 | 0.754 |
| *NPR* × *Analyst* | 0.038 | 0.474 | 0.085 | 0.327 |
| *Size* | −1.042 | 0.002 | −1.460 | 0.001 |
| *NPR* × *Size* | −0.750 | 0.013 | −1.494 | 0.003 |
| *Tech* | 0.411 | 0.768 | 0.825 | 0.716 |
| *NPR* × *Tech* | 1.464 | 0.089 | 1.111 | 0.524 |
| *Hold* | 0.402 | 0.015 | 0.526 | 0.045 |
| *NPR* × *Hold* | −0.084 | 0.628 | −0.113 | 0.681 |
| *Ret_Current* | −0.108 | 0.036 | 0.009 | 0.070 |
| *Ret_Past* | 0.008 | 0.621 | 0.051 | 0.001 |
| Industry FE | Yes | | Yes | |
| Month FE | Yes | | Yes | |
| *N* | 19,410 | | 19,410 | |
| *Adjusted* $R^2$ | 38.86% | | 3.50% | |

This table reports results from the following regression:
$RET(ARET) = \alpha_0 + \alpha_1 NPR + \alpha_2 NPR \times PILOT + \alpha_3 NPR \times DURING + \alpha_4 NPR \times POST + \alpha_5 NPR \times PILOT \times DURING + \alpha_6 NPR \times PILOT \times POST + \alpha_7 PILOT + \alpha_8 PILOT \times DURING + \alpha_9 PILOT \times POST + \beta Control\_Variable + \theta NPR \times Control\_Variable + Industry, monthFE + \varepsilon$
The sample includes 19,410 firm-months from 1532 firms, including 527 pilot firms and 1005 control firms, in the pre, during and post periods. Please see the Appendix for variable definitions. The continuous control variables are demeaned. The p-values are based on standard errors adjusted for firm and calendar month level clustering (two sided tests).

– **Change in stock returns.** One might argue that the decrease in stock returns following insider sales is related to the possibility that pilot firms experience a stock price decrease during the pilot program due to the increased short-selling. However, this effect should be captured by the coefficient on *PILOT* × *DURING*. In addition, prior research finds that pilot firms do not differ from control firms in stock returns during the pilot program (e.g., Grullon et al. 2015). We also confirm that pilot and control firms have similar stock returns in both the pre and the during periods and experience similar change in stock returns from the pre to the during period, suggesting that this alternative story does not explain our results.

Given that the results based on raw returns and four-factor adjusted returns are similar, in the subsequent analyses, we only tabulate and discuss the results based on four-factor adjusted returns.

### 4.2. Cross-sectional analyses

#### 4.2.1. Accounting information quality

To test H2, we partition the sample into two subsamples based on accounting information quality and estimate Equation (1) separately for the two subsamples. H2 predicts that the effect of the pilot program is stronger in the subsample with poor accounting information quality.

We use two proxies for accounting information quality following prior research (Khan and Lu 2013).[17] The first is the Dechow and Dichev's (2002) measure of working capital accrual quality, and the second is based on the discretionary total accruals estimated from the modified Jones model. For each approach, we first take the residuals from the corresponding accru-

[17] In an untabulated sensitivity test, we use a third proxy for accounting information quality, the magnitude of the market reaction to earnings announcements (Huddart and Ke 2007). Greater market reaction to earnings announcements can indicate poor accounting quality, because less information has been impounded into prices before the earnings announcement. The inferences remain the same.

**Table 4**
Short Sellers and Insider Trading Profitability– Accounting Information Quality.

Panel A: Standard deviation of discretionary working capital accruals (Std_DD) based on the Dechow and Dichev (2002) model as the proxy for accounting information quality

| | Firms with poor quality | | Firms with good quality | |
|---|---|---|---|---|
| | Coef. | P-value | Coef. | P-value |
| *NPR* | 0.565 | 0.772 | 4.440 | 0.002 |
| *NPR* × *PILOT* | 3.242 | 0.243 | −1.402 | 0.423 |
| *NPR* × *DURING* | 2.616 | 0.340 | −2.575 | 0.081 |
| *NPR* × *POST* | 2.776 | 0.351 | −0.542 | 0.858 |
| ***NPR* × *PILOT* × *DURING*** | **−10.344** | **0.010** | **0.291** | **0.926** |
| *NPR* × *PILOT* × *POST* | −2.109 | 0.623 | 1.212 | 0.823 |
| *PILOT* | 1.366 | 0.623 | −1.556 | 0.382 |
| *PILOT* × *DURING* | −7.044 | 0.082 | 2.347 | 0.471 |
| *PILOT* × *POST* | −1.405 | 0.792 | −2.860 | 0.627 |
| *Control variables* | Yes | | Yes | |
| Industry FE | Yes | | Yes | |
| Month FE | Yes | | Yes | |
| *N* | 6416 | | 6419 | |
| *Adjusted* $R^2$ | 4.90% | | 5.47% | |
| The difference in the coefficient across the two subsamples: | | | | |
| ***NPR* × *PILOT* × *DURING*** | **−10.635** | **0.028** | | |

*Panel B: Standard deviation of discretionary total accruals (Std_DA) based on the modified Jones model as the proxy for accounting information quality*

| | Firms with poor quality | | Firms with good quality | |
|---|---|---|---|---|
| | Coef. | P-value | Coef. | P-value |
| *NPR* | 0.658 | 0.763 | 2.313 | 0.330 |
| *NPR* × *PILOT* | 2.528 | 0.524 | −1.829 | 0.625 |
| *NPR* × *DURING* | 3.02 | 0.262 | −0.543 | 0.823 |
| *NPR* × *POST* | −2.227 | 0.404 | −2.544 | 0.475 |
| ***NPR* × *PILOT* × *DURING*** | **−13.008** | **0.018** | **0.712** | **0.880** |
| *NPR* × *PILOT* × *POST* | −1.614 | 0.749 | 2.073 | 0.706 |
| *PILOT* | 0.412 | 0.92 | −1.767 | 0.630 |
| *PILOT* × *DURING* | −12.226 | 0.029 | 2.265 | 0.633 |
| *PILOT* × *POST* | 0.891 | 0.856 | 0.479 | 0.93 |
| *Control variables* | Yes | | Yes | |
| Industry FE | Yes | | Yes | |
| Month FE | Yes | | Yes | |
| *N* | 6466 | | 6471 | |
| *Adjusted* $R^2$ | 4.74% | | 5.03% | |
| The difference in the coefficient across the two subsamples: | | | | |
| ***NPR* × *PILOT* × *DURING*** | **−13.720** | **0.028** | | |

