Publicizing Private Information

Bige Kahraman and Salil Pachare*

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Abstract

How does greater public disclosure of arbitrage activity and informed trading affect price efficiency? To answer this, we exploit rule amendments in U.S. securities markets, which increased the frequency of public disclosure of short positions. Higher public disclosure can hurt the production of information and deteriorate efficiency, or it can be beneficial by helping short-sellers diffuse their information faster. With more frequent disclosure, information encapsulated within short interest is incorporated into prices faster, improving price efficiency. Furthermore, we find important reductions in short-sellers' horizon risk, and increases in short-sales with the rule amendments.

*Author contact information: Said Business School, University of Oxford, bige.kahraman@sbs.ox.ac.uk; U.S. Securities and Exchange Commission, Washington D.C., pachares@sec.gov. The Securities and Exchange Commission, as a matter of policy, disclaims responsibility for any private publication or statement by any of its employees. The views expressed herin are those of the author and do not necessarily reflect the views of the Commission or of the author's colleagues on the staff of the Commission. We would like to thank Nick Barberis and Thierry Foucault for their detailed suggestions. We also significantly benefited from feedback from William Goetzmann, Charles Jones, Marcin Kacperczyk, Roni Michaely, Dmitriy Muravyev, Joel Peress, Tarun Ramadorai, Christophe Spaenjers, Heather Tookes, Raman Uppal and seminar participants at the 2018 American Finance Association Meetings, Rodney L. White Center Conference at the Wharton School, Financial Intermediation Research Society Conference, European Summer Symposium in Financial Markets in Gerzensee, 4 Nations Cup, CEPR Second Annual Spring Symposium in Financial Economics, Midwest Financial Association Meetings, Tilburg University, Stockholm School of Economics, University of Oxford, University of Amsterdam, Nova School of Business, Bilkent University, University of Cambridge, Durham Business School, Birmingham Business School, Lancaster University Management School, U.S. Securities and Exchange Commission, Moody's Analytics, The Clearing House, and the Office of the Comptroller of the Currency. An earlier version of this paper circulated with the title "Show Us Your Shorts!". All errors are our own.

1 Introduction

Arbitrageurs' activities are often viewed as essential for bringing prices in line with their fundamental value and creating efficient markets. In the aftermath of the financial market crisis and in particular with the Dodd-Frank Act, there has been increased attention in understanding the role of arbitrageurs and informed traders in financial markets. Specifically, there has been heightened interest and debate as to whether arbitrageurs and informed traders should face more stringent public disclosure requirements.[1] Regulatory policies aimed at greater public disclosure can help reduce opaque trading; however, these policies may also distort incentives to produce private information and to trade, and this can be harmful to price efficiency. In this paper, we aim to contribute to this debate by analyzing the impact of greater disclosure requirements in the shorting market.

We focus on the shorting market primarily for two reasons. First, there is ample evidence showing that short-sellers are an example of arbitrageurs and informed traders, adept at identifying mispriced securities and the direction of future price movements.[2] Second, there have been rule amendments in the U.S. securities market that have increased the public disclosure requirements of short positions. This policy change provides a useful experiment that allows us to identify the causal impact of greater public disclosure requirements imposed on arbitrageurs and informed traders.

Specifically, how does greater publicity of short positions affect efficiency? Greater public disclosure can potentially have both costs and benefits. A commonly held view is that greater public disclosure of arbitrageurs' positions can be costly as arbitrageurs may lose their informational advantages.[3] For instance, with greater public disclosure requirements, short-sellers may end up having to disclose their positions before they fully build them up, therefore revealing their private information prematurely. Furthermore, short-sellers may lose their informational advantage because detailed information on positions can enable

[1]See, for example, Title IV of the Dodd-Frank Act, which broadened the scope of regulatory disclosure requirements on investor advisors, including hedge funds. Currently, hedge funds are required to disclose with regulators; however, there is a discussion on whether they should be disclosing also to the public.

[2]See, for instance, Asquith, Pathak and Ritter (2005); Boehmer, Jones and Zhang (2008); Desai, et al. (2002); Fang, Huang and Karpoff (2015); Jones and Lamont (2002); Karpoff and Lou (2010).

[3]See, for example, recent papers by Agarwal, et al. (2013); Agarwal, et al. (2015); Christoffersen, Danesh and Musto (2015); Easley, O'Hara and Yang (2013). Foucault, Pagano and Roell (2013) provide an excellent survey reviewing the literature on market transparency.

other market participants to uncover their underlying proprietary investment strategies. This may prevent short-sellers from fully reaping the benefits of their private information, which reduce the incentives to produce information in the first place, thereby worsening efficiency [Grossman and Stiglitz (1980)].

A newly emerging view highlights that increased public disclosure requirements could be beneficial by helping arbitrageurs overcome the limits to arbitrage. Arbitrageurs can be hesitant to attack a mispricing because of horizon risk – the risk that the mispricing can take too long to correct so that potential profits are eroded due to accumulating transaction costs or the risk that the mispricing worsens in the short-run [Dow and Gorton (1994); Abreu and Brunnermeier (2002); Barberis and Thaler (2003)].[4] For instance, in Abreu and Brunnermeier (2002), arbitrageurs learn about an arbitrage opportunity sequentially, and arbitrageurs may prefer to wait when they are unsure that other market participants will also attack the mispricing. Public disclosure of short-sales positions can be helpful as it can allow the rest of the investing public to learn from short-sellers more promptly. Moreover, if increased public disclosure of short positions hastens the diffusion of short-sellers' information, then short-sellers' horizon risk would be reduced, thereby increasing short-selling activity and improving price efficiency.

In light of the two competing hypotheses discussed above, the effect of increased public disclosure in the shorting market is ultimately an empirical question. We analyze this question by studying the effects of amendments approved by the U.S. Securities and Exchange Commission ("SEC") to rules which increased the frequency of short interest reporting requirements from once-a-month to twice-a-month, effective September 7, 2007. U.S. securities exchanges publicize each stock's total short interest, which is defined as the total outstanding short positions in a given stock.

Prior to the amendments, investors in the U.S. received new information on short interest only after the settlement date on the 15th of each month. In the post-amendment period, investors receive additional new information on short interest after the settlement date at the end of each month. Our identification strategy exploits the fact that in the post-amendment period, additional information on short interest is publicly reported after the settlement date at the end of each month, while in the pre-amendment period, short-sellers were not required

[4] Although the term "arbitrage", strictly speaking, refers to riskless speculation, we follow the recent literature and use the term referring to an investor's ability to detect mispriced securities.

to disclose their positions on these dates.

We therefore generate "placebo dates", that is, dates where short interest would have been publicly reported had broker-dealers been required to report the short positions at the end of the month in the pre-amendment period. Our methodology is a differences-in-differences test in which we test the difference in price efficiency after the end-of-month report dates (including the placebo dates) between pre- and post-amendment periods, over and above the differences in price efficiency after the mid-month report dates between pre- and post-amendment periods. By taking the difference over and above the differences in price efficiency after the mid-month report dates (which are available in both pre- and post-amendment periods), we control for the possible market-wide changes in price efficiency from pre- to post-amendment periods. This methodology therefore allows us to isolate the impact of the extra short interest announcement from potential confounding effects.

Our results show that the new disclosure regime has an important impact on a stock's informational environment. Information encapsulated within short interest, which contains information about future company news such as earnings announcements, is more quickly incorporated into prices, thereby increasing price informativeness and efficiency. Our estimates show that, in the pre-amendment period, price efficiency on average was 7-10% worse in the two weeks period after the placebo end-of-month report dates. However, in the post-amendment period, this difference almost completely dissipates.

We find that the effects are stronger for stocks with higher arbitrage risk – the group of stocks for which the benefits of higher public disclosure are expected to be particularly important. However, for illiquid stocks which have low market depth, the effects are diminished, in some cases, the effects even reverse. This is consistent with the idea that, for stocks which do not have enough market depth, informed traders may need more time and secrecy in executing their trades; therefore, greater public disclosure requirements in such cases may lead to losses in informational advantages. Furthermore, we analyse the asymmetry in the average effects and we find that the effects of short interest disclosure are larger for stocks with negative information, indicating that the new disclosure regime particularly helps with the diffusion of negative information.

We complement the main findings with additional analyses to shed light on the basic mechanism and uncover the implications of greater public disclosure on short-sellers' horizon risks and trading activity. If the main results are driven by the mechanism that short-sellers' information is diffusing faster, then short interest is expected to contain valuable information that the investing public utilizes. To assess this, we follow Senchack and Starks (1993) and examine the price adjustment that takes place on short interest announcement days. While there might be alternate ways through which investors may gather information on short-selling activity (e.g., access to proprietary datasets or informal contact with brokers), we find that there are significant price reactions to changes in short interest on short interest announcement days. This result highlights the significance that public disclosure of short interest provides to investors. Furthermore, we find that price reactions on short interest announcement days are stronger in the post-amendment period, suggesting that short interest has become more informative in more recent periods.

In addition, we investigate the possibility that there might be an overreaction to short interest announcements. Overreactions may occur if investors believe short interest to be more informative than what it actually is or if short-sellers use disclosures to send a false signal to the public to manipulate stock prices [Brunnermeier and Oehmke (2013)]. The prior literature has documented limited evidence for manipulation, and the evidence which has been found has been concentrated around seasoned equity offerings [Henry and Koski (2010)]. If investors overreact to short interest announcements or if manipulative short-selling is taking place, we would expect to find return reversals. However, we find that price reactions to short-interest announcements are long lasting.

We next examine the impact of the more frequent public disclosure requirements on the horizon risk that short-sellers face. If the improvements in price efficiency that we find after the amendments are being driven by short-sellers' private information diffusing faster, we would expect a decline in their holding periods due to them cashing their positions more quickly. Furthermore, in response to there being lower horizon risk, we would expect them to take larger positions. In line with this, we find that a short-sellers' holding period (approximately 80 calendar days for a typical stock) is reduced by 10 calendar days under the new disclosure regime, and that short sellers (as a group) also take larger positions in the post-amendment period. We also find that there is a higher reward-to-risk following the days after the public disclosure of the additional short interest announcement in the post-amendment period, consistent with the idea that public disclosure of short interest accelerates the diffusion of short-sellers' information, allowing them to obtain returns with lower volatility.

Our paper contributes to the literature that studies the effects of increased publicity of arbitrage activity and informed trading. The views in this literature are mixed. Some authors argue that greater publicity is harmful as arbitrageurs may lose their informational advantages [e.g., Agarwal, et al. (2013); Agarwal, et al. (2015); Christoffersen, Danesh and Musto (2015); Easley, O'Hara and Yang (2013)]. Public disclosure could allow other investors to infer their information, and thereby eroding the profitability of their trading strategies. A manifestation of this in the shorting market has been documented by Jones, Reed and Waller (2017), who study public disclosure rules in the European Union (E.U.) and find that immediate disclosure of trader-level short positions negatively affects the amount of short-selling and price efficiency.[5] This is consistent with the view that timely public disclosure of trader-level positions may pose a threat to proprietary investment strategies as traders may end up having to disclose before the trade is completed. To protect their informational advantages, informed investors may diminish their activities, which can deteriorate price efficiency.

Contrary to the view that informed traders may not want to reveal their private information and that public disclosure results in a loss of their informational advantage, a newly emerging literature emphasizes the benefits that publicly disclosing private information provides [e.g., Kovbasyuk and Pagano (2015); Ljungqvist and Qian (2016); Makarov and Plantin (2012)]. These studies argue that public disclosure can help arbitrageurs overcome the limits to arbitrage arising from capital constraints and horizon risk, and subsequently, public disclosure can improve price discovery. To date, the only evidence in support of this view is provided by Ljungqvist and Qian (2016) who document that some arbitrageurs occasionally share their information with the public. Our paper fits in with this strand of literature, by showing that bi-monthly disclosure of stock-level short positions on pre-announcement dates – which can provide time and flexibility to traders to execute their trades – can benefit the market by improving price efficiency. Overall, our findings complement Ljungqvist and Qian (2016). Different from voluntary information sharing, mandatory disclosures organized by exchanges are regular and frequent, reflect the overall view in a given stock and easier to locate by investing public. With these disclosures, not only can the rest of the investing public learn from short-sellers more promptly, but also the public disclosure can help short-sellers

[5]Specifically, E.U regulations require short-sellers with positions more than 0.5% of a stock's shares outstanding disclose their positions to the public on a next-day basis.

mitigate their horizon risk.

Our paper sheds light on a current policy debate about on how frequently short positions should be disclosed. In a Congressional study on short-sale position and transaction reporting required as part of the Dodd-Frank Act, the SEC (2014) acknowledged that public real-time short position reporting "could help the market adjust to new information faster, promoting price efficiency". However, they also acknowledged that a more frequent short-selling reporting regime could "facilitate copycat and order anticipation strategies that could discourage fundamental analysis vital for price efficiency." Considering this, our paper provides evidence that publicly disclosing stock-level short interest information on a bi-monthly basis on pre-scheduled announcement dates strikes a balance between these opposite effects. The dislosure regime in the U.S. mitigates the harmful effects of timely disclosure of private information by individual traders (e.g., disclosure requirements in the E.U., as in Jones, Reed and Waller (2017)) while bringing out the benefits that public disclosure of short interest provides in improving price efficiency.

This paper is organized as follows. Section 2 describes the data and methodology; Section 3 presents the results; Section 4 concludes the paper.

2 Methodology and Data Sources

2.1 Methodology

On March 6, 2007, the SEC approved amendments to revise the short interest reporting requirements of all major securities exchanges and the National Association of Securities Dealers ("NASD"), now known as the Financial Industry Regulatory Authority ("FINRA"). The amendments required that as of September 7, 2007, member firms of these securities exchanges and FINRA increase the frequency of short interest reporting from once-per-month to twice-per-month.[6] Prior to the amendments, member firms were required to submit a mid-month short interest report which was based on short positions held on the settlement date,

[6]The entities that were affected by these SEC approved amendments include the Boston Stock Exchange ("BSE"), Chicago Board Options Exchange ("CBOE"), Chicago Stock Exchange ("CHX"), FINRA, International Stock Exchange ("ISE"), NASDAQ, National Stock Exchange ("NSX"), NYSE, NYSE Arca, American Stock Exchange (now known as NYSE MKT), and the Philadelphia Stock Exchange ("PSX"). https://www.finra.org/sites/default/files/NoticeDocument/p019161.pdf

namely the 15th of each month.[7] If the 15th happened to fall on a weekend, the designated settlement date was the previous business day on which the transactions settled. After the amendments however, in addition to the mid-month short interest report, member firms are also required to submit an end-of-month short interest report based on short positions held on the last business day of the month on which transactions settle. Member firms have until 6:00 p.m. (E.T.) two business days after the settlement date to report their short positions. Short interest is then aggregated on a stock-by-stock basis across all member firms and publicly disseminated after 4:00 p.m. (E.T.), eight business days later, on pre-scheduled announcement days.[8] In this paper, we denote the date of public dissemination of short interest as $REPDATE$. Since the time of public dissemination of short interest is after the market close, the next business day after $REPDATE$ is the date of interest in this paper, as the next business day is when the market is able to react to this public information.

