Effect of Continuous Disclosure Requirement on Information Leakage Around Earnings Announcements

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Abstract

The Indian market regulator introduced continuous disclosure regulation requiring listed firms to report their financial results within 30 minutes of the board meeting. This provides us with a unique setting to investigate the effect of the low-cost regulatory intervention on information leakage. Using a sample of earnings announcement (EA) made by the firms during the market hours, we find the following effects of the regulations. First, the trading induced by leaked information shifted to inside 30 minutes before EA and became more informative. Second, returns during 120 to 30 minutes before the EA lost its ability to predict earning surprises. Third, we find that the difference observed in the volatility pick-up before EA with and without surprises before regulatory change disappeared. Our findings suggest that firms took the regulation seriously, and the information leakage has been limited to less than the stipulated 30-minutes window.

Keywords: Earnings Announcements, Disclosure regulations, Information Leakage, Market Efficiency, Emerging Markets

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1. Introduction

Securities trading by corporate insiders causes trading losses to public shareholders who do not have access to the inside information (Shin, 1996). Regulators have tried to address this problem by prohibiting and punishing insider trading, but this punitive approach is highly resource-intensive. For example, high-profile insider trading convictions in the United States have relied on wiretaps of incriminating conversations to prove insider trading (Pulliam and Siconolfi, 2011). An alternative approach (Shin, 1996) is to force insiders to disclose more information more promptly and level up the playing field. Regulation FD in the United States, which requires public disclosure of any information that has been selectively disclosed, falls into this category. The Indian securities market provides an opportunity to study the impact of the disclosure approach to informed trading because of a tight timeline imposed in 2015. Quarterly earnings information (and several other categories of information) were required to be disclosed[1] to the stock exchange within 30 minutes of the conclusion of the board meeting, while, by contrast, the US regulations provide up to as much as four days' time to companies to disclose material events by filing Form-8K. The Indian stock exchanges promptly disseminate this information publicly with accurate timestamp.

While tentative earnings information circulates among a small set of people in the company for a week or more before the earnings announcement (EA), the board meeting is an important event for three reasons. First, the earnings numbers become final only after the board meeting as the final decision on many management estimates (for example, impairment charges and provisions) vest with the board and its audit committee. Technically, the statutory auditors express an audit opinion on the financial statements only after the board has approved them. Therefore, until the board meeting, all earnings numbers are technically unaudited. Second, the board meeting leads to a large increase in the number of people who know the earnings numbers, which leads to a greater chance of leakage. Third, even those with prior access to tentative numbers might wait till the

[1] "Continuous Disclosure Requirements for Listed Entities Regulation 30 of Securities and Exchange Board of India (Listing Obligations and Disclosure Requirements) Regulations, 2015." SEBI Circular No. CIR/CFD/CMD/4/2015 dated September 9, 2015.

board meeting to reduce the risk of detection. There is, therefore, a strong reason to believe that informed trading would be concentrated in the period between the conclusion of the board meeting and the EA. After the regulation change, this period would begin around 30 minutes prior to the timestamp of the EA, while before the regulation, the period would stretch back significantly longer.

Our study is related to the strand of research which has examined the possibility of information flow from the directors on the board and have found evidence of informed trading around the EA (Anderson, Reeb and Zhao, 2012; Cheng, Felix and Zhao, 2019) and other important announcements (Kim, 2016). As far as the EA is concerned, considerable empirical evidence exists of increased market activity around the EA (Kim and Verrecchia, 1994; Roll, Schwartz and Subrahmanyam, 2010; Truong and Corrado, 2014). Another strand of literature has examined the consequences of potential/actual leakage of important earnings-related information. Such leakage can increase "adverse selection" costs for the uninformed investors (Diamond and Verrecchia, 1991). In line with this evidence, it has been argued that any improvement in the disclosures and reduction in information asymmetry that reduces appropriation by insiders is expected to improve the firm's valuation by increased liquidity (Diamond and Verrecchia, 1991; Kim and Verrecchia, 1994), reduced cost of capital, increased institutional ownership, increased analysts' coverage, and decreased agency costs (Lambert, Leuz and Verrecchia, 2007; Verrecchia, 2001).

