Publicizing Arbitrage: Impact of Mandatory Disclosures

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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 impose a higher 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 mitigating the limits to arbitrage and diffusing arbitrageurs' information faster. With more frequent disclosure, information encapsulated within short interest is incorporated into prices faster, improving price efficiency. We find important reductions in short-sellers' horizon risk and increases in short-sales with the rule amendments.

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I. 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. Shorting market is a useful laboratory to study our research question for a number of reasons. First, there is ample evidence showing that short-sellers are an example of arbitrageurs and informed traders, adept at identifying mispriced securities.[2] Moreover, 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 impact of greater public disclosure requirements imposed on arbitrageurs and informed traders.

Specifically, how does greater publicity of arbitrageurs' positions affect price 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

[1] See, for instance, 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] Asquith, Pathak and Ritter (2005); Boehmer, Jones and Zhang (2008); Jones and Lamont (2002); Karpoff and Lou (2010).

[3] Agarwal, et al. (2015); Christoffersen, Danesh and Musto (2015); Easley, O'Hara and Yang (2013).

them up, therefore revealing their private information prematurely. Furthermore, short-sellers may lose their informational advantage because detailed information on positions can enable 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 can actually be beneficial by helping arbitrageurs overcome the limits to arbitrage (Kovbasyuk and Pagano (2015); Ljungqvist and Qian (2016)). 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 therefore 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.

We provide an empirical examination of these two views by studying the effects of amendments approved by the U.S. Securities and Exchange Commission ("SEC") to the 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

[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.

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 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, is more quickly incorporated into prices, thereby increasing price efficiency. Our estimates show that, in the pre-amendment period, price efficiency is on average 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.

The results are asymmetric in that the effects are larger for stocks with negative information and they are pronounced for stocks with higher arbitrage risk indicating that the rule change helps with overcoming limits to arbitrage. The regime change matters more for ob-

servations that are further away from the last short interest announcement, consistent with the impact of the disclosure of short interest announcement decaying over time. In extended analysis, we find significant market reactions to changes in short interest on announcement dates, which shows that these announcements indeed reveal new information from which the market learns.

We next examine the impact of the more frequent public disclosure requirements on the horizon risk that short-sellers face and their trading activities. 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.

Results confirm these predictions. We find that 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-selling activity is higher after the announcement days 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, enabling more reliable profits.

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 can be harmful to price efficiency. With more disclosure, arbitrageurs may lose their informational advantages and therefore diminish their activities (e.g., Agarwal, et al. (2015); Christoffersen, Danesh and Musto (2015); Easley, O'Hara and Yang (2013)). This then negatively impacts price efficiency.

A manifestation of this view in the context of shorting market has been documented by Jones, Reed and Waller (2017), who study public disclosure rules in the European Union (E.U.). The E.U. rules require short-sellers to immediately disclose their positions to the

public when their positions cross a threshold (0.5% of shares outstanding). Authors find that the E.U.'s disclosure regime negatively affects the amount of short-selling and therefore, it deteriorates price efficiency.

We study the policy adopted in the U.S., which is different from E.U. rules in a number of ways. Different from their E.U. counterpart, U.S. regulators require public disclosure of each stock's total short interest as opposed to releasing trader-level information. Furthermore, in contrast with immediate disclosure requirements required in the E.U., U.S. regulators publicly disclose short interest information on a bi-monthly basis on pre-scheduled announcement dates, which arguably provides enough time and flexibility to short-sellers to execute their trades without revealing them prematurely. The new finding that emerges from our analysis is that the U.S. rules can alleviate the potential negative consequences such that the benefits of public disclosures outweigh the potential costs.

In this regard, our findings are consistent with studies which emphasize the benefits that publicizing arbitrageurs' positions can provide (e.g., Kovbasyuk and Pagano (2015); Ljungqvist and Qian (2016); Makarov and Plantin (2012)). These studies argue that public disclosures can help arbitrageurs overcome the limits to arbitrage arising from horizon risk, and subsequently, public disclosures can improve price efficiency. Our paper contributes to the literature by providing new evidence using the mandatory disclosure rules implemented in the U.S. shorting market. To date, the only evidence consistent with the latter view is provided by Ljungqvist and Qian (2016) who document that some boutique hedge funds occasionally share their information with the public voluntarily. While Ljungqvist and Qian (2016) is interested in understanding whether market responds to these voluntary disclosures, we examine the broader efficiency implications of mandatory public disclosures.

II. Methodology and Data Sources

A. 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.[5] 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, namely the 15th of each month. 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.[6] 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 an impact on price efficiency. The SEC approved amendments provide a 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, there is an extra short interest announcement occurring

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

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

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 relies on 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 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:

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

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 x POST is the interaction term between POST and e. In extended tests, we include a vector of control variables, which the previous literature shows to be related to our dependent variable, along with Fama-French industry, year, month and day-of-week time fixed effects. Standard errors are double-clustered by stock and day.

β_2 is the main variable of interest 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. Therefore, this methodology allows us to isolate the impact of the extra short interest announcement from potential confounding effects arising from market-wide changes. Figure 1 provides a graphical representation of the empirical methodology . 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.

The important identifying assumption is that bi-monthly report dates are specific to short interest announcements. We don't assume that the rule change does not affect short sellers' trading strategies. In fact, a potential change in short seller's trading strategies would be part of the mechanism leading to results. For instance, after the regulatory regime, if short-sellers reduce (increase) their activities, price informativeness is expected to worsen (improve). Later in the paper, we examine the change in short-selling activity. To the extent that a potential change in short sellers' trading strategies has spill-over effects affecting price efficiency also in the two-weeks period after the mid-month short interest announcements, the diffrences-in-differences estimate (β_2) would be attenuated. Therefore, a cautious interpretation of the findings is that β_2 provides a lower bound for the total economic effect.[7]

Our main measure of price efficiency is the cumulative abnormal returns around quarterly firm earnings announcements; specifically, 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 setting. First, this measure of price efficiency nicely

[7]Since there is no end-of-month short interest announcement in the pre period, it is reasonable to expect that the marginal impact of the rule change would be larger for the two weeks period after the end-of-month short interest announcement.

ties in with the related literature which shows that short-sellers possess information about upcoming earnings announcements (e.g., Boehmer, Jones and Zhang (2019); Christophe, Ferri and Angel (2004); Christophe, Ferri and Hsieh (2010)). 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 the paper, we broaden the analysis to alternative measures of price efficiency.