The objective of this paper is to understand whether increased public disclosure of short interest has a causal impact on price efficiency. The SEC approved amendments provide a particularly useful setting for identifying the impact of short interest disclosure, because in the pre-amendment period, the short interest announcement occurred on a fixed date in the middle of the month, and in the post-amendment period, due to the the change in the frequency of disclosure, there is an extra short interest announcement occurring on a fixed date at the end of the month. Our analysis therefore focuses on whether this extra short interest disclosure affects efficiency.

Our identification strategy comes from generating "placebo dates", that is, dates when short interest would have been publicly reported had broker-dealers been required to report short interest positions at the end-of-month in the pre-amendment period. We generate the placebo dates in the pre-amendment period following the disclosure rules explained above. Using both the actual and placebo $REPDATEs$, we estimate the causal impact of more frequent reporting of short interest on price efficiency.

To estimate the effect the additional short interest disclosure has on price efficiency, we estimate the following regression model:

[7] This settlement date is different than the settlement period, which is the period allotted to the parties of a transaction to satisfy the transaction's obligations. The settlement date, in the context of short interest disclosure, refers to the date as of which short positions are required to be reported.

[8] Publication schedules for short interest dissemination are available at: http://www.nasdaqtrader.com/Trader.aspx?id=ShortIntPubSch.

$$EFF_{i,t} = \alpha_i + \beta_0 e_{i,t} + \beta_1 POST_{i,t} + \beta_2 [e \times POST]_{i,t} + \gamma X_{i,t} + \varepsilon_{i,t} \tag{1}$$

EFF denotes our measures of price efficiency for stock i at time t. For the independent variables, we include e, which is a dummy variable that equals 1 for observations after the end-of-month $REPDATE$ and before the mid-month $REPDATE$ the following month, and equals 0 for observations after the mid-month $REPDATE$ and before the end-of-month $REPDATE$. The variable, $POST$, is a dummy variable that equals 1 for observations in the post-amendment period, that is, after September 7, 2007, and zero otherwise; and the variable $[e \times POST]$ is the interaction term between $POST$ and e.

β_2 is the main variable of interest in our analysis as it quantifies the impact of the extra short interest disclosure in the post-amendment period. This coefficient captures the differences in price efficiency after the end-of-month $REPDATE$ between pre- and post-amendment periods, over and above the differences in price efficiency measured after the mid-month $REPDATE$ between pre- and post-amendment periods. While mid-month short interest announcements take place in both the pre- and post-amendment periods, end-of-month short interest announcements take place only in the post-amendment period. By calculating the effect as over and above the differences in price efficiency measured after the mid-month short interest announcements, we control for the possible aggregate changes in efficiency from the pre- to post-amendment period. Thus, this methodology allows us to isolate the impact of the extra short interest announcement from potential confounding effects arising from market-wide changes. We provide a graphical representation of our empirical methodology in Figure 1. If greater public disclosure of short-sales negatively affects the production of information by short-sellers, price efficiency would worsen; if it does not negatively impact information production—instead it helps with incorporating short-sellers' information into prices faster—then price efficiency is expected to increase.

Our main measure of price efficiency is the cumulative abnormal returns around quarterly firm earnings announcements [e.g., Boehmer and Wu (2013); Kelly and Ljungqvist (2012); Kim and Verrecchia (1991)]. We calculate the absolute value of cumulative abnormal returns to earnings news that arrive after the actual or placebo $REPDATE$. There are a number of advantages of using this measure in our empirical setting. First, this measure of price efficiency nicely ties in with the related literature which shows that short-sellers possess information about upcoming earnings announcements [e.g., Boehmer, Jones and Zhang

(2015); Christophe, Ferri and Angel (2004); Christophe, Ferri and Hsieh (2010); Francis, Venkatachalam and Zhang (2005)]. For instance, short interest announcements can provide an informed signal to investors from which they can learn about a firm's news more readily. Second, earnings announcements allow us to analyze the asymmetric effects of positive versus negative information—a feature that cannot be easily captured by other measures of price efficiency. If, with the new regulatory regime, prices become more (less) informative, then market surprises to earnings announcements thereafter are expected to be smaller (larger). We use earnings announcements returns as the main measure, but later in Section 3.2.5, we broaden the analysis to alternative measures of price efficiency.

In robustness tests, we include a vector of control variables, X_{it}, which the previous literature shows to be related to our measures of price efficiency. In addition, we include year, month and day-of-week time fixed effects as well as industry and stock fixed effects.[9] Standard errors are double-clustered by stock and day.

2.2 Data Sources and Variables

The sample consists of common stocks (with share codes of 10 or 11) from the CRSP-Compustat universe. Market data is obtained from the CRSP Daily Files, and financial-statement related information is obtained from the Compustat Merged Security Monthly File. Analyses that are based on earnings announcements use additional data from I/B/E/S. When the earnings announcement date is included in both Compustat and I/B/E/S databases and the I/B/E/S date is different from the Compustat date, we use the earlier date as the date of the earnings announcement date.[10] Earnings announcements released after 4:00 p.m. (E.T.) are moved to the next trading day. Short-term and long-term market reactions to earnings announcements are measured using different windows, namely, [0,1] and [2,61] days after the earnings announcement.[11] For the long-term market reaction, we focus primarily on 60 days

[9] We use the Fama-French 10 industry classification from Kenneth French's website, available at http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/Data_Library/det_10_ind_port.html.

[10] DellaVigna and Pollet (2009) report that the earlier of the two dates is almost always the correct announcement date in the post-1994 period.

[11] We calculate abnormal returns to earnings announcements both in a short-horizon as well as a longer-horizon window. Changes in the degree of price informativeness can impact both the immediate abnormal returns as well as abnormal returns going forward. For instance, in a hypothetical extreme case, whereby price fully reflects the upcoming earnings news, there would be no market surprise when the news arrives and also no post-announcement drift after the arrival of the news.

for the post-announcement window as the literature commonly follows Bernard and Thomas (1989), who report that most of the post-earnings announcement drift occurs during the first 60 days. We obtain similar results when we use 75 days as the post-announcement window.

We measure market reactions to earnings announcements by the absolute value of cumulative abnormal returns to earnings announcements. When defining the cumulative abnormal returns, we use two methods. First, similar to Hirshleifer, Lim and Teoh (2009), we compute the difference between the buy-and-hold return of the firm and that of a size and book-to-market (B/M) matched portfolio,[12] and then take the absolute value:

$$CAR[m,n]_{i,q} = \left| \left[\prod_{k=t}^{t+n} (1+R_{i,k}) - 1 \right] - \left[\prod_{k=t}^{t+n} (1+R_{p,k}) - 1 \right] \right| \tag{2}$$

$R_{i,k}$ is the return of stock i on day k, and $R_{p,k}$ is the return of the matching size and B/M portfolio on day k, where t is the earnings announcement date of quarter q's earnings. Second, similar to DellaVigna and Pollet (2009), we compute the difference between the buy-and-hold return of the firm and beta multiplied by the buy-and-hold return of the market, and then take the absolute value:

$$CAR[m,n]_{i,q} = \left| \left[\prod_{k=t}^{t+n} (1+R_{i,k}) - 1 \right] - \hat{\beta}_{i,q} \left[\prod_{k=t}^{t+n} (1+R_{m,k}) - 1 \right] \right| \tag{3}$$

Once again, $R_{i,k}$ is the return of stock i on day k, and $R_{m,k}$ is the return on the market on day k, and $\hat{\beta}_{i,q}$ for stock i in quarter q is obtained from the regression $R_{i,u} = \alpha_{i,q} + \beta_{i,q} R_{m,u} + \varepsilon_{i,u}$ for the days $u \in [t-300, t-46]$, where t is the date of the earnings announcement. We use the absolute value of cumulative abnormal returns since we are interested in examining the change in the size of earnings reactions after short interest announcements. Later in Section 3.2.4, we analyze whether this depends on the earnings announcement being a negative or a positive surprise.

As the objective of our paper is to analyze the impact of the new regulatory regime, we divide the sample into two sub-periods around the rule amendments. The first part

[12] Each stock is matched with one of 25 size and B/M portfolios at the end of June each year based on the market capitalization at the end of June and B/M, book equity of the last fiscal year end in the prior calendar year divided by the market value of equity at the end of December of the prior year. The daily returns of size and B/M portfolios are obtained from Kenneth French's website, available at http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

of our sample runs from January 1, 2003 to September 6, 2007, which we refer to as the "pre-amendment period", and the second part of our sample runs from September 7, 2007 to December 31, 2012, which we refer to as the "post-amendment period". In deciding our sample period, we aim to choose a period that is long enough to provide empirical power for our tests (since firms announce their earnings news quarterly, we have only four observations per firm in each year), but also narrow enough to capture the effect due to regulatory amendments. Later in the paper, we show that our results are robust to alternative sample periods.

Shortly after the SEC approved amendments, stock markets experienced dramatic turbulence and the SEC implemented temporary prohibitions and bans to short selling. Although our methodology would take into account the impact of market-wide changes between the pre- and post-amendment periods, we exclude the 2008 calendar year and financial stocks to prevent some extreme observations during this period from affecting our findings. Additionally, following the literature, we exclude stocks with price less than $1 (before split-adjustment) to minimize the possibility of data errors.

In robustness tests, we control for numerous variables which previous literature shows to be related to earnings reactions [e.g., Bernard and Thomas (1989); Chambers and Penman (1984); DellaVigna and Pollet (2009); Hirshleifer, Lim and Teoh (2009)]. We control for the number of analysts following the stock ($NUMEST$); earnings persistence ($EARNINGS\_PERSIST$); earnings volatility ($EARNINGS\_VOL$); forecast error (FE), the number of earnings announcements on the given day of a firm's own earnings announcement ($NUMANN$); and institutional ownership (IO). Definitions of these variables can be found in Appendix A.

As we expect our results on the market reactions to earnings announcements to also affect trading outcomes, we construct additional measures of the dependent variable, namely stock turnover ($TURNOVER$); stock price volatility ($VOLATILITY$); and bid-ask spread ($SPREAD$). Different from $TURNOVER$ and $VOLATILITY$, we measure $SPREAD$ prior to the earnings announcements since trading by informed investors, and thus asymmetric information, intensifies before earnings announcements. Definitions of these variables are available in Appendix A.

3 Results

3.1 Descriptive Statistics

In Table 1, we present descriptive statistics for our main analysis. Panel A presents the descriptive statistics for the sample of firms where $e = 0$, and Panel B presents the descriptive statistics for the sample of firms where $e = 1$. As our identification strategy hinges on the timing of the earnings announcement relative to the end-of-month $REPDATE$, we report the descriptive statistics for $e = 0$ and $e = 1$ separately and draw comparisons between them. We examine firm characteristics that the previous literature shows to be related to the size of earnings reactions.

The main result from Table 1 is that there are no meaningful differences between firms that issue their quarterly earnings announcements after the mid-month or end-of-month short interest announcement. For instance, the number of analysts giving EPS forecasts, the analyst forecast error, earnings persistence and earnings volatility are almost identical between the two samples. While some variables, such as institutional ownership as a fraction of shares outstanding and the number of concurrent earnings announcements, are slightly higher when $e = 1$ (60.57% and 4.67 respectively) than when $e = 0$ (56.93% and 4.09 respectively), the differences appear to be small. The fact that the difference in magnitude in the means and medians between these two samples appears to be small indicates that our results cannot be explained merely by the characteristics of the two samples; however, in robustness tests, we control for these variables in our empirical specifications. Overall, findings in Table 1 support our empirical design.

3.2 Main Results

3.2.1 Short-Term Price Reactions to Earnings Announcements

As discussed earlier, our identification hinges on the fact that in the post-amendment period, short interest is publicly disseminated after the end of each month in addition to the middle of each month. Therefore, if more frequent disclosure of short interest impacts price efficiency, these differences should be noticeable around the end-of-month $REPDATE$.

In Table 2, we estimate (1) using the absolute value of the cumulative abnormal returns in [0,1] day period around earnings announcements. Panel A shows the results when cumulative abnormal returns are estimated as in DellaVigna and Pollet (2009), and Panel B shows the results when cumulative abnormal returns are estimated as in Hirshleifer, Lim and Teoh (2009). Column 1 in both panels show the baseline results. We note that $POST$ is significant and positive, perhaps due to increased aggregate uncertainty in the post-amendment period. Importantly, our main variable of interest, $[e \times POST]$, is significantly negative. What this indicates is that with more frequent reporting of short interest, the market is less surprised after end-of-month short interest announcements in the post-amendment period. This is consistent with short interest announcements serving as an informative signal for investors, a signal that helps them learn about future news related to company earnings more readily.

The coefficient on $[e \times POST]$ in Panel A shows that in the post-amendment period, the market reaction to earnings announcements that occur after the end-of-month $REPDATE$ is 30 bps lower than after the mid-month $REPDATE$ in the pre-amendment period. Since the mean and median reaction to earnings announcements (in absolute value) in our sample are 4.3% and 2.8%, respectively, the economic magnitude of a 30 bps reduction translates to an approximately 7% reduction in mean and 11% reduction in median market reaction to earnings announcements.

Furthermore, we find that in the pre-amendment period, the market reaction to earning announcements that take place after the placebo $REPDATE$ is 32 bps higher than market reactions that take place after the mid-month $REPDATE$. This result provides further support for the hypothesis that the public dissemination of short interest allows investors to learn about firm fundamentals more readily. Thus, lack of information on short interest at the end of the month in pre-amendment period leads to larger market reactions to earnings announcements that come afterwards. Altogether, the estimates reported in Table 2 imply that the differences in efficiency measured after the mid-month $REPDATE$ and the efficiency measured after the end-of-month $REPDATE$ the following month dissipate in the post-amendment period. Since, in the post-amendment period, investors receive information about short interest in both the middle of the month and at the end of the month, there is no longer a difference between the periods that come after a mid-month or an end-of-month $REPDATE$. This a pattern that we find throughout our tests. This finding strengthens the conclusion that it is the change in the reporting frequency of short interest that drives our results. An alternative hypothesis should be able to explain not only the estimates on $[e \times POST]$, but also the estimates on e. This can be difficult because short interest public disclosure announcement dates, to the best of our knowledge, are specific to the short interest reporting regime.[13]

In column 2 of both panels, we include several stock characteristics which are shown to be related to reactions to earnings announcements such as $NUMEST$, IO, FE,$EARNINGS\_PERSIST$, $EARNINGS\_VOL$, and industry and time fixed effects. Consistent with the literature, we find that these characteristics are related to reactions to earnings announcements; however, the inclusion of these variables in our empirical specification does not change our conclusions. This is consistent with the descriptive statistics we provide in Table 1 showing that there are no meaningful differences in stock characteristics for firms which have their earnings announcement at different times within the month. In column 3 of both panels, we control for $NUMANN$, as it has been shown that the total number of earnings announcements in a day has a negative impact on reactions to earnings announcements [Hirshleifer, Lim and Teoh (2009)]. Consistent with Hirshleifer, Lim and Teoh (2009), the coefficient on $NUMANN$ is significant and negative, yet our results remain robust. Finally, in column 4 of both panels, we follow Michaely, Rubin and Vedrashko (2012) and include firm fixed effects to control for the potential impact of unobserved stock characteristics on market reactions to earnings news and find that our results still remain robust. Results in Table 2 indicate that the coefficient on $[e \times POST]$ is negative and statistically significant across all specifications.