Unlike the studies related to insider trading before the EA in the case of earnings surprises, our focus in this paper is on the continuous and prompt disclosure of nonpublic information or continuous disclosure requirement aimed at reducing the informational advantage of insiders, an issue that has received limited attention from academic research (Leuz and Wysocki, 2016). We empirically examine the effectiveness of a regulatory change that reduces the time available to insiders for exploiting the price-sensitive information made available to the directors in the board meeting for finalizing the earnings. While most of the items discussed in the board meeting are circulated before the meeting, the accounting information related to the firm's financial performance is presented to the

board on the day of the meeting for their approval. EA, therefore, provide an appropriate setting to evaluate whether the regulatory change introduced by the Indian regulator had any impact on the timing of increased market activity just before the EA. We use high-frequency data to study the impact of the regulatory change on the market activity and potential leakages before the quarterly EA, unlike many accounting studies that rely on low-frequency (daily) data. High-frequency data allows us to identify whether the market activity indicates leakage of information or speculative trading related to anticipated EA. Using high-frequency data, we can isolate the increase in trading activity just before the announcement as an indicator of trading induced by leaked information. This is because even though the date of EA is known to the market participants, the precise time of EA is not. Unlike speculative trading, which may happen anytime before the EA, any trading induced by leaked information is expected to occur just before the announcement made during market hours if the leakage happened during the board meeting or immediately after that. Accordingly, we would expect no significant impact of the regulatory change on the pre-EA market activity if the increased activity before EA is driven mostly by speculative trading. On the other hand, if the increased market activity before EA is driven by leaked information during or immediately after the board meeting, then the regulatory change is expected to shift trading induced by leaked information closer to the time of EA. The expectation of shift in information-induced trading is predicated on the assumption that the time of end of the board meeting is recorded correctly and the earnings are finalized close to the end of the meeting. The actual time of the end of the meeting and the time when earnings were finalized are unobservable and it is quite possible that the time recorded formally may not be the actual time in particularly if the board members do not take the issue of minimizing leakage seriously.

As far as the institutional context is concerned, the Indian securities market regulator, Securities and Exchange Board of India (SEBI), has been an evolving institution and has developed surveillance, investigation and enforcement capability as has been recognized by the IMF in its Financial Sector Assessment Program (FSAP) reports (International Monetary Fund, 2013). While India has strict regulations against informed

trading, identifying and investigating such informed trading is popularly believed to be relatively lax and uncommon despite such positive assessment in FSAP reports. There has been anecdotal evidence of leakages of impending information.[2] In such an institutional setting, it is interesting to empirically investigate whether this simple regulatory requirement of setting the time limit on disclosing the EA impacted the leakage-induced trading. As we did not have any baseline estimate of the extent and timing of informed trading around EA in the absence of any evidence based on high-frequency data in the Indian market, it was difficult to make unconditional conjectures on the likely impact. The impact was only expected if information leakage related to the EA started during or after the board meeting. We did not come across any such study of market activity around EA using high-frequency data in any market, including the Indian market. This could be because in most jurisdictions, including the US, the exact timing of earnings disclosure during market hours is not readily available, unlike in India.