This table compares the regression results between firms with poor accounting information quality (*PAQ* = 1) and those with good accounting information quality (*PAQ* = 0). The regression model is as follows:
$ARET = \alpha_0 + \alpha_1 NPR + \alpha_2 NPR \times PILOT + \alpha_3 NPR \times DURING + \alpha_4 NPR \times POST + \alpha_5 NPR \times PILOT \times DURING + \alpha_6 NPR \times PILOT \times POST + \alpha_7 PILOT + \alpha_8 PILOT \times DURING + \alpha_9 PILOT \times POST + \beta Control\_Variable + \theta NPR \times Control\_Variable + Industry, monthFE + \varepsilon$
Please see the Appendix for variable definitions. The continuous control variables are demeaned. The p-values are based on standard errors adjusted for firm and calendar month level clustering (two sided tests).

als model and calculate the standard deviation of the residuals. We then construct an indicator variable for poor accounting quality, *PAQ*, which is 1 if the standard deviation is above the sample median and 0 otherwise.[18]

Table 4 reports the regression results, Panel A based on discretionary working capital accruals and Panel B based on discretionary total accruals. For each panel, we split the sample based on the value of *PAQ*, 1 or 0. As shown in Panel A, the coefficient on *NPR* × *PILOT* × *DURING* is significantly negative for firms with poor accruals quality (p = 0.010), but is insignificant for firms with good accruals quality (p = 0.926). The F-test indicates that the coefficient is significantly different across the two subsamples (p = 0.028). The results in Panel B are similar. The coefficient on *NPR* × *PILOT* × *DURING* is significantly negative only for firms with poor accounting information quality (p = 0.018), and the coefficient is significantly different across the two subsamples (p = 0.028). The coefficients for *NPR* × *PILOT* × *POST* are not significant for firms with either poor or good accounting information quality, based on both measures of accruals quality.

The above findings are consistent with H2. That is, for firms with poor accounting information quality, insiders have more information advantage and are more likely to trade on private information. The relaxation of short-selling constraints during

[18] We use the sample median in the pre period to address the possibility that accounting information quality might be affected by REG SHO. Using the sample median in the full sample period leads to quantitatively similar results.

the pilot program limits insiders' ability to do so. This evidence is consistent with short sellers serving a more important role in reducing insider trading profitability when accounting information quality is poorer.

*4.2.2. Corporate restrictions on insider trading*

To test H3, we split the sample into two subsamples based on whether a firm has insider trading restrictions. We then estimate Equation (1) separately for the two subsamples. H3 predicts that the effect of the pilot program is more pronounced for the subsample of firms without insider trading restrictions.

Because there is no publicly available data on corporate insider trading policies, we follow prior research and infer insider trading restrictions using insider trading data in the pre period. Based on survey data, Bettis et al. (2000) find that the most common restriction is to only allow insiders to trade in the period right after earnings announcements. Following Roulstone (2003), we classify a trade as within the allowed trading windows if it occurs in the month after an earnings announcement. For a given firm, we calculate the percentage of insider shares traded within the allowed trading windows among all the insider shares traded in the pre period. If this percentage is 75% or above, the firm is classified as having insider trading restrictions (*No_Res* = 0); otherwise, the firm is classified as having no insider trading restrictions (*No_Res* = 1).[19] For the 18,790 firm-months with available data for the classification, 13,516 (72%) are from firms without restrictions and the remaining 5274 (28%) are from firms with restrictions. This breakdown is similar to what's reported in Roulstone (2003).

Table 5 reports the regression results. The coefficient on $NPR \times PILOT \times DURING$ is significantly negative (p = 0.006) for firms without insider trading restrictions.[20] In contrast, it is insignificant for firms with insider trading restrictions (p = 0.592). This coefficient is significantly different between the two subsamples (p = 0.038). As for the coefficients on $NPR \times PILOT \times POST$, they are not significant in both subsamples.

In sum, consistent with H3, we find that the decrease in short-selling constraints during the pilot program significantly reduces insider trading profitability for the pilot firms without insider trading restrictions, but not for the pilot firms with insider trading restrictions, whose insiders are less likely to trade on private information in the first place. This evidence suggests that the market disciplinary role of short sellers is more important when there is a lack of internal monitoring mechanism.

## 5. Additional analyses

*5.1. The channels through which the reduction in short-selling constraints affects insider trading profitability*

In this section, we conduct tests to shed light on the channels through which the reduction in short-selling constraints affects insider trading profitability. When developing H1, we argue that the reduction in short-selling constraints can lead to reduced insider trading profitability through its positive impact on short-selling and voluntary disclosures and its negative impact on earnings management. Therefore, we examine whether the reduction in insider trading profitability experienced by the pilot firms is systematically associated with (i) the increase in short interest, (ii) the decrease in earnings management, and (iii) the increase in voluntary disclosures, for the pilot firms during the pilot program.

For this purpose, we split the pilot firms into two groups depending on whether the pilot firms have a greater than sample median increase in short interest, decrease in earnings management, or increase in voluntary disclosures, from the pre to the during period. We then construct two indicator variables for the two groups of pilot firms: *PILOT_H* and *PILOT_L*. We set *PILOT_H* to 1 and *PILOT_L* to 0 for the group for which we expect a stronger result if the reduction in short-selling constraints reduces insider trading profitability through the channel. Note that the sum of *PILOT_H* and *PILOT_L* is *PILOT*. We then estimate the following regression to test the validity of each channel:

$$\begin{aligned} ARET = {} & \alpha_0 + \alpha_1 NPR + \alpha_2 NPR \times PILOT\_H + \alpha_3 NPR \times PILOT\_L + \alpha_4 NPR \times DURING + \alpha_5 NPR \times POST + \alpha_6 NPR \\ & \times PILOT\_H \times DURING + \alpha_7 NPR \times PILOT\_L \times DURING + \alpha_8 NPR \times PILOT \times POST + \alpha_9 PILOT\_H \\ & + \alpha_{11} PILOT\_L + \alpha_{10} PILOT\_H \times DURING + \alpha_{11} PILOT\_L \times DURING + \alpha_{12} PILOT \times POST + \beta Control\_Variable \\ & + \theta NPR \times Control\_Variable + Industry, monthFE + \varepsilon \end{aligned} \quad (2)$$

If the reduction in short-selling constraints reduces insider trading profitability through a specific channel, we expect $\alpha_6$ to be more negative than $\alpha_7$.