3.2.2 Other Short-Term Effects Around Earnings Announcements

If more frequent disclosure of short interest improves the price efficiency of stock prices, we would expect that gains to price efficiency are also manifested through trading activity. Furthermore, we would also expect that the end-of-month short interest disclosure reveals additional private information by short-sellers, reducing asymmetric information. To that effect, we estimate the regression model in (1); however instead, we use $TURNOVER$, $VOLATILITY$ and $SPREAD$ as the dependent variables.

[13] For instance, on July 6, 2007, the SEC removed the uptick rule in the remaining NYSE, Amex and NASDAQ stocks that had not been included in the original Reg SHO pilot in 2005. This could be viewed as relaxing short-sale constraints, thereby improving price efficiency. If the removal of the uptick rule were to explain our results, one would need to be able to explain why efficiency was worse after the (placebo) end-of-month short interest announcements in the pre-amendment period. It is not clear why this would be the case. Nonetheless, we reproduce our main results excluding the periods 2003 and 2004 as well as the stocks which experienced a change in the uptick test rule on July 2007. Table IA.4 shows that the results remain similar.

In Table 3, we start by using $TURNOVER$ as the dependent variable. We include the control variables discussed above, and time, industry and stock fixed effects. The coefficient on $[e \times POST]$ is negative (-0.0011) and statistically significant, implying that in the post-amendment period, there is on average a 7.2% reduction in turnover around earnings announcements that occur after the end-of-month $REPDATE$. Similarly, in Column 2, we use $VOLATILITY$ as the dependent variable and find that the coefficient on $[e \times POST]$ is negative (-0.0209) and statistically significant, suggesting that volatility around earnings announcements after the end-of-month $REPDATE$ is significantly lower (approximately 6.8%, on average) than in the pre-amendment period. Together, these results are in congruence with the pricing results presented in Table 2; that is, in the post-amendment period, earnings announcements occurring after the end-of-month short interest announcements are less of a surprise to the market, and thus, the lower price reactions are complemented by lower trading activity (turnover) and lower volatility.

We also expect the regulatory amendments to impact information asymmetry and liquidity. Revelation of short-sellers' private information through increased public disclosure of short interest may reduce market-makers' risks arising from asymmetric information, and therefore lower the bid-ask spread [e.g., Copeland and Galai (1983); Glosten and Milgrom (1985)]. We measure bid-ask spreads prior to the earnings announcements because earnings announcements are pre-scheduled announcements, thus market makers can anticipate an increase in informed trading activity before the earnings announcements. The results show that the coefficient on $[e \times POST]$ is negative (-0.0126) and statistically significant, indicating that in the post-amendment period, there is on average a 7% reduction in the pre-earnings announcement bid-ask spread. Intuitively, these results are indicative that more frequent disclosure of short interest expedites the incorporation of short-sellers' private information into the public domain. The market learns about their private information and this reduces asymmetric information between investors prior to firms' earnings announcements. These results complement the findings in Table 2.

3.2.3 Long-Term Price Reactions to Earnings Announcements

As returns tend to be positive after positive earnings surprises and negative after negative earnings surprises, this suggests that post-earnings announcement drift may be a sign of market inefficiency, as investors fail to recognize information embedded in earnings surprises and therefore prices seemingly do not fully incorporate earnings related information at the time of the announcement [Bernard and Thomas (1989)]. We examine whether long-term price reactions after earnings announcements are also mitigated once there is more frequent disclosure of short interest. Results so far indicate that market participants learn from short interest announcements about upcoming earnings announcements, and therefore price informativeness increases. As we discuss in Section 2.2, the increase in price informativeness is expected to affect not only the immediate price reactions to earnings announcements, but also price reactions in the period afterwards.

In Table 4, we estimate (1) using the [2,61] day period after earnings announcements as the measure of cumulative abnormal returns. Panel A of Table 4 shows that when cumulative returns are calculated as in DellaVigna and Pollet (2009). Across all specifications, the coefficient estimates on $[e \times POST]$ are negative and statistically significant, ranging between -66 bps and -83 bps. Panel B of Table 4 shows that when cumulative abnormal returns are calculated as in Hirshleifer, Lim and Teoh (2009), across all specifications, the coefficients on $[e \times POST]$ are negative and statistically significant, ranging between -60 bps and -75 bps. Overall, these estimates from both panels suggest that in the post-amendment period, there is on average a 7-9% reduction in long-term price reactions to earnings announcements after the end-of-month $REPDATE$. These results are in line with results from Table 2-3.

3.2.4 Cross-Sectional Differences

In this section, we analyze whether there are cross-sectional differences in the impact of new disclosure regime. To this end, we start by examining the role of arbitrage risk, which can be an important limitation to arbitrage activity. We measure arbitrage risk in two ways. First, we follow Engelberg, Reed, and Ringgenberg (2018), and we calculate $FeeRisk$, which is defined as the standard deviation in a stock's loan fees in a given month. Engelberg, Reed, and Ringgenberg (2018) provide evidence that changes in loan fees can pose important risks to short-sellers, especially if their holding periods are long. In addition, following Ljungqvist and Qian (2016) and Stambaugh, Yu and Yuan (2015), we use idiosyncratic volatility ($IVOL$) as a measure of risky arbitrage. High idiosyncratic volatility can cause adverse price movements and therefore lead to early liquidation risks. If the new disclosure regime helps short-sellers overcome the limits to arbitrage, then we would expect the effects to be more pronounced for stocks with higher arbitrage risks.

Second, we use proxies which capture a stock's market depth, thus the ease of trade execution. For stocks which do not have enough market depth, informed traders may need more time and secrecy in executing their trades. More frequent public disclosure can be costly in such stocks, thus we may see the main results reversing for stocks with low market depth. Intuitively, for stocks with high noise trading activity, informed traders may be able to execute their trades faster without having a large price impact. Although we don't have a direct measure of noise trading activity, we aim to capture this notion by introducing $RetailTrading$, which is a dummy equals to 1 when the stock's institutional ownership is low and the stock has a high trading activity. In the same vein, we follow the related literature and use Amihud's $ILLIQ$, which is designed to capture market depth [e.g, Foucault, Pagano and Roell (2013)].

Finally, we test whether the main results depend on whether the earnings announcement was a negative or a positive surprise. If more frequent disclosure of short interest helps investors promptly learn about short-sellers' private information (which contains negative information), we would expect the results to be more pronounced for stocks with negative information. To test this idea, we define $NegNew$, which is a dummy variable that equals 1 if the firm's earnings announcement is negative.

For each of these variables, we introduce triple-differences and we include all lower-level interaction terms in the empirical specification. Results are reported in Table 5. Columns 1 and 2 show the results for $FeeRisk$ and $IVOL$; Columns 3 and 4 show the results for $RetailTrading$ and $ILLIQ$; and Column 5 shows the results for $NegNew$. The main variable of interest in this section is the coefficient on triple interaction terms.

Table 5 reveals useful findings. First of all, Columns 1 and 2 consistently show that results are indeed more pronounced for stocks with higher arbitrage risk. Moreover, in Columns 3 and 4, we find that market depth plays an important role. For instance, results show that, stocks which have low market depth captured by high $ILLIQ$, experience a worsening in price informativeness after the rule amendments. This indicates that, for stocks with lower market depth, costs of new disclosure regime outweigh the benefits. Finally, Column 5 shows that the triple interaction term with $NegNew$ is negative and significant, showing that greater disclosure of short interest particularly helps with the diffusion of negative information which tends to travel slowly [Cohen, Lou and Malloy (2014); Hong, Lim and Stein (2000)].

3.2.5 Alternative Measures of Price Efficiency

In this section, we test whether our main results from Table 2-4 hold when we use alternative measures of price efficiency which do not depend on earnings announcements. Our first approach is to follow Hou and Moskowitz (2005) and estimate price delay—a measure of the delay in which stock prices respond to market information. The greater price delay is, the more the stock's return variation can be captured by lagged market returns, indicating less price efficiency.

We adopt a variant of Hou and Moskowitz's (2005) measures because Hou and Moskowitz (2005) estimate price delay only once per year using the time series of one year of lagged returns. We estimate Hou and Moskowitz's (2005) measures of price delay using the cross-section of all stocks between two consecutive $REPDATEs$ (including placebo report dates). Therefore, there is a single price delay corresponding to each $REPDATE$. Our first price delay measure is $DELAY1$, which considers the impact of lagged market returns predicting future stock returns. The second measure, $DELAY1\_NEG$, is similar to the first one, but it differs from it by using only negative lagged market returns for the estimation. The third measure, $DELAY3$, distinguishes between shorter and longer lags of market returns and accounts for the precision of estimates on the coefficient of lagged market returns. Further details regarding the calculation of these variables can be found in Appendix A.

We estimate our main regression equation using $DELAY1$, $DELAY1\_NEG$, and $DELAY3$ as our measures of information efficiency. Because our delay measures are estimated using the cross-section of all stocks between $REPDATEs$—as opposed to being estimated for each stock individually—stock specific control variables are no longer included in these regressions. Table 6 shows that results are consistent with previous findings. Coefficients on $[e \times POST]$ are significantly negative regardless of the delay measure used, which indicates improvements in price efficiency.

Furthermore, we calculate high frequency measures of price efficiency based on intraday trades and quotes from TAQ.[14] Our first high frequency measure of price efficiency is based on studies such as Boehmer and Kelley (2009) which use variance ratios to test whether prices follow a random walk. A random walk implies that the ratio of longer-term to shorter-term return variances, scaled by unit of time should be equal to one. We construct our measure of

[14]For further details regarding the processing of TAQ data and constructing of the high frequency measures of price efficiency, please refer to Appendix B.

variance ratio, defined as $VARRATIO = \left|1 - \frac{var(30min)}{30var(1min)}\right|$, where $var(30min)$ is the variance of overlapping 30-minute intraday returns and $var(1min)$ is the variance of overlapping 1-minute intraday returns.According to this measure, smaller $VARRATIO$ indicates that stock prices are more informationally efficient. Table 7 report results using $VARRATIO$ as the measure of price efficiency. Column 1 shows results with no control variables; Column 2 includes control variables that might be associated with high frequency measures of price efficiency. We find that the coefficient on $[e \times POST]$ in both specifications are significantly negative.

Our second high frequency measure of price efficiency is based on calculating pricing errors [e.g., Boehmer and Kelley (2009); Boehmer and Wu (2013); Hasbrouck (1993)]. We decompose log intraday transaction prices from TAQ into an efficient price, random walk component (m_t) and a stationary component, the pricing error (s_t). We then construct the scaled pricing error, $PE = \frac{\sigma(s)}{\sigma(p)}$, where $\sigma(s)$ is the standard deviation of the pricing error, which is assumed to follow a zero-mean, covariance-stationary process, and $\sigma(p)$ is the standard deviation of intraday transaction prices, used to control for cross-sectional differences in price volatility. According to this measure, small PE indicates that stock prices are more informationally efficient. Columns 3 and 4 of Table 7 show results using PE as the measures of price efficiency. Consistent with previous findings, we find that the coefficients on $[e \times POST]$ are significantly negative.

3.2.6 Summary

Findings in Section 3.2 show that the new reporting regime improves price efficiency. This finding is contrary to the view that higher public disclosure requirements would be harmful to efficiency as they hurt the production of information, but it is consistent with studies which emphasize the benefits that can come with publicizing private information [e.g., Kovbasyuk and Pagano (2015); Ljungqvist and Qian (2016); Makarov and Plantin (2012)]. To date the only empirical evidence in support of the latter view is provided by Ljungqvist and Qian (2016) who document that arbitrageurs occasionally share their information with the public. While Ljungqvist and Qian (2016) analyse voluntary information sharing, we study mandatory public disclosures of positions, which are different than voluntary information sharing in a number of ways. Voluntary information sharing are occasional, reflect only an individual investor's opinion and can be more costly to access as investors have to search through each trader's website. Mandatory disclosures organized by exchanges, on the other hand, are regular and frequent, reflect the overall view in a given stock and easier to locate by investing public. Overall, our findings complement the main message of Ljungqvist and Qian (2016).

3.3 Robustness Analyses

3.3.1 Alternative Sample Periods

As discussed in Section 2, our sample period runs from January 2003 to December 2012, excluding 2008. In Panel A of Table IA.1 (reported in the Internet Appendix), we re-estimate our results from Tables 2-4 using an equal 48-month window in the pre- and post-amendment period, excluding all observations from 2008. This ensures that the pre- and post-amendment periods are of equal distance from the date of the regulatory amendments. In Panel B, we re-estimate our results using 48 months in the pre-amendment period and 60 months in the post amendment period, excluding all observations from 2008. This ensures that there are an equal number of $REPDATEs$ in the pre- and post-amendment periods. These two empirical choices are complementary and we analyze whether our results are sensitive to using alternative sample periods. We find that in both panels, the coefficient on $[e \times POST]$ across all specifications is negative, statistically significant and of comparable magnitude to results presented in Tables 2-4. This robustness check provides support that the choice of sample period does not drive our results.

3.3.2 Timing of Earnings Announcements

The underlying idea behind our tests which use earnings reactions is that firms that release their earnings announcements after the mid-month $REPDATE$ are not meaningfully different from firms that release their earnings announcements after the end-of-month $REPDATE$. In support of this, in Table 1, we show that the timing of earnings announcements relative to the $REPDATE$ is not associated with significant differences in terms of firm characteristics. In Tables 2-5, we control for these firms characteristics in our regressions, and in further tests, we also include stock fixed effects to control for unobservable firm characteristics. Our results remain robust after including these controls.

To further assess whether the timing of a firm's earnings announcements affects our results, we re-estimate Tables 2-4 using a sub-sample of firms which have propensity to release their earnings announcements in the same time-frame relative to the end-of month $REPDATE$, in both the pre- and post-amendment periods. We determine propensity by calculating the average value of $e(\bar{e})$ for each firm in the pre- and post-amendment period. If $\bar{e} > 0.5$ ($\bar{e} < 0.5$) for a given firm in both the pre- and post- amendment period, we classify the firm as having a tendency to release earnings in the same timeframe relative to the end-of month $REPDATE$, in both the pre- and post-amendment periods. The sub-sample constructed in this way contains about 65% of the firms included in the original sample. Results are reported in Table IA.2 of the Internet Appendix. We observe that the coefficient on $[e \times POST]$ across all specifications is negative, statistically significant and of comparable magnitude to the results presented in Tables 2-4. This robustness check highlights that the timing of earnings announcements does not drive our results.

3.3.3 Alternative Ways to Acquire Information on Short Selling

There might be alternative ways through which investors can access some information on short-selling. For instance, Markit is a private data vendor that provides data on securities lending market. Investors who are subscribed to Markit receive regular updates on total short positions taken by Markit's subscribers.[15] The availability of Markit data may at first appear as a concern for the empirical design, however, for a number of reasons, we believe that the availability of Markit data is not central to the interpretation of our findings. First, Markit data has been available (either at the daily or weekly frequency) throughout our sample period including the pre-amendment period. Therefore, it is unlikely to explain our results; if anything, it would go against finding significant differences between the pre- and post-amendment periods. Second, due to its high subscription fees, Markit data is unlikely to be available to a large number of investors.

Therefore, we believe that the availability of Markit data is unlikely to be a major concern. Nevertheless, we conduct robustness tests to assess the potential role of Markit data. To this end, we exploit the dates when Markit changed its reporting frequency of its short-sales data. Markit has provided data on total short positions since June 2002. Markit initially released

[15] According to the information provided by Markit, brokers and hedge funds are their typical clients.

monthly data on total short positions on its covered universe between June 2002 and July 2004. It then released weekly data between August 2004 and June 2006, and finally released daily data from July 2006 through to present. Note that all of these changes occured in the pre-amendment period.