Based on our sample consisting of 4203 EA made during the market hours by the largest 500 firms during 2013 to 2017, our main results are as follows. There is a substantial increase in the volatility and trading volume before the EA is disclosed to the exchange. This is in line with the results using low-frequency data extensively reported in the literature on the nature of trading activity around EA. Further, the return volatility and trading volume, widely used indicators for informed trading activity, abnormally increase approximately 60 minutes prior to the EA before the regulatory change but only 30 minutes before EA after the regulatory change. The increase in activity indicates trading based on information leakage during or immediately after the board meeting. The standard Bai and Perron (2003) test for identifying structural breaks indicates two structural breaks in the volatility and volume trends before the regulatory change (at 48 and 18 minutes before EA) but only one break after the regulatory changes (at 18 minutes before EA). After examining the predictive ability (to predict earning surprises

[2]For example, 1. SEBI. Issuance of directions to axis bank limited in respect of leakage of unpublished price sensitive information relating to its financials through social networking application –Whatsapp. SEBI Order No WTM/GM/ISD/81/2017-18 dated December 27, 2017. 2. SEBI. Order in the matter of insider trading in the scrip of Deep Industries Limited. SEBI Order No. SEBI/WTM/MPB/IVD/ID–6/162/2018 dated April 16, 2018.

and cumulative abnormal returns) of the returns between 120 to 30 minutes before EA, we find that the regulatory change reduced the predictive ability of the returns during this period. This indicates that the information content of trades during this period reduced with the regulatory change. This implies that the regulatory change was effective, on average, in deferring the leakage and reducing the quality of any leakage 30 minutes prior to EA. Furthermore, the weighted price contribution (WPC) and weighted price contribution per trade ($WPCT$) analysis of different time intervals around EA gave us various interesting insights. First, we find that the price incorporated in two periods between $t = -60$ to $t = -1$ pre EA (t= 0 show EA time) came down, and consequently the WPC of post EA time period, particularly period between $t = 1$ to $t = 30$, increased after regulatory change (changes are statistically significant). Second, $WPCT$ of period $t = -60$ to $t = -31$ came down but the $WPCT$ in period $t = -30$ to $t = -1$ went up after regulatory change. The total time taken for pricing of the new information did not merely shift but got compressed, indicating an increase in the information content of trades during the t-30 to t+60 period. Lastly, and in line with our previous evidence, we find that the difference observed in the volatility pick-up between EA having surprise versus EA having no surprise before regulatory change disappears after the regulatory change.

In short, we find that the regulatory intervention by SEBI to speed up the disclosure by the listed firms has restricted the duration of information leakage before the EA disclosure. Based on the observed excessive trading, volatility and WPC just before the EA, we find that information leakage increases significantly when the information becomes available widely among insiders, particularly those who cannot be monitored easily. These findings might be useful to other market regulators in understanding the likely impact of any continuous disclosure regulatory regime to curb the problem of informed trading based on nonpublic information. Our paper contributes to the broader literature on the effectiveness of regulatory interventions to improve price discovery and market efficiency, particularly outside the US market (Healy and Palepu, 2001).

The rest of the paper is structured as follows: Section 2 provides an overview of

the related literature and draws the research questions. Section 3 provides details of the data, variable construction, and our research methodology. In section 4 and 5 we discuss our results from the main tests and from the battery of robustness and placebo tests, respectively. Section 6 concludes.

2. Literature review and research questions

2.1. Literature review

EA are known to generate abnormal volume and price changes (Beaver, 1968). While price reactions reflect average belief revisions in the aggregate market (Beaver, 1968), the trading volume reflects differential belief revisions (Kim and Verrecchia, 1991a,b). Bamber and Cheon (1995) found evidence of EA generating differential price and volume reaction and recommend the use of both price and volume reactions to study market reactions to EA. The magnitude and duration of abnormal trading volume reaction increases with the magnitude of unexpected quarterly earnings and decreases with firm size (Bamber, 1987). The increased trading activity is attributed to anticipated outcomes at the time of EA by the informed traders. Existing studies have noted the need for identifying exact EA time (Berkman and Truong, 2009) and immediate market responses to announcements (Jiang, Likitapiwat and McInish, 2012). Managers strategically choose the announcement time and attempt to hide bad news by making EA during low attention periods and with less advance notice (DeHaan, Shevlin and Thornock, 2015). For announcements made after the trading hours, the price impact of after-hour EA is reflected on the first trading day after the EA (Berkman and Truong, 2009).