Table 6 reports the regression results. Column (1) is based on the change in short interest. *PILOT_H* equals 1 for the pilot firms with a greater than sample median increase in short interest from the pre to during period,[21] and *PILOT_L* equals 1 for the other pilot firms. As reported, the coefficient on $NPR \times PILOT\_H \times DURING$ is significantly negative (p = 0.007), but the coefficient on $NPR \times PILOT\_L \times DURING$ is insignificant (p = 0.823). The F-test indicates that the two coefficients are significantly

[19] The 75% cut-off is consistent with the observed insider trading patterns of firms with insider trading restrictions as reported in Bettis et al. (2000).

[20] To ensure that the results are not affected by firms that started to implement insider trading restrictions in the during period, in an untabulated sensitivity test, we exclude those firms that are classified as having no insider trading restrictions in the pre period but are classified as having insider trading restrictions in the during period. The results remain quantitatively similar.

[21] Note that we cannot split the sample based on the change in short-selling activities (e.g., short-selling volume); while short interest is available in both the pre and the during periods, data on intraday short sales is only available in the during period per REG SHO.

**Table 5**
Short Sellers and Insider Trading Profitability –Corporate Restrictions on Insider Trading.

| | Firms without insider trading restrictions | | Firms with insider trading restrictions | |
|---|---|---|---|---|
| | Coef. | P-value | Coef. | P-value |
| *NPR* | 3.339 | 0.002 | 0.613 | 0.721 |
| *NPR* × *PILOT* | 1.590 | 0.315 | 1.400 | 0.404 |
| *NPR* × *DURING* | −0.403 | 0.741 | −1.700 | 0.468 |
| *NPR* × *POST* | −1.595 | 0.346 | 1.491 | 0.508 |
| ***NPR* × *PILOT* × *DURING*** | **−6.572** | **0.006** | **1.647** | **0.592** |
| *NPR* × *PILOT* × *POST* | −1.534 | 0.609 | −0.361 | 0.914 |
| *PILOT* | −1.103 | 0.480 | 1.340 | 0.511 |
| *PILOT* × *DURING* | −2.229 | 0.345 | 1.102 | 0.739 |
| *PILOT* × *POST* | 3.083 | 0.270 | −4.643 | 0.162 |
| *Control variables* | Yes | | Yes | |
| Industry FE | Yes | | Yes | |
| Month FE | Yes | | Yes | |
| *N* | 13,516 | | 5274 | |
| *Adjusted* $R^2$ | 4.29% | | 3.77% | |
| The difference in the coefficient across the two subsamples: | | | | |
| ***NPR* × *PILOT* × *POST*** | **−8.219** | **0.038** | | |

This table compares the regression results between firms without insider trading restrictions (*No_Res* = 1) and those with insider trading restrictions (*No_Res* = 0). The regression model is as follows:
$ARET = \alpha_0 + \alpha_1 NPR + \alpha_2 NPR \times PILOT + \alpha_3 NPR \times DURING + \alpha_4 NPR \times POST + \alpha_5 NPR \times PILOT \times DURING + \alpha_6 NPR \times PILOT \times POST + \alpha_7 PILOT + \alpha_8 PILOT \times DURING + \alpha_9 PILOT \times POST + \beta Control\_Variable + \theta NPR \times Control\_Variable + Industry, monthFE + \varepsilon$
The sample includes 18,790 firm-months in the pre, during and post periods, including 13,516 observations from firms without insider trading restrictions and 5274 observations from firms with insider trading restrictions. Please see the Appendix for variable definitions. The continuous control variables are demeaned. The p-values are based on standard errors adjusted for firm and calendar month level clustering (two sided tests).

**Table 6**
Short Sellers and Insider Trading Profitability – The Channels.

| | (1) Increase in short interest | | (2) Decrease in earnings management | | (3) Increase in voluntary disclosure | |
|---|---|---|---|---|---|---|
| | Coef. | P-value | Coef. | P-value | Coef. | P-value |
| *NPR* | 3.071 | 0.004 | 2.535 | 0.065 | 3.929 | 0.000 |
| ***NPR* × *PILOT_H* × *DURING*** | **−7.174** | **0.007** | **−7.241** | **0.064** | **−10.915** | **0.001** |
| ***NPR* × *PILOT_L* × *DURING*** | **−1.747** | **0.823** | **−3.706** | **0.229** | **−2.183** | **0.476** |
| *Control variables* | Yes | | Yes | | Yes | |
| Industry FE | Yes | | Yes | | Yes | |
| Month FE | Yes | | Yes | | Yes | |
| *N* | 19,410 | | 14,666 | | 19,410 | |
| *Adjusted* $R^2$ | 3.54% | | 3.28% | | 3.45% | |
| ***NPR* × *PILOT_H* × *DURING* - *NPR* × *PILOT_L* × *DURING*** | **−5.427** | **0.031** | **−3.535** | **0.274** | **−8.732** | **0.028** |