B. 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 CRSP and financial-statement related information is obtained from Compustat. 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.[8] 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.[9]

We measure market reactions to earnings announcements by the absolute value of cu-

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

[9]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, if 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.

mulative abnormal returns to earnings announcements. 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:

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

$R_{i,k}$ 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 the paper, we report results also with size and B/M matched portfolios.

To analyze the impact of the new disclosure regime, we divide the sample into two sub-periods. "Pre-amendment period" runs from January 1, 2003 to September 6, 2007, and the "post-amendment period" runs from September 7, 2007 to December 31, 2012. We aim to choose a sample period that is long enough to provide empirical power (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, 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., 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 all variables are provided in Appendix A.

Table 1 present the descriptive statistics for our main analysis. 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 rather small. Nevertheless, in our empirical specifications, we will control for these firm characteristics.

III. Results

A. Main Results on Price Efficiency

1. Short-Term Price Reactions to Earnings Announcements

In Table 2, we estimate (1) using the absolute value of the cumulative abnormal returns in [0,1] day period around earnings announcements. Column 1 shows the baseline results. Importantly, our main variable of interest, e x POST, is significantly negative. The coefficient estimate equals -30 bps. 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 x POST shows that in the post-amendment period, the average market reactions to earnings announcements that occur after the end-of-month REPDATE is 30 bps lower than the average market reactions 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% (11%) reduction in mean (median) market reaction to earnings announcements.

Furthermore, we find that the coefficient on e is 32 bps and it is statistically significant. This means that, in the pre-amendment period, the average market reactions to earning announcements that take place after the placebo REPDATE is 32 bps higher than the average 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. 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 almost entirely dissipate in the post-amendment period. This is because, 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. Therefore, there is no longer a difference between the periods that come after a mid-month or an end-of-month REPDATE.

We find such sign-flipping patterns throughout our tests. This 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 negative estimates on e x POST, but also the positive 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.

In column 2, we include several stock characteristics which are shown to be related to reactions to earnings announcements. 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. In column 3, we control for the total number of earnings announcements in a day has a negative impact on reactions to earnings announcements. Consistent with Hirshleifer, Lim and Teoh (2009), total number of earnings announcements in a day is in fact negatively related to earnings reactions, yet our results remain similar. Finally, in column 4, as an extended check, we include stock fixed effects to control for the potential impact of unobserved stock characteristics and find that our results remain robust. Results in Table 2 indicate that the coefficient on e x POST is negative and statistically significant across all specifications.[10]

An additional observation is that POST is significant and positive. Although our differences-in-differences estimator does not require POST to be zero, for completeness, we explore this further, and we show in Table IA.1 that this is due to higher aggregate uncertainty in the post period. POST becomes insignificant once we include empirical proxies of aggregate uncertainty in the regressions. Importantly, e x POST and e remain virtually unchanged by such modifications.

Arguably, the impact of the disclosure of short interest announcement decays over time; the absolute value of abnormal returns is therefore expected to be higher for earnings announcements that arrive much later after the disclosure of short interest filings. One implication is that, for observations with $e = 1$ and POST=0, the more time elapsed after the most recent short interest announcement, the higher CAR[0,1] is expected to be. Moreover,

[10]Including stock fixed effects enables to control for time-invariant unobserved firm characteristics. However, the analysis with stock fixed effects also implicitly conditions the test on firms with variation in e, which can be due to change in earnings announcement day. Throughout the paper, we report all of our main tests both with and without stock fixed effects. Furthermore, in the next section, we conduct additional robustness tests to control for the timing of a firm's earnings announcement day. Our results remain similar.

our hypothesis predicts that the impact of the change in the reporting regime (decrease in CAR[0,1] in the post period) should be more pronounced in such cases.

To test this idea, in Table 3, we introduce interaction terms with HIGH_DAYSSINCE, a dummy variable which equals to 1 when DAYSSINCE is above the sample median (and zero otherwise), where DAYSSINCE is defined as the number of trading days between an earnings announcement and the most recent short interest announcement prior to it. For earnings announcement that take place after the (placebo) end-of-month short interest announcement date in the pre-amendment period, DAYSSINCE is defined using the placebo REPDATE.[11]

Results are quite informative and consistent with our proposed mechanism. e x HIGH_DAYSSINCE is positive and significant, indicating that market reactions are indeed larger for earnings announcements that are much later after the disclosure of short interest filings. Importantly, POST x e x HIGH_DAYSSINCE is negative significant, showing that the new reporting regime matters the most for such cases. As in the main regression results, estimates of e x HIGH_DAYSSINCE and POST x e x HIGH_DAYSSINCE are similar in absolute values, such that POST x e x HIGH_DAYSSINCE nearly offsets e x HIGH_DAYSSINCE. These results provide strong support for our proposed mechanism.

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.