Traders and market participants, like financial analysts and shareholders, follow market trends and the company's performance closely and make informed trading decisions based on this information (Kim and Verrecchia, 1994). Financial analysts influence stock prices (Francis and Soffer, 1997) and are found to provide accurate (and new) forecast information (Healy and Palepu, 2001). They help in improving market efficiency by hastening the price discovery process (Barth and Hutton, 2000). On the other hand, it is also likely that there may be an increased market activity due to information leakage before

the announcement. Such traders will take market positions to exploit their information advantage (Agarwal and Singh, 2006). Trades from both categories of traders will lead to an increase in price volatility and trade volume. The presence of insider trading around significant announcements, including EA, has been empirically investigated and reported even in developed markets (Meulbroek, 1992). In an emerging market like India, the enforcement of prevalent regulations on insider trading laws is generally not considered very effective (Jain and Sunderman, 2014). Therefore, information leakage may significantly impact the market activity before important events and announcements, including EA. There are very few studies on insider trading and market behavior around major announcements in the Indian context. There is evidence of insider trading before industry mergers (Jain and Sunderman, 2014) and similarly using data from a small sample of 30 companies, Prasad and Prabhu (2020) found significant differences in the market responses to the EAs made during and after the trading hours. They also noticed that large earnings surprises induce firms to announce earnings after market hours.

Past studies have argued that insider trading leads to an increase in the cost of equity using theoretical models (Glosten and Milgrom, 1985; Kyle, 1985). Empirically also, the findings are consistent (Brennan and Subrahmanyam, 1996). Insider trading imposes "adverse selection costs" on the liquidity suppliers, who demand higher bid-ask spread to compensate for the probable loss from trading with the insiders. It is also likely that the controlling shareholder's ability to benefit from insider information may adversely affect the monitoring cost incurred by outsiders, which will cause the shareholders to increase the cost of equity (Maug, 2002; Beny, 2004). In a cross-country study, Bhattacharya and Daouk (2002) found a significant decrease in the cost of equity after the insider trading enforcement. While insider trading may be detrimental to the firm's valuation, it provides controlling shareholders and managers an avenue to extract private benefits. The insiders, therefore, may be reluctant to provide disclosures that limit their ability to consume private benefits (Leuz and Wysocki, 2016). Extant research has found insider trading to be profitable for insiders, with the insider purchases more profitable than the insider sales (Brochet, 2010). Insider trading also improves the price discovery process,

though the informativeness of insider trading depends on outsiders' ability to identify insider trading (Plott and Sunder, 1982). Insiders, therefore, have incentives to trade in small volumes to hide the information contents of their trades.

Regulatory bodies have incentives to design regulations that curb leakage of inside information and insider trading as efficient corporate laws help attract investments (Carlton and Fischel, 1983). While disclosures are costly, timely and efficient disclosure reduces uncertainty and search cost for the investors, they help in reducing information asymmetry and improving a firm's valuation. Cross-country studies have found stricter and better enforced securities laws to be associated with higher financial market development (La Porta, Lopez-De-Silanes and Shleifer, 2006), lower cost of capital (Hail and Leuz, 2006), lower trading costs (Eleswarapu and Venkataraman, 2006), attract more foreign investment (Aggarwal, Klapper and Wysocki, 2005). The extension of the mandated disclosure to the OTC market led to a faster price discovery process, a substantial decrease in returns volatility (Ferrell, 2003) and positive abnormal returns for OTC stocks (Greenstone, Oyer and Vissing-Jorgensen, 2006). Positive accounting literature has found both accounting choices and disclosure as part of contracting costs and discussed management's concern about political costs in terms of actions, taxes and penalties arising out of regulations and reputation costs (Watts and Zimmerman, 1978, 1986).