This table reports the results of the following regression:
$ARET = \alpha_0 + \alpha_1 NPR + \alpha_2 NPR \times PILOT\_H + \alpha_3 NPR \times PILOT\_L + \alpha_4 NPR \times DURING + \alpha_5 NPR \times POST + \alpha_6 NPR \times PILOT\_H \times DURING + \alpha_7 NPR \times PILOT\_L \times DURING + \alpha_8 NPR \times PILOT \times POST + \alpha_9 PILOT\_H + \alpha_{10} PILOT\_L + \alpha_{11} PILOT\_H \times DURING + \alpha_{12} PILOT\_L \times DURING + \alpha_{13} PILOT \times POST + \beta Control\_Variable + \theta NPR \times Control\_Variable + Industry, monthFE + \varepsilon$
The control variables are the same as in Equation (1) (Table 3). The continuous control variables are demeaned. In Column (1), *PILOT_H* equals 1 for the pilot firms with an above-the-sample-median increase in the average level of short interest from the pre to the during period, and zero otherwise. Short interest is calculated as the ratio of short interest in shares to the shares outstanding. In Column (2), *PILOT_H* equals 1 for the pilot firms with an above-the-sample-median decrease in the average level of absolute discretionary accruals from the pre to the during period, and zero otherwise. Discretionary accruals are from the modified Jones model. In Column (3), *PILOT_H* equals 1 for the pilot firms with an above-the-sample-median increase in the average management forecast frequency from the pre to the during period, and zero otherwise. *PILOT_L* is 1 for the pilot firms for which *PILOT_H* is 0, and zero otherwise. See the Appendix for other variable definitions. The p-values are based on standard errors adjusted for firm and calendar month level clustering (two sided tests).

different (p = 0.031). That is, insider trading profitability during the pilot period decreases more for the pilot firms that experience a greater increase in short interest than for the other pilot firms. This result suggests that the increase in short-selling is an important channel through which the reduction in short-selling constraints affects insider trading profitability.[22]

Column (2) reports the results based on the change in earnings management. *PILOT_H* equals 1 for the pilot firms with a greater than sample median decrease in the extent of earnings management, measured as the absolute value of discretionary

[22] The analysis for short interest argues that short-selling activities can reduce firms' information asymmetry and hence reduce insiders' trading portability. This argument hinges on an actual increase in short-selling activities for pilot firms during the pilot program. Prior research (e.g., Grullon et al. 2015) documents short-selling in the pilot firms increases relative to the control firms. We confirm in our sample that short-selling does increase for the pilot firms.

accruals, from the pre to the during period, and *PILOT_L* equals 1 for the other pilot firms. We use the absolute value of discretionary accruals to capture both upward and downward earnings management because both can increase information asymmetry between managers and investors (Hribar and Nichols 2007). As reported, the coefficient on *NPR* × *PILOT_H* × *DURING* is significantly negative (p = 0.064), and that on *NPR* × *PILOT_L* × *DURING* is not significant (p = 0.229). The F-test indicates that the two coefficients are not significantly different from each other (p = 0.274). This result suggests that while the decrease in earnings management contributes to the reduction in insider trading profitability, it does not seem to be the main channel through which the reduction in short-selling constraints affects insider trading profitability of the pilot firms.

Column (3) reports the results based on the change in voluntary disclosures. *PILOT_H* equals 1 for the pilot firms with a greater than sample median increase in management forecast frequency from the pre to during period, and *PILOT_L* equals 1 for the other pilot firms. As reported, the coefficient on *NPR* × *PILOT_H* × *DURING* is significantly negative (p = 0.001), and that on *NPR* × *PILOT_L* × *DURING* is not significant (p = 0.476). The F-test indicates that the two coefficients are significantly different (p = 0.028). This result indicates that the increase in voluntary disclosures is an important channel through which the reduction in short-selling constraints affects insider trading profitability.

Overall, the above findings suggest that both the increase in short-selling and the increase in voluntary disclosures are important channels through which the reduction in short-selling constraints affects insider trading profitability. The decrease in earnings management, however, does not appear to be a key channel.

### 5.2. Separating insider trades into purchases and sales

As discussed in Section 2, we expect the relaxation of short-selling constraints to reduce the profitability of both insider purchases and insider sales. Some might expect the results to be driven by insider sales since short-selling speeds up the incorporation of bad news into share prices. We argue that insider purchase profitability is also expected to decrease; with the relaxation of short-selling constraints, short interest is more informative and the information environment is richer, facilitating the discovery of good news as well as bad news, as discussed in Section 2.3.

In this section, we separately examine insider purchases and sales. For this purpose, we construct two indicator variables, *BUY* and *SELL*. *BUY* equals one for firm-months with positive *NPR*, and *SELL* equals one for firm-months with negative *NPR*. We drop firm-months with zero *NPR*, i.e., when there is an equal number of insider purchase and sale transactions. We then replace *NPR* in Equation (1) with these two indicator variables.

The regression results are reported in Table 7. Because *BUY* and *SELL* add to one and the regression includes industry and month fixed effects, *BUY*, *DURING*, *POST*, *BUY* × *DURING*, and *BUY* × *POST* are not included in the regression. The coefficients on *BUY* × *PILOT* × *DURING* and *SELL* × *PILOT* × *DURING* capture the effect of the pilot program on the profitability of insider purchases and insider sales, respectively. If the pilot program reduces insider purchase and sale profitability, the coefficients on *BUY* × *PILOT* × *DURING* and *SELL* × *PILOT* × *DURING* are expected to be negative and positive, respectively (Note that insider sales, if profitable, are expected to be followed by negative returns). As reported in Table 7, for the pilot firms, both insider purchases and insider sales become less profitable during the pilot program (p = 0.045 and 0.074, respectively). In sum, we find that after the relaxation of short-selling constraints, both insider purchases and insider sales are less profitable.

### 5.3. Parallel trend analysis

The difference-in-differences analysis assumes no difference between the pilot firms and the control firms before the pilot program. To validate this parallel trend assumption, we define several subperiods for the pre, during or post periods: *PRE1* includes the firm-months from December 2002 to June 2003, *PRE2* includes the firm-months from July 2003 to January 2004, *DURING1* includes the firm-months from May 2005 to February 2006, *DURING2* includes the firm-months from March 2006 to December 2006, *POST1* includes the firm-months from August 2007 to June 2008, *POST2* includes the firm-months from July 2008 to March 2009[23], and the remaining firm-months from June 2002 to November 2002 are used as the benchmark. We then include interactions of the above six indicator variables with *NPR* and *PILOT*, and run the following regression:

$$\begin{aligned} ARET = {} & \alpha_0 + \alpha_1 NPR + \alpha_2 NPR \times PILOT + \alpha_3 NPR \times PRE1 + \alpha_4 NPR \times PRE2 + \alpha_5 NPR \times DURING1 + \alpha_6 NPR \\ & \times DURING2 + \alpha_7 NPR \times POST1 + \alpha_8 NPR \times POST2 + \alpha_9 NPR \times PILOT \times PRE1 + \alpha_{10} NPR \times PILOT \times PRE2 \\ & + \alpha_{11} NPR \times PILOT \times DURING1 + \alpha_{12} NPR \times PILOT \times DURING2 + \alpha_{13} NPR \times PILOT \times POST1 + \alpha_{14} NPR \\ & \times PILOT \times POST2 + \alpha_{15} PILOT + \alpha_{16} PILOT \times PRE1 + \alpha_{17} PILOT \times PRE2 + \alpha_{18} PILOT \times DURING1 + \alpha_{19} PILOT \\ & \times DURING2 + \alpha_{20} PILOT \times POST1 + \alpha_{21} PILOT \times POST2 + \beta Control\_Variable + \theta NPR \times Control\_Variable \\ & + Industry, monthFE + \varepsilon \end{aligned} \tag{3}$$

All other variables are the same as in Equation (1). The results are presented in Table 8. The coefficients of *NPR* × *PILOT* × *PRE1* and *NPR* × *PILOT* × *PRE2* capture the difference in insider trading profitability between the pilot firms and the control firms in the pre period, and both are insignificant. The coefficients of *NPR* × *PILOT* × *POST1* and

[23] The split of the post period is based on the occurrence of financial crisis.

**Table 7**
Short Sellers and Insider Trading Profitability – Separating Insider Purchases from Sales.

| | Coef. | P-value |
|---|---|---|
| *BUY* × *PILOT* | 2.002 | 0.440 |
| ***BUY* × *PILOT* × *DURING*** | **−8.905** | **0.045** |
| *BUY* × *PILOT* × *POST* | −3.871 | 0.392 |
| *SELL* | −5.973 | 0.006 |
| *SELL* × *PILOT* | −1.958 | 0.132 |
| *SELL* × *DURING* | 0.981 | 0.687 |
| *SELL* × *POST* | 2.727 | 0.467 |
| ***SELL* × *PILOT* × *DURING*** | **2.903** | **0.074** |
| *SELL* × *PILOT* × *POST* | 2.080 | 0.374 |
| *Control variables* | Yes | |
| Industry FE | Yes | |
| Month FE | Yes | |
| *N* | 19,204 | |
| *Adjusted* $R^2$ | 3.47% | |

This table reports results from the following regression:
$ARET = \alpha_0 + \alpha_1 BUY \times PILOT + \alpha_2 BUY \times PILOT \times DURING + \alpha_3 BUY \times PILOT \times POST + \alpha_4 SELL + \alpha_5 SELL \times PILOT + \alpha_6 SELL \times DURING + \alpha_7 SELL \times POST + \alpha_8 SELL \times PILOT \times DURING + \alpha_9 SELL \times PILOT \times POST + \beta Control\_Variable + \theta BUY \times Control\_Variable + \lambda SELL \times Control\_Variable + Industry, monthFE + \varepsilon$
The full sample includes 19,204 firm-months from 1532 firms, including 527 pilot firms and 1005 control firms, in the pre, during and post periods. *BUY* equals one for firm-months with positive net purchase ratio (*NPR*) and *SELL* equals one for firm-months with negative *NPR*. We exclude firm-months where *NPR* is zero. Please see the Appendix for the definitions of other variables. The control variables are the same as in Equation (1) (Table 3). The continuous control variables are demeaned. The p-values are based on standard errors adjusted for firm and calendar month level clustering (two sided tests).

**Table 8**
Short Sellers and Insider Trading Profitability – Parallel Trend Analysis.

| | Coef. | P-value |
|---|---|---|
| *NPR* | 2.756 | 0.024 |
| ***NPR* × *PILOT* × *PRE1*** | **−2.291** | **0.265** |
| ***NPR* × *PILOT* × *PRE2*** | **2.991** | **0.241** |
| ***NPR* × *PILOT* × *DURING1*** | **−8.590** | **0.009** |
| ***NPR* × *PILOT* × *DURING2*** | **−3.984** | **0.105** |
| ***NPR* × *PILOT* × *POST1*** | **−1.522** | **0.661** |
| ***NPR* × *PILOT* × *POST2*** | **−4.095** | **0.236** |
| *Control variables* | Yes | |
| Industry FE | Yes | |
| Month FE | Yes | |
| *N* | 19,410 | |
| *Adjusted* $R^2$ | 3.56% | |

This table reports results from the following regression:
$ARET = \alpha_0 + \alpha_1 NPR + \alpha_2 NPR \times PILOT + \alpha_3 NPR \times PRE1 + \alpha_4 NPR \times PRE2 + \alpha_5 NPR \times DURING1 + \alpha_6 NPR \times DURING2 + \alpha_7 NPR \times POST1 + \alpha_8 NPR \times POST2 + \alpha_9 NPR \times PILOT \times PRE1 + \alpha_{10} NPR \times PILOT \times PRE2 + \alpha_{11} NPR \times PILOT \times DURING1 + \alpha_{12} NPR \times PILOT \times DURING2 + \alpha_{13} NPR \times PILOT \times POST1 + \alpha_{14} NPR \times PILOT \times POST2 + \alpha_{15} PILOT + \alpha_{16} PILOT \times PRE1 + \alpha_{17} PILOT \times PRE2 + \alpha_{18} PILOT \times DURING1 + \alpha_{19} PILOT \times DURING2 + \alpha_{20} PILOT \times POST1 + \alpha_{21} PILOT \times POST2 + \beta Control\_Variable + \theta NPR \times Control\_Variable + Industry, monthFE + \varepsilon$
The full sample includes 19,410 firm-months from 1532 firms, including 527 pilot firms and 1005 control firms, in the pre, during and post periods. *PRE1* includes the firm-months from December 2002 to June 2003, *PRE2* includes the firm-months from July 2003 to January 2004, *DURING1* includes the firm-months from May 2005 to February 2006, *DURING2* includes the firm-months from March 2006 to December 2006, *POST1* includes the firm-months from August 2007 to June 2008, and *POST2* includes the firm-months from July 2008 to March 2009; the remaining firm-months from June 2002 to November 2002 are used as the benchmark. Please see the Appendix for the definitions of other variables. The control variables are the same as in Equation (1) (Table 3). The continuous control variables are demeaned. The p-values are based on standard errors adjusted for firm and calendar month level clustering (two sided tests).