In Table 4, we start by using TURNOVER as the dependent variable. The coefficient

[11]Panel A of Table IA.2 reports the summary statistics for DAYSSINCE for observations after the mid- and end-of-month short interest announcements in pre and post-amendment periods. We observe that DAYSSINCE is typically 6 days with no noticeable differences across different subsamples. Panel B of Table IA.2 formally shows this in a regression analysis.

on e x 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 x 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 (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 x 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. Long-Term Price Reactions to Earnings Announcements

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 II, the increase in price informativeness is expected to affect not only the immediate price reactions to earnings announcements, but also the price reactions thereafter. In Table 5, we estimate (1) using the [2,61] day period after earnings announcements as the measure of cumulative abnormal returns. Across all specifications, the coefficient estimates on e x POST are negative and statistically significant, ranging between -66 bps and -83 bps. These estimates indicate an average of a 7-9% reduction in long-term price reactions to earnings announcements after the end-of-month REPDATE in the post period.[12]

4. Robustness

In this section, we conduct a number of robustness tests. First, we assess whether the timing of a firm's earnings announcements affects our results. We re-conduct the analysis 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. Specifically, we select the firms which release their earnings news in the same timeframe (that is, either in the first or the second two weeks defined with respect to short interest announcement dates) for more than 50% of the time, 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 Panel A of Table 6. We observe that the coefficient on e x POST across all specifications is negative, statistically significant and of comparable magnitude to the results presented previously. This robustness check highlights that the timing of earnings announcements does not drive our results.

Recently, Heitz, Narayanamoorthy, and Zekhini (2019) show that, with the Sarbanes Oxley Act, number of 8-K fillings increased significantly since 2004 and the earnings an-

[12]Table IA.3 reproduces Table 2 and Table 5 using size and B/M adjusted returns in the dependent variable. Findings are remarkably similar.

nouncement premium has vanished as a result. To ensure that the results we document are not stemming from 8-K filings, from Edgar, we download all 8-K filings for each firm during our sample period and we conduct robustness tests. We define #8KFILINGS as the total number of 8-K filings (per firm) reported between two consecutive REPDATEs prior to the earnings announcement plus the number of filings since the last REPDATE before the earnings announcement. For observations that are after the (placebo) end-of-month short interest announcement date in the pre-amendment period, #8KFILINGS is defined using the placebo REPDATE. Results reported in Panel B show the robustness of our findings to 8-K filings.[13]

On July 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 inplemented in May 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 from January 2003 to May 2005 as well as the stocks which had a change in the uptick test rule on July 2007. Therefore, the new sample uses only stocks which did not experience a change in the uptick rule during our sample period. Panel C shows that the results remain similar.

In Panel D, we define CAR[0,1] and VOLATILITY using high frequency returns. In columns 1 and 3, respectively, CAR[0,1] is the absolute value of the sum of one- and thirty-minute returns; in columns 2 and 4, VOLATILITY is the realized variance (in basis points) of these high frequency returns over the [0,1] days around the earnings announcement. Our findings carry over when we use high frequency returns around earnings announcement dates. Finally, we test whether the results are robust to the inclusion of aggregate short interest in

[13]As an alternative approach to control for information released through 8-K filings, we also control for the total abnormal returns realized after 8-K filings released prior to the earnings announcement date. Our results remain unaffected (Table IA.4).

regressions (Table IA.4) and to using alternative sample periods (Table IA.5). We find in both analyses that the findings are robust.

5. Alternative Measures of Price Efficiency

In this section, we test whether our main results carry over 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— 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) price delay measures because Hou and Moskowitz (2005) estimate each stock's price delay measures only once per year using the time series of one year of lagged stock returns. We estimate Hou and Moskowitz's (2005) measures of price delay by pooling daily stock returns between two consecutive REPDATEs (including the placebo ones) for each stock pertaining to each POST and e. 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. Appendix A provides the details regarding the calculation of these variables. We re-estimate our regression equation using DELAY1, DELAY1_NEG, and DELAY3 as our measures of information efficiency. Panel A of Table 7 shows that results are consistent with previous findings. Coefficients on e x 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

[14]For further details regarding the processing of TAQ data and constructing of the high frequency measures

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 variance ratio, defined as $VARRATIO = \left|1 - \frac{var(30min)}{30var(1min)}\right|$, where VAR(30MIN) is the variance of 30-minute intraday returns and VAR(1MIN) is the variance of 1-minute intraday returns.According to this measure, smaller VARRATIO indicates that stock prices are more informationally efficient. Panel B of 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 x 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 in Panel B of Table 7 show results using PE as the measures of price efficiency. Consistent with previous findings, we find that the coefficients on e x POST are significantly negative.

6. Summary

Findings in Section III 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.

of price efficiency, please refer to the Internet Appendix.

Overall, our findings are consistent with Ljungqvist and Qian (2016) who document that some boutique hedge funds 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 costly to access as investors have to search through each arbitrageur'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 the investing public. Importantly, Ljungqvist and Qian (2016) examine whether market reacts to voluntary disclosures; we instead focus on broader efficiency implications of mandatory public disclosures.

B. 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 (Barberis and Thaler (2003)). 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 a decline in the holding periods of short sellers and increase in their rewards. 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 IHS Markit. IHS 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 IHS Markit commenced reporting data at a daily frequency.[15] We take the average of all loans

[15]IHS Markit is a private data vendor that provides information on short positions taken by its subscribers.

for a stock between two consecutive short interest announcement days and run the following regression:

$$LOANLENGTH_{i,t+1} = \alpha_i + \theta_0 e_{i,t} + \theta_1 POST_{i,t} + \theta_2 [e \times POST]_{i,t} + \lambda X_{i,t} + \varepsilon_{i,t} \quad (3)$$

where LOANLENGTH 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). In an extended specification, we also include control variables for stock characteristics which 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) 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 in the post period. Specifically, we would observe $\theta_0 > 0$ and $\theta_2 < 0$. This is precisely what we find. In Table 8, we find that e is 9.6 while e x POST is -9.8, and both are statistically significant. Similar to the main results on price efficiency, there is a complete sign-flipping pattern in estimates, which provide strong support for the hypothesis. Short-sellers have a holding period of (approximately) 80 calendar days for a typical stock, thus the estimates correspond to an approximate 9-12% change 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 more reliably. We test this prediction using the IHS Markit database because it

IHS Markit initially released monthly data between June 2002 and July 2004. It then released weekly data between August 2004 and June 2006, and finally started releasing daily data from July 2006. Note that all of these changes occured in the pre period. In Table IA.7, we document no important effects with higher disclosure frequency of IHS Markit data in the pre period. This is consistent with our findings in Table 2 that, in the pre-amendment period, price efficiency was worse during the 2-weeks period after the placebo end-of-month report date (despite the availability of weekly or daily IHS Markit during this time period).

allows us to observe short positions on both actual and placebo report dates – short interest from Compustat is what is disclosed to the public, thus it allows us to observe short interest only on actual report dates.