There are substantial direct (preparation, certification and dissemination) and indirect costs (competition, regulators, labor unions) of mandatory disclosure regulations (Leuz and Wysocki, 2016). However, unlike other disclosures regulation like Regulation FD, the intervention made by the Indian regulator (SEBI) in focus did not have any significant implementation costs for the firm or the society. The regulatory change of interest in this study only mandated the prompt release of information, thereby shortening the period during which the firm had to keep the information protected confidentially. The high implicit costs of insider trading and the associated reputation costs may lead to some firms spending resources to monitor insider trading activities and information leakage. Since insiders have incentives to delay disclosures, firms would have ended up incurring the direct cost of protecting the information from snooping (Easterbrook, 1981)

and on monitoring the insiders for a longer period than after the regulatory change. Thus, the regulatory change could have only led to the saving of monitoring costs incurred by firms. The only additional cost associated with the regulatory change of interest would have been the cost associated with the regulator's monitoring and enforcement activities.

Our study focuses on information leakage rather than on insider trading around EA. While insiders other than the outside directors could trade on private information on earnings even before the board meeting, an insider may prefer to delay taking any position till the information is known to a larger set of people (after the board meeting). Of course, if the leakage is due to outside (independent) directors, then the leakage can only be after the start of the board meeting as they get to know the earnings only in the meeting. The insiders may also wait because any unusual volume/trade before the actual information release faces the risk of falling under the radar of the surveillance and investigation team of the stock exchanges and the market regulators, and the internal investigation teams of the firms. They are also vulnerable to market risk, unexpected idiosyncratic risk and any changes made to the earnings numbers during the board meeting if they were to take a position early. Indian regulations prohibit designated insiders to trade in a window of the period around events such as EA [3], but that may not prevent leakage as long as trades can't be traced back to the designated insiders. However, the situation changes once the nonpublic information is shared with a larger group (here, the Board of directors and a broader set of insiders). Once shared, it becomes difficult to trace the leakage to an insider who traded based on private information. While the delay reduces the risk of being traced by investigators, it also reduces potential profits if the insider is front-run by another insider. It has been pointed out in the literature that the informed traders are likely to trade stealthily (Kyle, 1985; Holden and Subrahmanyam, 1992; Foster and Viswanathan, 1994) if they have time but not when the private information is likely to be revealed quickly, and when there is competition (Easley and O'Hara, 1987; Karpoff, 1987). Based on this reasoning, we expect the leakage of information to start or intensify

[3] https://www.sebi.gov.in/legal/regulations/jan-2015/sebi-prohibition-of-insider-trading-regulations-2015-issued-on-15-jan-2015-$_2$8884.*html*

once shared among a broader set of persons as the results are discussed and finalized in the board meeting.

We also expect that the shortening of the time available with insiders to leak earnings-related information will cause information-induced trades closer to the EA to become more informative. The price reactions and market activity will become more concentrated during a shorter time window. Arguably, the regulatory change has also increased the likelihood of attracting the regulators and media attention on the period just before EA (in terms of unusually high trading volume and price reactions). This increases the threat of being investigated and the associated reputation costs. That may also lead to firms and insiders taking steps to prevent leakages compared to a setting where the period for which information is available with insiders is for a longer period. In short, we expect that the effect on reduced leakage before EA would result in the volume and volatility increase to be closer to the time of EA.

Though there has been extensive research on the market reactions and informed trading around EA, our study seeks to contribute to the existing literature on a related regulatory intervention in the Indian stock market seeking to reduce the time gap between the finalization of earnings by the board and the EA. To understand the impact, we use high-frequency data to examine the effect of regulatory change and market behaviour around EA, unlike most studies based on low-frequency data. Further, our analyses seek to compare the change in the market behavior around EA based on earning surprise. While we seek to fill the gap in research around EA in India using high-frequency data, the impact of the regulatory change relating to the speed of disclosure on the market behavior and price discovery around EA might be of interest to regulators elsewhere.