*NPR* × *PILOT* × *POST2* capture the difference in the change of insider trading profitability from the pre to the post period, and both are also insignificant. By contrast, the coefficients of *NPR* × *PILOT* × *DURING1* and *NPR* × *PILOT* × *DURING2* that capture the difference in the change of insider trading profitability from the pre to the during period are significant. The results validate the parallel trend assumption.

### *5.4. Transaction size of insider trades during the pilot program*

In this section, we examine whether the pilot program has a significant impact on the transaction size of insider trades. Intuitively, when insiders trade on private information, they likely buy or sell a large number of shares, resulting in large but

infrequent insider transactions (e.g., Khan and Lu 2013). When insiders trade for liquidity or diversification reasons, they are more likely to trade frequently with small transaction size. It thus follows that if insiders of the pilot firms are less likely to trade on private information during the pilot program, we should observe that the transaction size of insider trades becomes smaller for the pilot firms during the pilot program, compared with the control firms.

To test this prediction, we examine the transaction size, frequency, and total trading size of insider trades for pilot and control firms. We find that compared with control firms, the number of insider transactions becomes larger and the average transaction size becomes smaller during the pilot program for the pilot firms, while the total transaction size remains similar. These results suggest that when short-selling constraints are reduced, insiders trade more frequently with smaller transaction size, corroborating the earlier results of reduced profitability for such transactions. (Results untabulated to save space)

### *5.5. An alternative explanation based on short sellers front-running insider sales*

Khan and Lu (2013) find that information about impending insider sales can be leaked to short sellers, creating an opportunity for short sellers to front-run insider sales. Given that the pilot firms have lower short-selling constraints during the pilot program, it may become easier for short sellers to front-run insider sales for the pilot firms, which can lead to a decrease in insider trading profitability. To examine whether this alternative story can explain our results, we investigate whether front-running is more likely for the pilot firms than for the control firms during the pilot program.[24]

Using a similar research design as Khan and Lu (2013), we find that short sellers front-run large insider sales, but not small insider sales, as documented in Khan and Lu (2013). However, we do not find any evidence suggesting that front-running is more prevalent for the pilot firms than for the control firms during the pilot program (untabulated). This indicates that our results are not driven by short sellers front-running insider sales.

## 6. Conclusion

This paper examines whether short sellers help reduce insider trading profitability using a natural experiment – the SEC's pilot program of suspending the short sale tick test over the period of 2005–2007 for a group of randomly selected pilot firms. The pilot program introduced an exogenous shock that reduced the short-selling constraints for the pilot firms relative to the control firms.

We find that the relaxation of short-selling constraints significantly reduces insider trading profitability, measured as the association between insider trades and future stock returns. For the pilot firms, this association decreases significantly from the pre period to the during period, while there is no such change for the control firms. Further analyses indicate that the result is stronger for the pilot firms with poor accounting information quality, and for the pilot firms without insider trading restrictions. We provide evidence that the increase in short interest and voluntary disclosures are important channels through which the reduction in short-selling constraints affects insider trading profitability.

Overall, our findings shed light on the role of short sellers in constraining insiders' exploitation of private information through trading. The results help us to better understand the influence of short sellers and point out an external mechanism that reduces insider trading profitability and keeps insiders in check.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Acknowledgement

We thank Inder Khurana, Christian Laux, Hai Lu, Shiva Rajgopal, and workshop and conference participants at the University of Illinois at Urbana-Champaign and the 2015 EAA Annual Congress for helpful comments.

Funding: This work was supported by School of Accountancy Research Center (SOAR) at Singapore Management University; Lee Kong Chian Fellowship; National Natural Science Foundation of China (Grant No. 71672097).

[24] Note that we can only examine front-running during the pilot program, when data on intraday short sales is made available for stocks listed on NYSE and Nasdaq per REG SHO.

## Appendix. Variable measurement

| | |
|---|---|
| *Dependent variable* | |
| *RET* = | Future stock returns (%), calculated as the 6-month cumulative daily raw stock returns beginning the day after the last insider transaction for a given firm-month; |
| *ARET* = | Future abnormal stock returns (%), calculated as the 6-month cumulative daily four-factor adjusted stock returns beginning the day after the last insider transaction for a given firm-month; |
| *Independent variables of interest* | |
| *NPR* = | Net purchase ratio, calculated by dividing insiders' net purchases in a given month by the total number of insider transactions in the same month; net purchases are calculated as the number of insider purchase transactions minus the number of insider sale transactions; |
| *PILOT* = | Indicator for the pilot firms, defined as 1 if a firm was selected by the SEC for the pilot program, and 0 otherwise; |
| *DURING* = | Indicator for the during period, defined as 1 for the during period (i.e., during the pilot program), and 0 for the other periods; |
| *POST* = | Indicator for the post period, defined as 1 for the post period (i.e., during the permanent removal period), and 0 for the other periods; |
| *Control variables* | |
| *RetVol* = | Stock return volatility, calculated as the standard deviation of daily stock returns over the current quarter; |
| *M/B* = | Market to book ratio, calculated as the market capitalization of equity divided by the book value of equity at the end of the previous quarter; |
| *Analyst* = | Analyst following, defined as the number of analysts who provide earnings forecasts for the firm in the previous year; |
| *Size* = | Firm size, calculated as total assets (in millions) at the end of the previous quarter; we use its log transformation in the correlation and regression analyses; |
| *Tech* = | Indicator for high-tech firms, defined as 1 for firms in high-tech industries (with SIC codes of 2833–2836, 8731–8734, 7371–7379, 3570–3577, or 3600–3674), and 0 otherwise; |
| *Hold* = | Insider holding, defined as the average number of shares held by those insiders who trade in the month; we use its log transformation in the correlation and regression analyses; |
| *Ret_Current* = | Current stock returns (%), calculated as the cumulative daily raw or four-factor adjusted stock returns beginning on the first day of the month and ending on the day of the last insider transaction for a given firm-month; |
| *Ret_Past* = | Past stock returns (%), calculated as the cumulative daily raw or four-factor adjusted stock returns over the 11-month period before the current month; |
| *Cross sectional variables* | |
| *PAQ* = | Indicator for firms with poor accounting information quality; it is based on two alternative accrual measures, the standard deviation of the discretionary working capital accruals (*Std_DD*) and the standard deviation of the discretionary total accruals (*Std_DA*); *PAQ* equals 1 if *Std_DD* or *Std_DA* for the firm is above or equal to the corresponding sample median, and 0 otherwise; *Std_DD (Std_DA)* is calculated as the standard deviation of the residuals from the Dechow and Dichev (2002) model (the modified Jones model), estimated by industry-year, over the three years in the pre period; |
| *No_Res* = | Indicator for firms without insider trading restrictions; for a given firm, we calculate the percentage of insider shares traded in the one-month period following earnings announcements among all the insider shares traded in the pre period; *No_Res* equals 1 if the percentage is below 75%, and 0 otherwise. |