On each REPDATE (including the placebo one), for each stock, we first calculate the change in short interest (in IHS Markit) from previous REPDATE. Short interest is the daily total short positions in a given stock divided by the stock's shares outstanding. Based on changes in short interest, we form 10 portfolios and hold these portfolios until the next REPDATE (approximately 15 calendar days). We then pool the daily portfolio returns pertaining to each four cases – POST=0 and $e = 0$, POST=0 and $e = 1$, POST=1 and $e = 0$, and POST=1 and $e = 1$ – and run the 4-factor model for each POST and e using the time-series of portfolio returns. Table 9 reports the reward-to-risk ratios (4-factor alpha divided by its standard error) for each of the four cases. 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 $\Delta SHORT$ below the 10th percentile and short on stocks with $\Delta SHORT$ 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. Consistent with the hypothesis, this difference is mostly driven by stocks that are heavily shorted.[16]

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 regression in equation (3) using $\Delta SHORT$ as the dependent variable. It is defined as the change in short interest (reported by IHS Markit) scaled by the stock's shares outstanding and it is calculated after

[16]Table IA.7 reports reward-to-risk ratios (along with alphas and standard errors) for all decile portfolios. Our conclusions hold throughout.

REPDATE and before the next REPDATE. If short-sellers are more active after the regulatory amendments, this would result in $\theta_0 < 0$ and $\theta_2 > 0$. Table 10 show results that are consistent with these predictions across all specifications. There is a significant increase in the amount of short-selling after the regulatory amendments. Overall, these results provide evidence that higher public disclosure of short interest has important implications. The regulatory amendments reduce short-sellers' holding periods, assist short-sellers obtain better rewards and increase short-selling activity.

C. Does the Market React to Short Interest Announcements?

In Section III, we show that increasing the frequency of short interest disclosure improves price informativeness. If this result is driven by the mechanism that, with greater disclosure, wider investing public learn about short sellers' private information more promptly, then it should be that short interest announcements reveal new information to which the market reacts.

While short interest tends to be persistent, existing papers in the literature show that changes in short interest contain important information about future company news and subsequent stock returns. A number of studies provide insights on the nature of the information that change in short interest has. For instance, there is a significant increase in short interest for stocks which newly enter anomaly portfolios (Hanson and Sunderam (2013); Daniel, Klos and Rottke (2017)). Moreover, short interest seems to increase substantially prior to the release of negative earnings announcements (Boehmer, Jones and Zhang (2019); Christophe, Ferri and Angel, 2004)).

Therefore, we examine market reactions to changes in short interest between two successive short interest announcements. We use short interest from Compustat as this is precisely the short interest that is disseminated to the public. If the investing public is already gathering information on short-selling activity from alternative sources (e.g., through access to proprietary datasets, informal contacts with brokers or alike), then short interest announcements by exchanges would not matter and thus we would not find significant price reactions

to changes in short interest.[17]

In Panel A of Table IA.9, we find a significant negative relationship between changes in short interest and average 2-day announcement returns.[18] A strategy that buys the stocks in the bottom portfolio and sells the stocks in the top portfolio earns an average daily 4-factor alpha of 15 bps. There is a monotonic pattern across portfolios with the statistical significance being the strongest for the top and bottom decile portfolios, as one would expect. As short interest conveys pessimistic information, price reactions (in absolute terms) are largest for the top decile portfolio.

Furthermore, we test whether market reactions to short interest announcements have been different in the pre- and post-amendment periods. Although the average price reaction is significant during our sample period, it might be that this is mostly driven by the pre period if alternative ways to acquire information on short-sales has become more widely available in the post period. We find that this is not the case. Panel B of Table IA.9 shows that price adjustments are, if anything, larger (about doubled) in the post-amendment period, suggesting that short interest is arguably more informative in the post period. These findings reveal that short interest announcements matter despite the availability of possible alternative channels (perhaps due to alternative channels being costly or not providing complete information).

Next, we assess whether the market may view mid-month and end-of-month short interest announcements differently. Since end-of-month announcements are made only in the post period (and there are significant differences in reactions between pre and post periods), for a more meaningful analysis, we compare the differences in market reactions to mid-month and end-of-month short interest announcements in the post period. Results show no indication

[17]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 availability of more information on short-selling activity. Also, we can overcome the data limitations – 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 Compustat firms.

[18]For compatibility with panel regressions where each observation is equally weighted, the portfolio results that we report use equal-weighted returns. Our findings are similar with value-weighted returns.

of differential reaction to mid-month versus end-of-month announcements (Panel C of Table IA.9).

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. We don't observe any noticeable pattern in alphas before the short interest announcements, suggesting that there is no significant front running. In Table IA.10, we conduct formal tests to confirm this. Table IA.11 extends the analysis to the measures of trading activity prior to the announcements. From Panel A to F, we use turnover, volatility, bid-ask spread, short interest, number of loans and loan concentration, respectively. Results are mostly insignificant, though there are some weak effects in turnover and volatility. Taken together with Table IA.10, there seems to be some degree of trading activity prior to the announcements, however it isn't significant enough to generate an important price impact.[19]

Finally, we check whether there is an overreaction to short interest announcements, which 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 been concentrated around seasoned equity offerings (Henry and Koski (2010)). If investors overreact to short interest announcements, we would expect to find return reversals. In Figure IA.1, we show the cumulative 4-alphas over the next 60 trading days after the announcement date for the top decile portfolio. We conduct subsample tests repeating this analysis (i) for small stocks, which might be more susceptible to manipulation as they don't have enough liquidity, and (ii) for growth stocks, which tend to have high short-selling activitiy. We do not find any reversals in any of the samples that we study.