We analyze whether this more frequent disclosure of Markit data had any effect on the price efficiency. Specifically, we conduct before-and-after analyses using the three experiements took place on: (i) June 2002, where Markit first started providing monthly data; (ii) August 2004, when reporting frequency of Markit data increased from monthly to weekly; and (iii) July 2006, when the reporting frequency increased from weekly to daily. We introduce dummy variables ($MONTHLY$, $WEEKLY$, and $DAILY$) to capture the effects before and after each change. Results are reported in Table IA.3 of the Internet Appendix. With the exception of the first experiment (for which there is some, albeit weak, evidence suggesting increases in price efficiency), we find that change in the reporting frequency of Markit data does not have an impact on price efficiency. This is perhaps not surprising for the reasons discussed above.

In addition to Markit data, commencing from the fourth quarter of 2009, FINRA started publishing aggregate short volume data by security on each day. As opposed to short interest, which is calculated as the total outstanding open positions at the end of each day, short volume is the amount of short-sale trades executed within a trading day. While part of short volume is due to intra-day short selling for market-making purposes and by high-frequency traders, short interest is likely to capture negative information relevant over longer horizons. Importantly, short volume data is released to public with a one-month delay, therefore it does not provide timely information.

If there are alternative ways through which the wider investing public can gather information on short-selling activity (e.g., access to proprietary datasets, informal contacts with brokers or alike), then short interest announcements by exchanges would not contain new information, and therefore we would not observe significant market reactions to changes in short interest on short interest announcement days. We analyze this in the next section.

3.4 Market Reactions to Short Interest Announcements

So far we have shown that increasing the frequency of short interest disclosure improves price informativeness and thus efficiency. If this result is driven by the mechanism that wider investing public learn about short sellers' private information more promptly with greater disclosure, then it should be that short interest contain new information and market participants watch short interest announcements to improve their inferences. This would imply significant price adjustments on short interest announcement days. If market participants already have access to short-selling information from other potential sources, we then would not find any market reactions to short interest announcements.

To examine this, we calculate the price reactions to $\Delta SHORT$, which is the change in short interest between two successive short interest announcements, scaled by stock's shares outstanding at the end of the month. We use changes in short interest, as opposed to the levels of short interest, as we expect the market to react to new information. Using data on short interest from Compustat, we form 10 portfolios based on changes in short interest on each announcement date.[16] For consistency, our sample period is from January 2003 to December 2012 (excluding 2008); and, the universe of stocks is the merged CRSP-Compustat universe. As short-selling conveys pessimistic information, we expect a negative relationship between changes in short interest and price adjustments.

Previously, Senchack and Starks (1993) have studied market reactions to short interest announcements from 1980 to 1986. We re-conduct this analysis during our sample period because market reactions to short interest announcements might be different in more recent periods, for instance, due to the availability of more information on short-selling activity. Furthermore, we can overcome the data limitations experienced by Senchack and Starks (1993)—while Senchack and Starks (1993) were able to hand collect data on short interest only for a group of stocks, we can observe this for all firms on listed exchanges.

Panel A of Table 8 reports the average 2-day announcement returns adjusted for size and book-to-market ratio, and alphas estimated from a 3-factor and a 4-factor model by for portfolios formed on $\Delta SHORT$. Using all three measures, we find a significant negative relationship between changes in short interest and announcement returns. For instance, a strategy that buys the stocks in the bottom decile portfolio and sells the stocks in top decile

[16] Compustat consolidates data from the exhanges' websites on short interest from the public announcements, therefore it is precisely the information disseminated to public.

portfolio earns an average daily 4-factor alpha of 15 bps (approximately a monthly alpha of 300 bps) and is significant at the 1% level. As short interest conveys pessimistic information, price reactions (in absolute terms) are much larger for the top decile portfolio than for the bottom decile portfolio.[17]

Results in Panel A show the average price effects during our sample period. We conduct a subsample analysis to see whether market reactions to short interest announcements have been different in the pre- and post-amendment periods. Although the average price effects is significant during our sample period, it might be that this is mostly driven by the pre-amendment period if alternative ways to acquire information on short-sales has become more widely available in the post-amendment period. We assess this possibility and find that this is not the case. Panel B of Table 8 reports the average 2-day short interest announcement returns before and after the rule amendments. Market reactions to short interest announcements are, if anything, significantly larger (about doubled) in the post-amendment period. Overall, findings in Panels A and B show that the availability of alternative ways to access information on short-selling does not undermine the short interest announcements by exchanges. This result may not be too surprising considering the fact that the alternative ways are costly to access.

To visualize the price adjustments taking place, Figure 2 plots the cumulative 4-factor alphas for the top and bottom decile portfolios starting from 7 trading days prior to the short-interest announcements until 10 trading days after the short-interest announcements. The patterns Figure 2 show that there is no noticeable pattern in alphas before the short interest announcements, suggesting that there is no significant price effects from potential front-running prior to the announcements. We also confirm this in portfolio tests reported in Panel C of Table 8.

Finally, we check for the possibility that there might be an overreaction to short interest announcements. An overreaction to short interest may occur if investors believe that short interest is more informative than it actually is or if abusive short-sellers use public announcements to manipulate other market participants' beliefs. The prior literature has documented limited evidence for manipulation, and the evidence which has been found has

[17]These results are both qualitative and quantitatively similar to the results from related studies. For instance, Kelley and Tetlock (2016) reports that a high-minus-low portfolio constructed on quintiles of lagged retail daily short-selling activity lead to a daily alpha of 7 bps over the next day.

been concentrated around seasoned equity offerings [Henry and Koski (2010)]. If investors overreact to short interest announcements or if manipulative short-selling is taking place, we would expect to find return reversals. To detect a possible reversal effect, in Figure 3, we show the cumulative 4-alphas over the next 60 trading days after the $REPDATE$ for the top decile portfolio. Furthermore, we repeat this analysis for the small stocks, which might be more susceptible to market manipulation as they don't have enough liquidity, and growth stocks, which tend to have high short-selling activitiy. The plot shows the long-term patterns not only for the full sample, but also for the subsamples of small and growth stocks. We do not find any reversals in any of our samples, indicating that the price reactions due to short interest announcements are long-lasting.

3.5 Short-Sellers' Holding Periods, Reward-to-Risk Ratios and Activity

Short-sellers may face important horizon risks—the risk that a mispricing can take too long to correct so that potential profits are eroded by accumulating transaction costs or the risk that the mispricing worsens in the short-run due to noise trading activity. For instance, short-sellers need to maintain margin requirements, thus large adverse price movements can lead to early liquidation risk; moreover, short-sellers need to pay fees to keep their positions open. As argued by the seminal papers of Dow and Gorton (1994) and Abreu and Brunnermeier (2002), horizon risk can discourage arbitrage activity. If, with the new disclosure regime, short-sellers' information is more quickly incorporated into prices, then we would expect: (i) a decline in the holding periods of short sellers, and (ii) a reduction in the risk of experiencing adverse price movements. Furthermore, if limits to arbitrage arising from horizon risk are mitigated with the new disclosure rules, then we also expect to see an increase in the amount of short-selling. In this section, we examine these hypotheses.

We start by measuring the holding periods of short-sellers' positions using data from Markit. Markit reports the weighted average number of (calendar) days that transactions have been open. We use data from July 3, 2006 onwards—the date in which Markit commenced reporting data at a daily frequency. We take the average of all loans for a stock between two consecutive short interest announcement days and run the following regression:

$$LOANLENGTH_{i,t+1} = \alpha_i + \theta_0 e_{i,t} + \theta_1 POST_{i,t} + \theta_2 [e \times POST]_{i,t} + \lambda X_{i,t} + \varepsilon_{i,t} \quad (4)$$

where $LOANLENGTH_{i,t+1}$ is the average loan tenure for a stock after a short interest announcement and prior to the next short interest announcement (including both actual and placebo announcements). We include control variables for stock characteristics that might be related to short-sellers' holding periods such as stock's market capitalization, book-to-market ratio, idiosyncratic volatility, past cumulative monthly returns and illiquidity. We also include year, month, day-of-week time fixed effects as well as stock fixed effects. If the regulatory amendments hasten the speed in which information is impounded into prices, then the holding periods of short sellers' positions would be reduced. If this is the case, we should then observe $\theta_2 < 0$. In Table 9, we show that in both specifications, the coefficient on $[e \times POST]$ is indeed negative and statistically significant. Short-sellers have a holding period of (approximately) 80 calendar days for a typical stock, thus the estimates correspond to an approximate 9-12% decrease in short sellers' holding periods.

We next analyze the impact of the regulatory amendments on the reward-to-risk ratios of short-sellers' positions. If short-sellers' information is impounded into prices more readily with the regulatory amendments, then short-sellers would be able to earn returns to their information with lower volatility. We test this prediction using the Markit database because it allows us to observe short positions on both actual and placebo report dates, while short interest from Compustat is what is disclosed to the public, thus it only allows us to observe short interest only on actual report dates.

On each $REPDATE$ (including placebo report dates), we form 10 portfolios based on changes in short interest from the previous $REPDATE$. $\Delta SHORT\_MARKIT$ is the change in short interest based on Markit data between two consecutive $REPDATEs$, scaled by stock's shares outstanding at the end of the month. After forming the portfolios, we use the daily returns until the next $REPDATE$ and calculate the 4-factor alphas and its standard deviations for each portfolio. Table 10 reports the reward-to-risk ratios (4-factor alpha divided by its standard deviation) to each decile portfolio in the approximately two weeks period after $REPDATE$. Results indicate that, with the new reporting regime, short-sellers earn higher reward-to-risk ratios in the days following the short interest announcement. For instance, consider a strategy that is long on stocks with $\Delta SHORT\_MARKIT$ below the 10th percentile and short on stocks with $\Delta SHORT\_MARKIT$ above the 90th percentile. Portfolios formed after the end-of-month $REPDATE$ in the post-amendment period ($POST = 1$ and $e = 1$) have a reward-to-risk ratio of 2.5, while portfolios formed after the placebo end-of-month $REPDATE$ in the pre-amendment period ($POST = 0$ and $e = 1$) have a reward-to-risk ratio of 1.54. In line with our previous results, this difference is mostly driven by stocks that are heavily shorted.

Finally, in addition to examining short-sellers' holdings periods and reward-to-risk ratios, we ask whether the amount of short-selling is also affected after the rule amendments. We expect that after the regulatory amendments, due to declines in horizon risk, short-sellers might be more willing to take positions. To examine this, we run the following regression:

$$\Delta SHORT\_MARKIT_{i,t+1} = \alpha_i + \kappa_0 e_{i,t} + \kappa_1 POST_{i,t} + \kappa_2 [e \times POST]_{i,t} + \Upsilon X_{i,t} + \varepsilon_{i,t} \quad (5)$$

$\Delta SHORT\_MARKIT$ is the change in short interest based on Markit data, scaled by stock's shares outstanding at the end of the month. It is calculated after $REPDATE$ and before the next $REPDATE$. Regressions include control variables for stock characteristics that might be related to changes in short interest, such as stock's market capitalization, book-to-market ratio, idiosyncratic volatility, past cumulative monthly returns and illiquidity. If short-sellers are more active after the regulatory amendments, this would result in larger short positions, that is, $\kappa_2 > 0$. Table 11 show results that are consistent with this hypothesis. We find that the coefficient on $[e \times POST]$ is positive and significant across all specifications, indicating that there is an increase in the amount of short-selling after the regulatory amendments.

Overall, these results provide evidence corroborating the findings we previously presented. Although the analysis in this section uses data that covers only a part of short-sales (the part covered by Markit), the results are useful in suggesting that extra short interest disclosure at the end of each month in the post-amendment period have important implications. The regulatory amendments seem to reduce short-sellers' holding periods, assist short-sellers reduce price risks and increase short-selling activity.

4 Conclusion

In this paper, we investigate the role that greater disclosure of arbitrage activity and informed trading has on price efficiency. To answer this question, we study the shorting market and exploit SEC approved amendments to exchange rules, which increased the frequency of public disclosure of short positions. Greater public disclosure can potentially have both costs and benefits, thus the impact it has on price efficiency, a priori, is not immediately obvious. On the one hand, greater disclosure may hurt the production of information if it reduces the ability of arbitrageurs to profit from their information. On the other hand, disclosure can be beneficial as it can help arbitrageurs overcome the limits to arbitrage arising from horizon risk.

We estimate the changes to price efficiency with more frequent reporting of short interest using an identification strategy which relies on placebo dates—dates when short interest would have been publicly reported had broker-dealers been required to report short interest positions at the end-of-month in the pre-amendment period. The identification strategy allows us to identify the causal effects of higher public disclosure requirements. Our findings indicate that the new reporting regime has an important impact on a stock's informational environment. Specifically, information encapsulated within short interest is more quickly incorporated into prices, thereby increasing price informativeness. In extended analyses, we find that greater short interest disclosure reduces short-sellers' horizon risk and increases the amount of short-selling.

Our work has implications on regulatory policy of short selling public disclosure, and more broadly, public disclosure of private information. While in the E.U., regulations requiring the immediate disclosure of trader-level positions have discouraged short-selling and hampered price efficiency, our paper provides evidence that bi-monthly disclosure of aggregated short positions in the U.S. can ameliorate the negative consequences associated with higher publicity. Regulatory policies should consider both the potential costs as well as the potential benefits of higher public disclosure requirements imposed on arbitrageurs and informed trading. Public disclosure requirements should aim to maximize the benefits by helping the wider investing public learn from informed traders while not distorting incentives for informed traders to produce private information. Designed in this way, public disclosure requirements can help arbitrageurs overcome market frictions and therefore foster price efficiency.