## References

Allen, S., Ramanan, R., 1995. Insider trading, earnings changes, and stock prices. Manage. Sci. 41 (4), 653–668.
Ausubel, L., 1990. Insider trading in a rational expectations economy. Am. Econ. Rev. 80 (5), 1022–1041.
Baiman, S., Verrecchia, R.E., 1996. The relation among capital markets, financial disclosure, production efficiency, and insider trading. J. Account. Res. 34 (1), 1–22.
Battalio, R., Schultz, P., 2011. Regulatory uncertainty and market liquidity: the 2008 short sale ban's impact on equity option markets. J. Finance 66 (6), 2013–2053.
Bebchuk, L.A., Fershtman, C., 1994. Insider trading and managerial choice among risky projects. J. Financ. Quant. Anal. 29, 1–14.
Bettis, J.C., Coles, J.L., Lemmon, M.L., 2000. Corporate policies restricting trading by insiders. J. Financ. Econ. 57 (2), 191–220.
Bhattacharya, U., Daouk, H., 2002. The world price of insider trading. J. Finance 57 (1), 75–108.
Boehme, R.D., Danielsen, B.R., Sorescu, S.M., 2006. Short-sale constraints, differences of opinion, and overvaluation. J. Financ. Quant. Anal. 41 (2), 455–487.
Boehmer, E., Huszar, Z.R., Jordan, B.D., 2010. The good news in short interest. J. Financ. Econ. 96 (1), 80–97.
Boehmer, E., Jones, C.M., Zhang, X., 2008. Which shorts are informed? J. Finance 63 (2), 491–527.