[19]As for the levels of short interest, the top portfolio has higher short interest than the bottom portfolio, consistent with the fact that the top (bottom) decile portfolio includes stocks with recent large increases (decreases) in short interest.

D. Cross-Sectional Evidence

In this section, we analyze whether there are cross-sectional differences in the impact of new disclosure regime on price efficiency. We start by examining the role of arbitrage risk. We measure arbitrage risk in a number of 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. In addition, following 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. In a similar vein, we introduce a measure of noise trading activity, RETAILTRADING, which equals 1 when the stock's institutional ownership is low and the stock has a high trading activity. If the new disclosure regime helps short-sellers overcome the limits to arbitrage, we then expect the effects to be pronounced for stocks with higher arbitrage risk.

Next, 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 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 surprise 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 11. The main variables of interest are the coefficients on triple interaction terms. Findings are quite useful in that, we consistently find that results are pronounced for stocks with higher arbitrage risk. Through columns 1 to 3, we find that the estimates are nearly doubled for stocks with higher arbitrage risk, providing strong support for the mechanism. In the final column, we observe that while e x POST is -0.0014 and statistically significant at 10%, e x POST x NEGNEW is -0.0021 with statistical significance at 5% level. This shows that greater disclosure of short interest particularly helps with the diffusion of negative information which tends to travel

slowly (Hong, Lim and Stein (2000)).[20]

IV. 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. Our findings indicate that the new reporting regime has an important impact on a stock's informational environment. 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 also reduces short-sellers' holding periods and increases the amount of short-selling.

Our work has implications on regulatory policy of short selling public disclosure, and more broadly, the public disclosure of private information. While in the E.U., regulations requiring the immediate disclosure of short positions have discouraged short-selling and hampered price efficiency, we find that bi-monthly disclosure of short positions in the U.S. can

[20] Although the effects are small, the market reacts positively to decreases in short interest (Table IA.9). Consistent with this, in column 4 of Table 11, we observe that there appears to be small efficiency gains also for stocks which do not have negative earnings surprises.

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 providing enough time and flexibility to traders to execute their trades and build their positions. Designed in this way, potential costs associated with distorting incentives to produce private information can be mitigated, therefore public disclosure requirements can foster price efficiency.

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Appendix A. Definition of Variables

Variable Label	Description	Source
#8KFILINGS	Total number of 8-K filings per firm during the period between a short interest announcement and the previous one plus the number of 8-K filings that were reported after the most recent short interest announcement prior to the earnings announcement date. For observations with POST =0 and e=1, it is defined using the placebo short interest announcement date	SEC Edgar, Compustat
BM	Book Equity in June of calendar year, *t*, divided by market equity in December of previous calendar year, *t*-1.	CRSP, Compustat
CAR[0,1]	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]	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
DAYSSINCE	Number of trading days between an earnings announcement date and the last short interest announcement prior to it. For observations with POST=0 and e=1, it is calculated since the last placebo short interest announcement.	I/B/E/S, Compustat
*DELAY*1	For a given *POST* and *e*, using daily stock data between consecutive *REPDATEs*, we first run the following regression for each stock: $$r_{j,t} = \alpha + \beta R_{m,t} + \sum_{n=1}^{4} \delta^{(-n)} R_{m,t-n} + \varepsilon_{j,t}$$ 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*	*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	Coefficient estimates are first calculated using the regression from *DELAY*1. Next, we calculate *DELAY*3 between *REPDATEs* as follows: $$DELAY3 = \frac{\sum_{n=1}^{4} n\delta^{(-n)} / se\left(\delta^{(-n)}\right)}{\beta / se(\beta) + \sum_{n=1}^{4} \delta^{(-n)} / se(\delta^{(-n)})}$$ where se(.) is the standard error of the coefficient estimate.	CRSP
e	Dummy variable that equals 1 for observations after the end-of-month *REPDATE* and before the mid-month *REPDATE* the following month.	Compustat
EARNINGS_PERSIST	First-order autocorrelation coefficient of quarterly EPS during the past 4 years.	I/B/E/S, Compustat
EARNINGS_VOL	Standard deviation of quarterly EPS in the past four years.	I/B/E/S, Compustat
FE	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
FEERISK	Standard deviation of loan fees (for a stock) in previous month	IHS Markit
ILLIQ	Average ratio of the absolute value of daily returns to the stock daily volume in the past six months, as in Amihud (2002).	CRSP
IO	Fraction of all shares outstanding held by institutional investors for a given stock at the end of the quarter (in %).	Thomson Reuters
IVOL	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
LOANLENGTH	Average loan tenure for short-sale positions after each *REPDATE* and before the next *REPDATE*.	IHS Markit
NEGNEW	Dummy variable that equals 1 if the firm's earnings surprise is negative.	Compustat, I/B/E/S
NUMANN	Total number of earnings announcements by other firms on the day of a firm's own earnings announcement	I/B/E/S
NUMEST	Natural logarithm of one plus the number of analysts giving EPS forecasts for the given firm in that quarter.	I/B/E/S
PASTRETURNS	Cumulative monthly returns over the past six months.	CRSP

PE	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
POST	Dummy variable that equals 1 for observations in the post-amendment period, that is, after September 7, 2007, and zero otherwise.	Compustat
REPDATE	Mid-month and end-of-month short interest announcement dates, including the placebo *REPDATEs* in the pre-amendment period.	Compustat
SIZE	Market capitalization of a stock measured by price in month *t* multiplied by shares outstanding in month *t*, measured in $ million	CRSP
SPREAD	Daily (%) average bid-ask spread over the [-4,-2] window before the earnings announcement.	CRSP
TRADINGACTIVITY	A stock's average turnover (volume divided by shares outstanding) in previous month	CRSP
TURNOVER	Average daily trading volume in the [0,1] days around the earnings announcement divided by shares outstanding	CRSP
VARRATIO	Calculated for each stock on each trading day as follows: $$VARRATIO = \left\lvert 1 - \frac{var(30\text{min})}{30 \times var(1\text{min})} \right\rvert$$ 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
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
Δ*SHORT*	Change in short interest between two successive short interest announcement dates, scaled by stock's shares outstanding (in %). In the pre period, it captures monthly changes; in the post period, it is bi-monthly changes	CRSP, Compustat
Δ*SHORT_MARKIT*	Change in short interest (in %) based on the universe of market participants covered by IHS Markit. It is calculated as the difference between two consecutive *REPDATEs* (including the placebo *REPDATE*s), scaled by stock's shares outstanding	IHS Markit, CRSP

Table 1. Descriptive Statistics

This table presents 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. 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. 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 Appendix A), and include industry, time (year, month-of-year 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.