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Appendix A. Definition and Description of Variables

Variable Name	Name	Description	Source
REPDATE	Disclosure date of Short Interest Announcement	Date of mid-month and end-of-month short interest announcements. This also includes the placebo *REPDATEs* in the pre-amendment period.	Compustat
POST	Post-Amendment Period	Dummy variable that equals 1 for observations in the post-amendment period, that is, after September 7, 2007, and zero otherwise.	Compustat
e	Observations relative to Short Interest announcement date	Dummy variable that equals 1 for observations after the end-of-month *REPDATE* and before the mid-month *REPDATE* the following month.	Compustat
CAR[0,1]	Cumulative abnormal returns over announcement period	Calculated two ways: (1) Absolute value of difference between buy-and-hold returns of the stock over [0,1] and *beta* multiplied by the buy-and-hold return of the market over [0,1]; (2) Absolute value of difference between buy-and-hold returns of the stock over [0,1] and that of a size and book-to-market matched portfolio over [0,1]. *beta* used in (1) is estimated from regressing daily stock returns on daily market returns using [*t*-300,*t*-46] window where *t* is the date of the earnings announcement.	CRSP, Fama-French
CAR[2,61]	Cumulative abnormal returns over post-announcement period	Calculated two ways: (1) Absolute value of difference between buy-and-hold returns of the stock over [2,61] and *beta* multiplied by the buy-and-hold return of the market over [2,61]; (2) Absolute value of difference between buy-and-hold returns of the stock over [2,61] and that of a size and book-to-market matched portfolio over [2,61]. *beta* used in (1) is estimated from regressing daily stock returns on daily market returns using [*t*-300,*t*-46] window where *t* is the date of the earnings announcement.	CRSP, Fama-French
NUMEST	Number of Analysts	Natural logarithm of one plus the number of analysts giving EPS forecasts for the given firm in that quarter.	I/B/E/S
EARNINGS_PERSIST	Earnings Persistence	First-order autocorrelation coefficient of quarterly EPS during the past 4 years.	I/B/E/S, Compustat
EARNINGS_VOL	Earnings Volatility	Standard deviation of quarterly EPS in the past four years.	I/B/E/S, Compustat

FE	Forecast Error	Absolute value of difference between the announced earnings and the consensus EPS forecast normalized by the firm's stock price at the end of the corresponding quarter. The consensus EPS forecast is calculated as in Hirshleifer, Lim and Teoh (2009).	I/B/E/S, Compustat, CRSP
IO	Institutional Ownership	Fraction of all shares outstanding held by institutional investors for a given stock at the end of the quarter (in %).	Thomson Reuters
TURNOVER	Stock Turnover	Average daily trading volume in the [0,1] days around the earnings announcement divided by shares outstanding at the end of the month.	CRSP
VOLATILITY	Stock Price Volatility	Difference between the highest and the lowest share prices over the [0,1] days around the earnings announcement, normalized by the average of the two.	CRSP
SPREAD	Bid-Ask Spread	Daily (%) average bid-ask spread over the [-4,-2] window before the earnings announcement.	CRSP
NEGNEW	Negative Earnings Announcement	Dummy variable that equals 1 if the firm's earnings surprise is negative.	Compustat, I/B/E/S
FeeRisk	Stock Fee Risk	Standard deviation of loan fees (for a stock) in previous month	Markit
TradingActivity	Trading Activity	A stock's average turnover (volume divided by shares outstanding) in previous month	CRSP
*DELAY*1	Price Delay (1st Measure)	Using data between consecutive *REPDATEs*, we first run the following regression across all stocks: $$r_{j,t} = \alpha + \beta R_{m,t} + \sum_{n=1}^{4} \delta^{(-n)} R_{m,t-n} + \varepsilon_{j,t}$$ where $r_{j,t}$ is the stock's return in week *t* and $R_{m,t}$ is the return on the CRSP value-weighted market index in week *t*. We then calculate *DELAY*1 between *REPDATEs* as follows: $$DELAY1 = 1 - \frac{R^2_{\delta^{(-n)}=0,\forall n\in[1,4]}}{R^2}$$ where $R^2_{\delta^{(-n)}=0,\forall n\in[1,4]}$ is the R^2 from the regression above where all the coefficients on $\delta^{(-n)}$ are restricted to zero, is divided by the R^2 from the regression above with no restrictions.	CRSP
*DELAY*1*_NEG*	Price Delay (2nd Measure)	*DELAY*1*_NEG* is calculated using the same method as *DELAY*1, except we only use negative market returns in the estimation (positive market returns are set to equal zero).	CRSP

*DELAY*3	Price Delay (3rd Measure)	Coefficient estimates are first calculated using the regression from *DELAY*1. Next, we calculate *DELAY*3 between *REPDATEs* as follows: $$DELAY3 = \frac{\sum_{n=1}^{4} n\delta^{(-n)} / se\left(\delta^{(-n)}\right)}{\beta / se(\beta) + \sum_{n=1}^{4} \delta^{(-n)} / se\left(\delta^{(-n)}\right)}$$ where se(.) is the standard error of the coefficient estimate.	CRSP
VARRATIO	Variance Ratio	Calculated for each stock on each trading day as follows: $$VARRATIO = \left\|1 - \frac{var(30\text{min})}{30 \times var(1\text{min})}\right\|$$ where *var*(30min) is the variance of 30-minute returns and *var*(1min) is the variance of 1-minute returns. We then calculate the average *VARRATIO* between *REPDATEs.*	TAQ
PE	Scaled Pricing Error	Calculated for each stock on each trading day as follows: $$PE = \frac{\sigma(s)}{\sigma(p)}$$ where $\sigma(s)$ is the standard deviation of the pricing error, which is assumed to follow a zero-mean, covariance-stationary process, and $\sigma(p)$ is the standard deviation of intraday transaction prices. We then calculate the average *PE* between *REPDATEs*.	TAQ
SIZE	Size	Market capitalization of a stock measured by price in month *t* multiplied by shares outstanding in month *t*, measured in $ million	CRSP
BM	Book-to-Market Ratio	Book Equity in June of calendar year, *t*, divided by market equity in December of previous calendar year, *t*-1.	CRSP, Compustat
IVOL	Idiosyncratic Volatility	Standard deviation of idiosyncratic monthly returns over the past 2-year window (in %), where idiosyncratic monthly returns are the residuals in a regression of a stock's monthly return on the three Fama and French (1993) factors.	CRSP, Fama-French
ILLIQ	Illiquidity	Average ratio of the absolute value of daily returns to the stock daily volume in the past six months, as in Amihud (2002).	CRSP
PASTRETURNS	Past Returns	Cumulative monthly returns over the past six months.	CRSP

MONTHLY	Period before and after Markit started providing monthly total short interest data	Dummy variable that equals 1 for the period from June 2002 to December 2003; and zero for the period from January 2001 to May 2002	Markit
WEEKLY	Period before and after where Markit started providing weekly total short interest data	Dummy variable that equals 1 for the period from August 2004 to June 2006; and zero for the period from October 2002 to July 2004	Markit
DAILY	Period before and after where Markit started providing daily total short interest data	Dummy variable that equals 1 for the period from July 2006 to August 2007; and zero for the period from May 2005 to June 2006	Markit
Δ*SHORT*	Change in Short Interest	Change in short interest between two successive short interest announcement dates, scaled by stock's shares outstanding at the end of the month (in %). In the pre period, it captures monthly changes; in the post period, it is bi-monthly changes	CRSP, Compustat
Increased Shorting	Portfolio of stocks with the greatest increase in Short Interest	Portfolio of stocks that has Δ*SHORT* above the 90^{th} percentile at each *REPDATE*.	CRSP, Compustat
Decreased Shorting	Portfolio of stocks with the greatest decrease in Short Interest	Portfolio of stocks that has Δ*SHORT* below the 10^{th} percentile at each *REPDATE*.	CRSP, Compustat
LOANLENGTH	Holding Period of Short-Sellers' Positions	Average loan tenure for short-sale positions after each *REPDATE* and before the next *REPDATE*.	Markit
Δ*SHORT_MARKIT*	Change in Short Interest based on Markit	Change in short interest based on the universe of market participants covered by Markit. It is calculated as the difference between two consecutive *REPDATEs* (including the placebo *REPDATE*s), scaled by shares outstanding at the end of the month. Defined in %s.	Markit, CRSP

Appendix B. Explanation of TAQ Data Processing and Construction of High-Frequency Measures of Informational Efficiency

This appendix explains the method used to process TAQ data and construct the high-frequency measures of informational efficiency. We first process all trades and quotes in the TAQ database from January 1, 2003 to December 31, 2012, excluding 2008. We follow Hasbrouck (1993) and exclude overnight returns. We focus solely on trades and quotes within regular trading hours, that is, between 9:30 am and 4:00 pm Eastern Time. For the processing of the trade files, we follow Boehmer and Wu (2013) and remove trades with non-positive prices or sizes. Furthermore, we require that TAQ's CORR file to equal zero, and TAQ's COND field is either blank or equal to *, B, E, J, or K. We also follow Boehmer and Wu (2013) and remove trades with a price greater than 150% or less than 50% of the price of the previous trade. For the processing of the quote files, we remove quotes with non-positive bid or ask prices or where the bid price is strictly higher than the ask price—that is, we remove cases of locked and crossed markets. We requite that TAQ's mode field is equal to 1, 2, 3, 6, 10, 12, 15, 19, 20, 27, or 28. We also follow Boehmer and Wu (2013) and require that quotes with an ask price that is greater than 150% of the bid price are excluded. For each stock, we aggregate all trades during the same second that execute at the same price, and retain only the last quote for each second, in the case that multiple quotes are reported. To combine the quote and trade file, we use the Lee and Ready's (1991) method for assigning trade directions. That is, we denote the trade as "buyer-initiated" if the trade price is greater than the prevailing mid-quote, and we denote the trade as "seller-initiated" if the trade price is less than the prevailing mid-quote.

To calculate the Variance Ratio, we first generate overlapping 1-minute and 30-minute returns for each stock in each trading day. As is customary in the market microstructure literature, we use the quote mid-point as opposed to the trade price in calculating returns. We then construct take the variance of all overlapping 30-minute and 1-minute returns for each stock each trading day and compute the variance ratio as follows:

$$VARRATIO = \left|1 - \frac{var(30\text{min})}{30 \times var(1\text{min})}\right|$$

To calculate the Pricing Error, we follow Hasbrouck (1993) and Boehmer and Wu (2013), and decompose log transaction prices, p_t, as follows:

$$p_t = m_t + s_t$$

In the equation above, m_t represents the efficient (random walk) component of the stock price. It is the expectation of the stock's fundamental value. m_t changes in response to new public information. s_t represents the pricing error, and measures temporary deviations relative to m_t. It is assumed to follow a zero-mean covariance-stationary process, however, it can be serially correlated or correlated with the innovations from m_t. The standard deviation of the pricing error, $\sigma(s)$ measures the magnitude of deviations from the efficient price and can be interpreted as a measure of informational efficiency.

To empirically estimate this model, we follow Boehmer and Wu (2013) and run a vector autoregression (VAR) system for each stock each trading day, using five lags over the following jointly determined system of variables, $\{r_t, x_t\}$, where r_t is the difference in log prices, p_t, and x_t is a vector representing trade-related variables such as, trade sign indicator—a variable which equals 1 for a buy and -1 for a sale, signed trading volume, and signed square root of trading volume. Estimating this system of equations using a VAR yields estimates of $\sigma(s)$ for each stock each trading day. We scale $\sigma(s)$ by the standard deviation of log transaction prices, $\sigma(p)$, to compute the pricing error, *PE*. Finally, to reduce the influence of outliers, we follow Boehmer and Wu (2013) and remove observations where $\sigma(s) > \sigma(p)$.

Table 1. Descriptive Statistics

In this table, we present the descriptive statistics for our main analysis. We divide our sample into two sub-samples: *e* = 0 pertains to observations where the firm's earnings announcement occurs after the mid-month *REPDATE* and before the end-of-month *REPDATE*; and *e* = 1 pertains to observations where the firm's earnings announcement occurs after the end-of-month *REPDATE* and before the mid-month *REPDATE* the following month. *NUMEST* is the natural logarithm of one plus the number of analysts giving EPS forecasts for the given firm in that quarter; *IO* is the fraction of all shares outstanding held by institutional investors for a given stock at the end of the quarter (in %); *FE* is the difference between the announced earnings and the consensus EPS forecast normalized by the firm's stock price at the end of the corresponding quarter; *EARNINGS_PERSIST* is the first-order autocorrelation coefficient of quarterly earnings per share during the past 4 years; *EARNINGS_VOL* is the standard deviation of quarterly EPS in the past 4 years; *NUMANN* is the natural logarithm of one plus the number of concurrent earnings announcements that occur on the same day as the earning's announcement for the given stock.

	VARIABLES	Mean	Median	Standard Deviation
e = 0	*NUMEST*	1.5093	1.6094	0.8896
	IO	56.9318	59.9246	26.7693
	FE	0.0073	0.0023	0.0170
	EARNINGS_PERSIST	0.2489	0.2370	0.3044
	EARNINGS_VOL	0.4646	0.2229	0.8796
	NUMANN	4.0884	4.2047	0.8442
e = 1	*NUMEST*	1.5143	1.6094	0.8181
	IO	60.5778	63.7538	25.2301
	FE	0.0074	0.0027	0.0162
	EARNINGS_PERSIST	0.2449	0.2252	0.2971
	EARNINGS_VOL	0.4951	0.2469	0.9265
	NUMANN	4.6722	4.8978	0.8584

Table 2. Short-Term Price Reactions to Earnings Announcements

In this table, we present the regression results for the short-term price reactions to earnings announcements. In Panel A, we present the regression results where the dependent variable, *CAR*[0,1] is the absolute value of 2-day cumulative abnormal return in the [0,1] days around the earnings announcement, defined as the difference between buy-and-hold returns of the stock and beta multiplied by the buy-and-hold return of the market. In Panel B, we present the regression results where the dependent variable, *CAR*[0,1] is the absolute value of 2-day cumulative abnormal return in the [0,1] days around the earnings announcement, defined as the difference between buy-and-hold returns of the stock and that of a size and book-to-market matched portfolio. The explanatory variables include: *POST* is a dummy variable that equals 1 for the firm's earnings announcement dates after September 7, 2007; *e* is a dummy variable that equals 1 when the firm's earnings announcement occurs after the end-of-month *REPDATE* and before the mid-month *REPDATE* the following month; *POST* x *e* is an interaction term between *POST* and *e*. In columns 2 to 4, we control for *NUMEST*, *IO*, *FE*, *EARNINGS_PERSIST*, *EARNINGS_VOL*, *NUMANN* (which are defined in Table 1 and Appendix A), and include industry, year, month and day-of-week fixed effects. In column 4, we also include stock fixed effects. All regressions include a constant term, whose coefficient is suppressed for reporting purposes. We present ordinary least squares estimates with standard errors double-clustered by stock and earnings announcement day; *, **, *** indicate 10%, 5% and 1% level of significance respectively.