2.2. Research questions

The information about the prevalence and extent of insider trading is an important question for investors, owner-manager, outside managers, and regulators across the globe. Also, EA are frequent and important corporate announcements known to have significant price and volume impact. Our first research agenda is to investigate and confirm whether

abnormally high trading volume and volatility are observed around EA in the Indian context during the study period as observed elsewhere. In the context of this agenda, our main focus is on identifying the timing of increased market activity just prior to EA to infer the presence of information leakage.

Our second research question is related to the impact of the regulatory change in December 2015. As there are no similar instances of such a regulatory change, we use this as a natural experiment setting to assess the impact of a low-cost regulatory intervention to speed up disclosure on the information leakage-induced trading in the market prior to EA.

We answer these two research questions by analyzing the returns, volume and volatility around the EA. We measure the extent of price discovery at different time intervals before and after the EA to determine the impact of the regulatory change on information leakage. Our findings from these two research questions allow us to infer whether the pre-EA market behavior is driven mainly by speculative trading or by trading induced by information leakage. In line with the argument made earlier, we expect the regulatory change to have a minimal impact if the abnormal trading volume and volatility were purely driven by speculative trading. Contrariwise, if the leakage-induced trading was a significant source of increased volume and volatility, then the regulatory change would result in the abnormal trading activity shifting closer to the time of EA.

In a semi-strong efficient market, insiders' profits and trading activity are directly proportional to the difference between the private information and the market expectation about the impending information (Fama, 1970). Therefore, one would expect leakage of the information would be higher where the surprise is high. It is known that the insiders may not be able to foresee the market reactions to EA when the dispersion in market expectations is large. Thus, our third research agenda is to analyze the market behavior and the impact of the regulatory change for EA classified based on earnings surprises. We expect the market behavior and the impact of the regulatory change to be starker in case of earning surprises. We supplement our analysis by determining the predictive

ability of pre-EA return for earnings surprises.

3. Data, variable construction and method

3.1. Data

Our sample consists of the top 500 National stock exchange (NSE)[4] listed firms by market capitalization as on December 2017. The selected firms represent more than 90% of the overall market capitalization of the stocks listed on NSE.[5] The sample spans from 2013 to 2017, around two years before and after the new regulation.

The data used in the study is gathered from various sources. The exact broadcast time of the quarterly EA made by the firms are complied from the corporate announcement pages of respective firms on the NSE website. To identify EAs, we used a text identifier on the "subject" of the announcement with the keyword "Result/s". We exclude those having the following keywords ("Publish Audited Results", "Postal Ballot", "Clarification", "Results/Others") in the subject. We limited our study only to EA during the market hours, as our main objective was to analyze the impact of the regulatory change on market efficiency and the price discovery process. We observe that most companies had separate announcements on the same date for standalone results and consolidated results, results and result presentation, results and key figures, and quarterly and annual results (for the last quarter). To avoid duplication, we only considered the timings of the first announcement for each company-quarter in our analysis. This resulted in 479 unique firms and 4203 EA.

The for each stock-EA day is obtained from the NSE trade book. We use the trade data only from the continuous auction market i.e., 9:15 AM to 3:30 PM in our analysis.[6] The information about a stock's daily returns and quarterly EPS is obtained from the

[4]NSE is India's multi-asset leading stock exchange and is also ranked 11 in the list of the world's largest stock exchanges as of April 2018. Monthly Insights, World Federation of Exchanges (https://www.world-exchanges.org/our-work/statistics).

[5]https://www1.nseindia.com/products/content/equities/indices/nifty_500.htm

[6]NSE has a short call auction window before the market opens at 9:15 AM where all the trades are settled at the equilibrium price. The trade book data consists of time stamp, volume and price of each trade. A typical day (January 4, 2016) had 7.5 million trades.