	(1)	(2)	(3)	(4)
VARIABLES	*CAR*[0,1]	*CAR*[0,1]	*CAR*[0,1]	*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

Table 3. Number of Days since the Last Short Interest Announcement

In this table, we examine the role of time elapsed since the most recent short interest announcement before an earnings announcement. We first define *DAYSSINCE*, which is the number of trading days between an earnings announcement and the most recent short interest announcement prior to it. For earnings announcement that take place after the (placebo) end-of-month short interest announcement date in the pre-amendment period, *DAYSSINCE* is defined using the placebo *REPDATE*. Later we introduce interaction terms with *HIGH_ DAYSSINCE*, a dummy variable which equals 1 when the firm's *DAYSSINCE* is above the sample median (zero otherwise). All other variables are defined as in Table 2. The explanatory variables include all interaction terms between *POST*, *e* and *HIGH_DAYSSINCE*. In columns 2 to 4, we control for *NUMEST, IO, FE, EARNINGS_PERSIST, EARNINGS_VOL, NUMANN*, and include industry, time (year, month-of-year 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.

	(1)	(2)	(3)	(4)
VARIABLES	*CAR*[0,1]	*CAR*[0,1]	*CAR*[0,1]	*CAR*[0,1]
POST x e	-0.0007	-0.0003	-0.0002	-0.0003
	(0.0009)	(0.0010)	(0.0010)	(0.0010)
POST x e x HIGH_DAYSSINCE	-0.0033**	-0.0044***	-0.0041***	-0.0031**
	(0.0014)	(0.0015)	(0.0015)	(0.0015)
POST x HIGH_DAYSSINCE	0.0012	0.0010	0.0004	0.0012
	(0.0010)	(0.0010)	(0.0010)	(0.0010)
e x HIGH_DAYSSINCE	0.0022**	0.0036***	0.0039***	0.0036***
	(0.0011)	(0.0012)	(0.0012)	(0.0012)
HIGH_DAYSSINCE	0.0011	0.0013	0.0009	0.0004
	(0.0008)	(0.0008)	(0.0008)	(0.0008)
POST	0.0099***	0.0104***	0.0106***	0.0105***
	(0.0014)	(0.0015)	(0.0015)	(0.0014)
e	0.0019*	0.0010	0.0012*	0.0008
	(0.0011)	(0.0007)	(0.0007)	(0.0007)
NUMEST		-0.0051***	-0.0051***	-0.0016***
		(0.0003)	(0.0003)	(0.0005)
IO		0.0000***	0.0000***	0.0000*
		(0.0000)	(0.0000)	(0.0000)
FE		0.1568***	0.1568***	0.0976***
		(0.0131)	(0.0131)	(0.0132)
EARNINGS_PERSISTENCE		0.0031***	0.0032***	0.0033***
		(0.0006)	(0.0006)	(0.0008)
EARNINGS_VOL		0.0005**	0.0005***	0.0017***
		(0.0002)	(0.0002)	(0.0003)
NUMANN			-0.0015***	-0.0017***
			(0.0003)	(0.0003)
Observations	71,976	59,020	59,020	59,020
R-squared	0.105	0.121	0.121	0.063
Controls	No	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Stock FE	No	No	No	Yes

Table 4. 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 stock's shares outstanding; 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-of-year and day-of-week fixed effects. Controls variables are defined in Appendix A. We 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)
VARIABLES	*TURNOVER*	*VOLATILITY*	*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 5. Long-Term Price Reactions to Earnings Announcements

In this table, we present the regression results for the long-term price reactions to earnings announcements. 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. 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 Appendix A), and include industry, time (year, month-of-year 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.

	(1)	(2)	(3)	(4)
VARIABLES	*CAR*[2,61]	*CAR*[2,61]	*CAR*[2,61]	*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

Table 6. Robustness Tests

In this table, we present the robustness test results for the main regressions on price efficiency. In Panel A, we present the results 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. In Panel B, we present the robustness of regression results to the number of 8-K filings that firms have released prior to their earnings announcements. *#8KFILINGS* is the total number of 8-K filings reported between two consecutive *REPDATE*s prior to the earnings announcement plus the number of filings since the last *REPDATE* before the earnings announcement date. For observations that are after the (placebo) end-of-month short interest announcement date in the pre-amendment period, *#8KFILINGS* is defined using the placebo *REPDATE*. In Panel C, we present the robustness of regression results 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 from January 2003 to May 2005 as well as the stocks which experienced a change in the uptick test rule on July 2007. In Panels A to C, the dependent variables are *CAR*[0,1], *TURNOVER, SPREAD, VOLATILITY* and *CAR*[2,61], respectively. *CAR*[0,1] and C*AR*[2,61] are 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 D, we define *CAR*[0,1] and *VOLATILITY* using high frequency returns. In columns 1 and 3, *CAR*[0,1] is the absolute value of the sum of one- and thirty-minute returns, respectively; in columns 2 and 4, *VOLATILITY* is the realized variance (in basis points) of these high frequency returns over the [0,1] days around the earnings announcement. The explanatory variables include: *POST*, *e*, *POST* x *e* and control variables of *NUMEST, IO, FE, EARNINGS_PERSIST, EARNINGS_VOL, NUMANN*. All variables are defined in Appendix A. Regressions include a constant term which 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. The Timing of Earnings News