Boehmer, E., Wu, J., 2013. Short selling and the price discovery process. Rev. Financ. Stud. 26 (2), 287–322.
Bushman, R., Piotroski, J.D., Smith, A.J., 2005. Insider trading restrictions and analysts' incentives to follow firms. J. Finance 47 (1), 35–66.
Carlton, D.W., Fischel, D.R., 1983. The regulation of insider trading. Stanford Law Rev. 35 (5), 857. https://doi.org/10.2307/1228706.
Chen, Q.i., Chen, X., Schipper, K., Xu, Y., Xue, J., 2012. The sensitivity of corporate cash holdings to corporate governance. Rev. Financ. Stud. 25 (12), 3610–3644.
Chen, H., Chen, Y., Lin, B., Wang, Y., 2019. Can short selling improve internal control? An empirical study based on the difference-in-differences model. Account. Finance 58 (5), 1233–1259.
Chen, X., Cheng, Q., Luo, T., Yue, H., 2020. Short sellers and long run management forecasts. Contemp. Account. Res. 37 (2), 802–828.
Cheng, Q., Lo, K., 2006. Insider trading and voluntary disclosures. J. Account. Res. 44 (5), 815–848.
Cheng, Q., Luo, T., Yue, H., 2013. Managerial incentives and management forecast precision. Account. Rev. 88, 1575–1602.
Christophe, S.E., Ferri, M.G., Hsieh, J., 2010. Informed trading before analyst downgrades: evidence from short sellers. J. Financ. Econ. 95 (1), 85–106.
Chung, S.G., Goh, B.W., Lee, J., Shevlin, T., 2019. Corporate tax aggressiveness and insider trading. Contemp. Account. Res. 36 (1), 230–258.
Clinch, G.J., Li, W., Zhang, Y., 2019. Short selling and firms' disclosure of bad news: evidence from Regulation SHO. J. Financ. Rep. 4 (1), 1–23.
Cohen, L., Diether, K., Malloy, C., 2007. Supply and demand shifts in the shorting market. J. Finance 62, 2061–2096.
Cohen, L., Malloy, C., Pomorski, L., 2012. Decoding inside information. J. Finance 68, 1009–1043.
Dai, L., Parwada, J., Zhang, B., 2015. The governance effect of the media's news dissemination role: Evidence from insider trading. J. Account. Res. 53 (2), 331–366.
Damodaran, A., Liu, C.H., 1993. Insider trading as a signal of private information. Rev. Financ. Stud. 6 (1), 79–119.
De Angelis, D., Grullon, G., Michenaud, S., 2017. Downside risk and the design of CEO incentives: evidence from a natural experiment. Rev. Financ. Stud. 30, 1627–1659.
Dechow, P.M., Dichev, I., 2002. The quality of accruals and earnings. Account. Rev. 77 (Supplement), 35–59.
Dechow, P.M., Hutton, A.P., Meulbroek, L., Sloan, R.G., 2001. Short-sellers, fundamental analysis, and stock returns. J. Financ. Econ. 61, 77–106.
Deng, X., Gao, L., Kim, J.-B., 2020. Short-sale constraints and stock price crash risk: causal evidence from a natural experiment. J. Corp. Finance 60, 101498. https://doi.org/10.1016/j.jcorpfin.2019.101498.
Diamond, D.W., Verrecchia, R.E., 1987. Constraints on short selling and asset price adjustment to private information. J. Financ. Econ. 18 (2), 277–311.
Diether, K.B., Lee, K., Werner, I.M., 2009. It's SHO time! Short-sale price tests and market quality. J. Finance 64, 37–73.
Engelberg, J.E., Reed, A.V., Ringgenberg, M.C., 2012. How are shorts informed? Short sellers, news, and information processing. J. Financ. Econ. 105 (2), 260–278.
Fang, V.W., Huang, A.H., Karpoff, J.M., 2016. Short selling and earnings management: a controlled experiment. J. Finance 71 (3), 1251–1294.
Frankel, R., Li, X.u., 2004. Characteristics of a firm's information environment and the information asymmetry between insiders and outsiders. J. Account. Econ. 37 (2), 229–259.
Fried, J., 1998. Reducing the profitability of coporate insider trading through pretrading disclosure. Southern California Law Rev. 71 (2), 303–392.
Grullon, G., Michenaud, S., Weston, J., 2015. The real effects of short-selling constraints. Rev. Financ. Stud. 28 (6), 1737–1767.
Hendershott, T., Kozhan, R., Raman, V., 2020. Short selling and price discovery in corporate bonds. J. Financ. Quant. Anal. 55 (1), 77–115.
Hirshleifer, D., Teoh, S., Yu, J., 2011. Short arbitrage, return asymmetry and the accruals anomaly. Rev. Financ. Stud. 24, 2429–2461.
Hong, H., Kubik, J.D., Fishman, T., 2012. Do arbitrageurs amplify economic shocks? J. Financ. Econ. 103 (3), 454–470.
Hribar, P., Nichols, D.C., 2007. The use of unsigned earnings quality measures in tests of earnings management. J. Account. Res. 45 (5), 1017–1053.
Huddart, S.J., Ke, B., 2007. Information asymmetry and cross-sectional variation in insider trading. Contemp. Account. Res. 24, 195–232.
Huddart, S.J., Louis, H., 2010. Insider selling, earnings management, and the 1990s stock market bubble. Working paper. Pennsylvania State University, University Park.
Jagolinzer, A.D., 2009. SEC rule 10b5-1 and insiders' strategic trade. Manage. Sci. 55 (2), 224–239.
Jagolinzer, A.D., Larcker, D.F., Taylor, D.J., 2011. Corporate governance and the information content of insider trades. J. Account. Res. 49 (5), 1249–1274.
Jones, C.M., Lamont, O.A., 2002. Short-sale constraints and stock returns. J. Financ. Econ. 66 (2-3), 207–239.
Karpoff, J.M., Lee, D., 1991. Insider trading before new issue announcements. Financ. Manage. 20 (1), 18. https://doi.org/10.2307/3666093.
Karpoff, M., Lou, X., 2010. Short sellers and financial miscondut. J. Finance 65 (5), 1879–1913.
Khan, M., Lu, H., 2013. Do short sellers front-run insider sales? Account. Rev. 88, 1743–1768.
Kolasinski, A., Li, X.u., 2010. Are corporate managers savvy about their stock price? Evidence from insider trading after earnings announcements. J. Account. Public Policy 29 (1), 27–44.
Kyle, A.S., 1985. Continuous auctions and insider trading. Econometrica 53 (6), 1315. https://doi.org/10.2307/1913210.
Lakonishok, J., Lee, I., 2001. Are insider trades informative? Rev. Financ. Stud. 14 (1), 79–111.
Li, Yinghua, Zhang, Liandong, 2015. Short selling pressure, stock price behavior, and management forecast precision: evidence from a natural experiment. J. Account. Res. 53 (1), 79–117.
Liu, X., 2015. Short-selling attacks and creditor runs. Manage. Sci. 61 (4), 814–830.
Manne, H.G., 1966. Insider Trading and the Stock Market. Free Press, New York.
Manove, M., 1989. The harm from insider trading and informed speculation. Quart. J. Econ. 104 (4), 823. https://doi.org/10.2307/2937869.
Massa, M., Qian, W., Xu, W., Zhang, H., 2015a. Competition of the informed: does the presence of short sellers affect insider selling? J. Financ. Econ. 118 (2), 268–288.
Massa, M., Zhang, B., Zhang, H., 2015b. The invisible hand of short selling: does short selling discipline earnings management? Rev. Financ. Stud. 28 (6), 1701–1736.
Noe, C.F., 1999. Voluntary disclosures and insider transactions. J. Account. Econ. 27 (3), 305–326.
Ofek, E., Richardson, M., 2003. Dotcom mania: the rise and fall of Internet stock prices. J. Finance 58 (3), 1113–1137.
Ravina, E., Sapienza, P., 2010. What do independent directors know? Evidence from their trading. Rev. Financ. Stud. 23 (3), 962–1003.
Ronen, J., Tzur, J., Yaari, V.(., 2006. The effect of directors' equity incentives on earnings management. J. Account. Public Policy 25 (4), 359–389.
Roulstone, D.T., 2003. The relation between insider-trading restrictions and executive compensation. J. Account. Res. 41 (3), 525–551.
Savor, P., Gamboa-Cavazos, M., 2011. Holding on to your shorts: When do short sellers retreat? Working paper. University of Pennsylvania, Philadelphia.
Seligman, J., 1985. The reformulation of federal securities law concerning nonpublic information. Georgetown Law J. 73, 1083–1140.
Senchack, A.J., Starks, L.T., 1993. Short-sale restrictions and market reaction to short-interest announcements. J. Financ. Quant. Anal. 28 (2), 177. https://doi.org/10.2307/2331285.
Seyhun, H.N., 1998. Investment Intelligence from Insider Trading. MIT Press, Cambridge, MA.
Skaife, H.A., Veenman, D., Wangerin, D., 2013. Internal control over financial reporting and managerial rent extraction: evidence from the profitability of insider trading. J. Account. Econ. 55 (1), 91–110.
Veenman, D., 2012. Disclosures of insider purchases and the valuation implications of past earnings signals. Account. Rev. 87, 313–342.
Wang, K., Wang, R., Wei, K., Zhang, B., Zhou, Y., 2021. Insider sales under the threat of short sellers: New hypothesis and new tests. Account. Rev. forthcoming.
Zhang, I.X., Zhang, Y., 2018. Insider trading restrictions and insiders' supply of information: evidence from earnings smoothing. Contemp. Account. Res. 35 (2), 898–929.