Panel A. Short-Term Price Reactions: 2 Days, Beta-Adjusted Returns

VARIABLES	(1) *CAR*[0,1]	(2) *CAR*[0,1]	(3) *CAR*[0,1]	(4) *CAR*[0,1]
POST x *e*	-0.0030***	-0.0025***	-0.0023**	-0.0021***
	(0.0010)	(0.0010)	(0.0010)	(0.0007)
POST	0.0124***	0.0121***	0.0122***	0.0120***
	(0.0018)	(0.0019)	(0.0019)	(0.0014)
e	0.0032***	0.0027***	0.0034***	0.0028***
	(0.0007)	(0.0006)	(0.0007)	(0.0005)
NUMEST		-0.0051***	-0.0051***	-0.0016***
		(0.0004)	(0.0004)	(0.0005)
IO		0.0000***	0.0000***	0.0000*
		(0.0000)	(0.0000)	(0.0000)
FE		0.1565***	0.1564***	0.0973***
		(0.0141)	(0.0141)	(0.0132)
EARNINGS_PERSIST		0.0031***	0.0032***	0.0033***
		(0.0008)	(0.0008)	(0.0008)
EARNINGS_VOL		0.0005*	0.0005*	0.0016***
		(0.0003)	(0.0003)	(0.0003)
NUMANN			-0.0015***	-0.0017***
			(0.0004)	(0.0003)
Observations	78,317	59,020	59,020	59,020
R-squared	0.071	0.121	0.121	0.063
Controls	No	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Industry FE	No	Yes	Yes	Yes
Stock FE	No	No	No	Yes

Panel B. Short-Term Price Reactions: 2 Days, SMB-Adjusted Returns

VARIABLES	(1) *CAR*[0,1]	(2) *CAR*[0,1]	(3) *CAR*[0,1]	(4) *CAR*[0,1]
POST x *e*	-0.0028***	-0.0021**	-0.0019**	-0.0017**
	(0.0010)	(0.0010)	(0.0010)	(0.0007)
POST	0.0125***	0.0120***	0.0121***	0.0119***
	(0.0018)	(0.0019)	(0.0019)	(0.0013)
e	0.0032***	0.0027***	0.0034***	0.0027***
	(0.0007)	(0.0006)	(0.0007)	(0.0005)
NUMEST		-0.0050***	-0.0050***	-0.0015***
		(0.0004)	(0.0004)	(0.0005)
IO		0.0000***	0.0000***	0.0000
		(0.0000)	(0.0000)	(0.0000)
FE		0.1581***	0.1580***	0.1003***
		(0.0139)	(0.0139)	(0.0129)
EARNINGS_PERSIST		0.0031***	0.0031***	0.0034***
		(0.0008)	(0.0008)	(0.0008)
EARNINGS_VOL		0.0006**	0.0006**	0.0017***
		(0.0003)	(0.0003)	(0.0003)
NUMANN			-0.0015***	-0.0017***
			(0.0004)	(0.0003)
Observations	78,327	59,026	59,026	59,026
R-squared	0.071	0.119	0.119	0.062
Controls	No	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Industry FE	No	Yes	Yes	Yes
Stock FE	No	No	No	Yes

Table 3. Other Short-Term Effects Around Earnings Announcements

In this table, we present the regression results for the other effects measures around earning announcements. The dependent variables are: in column (1) *TURNOVER* is average daily volume over the [0,1] days around the earnings announcement divided by shares outstanding at the end of the month; in column (2) *VOLATILITY* is difference between the highest and lowest share prices over the [0,1] days around the earnings announcement, normalized by an average of the two; in column (3) *SPREAD* is the daily average bid-ask spread over the [-4,-2] days before the earnings announcement. The explanatory variables include: *POST* is a dummy variable that equals 1 for the firm's earnings announcement dates after September 7, 2007; *e* is a dummy variable that equals 1 when the firm's earnings announcement occurs after the end-of-month *REPDATE* and before the mid-month *REPDATE* the following month; *POST* x *e* is an interaction term between *POST* and *e*. All regressions include the following control variables: *NUMEST, IO, FE, EARNINGS_PERSIST, EARNINGS_VOL, NUMANN*, and industry, stock, year, month and day-of-week fixed effects. Controls variables are defined in Table 1 and Appendix A. We also include a constant term in all regression specifications, but suppress it for reporting purposes. We present ordinary least squares estimates with standard errors double-clustered by stock and earnings announcement day; *, **, *** indicate 10%, 5% and 1% level of significance respectively.

VARIABLES	(1) *TURNOVER*	(2) *VOLATILITY*	(3) *SPREAD*
POST x *e*	-0.0011***	-0.0209***	-0.0126**
	(0.0003)	(0.0066)	(0.0057)
POST	0.0010*	0.0077*	0.1061***
	(0.0005)	(0.0045)	(0.0097)
e	0.0009***	0.0149***	0.0079*
	(0.0002)	(0.0048)	(0.0044)
Observations	59,934	59,425	59,904
R-squared	0.082	0.022	0.132
Controls	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Stock FE	Yes	Yes	Yes

Table 4. Long-Term Price Reactions to Earnings Announcements

In this table, we present the regression results for the long-term price reactions to earnings announcements. In Panel A, we presents the regression results where the dependent variable, *CAR*[2,61] is the absolute value of 60-day cumulative abnormal returns in the [2,61] days after the earnings announcement, defined as the difference between buy-and-hold returns of the stock and beta multiplied by the buy-and-hold return of the market. In Panel B, we present the regression results where the dependent variable, *CAR*[2,61] is the absolute value of 60-day cumulative abnormal return in the [2,61] days after the earnings announcement, defined as the difference between buy-and-hold returns of the stock and that of a size and book-to-market matched portfolio. The explanatory variables include: *POST* is a dummy variable that equals 1 for the firm's earnings announcement dates after September 7, 2007; *e* is a dummy variable that equals 1 when the firm's earnings announcement occurs after the end-of-month *REPDATE* and before the mid-month *REPDATE* the following month; *POST* x *e* is an interaction term between *POST* and *e*. In columns 2 to 4, we control for *NUMEST*, *IO*, *FE*, *EARNINGS_PERSIST*, *EARNINGS_VOL*, *NUMANN* (which are defined in Table 1 and Appendix A), and include industry, year, month and day-of-week fixed effects. In column 4, we also include stock fixed effects. All regression specifications include a constant term, whose coefficient is suppressed for reporting purposes. We present ordinary least squares estimates with standard errors double-clustered by stock and earnings announcement day; *, **, *** indicate 10%, 5% and 1% level of significance respectively.

Panel A. Long-Term Price Reactions: 60 Days, Beta-Adjusted Returns

VARIABLES	(1) *CAR*[2,61]	(2) *CAR*[2,61]	(3) *CAR*[2,61]	(4) *CAR*[2,61]
POST x *e*	-0.0066**	-0.0083***	-0.0080***	-0.0075***
	(0.0026)	(0.0026)	(0.0026)	(0.0027)
POST	0.0309***	0.0269***	0.0270***	0.0269***
	(0.0039)	(0.0043)	(0.0043)	(0.0041)
e	0.0016	0.0042**	0.0050***	0.0053***
	(0.0019)	(0.0017)	(0.0019)	(0.0019)
NUMEST		-0.0166***	-0.0166***	-0.0058***
		(0.0009)	(0.0009)	(0.0020)
IO		-0.0003***	-0.0003***	-0.0005***
		(0.0000)	(0.0000)	(0.0001)
FE		0.8893***	0.8892***	0.5217***
		(0.0606)	(0.0606)	(0.0631)
EARNINGS_PERSIST		0.0071***	0.0072***	0.0085***
		(0.0021)	(0.0021)	(0.0030)
EARNINGS_VOL		0.0057***	0.0057***	0.0035**
		(0.0008)	(0.0008)	(0.0015)
NUMANN			-0.0017	-0.0061***
			(0.0010)	(0.0013)
Observations	74,733	56,609	56,609	56,609
R-squared	0.024	0.073	0.073	0.028
Controls	No	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Industry FE	No	Yes	Yes	Yes
Stock FE	No	No	No	Yes

Panel B. Long-Term Price Reactions: 60 Days, SMB-Adjusted Returns

	(1)	(2)	(3)	(4)
VARIABLES	*CAR*[2,61]	*CAR*[2,61]	*CAR*[2,61]	*CAR*[2,61]
POST x *e*	-0.0063**	-0.0075***	-0.0071***	-0.0060**
	(0.0025)	(0.0025)	(0.0025)	(0.0026)
POST	0.0274***	0.0239***	0.0239***	0.0228***
	(0.0038)	(0.0042)	(0.0042)	(0.0040)
e	0.0001	0.0031*	0.0041**	0.0040**
	(0.0018)	(0.0016)	(0.0017)	(0.0018)
NUMEST		-0.0147***	-0.0147***	-0.0045**
		(0.0009)	(0.0009)	(0.0019)
IO		-0.0003***	-0.0003***	-0.0004***
		(0.0000)	(0.0000)	(0.0001)
FE		0.8092***	0.8091***	0.4439***
		(0.0563)	(0.0563)	(0.0581)
EARNINGS_PERSIST		0.0057***	0.0057***	0.0084***
		(0.0020)	(0.0020)	(0.0029)
EARNINGS_VOL		0.0054***	0.0054***	0.0032**
		(0.0008)	(0.0008)	(0.0014)
NUMANN			-0.0021**	-0.0068***
			(0.0009)	(0.0012)
Observations	74,734	56,609	56,609	56,609
R-squared	0.027	0.073	0.073	0.031
Controls	No	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Industry FE	No	Yes	Yes	Yes
Stock FE	No	No	No	Yes

Table 5. Cross-Sectional Differences

In this table, we present the cross-sectional differences in the regression results reported in Table 2. In Column 1, we introduce interaction terms with *High FeeRisk*, which is a dummy equals to 1 when the firm's *FeeRisk* is above median; in Column 2, we introduce interaction terms with *High IVOL*, which is a dummy equals to 1 when the firm's idiosyncratic volatility is above median; in Column 3, we introduce interaction terms with *High RetailTrading*, which is a dummy equals to 1 when the firm's *IO* is below median and its *TradingActivity* above median; in Column 4, we introduce interaction terms with *Low ILLIQ,* which is a dummy equals to 1 when the firm's Amihud *ILLIQ* is above median; in Column 5, we introduce interaction terms with *NegNew*, if the firm's earnings announcement is negative. Definitions of *FeeRisk, IVOL, IO, TradingActivity*, *ILLIQ* are in Appendix A. Dependent variable is *CAR*[0,1], which is the absolute value of 2-day cumulative abnormal return in the [0,1] days around the earnings announcement, defined as the difference between buy-and-hold returns of the stock and beta multiplied by the buy-and-hold return of the market. *POST* is a dummy variable that equals 1 for the firm's earnings announcement dates after September 7, 2007; *e* is a dummy variable that equals 1 when the firm's earnings announcement occurs after the end-of-month *REPDATE* and before the mid-month *REPDATE* the following month. The explanatory variables include all interaction terms between *POST*, *e* and *Char*, which refers to the stock characteristics explained above. All regressions include the following control variables: *NUMEST*, *IO, FE, EARNINGS_PERSIST*, *EARNINGS_VOL, NUMANN*, and industry, year, month and day-of-week fixed effects. We also include a constant term in all regression specifications, but suppress it for reporting purposes. We present ordinary least squares estimates with standard errors double-clustered by stock and earnings announcement day; *, **, *** indicate 10%, 5% and 1% level of significance respectively.

VARIABLES	(1) *High FeeRisk*	(2) *High IVOL*	(3) *High RetailTrading*	(4) *Low ILLIQ*	(5) *NegNew*
POST x e	-0.0015*	-0.0012*	-0.0018*	-0.0029***	-0.0014*
	(0.0008)	(0.0007)	(0.0010)	(0.0010)	(0.0008)
POST x e x Char	-0.0010**	-0.0007*	-0.0014**	0.0033**	-0.0021**
	(0.0005)	(0.0004)	(0.0007)	(0.0015)	(0.0010)
e x Char	0.0007*	0.0001	0.0013*	-0.0015	0.0014**
	(0.0004)	(0.0016)	(0.0007)	(0.0016)	(0.0007)
POST x Char	0.0016	-0.0045**	-0.0026	-0.0020	0.0022**
	(0.0020)	(0.0018)	(0.0021)	(0.0019)	(0.0011)
Char	0.0029**	0.0175***	0.0100***	-0.0002	0.0012*
	(0.0013)	(0.0014)	(0.0015)	(0.0014)	(0.0007)
POST	0.0083***	0.0127***	0.0115***	0.0126***	0.0116***
	(0.0022)	(0.0020)	(0.0019)	(0.0019)	(0.0019)
e	0.0026***	0.0030***	0.0029***	0.0037***	0.0031***
	(0.0009)	(0.0007)	(0.0007)	(0.0007)	(0.0006)
Observations	42,294	56,255	59,019	58,671	59,020
R-squared	0.135	0.143	0.125	0.122	0.122
Controls	Yes	Yes	Yes	Yes	Yes
Time FEs	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes

Table 6. Alternative Measures of Informational Efficiency: Price Delay

In this table, we present the regression results from Equation (1) using alternative measures of informational efficiency which rely on the price delay measure of Hou and Moskowitz (2005). Specifically, we use the following dependent variables: in column (1), *DELAY*1 is a measure similar to Hou and Moskowitz's (2005) D1 measures of price delay, measured as one minus the ratio of the R^2 from the regression where coefficients on lagged market returns are constrained to zero and the unrestricted R^2; in column (2), *DELAY*1*_NEG* is a measure similar to *DELAY*1, except that only negative market returns are used (positive market returns are set to equal zero); in column (3), *DELAY*3 is a measure similar to Hou and Moskowitz's (2005) D3 measure of price delay, which distinguishes between shorter and longer lags of market returns and accounts for the precision of estimates on the coefficients of lagged market returns. *DELAY*1, *DELAY*1*_NEG*, and *DELAY*3 are calculated as cross-sectional averages between consecutive *REPDATEs*, therefore there is a single price delay measure corresponding to each *REPDATE*. Further details regarding the calculation of *DELAY*1, *DELAY*1*_NEG*, and *DELAY*3 can be found in Appendix A. The explanatory variables include: *POST* is a dummy variable that equals 1 for observations in the post-amendment period; *e* is a dummy variable that equals 1 when the delay measures are calculated after the end-of-month *REPDATE* and before the mid-month *REPDATE* the following month; *POST* x *e* is an interaction term between *POST* and *e*. All regressions include year, month and day-of-week fixed effects and a constant term whose coefficient is suppressed for reporting purposes. *, **, *** indicate 10%, 5% and 1% level of significance, respectively.

VARIABLES	(1) *DELAY*1	(2) *DELAY*1*_NEG*	(3) DELAY3
POST	-0.0346	-0.0094	-0.4632
	(0.0211)	(0.0611)	(0.2949)
e	0.0300*	0.1535***	0.4747**
	(0.0177)	(0.0338)	(0.1861)
POST x *e*	-0.0470**	-0.1666***	-0.5361**
	(0.0206)	(0.0484)	(0.2208)
Observations	216	216	216
R-squared	0.225	0.200	0.259
Time FE	Yes	Yes	Yes

Table 7. Alternative Measures of Informational Efficiency: High Frequency Measures

In this table, we use high-frequency measures of informational efficiency measured as the average between the current *REPDATE* and the following *REPDATE*: in columns (1) and (2), *VARRATIO* is the variance ratio of 1-minute and 30-minute overlapping intraday returns; in columns (3) and (4), *PE* is the scaled pricing error defined as the standard deviation of the pricing error divided by the standard deviation of log intraday prices. Further details regarding the calculation of *VARRATIO* and *PE* can be found in Appendix A and B. The explanatory variables include: *POST* is a dummy variable that equals 1 for observations in the post-amendment period; *e* is a dummy variable that equals 1 when the high frequency measures are calculated after the end-of-month *REPDATE* and before the mid-month *REPDATE* the following month; *POST* x *e* is an interaction term between *POST* and *e*. In addition to *POST*, *e*, and *POST* x *e*, we include the control variables of: idiosyncratic volatility (*IVOL),* stock's market capitalization (*SIZE),* book-to-market ratio (*BM)*, past cumulative monthly returns (*PASTRETURNS)* and illiquidity *(ILLIQ).* Further details regarding the definition of these variables can be in Appendix A. All regressions include industry, stock, year, month and day-of-week fixed effects. We also include a constant term in all regression specifications, but suppress it for reporting purposes. We present ordinary least squares estimates with standard errors clustered by stock and short-interest announcement days; *, **, *** indicate 10%, 5% and 1% level of significance, respectively.