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

Panel B. Number of 8-K Filings

VARIABLES	(1) *CAR*[0,1]	(2) *TURNOVER*	(3) *SPREAD*	(4) *VOLATILITY*	(5) CAR[2,61]
POST x e	-0.0018**	-0.0008***	-0.0135**	-0.0192***	-0.0077***
	(0.0007)	(0.0003)	(0.0057)	(0.0066)	(0.0027)
POST	0.0117***	0.0007	0.1067***	-0.0090	0.0270***
	(0.0014)	(0.0005)	(0.0097)	(0.0115)	(0.0041)
e	0.0023***	0.0005**	0.0071	0.0124**	0.0056***
	(0.0005)	(0.0002)	(0.0045)	(0.0048)	(0.0019)
#8KFILINGS	-0.0015***	-0.0013***	-0.0043***	-0.0085***	-0.0013*

	(0.0002)	(0.0001)	(0.0016)	(0.0019)	(0.0007)
Observations	59,020	59,934	59,904	59,425	56,609
R-squared	0.063	0.086	0.132	0.022	0.028
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 C. Reg SH0

	(1)	(2)	(3)	(4)	(5)
VARIABLES	*CAR*[0,1]	*TURNOVER*	*SPREAD*	*VOLATILITY*	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
Industry FE	Yes	Yes	Yes	Yes	Yes
Stock FE	Yes	Yes	Yes	Yes	Yes

Panel D. *CAR* and *VOLATILITY* using high frequency returns

	(1)	(2)	(3)	(4)
VARIABLES	*CAR*[0,1] using 1min returns	*VOLATILITY* using 1min returns	*CAR*[0,1] using 30min returns	*VOLATILITY* using 30min returns
POST x e	-0.0025***	-0.0133**	-0.0016**	-0.0861**
	(0.0008)	(0.0064)	(0.0007)	(0.0387)
POST	0.0126**	0.1616**	0.0109**	0.3473**
	(0.0056)	(0.0813)	(0.0053)	(0.1606)
e	0.0018***	0.0164**	0.0020***	0.0911*
	(0.0007)	(0.0083)	(0.0005)	(0.0480)
Observations	52,874	52,874	52,874	52,874
R-squared	0.039	0.043	0.042	0.045
Controls	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Stock FE	Yes	Yes	Yes	Yes

Table 7. Alternative Measures of Price Efficiency

This table presents the regression results using alternative measures of price efficiency. Panel A presents results with the price delay measure of Hou and Moskowitz (2005), Panel B presents results with high frequency measures. In Panel A, the dependent variables are *DELAY*1, *DELAY*1*_NEG* and *DELAY*3. *DELAY*1, *DELAY*1*_NEG*, and *DELAY*3 are estimated for each stock pertaining to each four cases, *POST=0* and *e=0*, *POST =0* and *e=1*, *POST =1* and *e=0*, and *POST =1* and *e=1*, by pooling daily stock returns between two consecutive *REPDATE*s (including the placebo ones). Further details of variable definitions are in Appendix A. Columns 2,4 and 6 include stock fixed effects and standard errors are clustered by stock. In Panel B, we use high-frequency measures of price efficiency measured as the average between the current *REPDATE* and the following *REPDATE*. The dependent variables in columns (1) and (2) is *VARRATIO*, it is *PE* in columns (3) and (4). The explanatory variables include: *POST*, *e* and *POST* x *e* along with 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)*. Definition of variables are in Appendix A and B. Regressions include time (year, month-of-year, day-of-week) fixed effects; in column 2 and 4, we also include the control variables, industry and stock fixed effects. Standard errors are clustered by stock and short-interest announcement days. All regressions include a constant term (unreported). *, **, *** indicate 10%, 5% and 1% level of significance, respectively.

Panel A. Price Delay

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	*DELAY1*	*DELAY1*	*DELAY1_NEG*	*DELAY1_NEG*	*DELAY3*	*DELAY3*
POST x e	-0.0184***	-0.0209***	-0.0343***	-0.0372***	-0.1187***	-0.0947***
	(0.0049)	(0.0044)	(0.0051)	(0.0047)	(0.0360)	(0.0357)
POST	0.0064	0.0035	0.0038	0.0021	0.0094	0.0055
	(0.0047)	(0.0043)	(0.0045)	(0.0042)	(0.0265)	(0.0268)
e	0.0207***	0.0247***	0.0574***	0.0617***	0.0790***	0.0866***
	(0.0034)	(0.0031)	(0.0035)	(0.0033)	(0.0260)	(0.0261)
Observations	21,033	21,033	21,033	21,033	18,187	18,187
R-squared	0.019	0.021	0.015	0.026	0.003	0.002
Stock FE	No	Yes	No	Yes	No	Yes

Panel B. Variance Ratio and Pricing Error

	(1)	(2)	(3)	(4)
VARIABLES	*VARRATIO*	*VARRATIO*	*PE*	*PE*
POST x *e*	-0.0236***	-0.0206***	-0.0039***	-0.0041***
	(0.0009)	(0.0010)	(0.0003)	(0.0003)
POST	0.0418***	0.0456***	0.0007	0.0061***
	(0.0023)	(0.0027)	(0.0007)	(0.0007)
e	0.0199***	0.0173***	0.0045***	0.0033***
	(0.0016)	(0.0017)	(0.0005)	(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	No	Yes	No	Yes
Stock FE	No	Yes	No	Yes

Table 8. 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*. *LOANLENGTH* is calculated using the daily IHS Markit data available from July 2006. 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 time (year, month-of-year, 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	No	Yes