VARIABLES	(1) *VARRATIO*	(2) *VARRATIO*	(3) *PE*	(4) *PE*
POST x *e*	-0.0236***	-0.0206***	-0.0039***	-0.0041***
	(0.0009)	(0.0010)	(0.0003)	(0.0003)
e	0.0199***	0.0173***	0.0045***	0.0033***
	(0.0016)	(0.0017)	(0.0005)	(0.0005)
POST	0.0418***	0.0456***	0.0007	0.0061***
	(0.0023)	(0.0027)	(0.0007)	(0.0007)
IVOL		-0.0020***		0.0037***
		(0.0001)		(0.0000)
BM		0.0541***		0.0290***
		(0.0011)		(0.0004)
SIZE		-0.0000***		-0.0000***
		(0.0000)		(0.0000)
ILLIQ		0.0097***		0.0066***
		(0.0004)		(0.0016)
PASTRETURNS		-0.0054***		-0.0142***
		(0.0013)		(0.0005)
Observations	533,604	419,321	451,621	357,784
R-squared	0.016	0.076	0.050	0.242
Controls	No	Yes	No	Yes
Time FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Stock FE	Yes	Yes	Yes	Yes

Table 8. Market Reactions to Short Interest Announcements

In this table, we present the results from the market reactions to short interest announcements during our sample period. We form 10 portfolios based on changes to short interest (Δ*SHORT*) on each announcement date, Δ*SHORT* is the change in short interest between two successive short interest announcements, scaled by shares outstanding at the end of the month. The bottom decile portfolio (Decile 1) has a Δ*SHORT* below the 10^{th} percentile, and the top decile portfolio (Decile 10) has a Δ*SHORT* above the 90^{th} percentile. In Panel A, we report the average 2-day return (in %) in the [1,2] days after the short interest announcement. We skip the day of announcement because short interest is disclosed after 4:00 p.m. In column 1, we report size and book-to-market adjusted abnormal returns; in columns 2 and 3, we present 3-factor and 4-factor alphas respectively. In Panel B, we report the average 4-factor alphas in the [1,2] days after the short interest announcement, in the pre- and post-amendment periods. In Panel C, we report the average 4-factor alphas in the [-3,0] days prior to the short interest announcement. We use Newey-West standard errors with 5 lags (reported in parentheses). *, **, *** indicate 10%, 5% and 1% level of significance respectively.

Panel A. Announcement Day Returns

	(1)	(2)	(3)
Decile	SMB	3-factor Alpha	4-factor Alpha
1	0.0432***	0.0479***	0.0477***
	(0.0137)	(0.0124)	(0.0125)
10	-0.1060***	-0.1008***	-0.1031***
	(0.0188)	(0.0160)	(0.0155)
Diff	-0.1492***	-0.1487***	-0.1508***
	(0.0172)	(0.0171)	(0.0166)

Panel B. Announcement Day Returns: pre- vs post-amendment periods

Decile	*POST*=0	*POST*=1	Diff
1	0.0171	0.0534***	0.0363**
	(0.0201)	(0.0157)	(0.0179)
10	-0.0654**	-0.1275***	-0.0621***
	(0.0286)	(0.0178)	(0.0218)
Diff	0.0825***	0.1809***	0.0984***
	(0.0277)	(0.0185)	(0.0302)

Panel C. Pre-Announcement Returns

Decile	*t* = 0	*t* = -1	*t* = -2	*t* = -3
1	-0.0021	-0.0151	-0.0035	-0.0263
	(0.0227)	(0.0211)	(0.0165)	(0.0247)
10	-0.0056	0.0345	-0.0201	0.0060
	(0.0225)	(0.0261)	(0.0189)	(0.0204)
Diff	-0.0036	0.0497*	-0.0167	0.0323
	(0.0222)	(0.0256)	(0.0185)	(0.0264)

Table 9. Short Sellers' Holding Periods

In this table, we present the regression results of the impact of the regulatory amendments have on short sellers' holding periods. The table presents the regression results where the dependent variable, *LOANLENGTH* is the average loan tenure (in calendar days) for short-sale positions after the current *REPDATE* and before the next *REPDATE*. The explanatory variables include: *POST* is a dummy variable that equals 1 for observations in the post-amendment period; *e* is a dummy variable that equals 1 when *LOANLENGTH* is calculated after the end-of-month *REPDATE* and before the mid-month *REPDATE* the following month; *POST* x *e* is an interaction term between *POST* and *e*. In column 2, we include the following control variables: idiosyncratic volatility (*IVOL),* stock's market capitalization (*SIZE),* book-to-market ratio (*BM),* past cumulative monthly returns (*PASTRETURNS),* illiquidity *(ILLIQ)* and stock fixed effects. Further details regarding the definition of control variables can be found in Appendix A. All regressions include year, month, day-of-week fixed effects. We also include a constant term in all regression specifications, but suppress it for reporting purposes. We present ordinary least squares estimates with standard errors double-clustered by stock and short-interest announcement days; *, **, *** indicate 10%, 5% and 1% level of significance, respectively.

VARIABLES	(1) *LOANLENGTH*	(2) *LOANLENGTH*
POST x *e*	-9.8280***	-9.0411***
	(2.9838)	(3.2552)
POST	3.2377***	2.1909**
	(0.7576)	(0.8690)
e	9.6129***	8.7815***
	(2.9862)	(3.2575)
SIZE		-0.0012***
		(0.0002)
IVOL		-0.5024***
		(0.0843)
ILLIQ		-0.0275
		(0.0358)
BM		4.6395***
		(0.6222)
PASTRETURNS		1.0262
		(0.7028)
Observations	382,612	306,198
R-squared	0.028	0.039
Controls	No	Yes
Time FE	Yes	Yes
Stock FE	Yes	Yes

Table 10. Reward-to-Risk Ratios of Short Sellers' Positions

In this table, we present the impact of the regulatory amendments on the reward-to-risk ratio of short-sellers' positions. Markit reports the total short positions taken on by the universe of market participants it covers (*SHORT_MARKIT*). On each *REPDATE*, we form 10 portfolios based on changes in short interest in Markit (Δ*SHORT_MARKIT*). Δ*SHORT_MARKIT* is the change in short interest between two consecutive *REPDATEs* (including the placebo *REPDATE*), scaled by shares outstanding at the end of the month. The bottom decile portfolio (*P1*) has a Δ*SHORT* below the 10^{th} percentile, and the top decile portfolio (*P10*) has a Δ*SHORT* above the 90^{th} percentile; *P1-P10* is the difference between the two portfolios. After forming the portfolios, we use the daily returns until the next *REPDATE* and calculate the average 4-factor alphas and its standard deviations for each portfolio. The table reports the reward-to-risk ratio, defined as the 4-factor alpha divided by its standard deviation. *POST* is a dummy variable that equals 1 for observations in the post-amendment period; *e* is a dummy variable that equals 1 when Δ*SHORT_MARKIT* is calculated after the end-of-month *REPDATE* and before the mid-month *REPDATE* the following month.

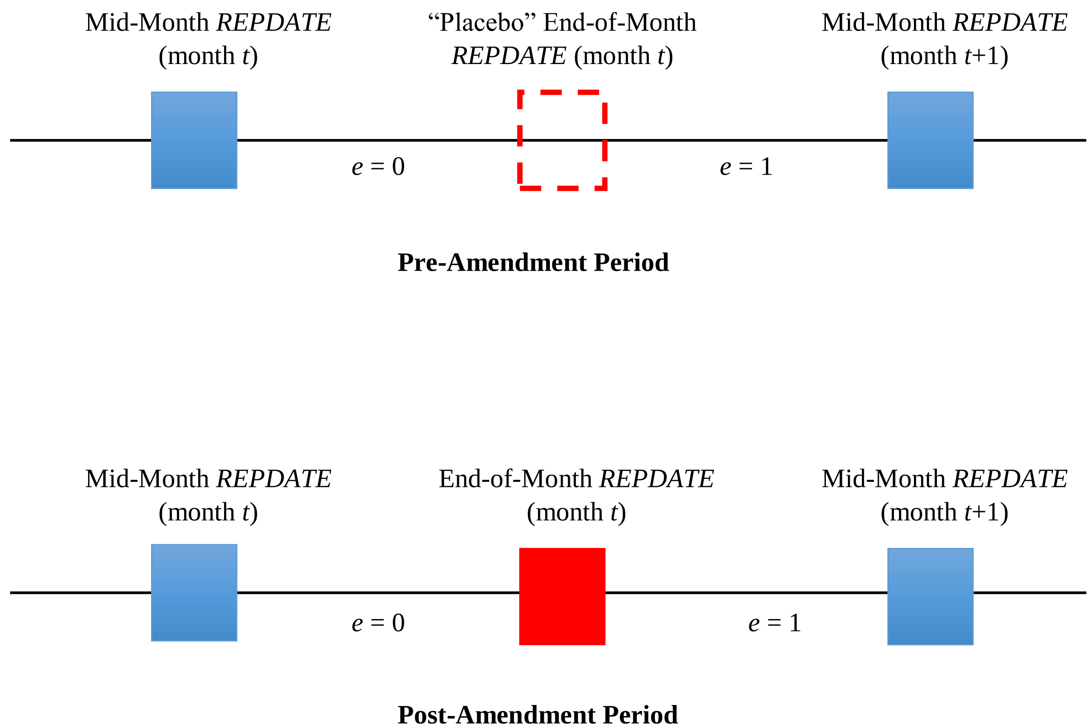
	e=0		*e=1*	
POST=0	**P1**	1.1857	**P1**	1.2400
	P10	-1.9921	**P10**	-1.6000
	P1-P10	1.8453	**P1-P10**	1.5370
POST=1	**P1**	1.2361	**P1**	1.2051
	P10	-2.0381	**P10**	-2.4476
	P1-P10	2.0897	**P1-P10**	2.4894

Table 11. Amount of Short Selling

In this table, we present the impact of the regulatory amendments on the amount of short-selling. The dependent variable used is Δ*SHORT_MARKIT*, which is the % change in total short positions reported by Markit between two consecutive *REPDATEs* (including the placebo *REPDATE*), scaled by shares outstanding at the end of the month. The explanatory variables include: *POST* is a dummy variable that equals 1 for observations in the post-amendment period; *e* is a dummy variable that equals 1 when Δ*SHORT_MARKIT* is calculated after the end-of-month *REPDATE* and before the mid-month *REPDATE* the following month; *POST* x *e* is an interaction term between *POST* and *e*. In column 2, we include the following control variables: idiosyncratic volatility (*IVOL)*, stock's market capitalization (*SIZE)*, book-to-market ratio (*BM)*, past cumulative monthly returns (*PASTRETURNS)*, illiquidity *(ILLIQ)* and stock fixed effects. Further details regarding the definition of control variables can be found in Appendix A. All regressions include year, month and day-of-week fixed effects. We also include a constant term in all regression specifications, but suppress it for reporting purposes. We present ordinary least squares estimates with standard errors double-clustered by stock and short-interest announcement days; *, **, *** indicate 10%, 5% and 1% level of significance, respectively.

	(1)	(2)
VARIABLES	Δ*SHORT_MARKIT*	Δ*SHORT_MARKIT*
POST x *e*	0.1582***	0.1632***
	(0.0427)	(0.0482)
POST	-0.1205	-0.1271
	(0.0734)	(0.0826)
e	-0.1244***	-0.1282***
	(0.0394)	(0.0448)
SIZE		-0.0000***
		(0.0000)
IVOL		-0.0006
		(0.0007)
ILLIQ		0.0006***
		(0.0002)
BM		-0.0193***
		(0.0054)
PASTRETURNS		0.0035
		(0.0137)
Observations	345,458	261,958
R-squared	0.008	0.009
Controls	No	Yes
Time FE	Yes	Yes
Stock FE	Yes	Yes

Figure 1. Diagrammatic Explanation of Empirical Methodology



The identification in our empirical design comes from the additional end-of-month short interest announcement in the post amendment period (red square). We look at differences between the end-of-month and placebo end-of-month short interest announcements in the pre-amendment period (red dashed square). There is no change in reporting regime for mid-month short interest announcements in pre- and post-amendment period. As such, e = 0 when the firm's earnings announcement occurs between the mid-month *REPDATE* and the end-of-month *REPDATE*, and e = 1 occurs when the firm's earnings announcement occurs between the end-of-month *REPDATE* and mid-month *REPDATE* the following month.

Figure 2. Market Reactions to Short Interest Announcements in the Full Sample

In this figure, we present the price reactions to short interest announcements. On each announcement date, we form 10 portfolios based on Δ*SHORT*, which is the change in short interest between two successive short interest announcements, scaled by stock's shares outstanding at the end of the month. The bottom decile (*Decreased Shorting*) portfolio has a Δ*SHORT* below the 10^{th} percentile, and the top decile portfolio (*Increased Shorting*) has Δ*SHORT* above 90^{th} percentile. In this figure, we show the cumulative 4-factor alphas (in %), starting from 7 trading days prior to the short-interest announcements until 10 trading days after the short-interest announcements. Short interest is publicly disclosed after 4:00 p.m. at t = 0.

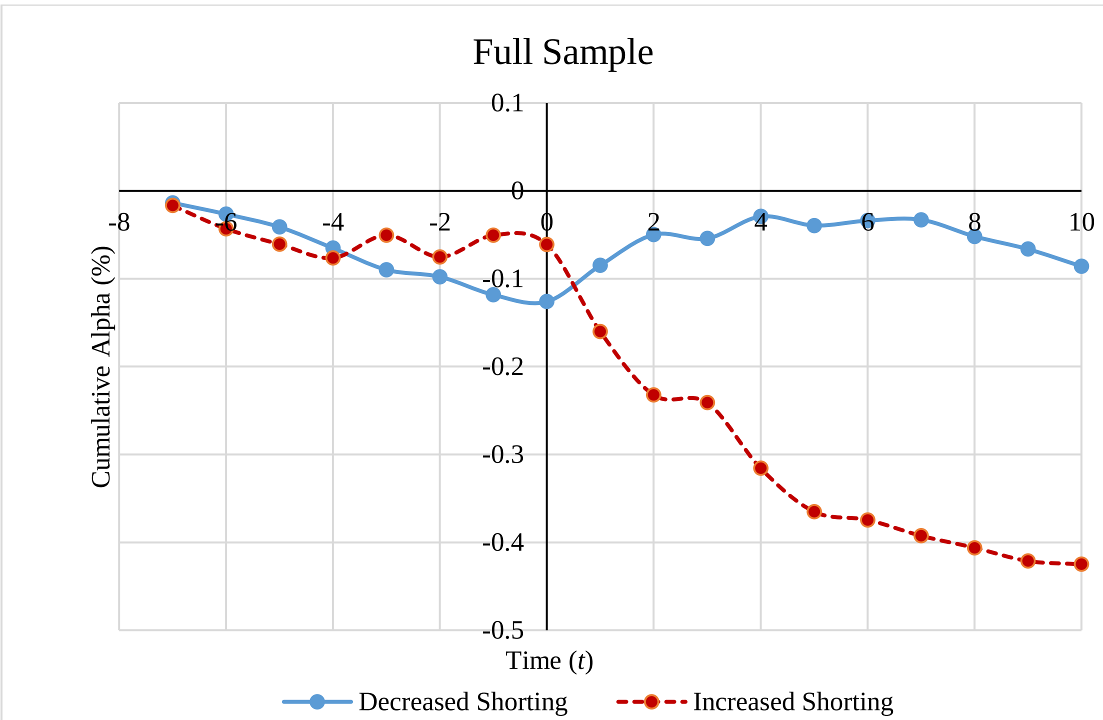
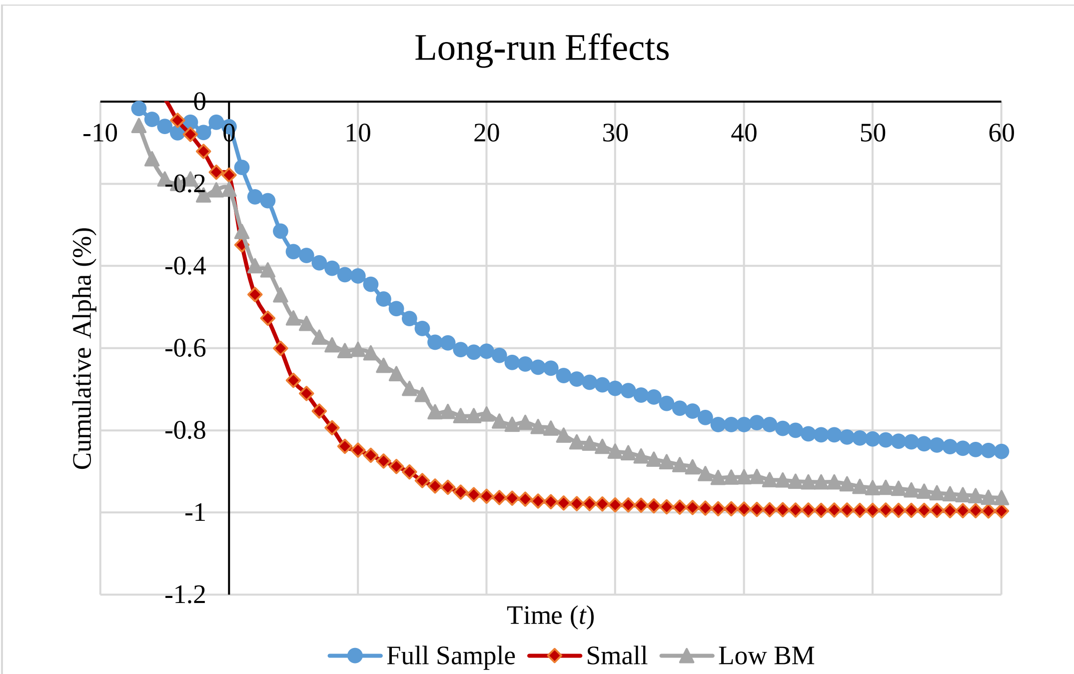