Table 9. Reward-to-Risk Ratios of Short Sellers' Positions

This table presents the impact of the regulatory amendments on the reward-to-risk ratio of short-sellers' position changes, using the IHS Markit data starting from July 2006. Starting from July 2006, IHS Markit reports the daily total short positions taken on by the universe of market participants that it covers. On each *REPDATE* (including the placebo one), for each stock, we first calculate the change in short interest (in IHS Markit) from previous *REPDATE*. Short interest is the daily total short positions in a given stock divided by the stock's shares outstanding. Based on changes in short interest, we form 10 portfolios and hold these portfolios until the next *REPDATE* (approximately 15 calendar days). We then pool the daily portfolio returns pertaining to each four cases – *POST=0* and *e=0*, *POST =0* and *e=1*, *POST =1* and *e=0*, and *POST =1* and *e=1* – and run the 4-factor model for each *POST* and *e* using the time-series of portfolio returns. From this procedure, we estimate the 4-factor alphas along with its standard errors (Newey-West standard errors with 5 lags). The table reports the reward-to-risk ratios, defined as the 4-factor alpha divided by its standard error, for each of the four cases. The bottom decile portfolio (*P1*) has a Δ*SHORT* below the 10th percentile, and the top decile portfolio (*P10*) has a Δ*SHORT* above the 90th percentile; *P1-P10* is the spread between the two portfolios.

		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 10. Amount of Short Selling

In this table, we present the impact of the regulatory amendments on the amount of short-selling. The dependent variable is Δ*SHORT_MARKIT*, which is the % change in total short positions reported by IHS Markit between two consecutive *REPDATEs* (including the placebo *REPDATE*), scaled by stock's shares outstanding. Δ*SHORT_MARKIT* is calculated using the daily IHS Markit data available from July 2006. 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 time (year, month-of-year 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.

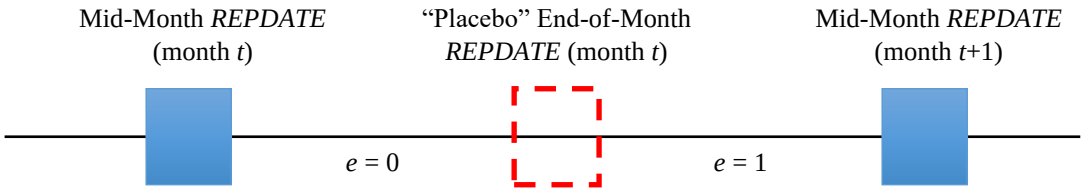
	(1)	(2)
VARIABLES	Δ*SHORT_MARKIT*	Δ*SHORT_MARKIT*
POST x *e*	0.1582***	0.1632***
	(0.0427)	(0.0482)
POST	-0.1205	-0.1271
	(0.0734)	(0.0826)
e	-0.1244***	-0.1282***
	(0.0394)	(0.0448)
SIZE		-0.0000***
		(0.0000)
IVOL		-0.0006
		(0.0007)
ILLIQ		0.0006***
		(0.0002)
BM		-0.0193***
		(0.0054)
PASTRETURNS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

Table 11. Cross-Sectional Differences

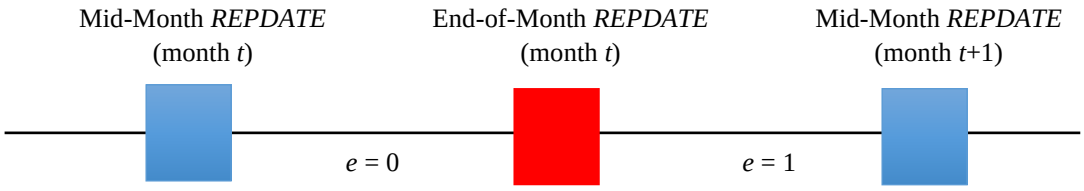
In this table, we present the cross-sectional differences in the regression results reported in Table 2. In Column 1, we introduce interaction terms with *HIGH_ FEERISK*, a dummy variable which equals 1 when the firm's *FEERISK* is above sample median; in Column 2, we introduce interaction terms with *HIGH_IVOL*, a dummy variable which equals 1 when the firm's idiosyncratic volatility is above sample median; in Column 3, we introduce interaction terms with *HIGH_RETAILTRADING*, a dummy variable which equals 1 when the firm's *IO* is below sample median and its *TRADINGACTIVITY* above sample median; in Column 4, we introduce interaction terms with *NEGNEW*, if the firm's earnings surprise is negative. Variable definitions 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, time (year, month-of-year 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.

	(1)	(2)	(3)	(4)
VARIABLES	*HIGH_FEERISK*	*HIGH_IVOL*	*HIGH_ RETAILTRADING*	*NEGNEW*
POST x e	-0.0015*	-0.0012*	-0.0018*	-0.0014*
	(0.0008)	(0.0007)	(0.0010)	(0.0008)
POST x e x CHAR	-0.0010**	-0.0007*	-0.0014**	-0.0021**
	(0.0005)	(0.0004)	(0.0007)	(0.0010)
e x CHAR	0.0007*	0.0001	0.0013*	0.0014**
	(0.0004)	(0.0016)	(0.0007)	(0.0007)
POST x CHAR	0.0016	-0.0045**	-0.0026	0.0022**
	(0.0020)	(0.0018)	(0.0021)	(0.0011)
CHAR	0.0029**	0.0175***	0.0100***	0.0012*
	(0.0013)	(0.0014)	(0.0015)	(0.0007)
POST	0.0083***	0.0127***	0.0115***	0.0116***
	(0.0022)	(0.0020)	(0.0019)	(0.0019)
e	0.0026***	0.0030***	0.0029***	0.0031***
	(0.0009)	(0.0007)	(0.0007)	(0.0006)
Observations	42,294	56,255	59,019	59,020
R-squared	0.135	0.143	0.125	0.122
Controls	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes

Figure 1. Diagrammatic Explanation of Empirical Methodology



Pre-Amendment Period



Post-Amendment Period

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. $e = 0$ 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. The bottom decile (*Decreased Shorting*) portfolio has a Δ*SHORT* below the 10th percentile, and the top decile portfolio (*Increased Shorting*) has Δ*SHORT* above 90th 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 $t = 0$.