Figure 3. Market Reactions to Short Interest Announcements: Long-run Effects

In this figure, we present the long-run price reactions to short interest announcements. On each announcement date, we form 10 portfolios based on Δ*SHORT*, which is the change in short interest between two successive short interest announcements, scaled by stock's shares outstanding at the end of the month. This figure shows the cumulative 4-factor alphas (in %), starting from 7 trading days prior to the short-interest announcements until 60 trading days after the short-interest announcements. Short interest is publicly disclosed after 4:00 p.m. at $t = 0$. The blue line shows cumulative 4-factor alphas for the *Increased Shorting* portfolio in the full sample. The grey and red lines show the cumulative 4-factor alphas for *Increased Shorting* portfolio within *Small* (stocks with market capitalization in bottom quintile) and *LowBM* (stocks with book-to-market ratios in bottom quintile), respectively.



Internet Appendix (not for publication)

Internet Appendix Table IA.1. Robustness: Alternative Sample Periods

In this table, we present the regression results reported in Tables 2-4 using alternative sample periods. In Panel A, we present the regression results using a [-48,48] month event window around the regulatory amendments on September 7, 2007, excluding 2008. In Panel B, we present the regression results using a [-48,60] month event window around the regulatory amendments on September 7, 2007, excluding 2008. In both panels, we use the following dependent variables: in column (1) *CAR*[0,1] is the absolute value of 2-day cumulative abnormal return in the [0,1] days around the earnings announcement, defined as the difference between buy-and-hold returns of the stock and beta multiplied by the buy-and-hold return of the market; in column (2) *TURNOVER* is average daily volume over the [0,1] days around the earnings announcement divided by shares outstanding at the end of the month; in column (3) *SPREAD* is the daily average bid-ask spread over the pre-event time window [-4,-2]; in column (4) *VOLATILITY* is difference between the highest and lowest share prices over the event time window [0,1], normalized by an average of the two; in column (5) *CAR*[2,61] is the absolute value of 60-day cumulative abnormal return in the [2,61] days after the earnings announcement, defined as the difference between buy-and-hold returns of the stock and beta multiplied by the buy-and-hold return of the market. The explanatory variables include: *POST* is a dummy variable that equals 1 for the firm's earnings announcement dates after September 7, 2007; *e* is a dummy variable that equals 1 when the firm's earnings announcement occurs after the end-of-month *REPDATE* and before the mid-month *REPDATE* the following month; *POST* x *e* is an interaction term between *POST* and *e*. All regressions include the following control variables: *NUMEST, IO, FE, EARNINGS_PERSIST, EARNINGS_VOL, NUMANN*, and industry, stock, year, month and day-of-week fixed effects. Controls variables are defined in Table 1 and Appendix A. We also include a constant term in all regression specifications, but suppress it for reporting purposes. We present ordinary least squares estimates with standard errors double-clustered by stock and earnings announcement day; *, **, *** indicate 10%, 5% and 1% level of significance respectively.

Panel A. [-48,48] Month Event Window Around the Regulatory Amendments (Excluding 2008)

VARIABLES	(1) *CAR*[0,1]	(2) *TURNOVER*	(3) *SPREAD*	(4) *VOLATILITY*	(5) *CAR*[2,61]
POST x *e*	-0.0027***	-0.0012***	-0.0139**	-0.0193***	-0.0078***
	(0.0008)	(0.0003)	(0.0057)	(0.0073)	(0.0029)
POST	0.0125***	0.0011**	0.0887***	-0.0132	0.0264***
	(0.0014)	(0.0005)	(0.0096)	(0.0119)	(0.0042)
e	0.0030***	0.0009***	0.0097**	0.0122**	0.0061***
	(0.0006)	(0.0002)	(0.0040)	(0.0052)	(0.0018)
Observations	47,687	48,436	48,425	48,055	46,747
R-squared	0.063	0.076	0.070	0.022	0.023
Controls	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes
Stock FE	Yes	Yes	Yes	Yes	Yes

Panel B. [-48,60] Month Event Window Around the Regulatory Amendments (Excluding 2008)

VARIABLES	(1) *CAR*[0,1]	(2) *TURNOVER*	(3) *SPREAD*	(4) *VOLATILITY*	(5) CAR[2,61]
POST x *e*	-0.0023***	-0.0012***	-0.0108*	-0.0221***	-0.0062**
	(0.0008)	(0.0003)	(0.0063)	(0.0070)	(0.0029)
POST	0.0120***	0.0008	0.1233***	-0.0121	0.0282***
	(0.0014)	(0.0005)	(0.0100)	(0.0116)	(0.0042)
e	0.0024***	0.0008***	0.0034	0.0152***	0.0036*
	(0.0005)	(0.0002)	(0.0047)	(0.0047)	(0.0019)
Observations	54,912	55,814	55,778	55,423	53,973
R-squared	0.061	0.083	0.190	0.019	0.030
Controls	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes
Stock FE	Yes	Yes	Yes	Yes	Yes

Internet Appendix Table IA.2. Robustness: The Timing of Earnings News

In this table, we present the regression results reported in Tables 2-4 for a subsample of firms, which tend to announce their earnings in the same time window relative to the short interest announcement (either *e* = 0 or *e* = 1 at each *REPDATE*) in both the pre- and post-amendment periods. The dependent variables are: in column (1) *CAR*[0,1] is the absolute value of 2-day cumulative abnormal return in the [0,1] days around the earnings announcement, defined as the difference between buy-and-hold returns of the stock and beta multiplied by the buy-and-hold return of the market; in column (2) *TURNOVER* is average daily volume over the [0,1] days around the earnings announcement divided by shares outstanding at the end of the month; in column (3) *SPREAD* is the daily average bid-ask spread over the pre-event time window [-4,-2]; in column (4) *VOLATILITY* is difference between the highest and lowest share prices over the event time window [0,1], normalized by an average of the two; in column (5) *CAR*[2,61] is the absolute value of 60-day cumulative abnormal return in the [2,61] days after the earnings announcement, defined as the difference between buy-and-hold returns of the stock and beta multiplied by the buy-and-hold return of the market. The explanatory variables include: *POST* is a dummy variable that equals 1 for the firm's earnings announcement dates after September 7, 2007; *e* is a dummy variable that equals 1 when the firm's earnings announcement occurs after the end-of-month *REPDATE* and before the mid-month *REPDATE* the following month; *POST* x *e* is an interaction term between *POST* and *e*. All regressions include the following control variables: *NUMEST, IO, FE, EARNINGS_PERSIST, EARNINGS_VOL, NUMANN*, and industry, stock, year, month and day-of-week fixed effects. Controls variables are defined in Table 1 and Appendix A. We also include a constant term in all regression specifications, but suppress it for reporting purposes. We present ordinary least squares estimates with standard errors double-clustered by stock and earnings announcement day; *, **, *** indicate 10%, 5% and 1% level of significance respectively.

VARIABLES	(1) *CAR*[0,1]	(2) *TURNOVER*	(3) *SPREAD*	(4) *VOLATILITY*	(5) CAR[2,61]
POST x *e*	-0.0027***	-0.0009***	-0.0136**	-0.0314***	-0.0082***
	(0.0009)	(0.0003)	(0.0069)	(0.0081)	(0.0030)
POST	0.0135***	0.0014**	0.0928***	0.0026	0.0286***
	(0.0016)	(0.0007)	(0.0115)	(0.0140)	(0.0051)
e	0.0033***	0.0008***	0.0097*	0.0219***	0.0033
	(0.0007)	(0.0003)	(0.0057)	(0.0062)	(0.0023)
Observations	39,171	39,734	39,710	39,362	37,519
R-squared	0.064	0.086	0.144	0.024	0.033
Controls	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes
Stock FE	Yes	Yes	Yes	Yes	Yes

Internet Appendix Table IA.3. Changes in the Frequency of Markit Data Availability

In this table, we present the regression results analyzing the impact of changes in the frequency in availability of Markit data. All the changes in the frequency of availability of Markit data all occurred in the pre-amendment period. The dependent variables in columns (1), (3), and (5) are *CAR*[0,1], which is the absolute value of 2-day cumulative abnormal return in the [0,1] days around the earnings announcement, defined as the difference between buy-and-hold returns of the stock and beta multiplied by the buy-and-hold return of the market. The dependent in columns (2), (4), and (6) are *CAR*[2,61], which is the absolute value of 60-day cumulative abnormal return in the [2,61] days after the earnings announcement, defined as the difference between buy-and-hold returns of the stock and beta multiplied by the buy-and-hold return of the market. Regressions use three experiments. First one occurred in June 2002, where Markit first started providing monthly data; second one is on August 2004, when reporting frequency of Markit data increased from monthly to weekly; and the third one is on July 2006, when the reporting frequency increased from weekly to daily. The explanatory variables include: *MONTHLY* is a dummy variable that equals 1 for the period after the first experiment and before the second experiment; *WEEKLY* is a dummy variable that equals 1 for the period after the second experiment and before the third experiment; and *DAILY* is a dummy variable that equals 1 for the period after the third experiment and before the SEC's rule amendment implemented in September 2007. Each regression uses an estimation window that is symmetric around the experiment date and ensures no overlapping observations with the consecutive experiment. More detailed definitions of these variables are in Appendix A. All regressions include the following control variables: *NUMEST*, *IO*, *FE*, *EARNINGS_PERSIST*, *EARNINGS_VOL*, *NUMANN*, and industry, stock, year, month and day-of-week fixed effects. Controls variables are defined in Table 1 and Appendix A. We also include a constant term in all regression specifications, but suppress it for reporting purposes. We present ordinary least squares estimates with standard errors double-clustered by stock and earnings announcement day; *, **, *** indicate 10%, 5% and 1% level of significance respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	*CAR*[0,1]	*CAR*[2,61]	*CAR*[0,1]	*CAR*[2,61]	*CAR*[0,1]	*CAR*[2,61]
MONTHLY	0.0013	-0.0087**				
	(0.0009)	(0.0044)				
WEEKLY			0.0001	0.0013		
			(0.0014)	(0.0051)		
DAILY					-0.0021	0.0043
					(0.0016)	(0.0068)
Observations	20,761	20,800	27,931	27,505	15,476	15,144
R-squared	0.066	0.079	0.105	0.083	0.111	0.051
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Stock FE	Yes	Yes	Yes	Yes	Yes	Yes

Internet Appendix Table IA.4. Robustness: Reg SH0

In this table, we present the robustness of regression results reported in Tables 2-4 to "Reg SHO" regulations. Regulation SHO is a regulation implemented on January 3, 2005 which removed the uptick rule for a pilot group of stocks. On July 6, 2007, the SEC implemented the rule for the remaining stocks that had not been included in the original Reg SHO pilot. We reproduce our results excluding the periods 2003 and 2004 as well as the stocks which experienced a change in the uptick test rule on July 2007. We use the following dependent variables: in column (1) *CAR*[0,1] is the absolute value of 2-day cumulative abnormal return in the [0,1] days around the earnings announcement, defined as the difference between buy-and-hold returns of the stock and beta multiplied by the buy-and-hold return of the market; in column (2) *TURNOVER* is average daily volume over the [0,1] days around the earnings announcement divided by shares outstanding at the end of the month; in column (3) *SPREAD* is the daily average bid-ask spread over the pre-event time window [-4,-2]; in column (4) *VOLATILITY* is difference between the highest and lowest share prices over the event time window [0,1], normalized by an average of the two; in column (5) *CAR*[2,61] is the absolute value of 60-day cumulative abnormal return in the [2,61] days after the earnings announcement, defined as the difference between buy-and-hold returns of the stock and beta multiplied by the buy-and-hold return of the market. The explanatory variables include: *POST* is a dummy variable that equals 1 for the firm's earnings announcement dates after September 7, 2007; *e* is a dummy variable that equals 1 when the firm's earnings announcement occurs after the end-of-month *REPDATE* and before the mid-month *REPDATE* the following month; *POST* x *e* is an interaction term between *POST* and *e*. All regressions include the following control variables: *NUMEST, IO, FE, EARNINGS_PERSIST, EARNINGS_VOL, NUMANN*, and industry, stock, year, month and day-of-week fixed effects. Controls variables are defined in Table 1 and Appendix A. We also include a constant term in all regression specifications, but suppress it for reporting purposes. We present ordinary least squares estimates with standard errors double-clustered by stock and earnings announcement day; *, **, *** indicate 10%, 5% and 1% level of significance respectively.

VARIABLES	(1) *CAR*[0,1]	(2) *TURNOVER*	(3) *SPREAD*	(4) *VOLATILITY*	(5) CAR[2,61]
POST x *e*	-0.0025**	-0.0009**	-0.0120	-0.0179*	-0.0057**
	(0.0011)	(0.0004)	(0.0088)	(0.0099)	(0.0026)
POST	0.0119***	0.0017**	0.0854***	-0.0139	0.0190***
	(0.0018)	(0.0007)	(0.0145)	(0.0154)	(0.0055)
e	0.0026***	0.0011***	-0.0002	0.0118	0.0027
	(0.0009)	(0.0003)	(0.0073)	(0.0082)	(0.0028)
Observations	27,793	28,265	28,265	27,963	26,486
R-squared	0.057	0.076	0.066	0.022	0.024
Controls	Yes	Yes	Yes	Yes	Yes
Time FEs	Yes	Yes	Yes	Yes	Yes
Ind FE	Yes	Yes	Yes	Yes	Yes
Stock FE	Yes	Yes	Yes	Yes	Yes