CMIE $Prowess_{dx}$ database.[7] The period before and after December 2, 2015 is defined as "before-regulation" and "after-regulation", respectively. Table 1 provides the definition of these variables. Table 2 provides the year-wise distribution of number of EA made during the market hours and after the market hours. The percentage of EA made by the firm during the market hours ranges between 42-49% over the years. Out of 4203 EA in our sample, 2511 and 1692 EA belong to before-regulation and after-regulation time period, respectively. Figure A1 which shows the distribution of EA across time of the day indicate that most of EAs in our sample were made after 11:00 AM. Table 3 provide the summary statistics of variables used in the study for full sample.

Insert Tables 1 to 3 here

3.2. Measurement of information leakage

We aim to analyze the information leakage before the EA, but it is not directly observable. Following the market microstructure literature, which argues that the high intraday return volatility and abnormal volume is a consequence of the arrival of new (private) information in the market (Admati and Pfleiderer, 1988; Berry and Howe, 1994), we use return volatility (denoted by absolute returns), and standardized volume (estimated by standardizing the volume traded during a particular time interval with respect to the day's volume) to infer the extent of information leakage. We estimate return volatility and standardized volume measures at three frequencies (1, 10 and 30 minutes). Volatility and standardized volume estimated at 1-minute frequency are used in our preliminary analysis, whereas 10 and 30-minute estimates are used in our regression model. The variables $|ret\_1|$, $|ret\_10|$, $|ret\_30|$ represent absolute returns (volatility) at 1-, 10-, and 30- minute frequencies. Similarly, variables $StdVol\_1$, $StdVol\_10$ and $StdVol\_30$ represent standardised volume at 1-, 10-, and 30- minute frequencies respectively. See Table 1 for more details. Methodologically it is similar to a study on the leakage of information before macroeconomic news announcements by Bernile, Hu and Tang (2016), which

[7] https://prowessdx.cmie.com

found evidence of informed trading during news embargoes ahead of monetary policy announcements by the FOMC, but not before FOMC news embargoes or before surprise announcements by other government agencies.

3.3. Estimating earnings surprises

We use two measures to identify earnings surprises. The first measure, Standardized Unexpected Earnings (SUE), is an ex-ante measure of earning surprise and the second measure, Cumulative Abnormal Return (CAR), is an ex-post measure based on the market reactions of the earnings information. Brandt, Kishore, Santa-Clara and Venkatachalam (2008) found the two measures are independent and capture different aspects of earnings disclosure. While SUE captures the surprise component in the earnings measure, the CAR captures the surprise component of earnings and the concurrent disclosures of other non-earnings information during the EA. Such concurrent disclosures occur through various channels like media releases, corporate presentations, and analysts' meetings and are found to be increasing over the years (Francis, Schipper and Vincent, 2002).

Following the literature, we define the SUE for a firms' quarterly EA as the earnings surprise divided by the standard deviation of the earnings surprise:

$$SUE_{i,q} = \frac{X_{i,q} - E(X_{i,q})}{\sigma_{i,q}} \tag{1}$$

where, $X_{i,q}$ is actual earnings per share (EPS) before extraordinary item, $E(X_{i,q})$ is the expected EPS, and $\sigma_{i,q}$ is the standard deviation of the earnings surprises during the previous eight quarters. We use a seasonal random walk with drift model to estimate expected earnings. Specifically, we use the following equation to estimate $E(X_{i,q})$:

$$E(X_{i,q}) = X_{i,q-4} + \mu_{i,q} \tag{2}$$

$$\mu_{i,q} = \frac{\sum_{n=1}^{8}(X_{i,q-n} - X_{i,q-n-4})}{8} \tag{3}$$

Our second measure – CAR, is the cumulative abnormal returns recorded during a 3-day window centered around the EA day. To estimate CAR, we use the market-adjusted return of the stocks in a 3-day window around EA. This measure is an ex-post measure of surprise and is used by many studies in the EA literature to identify surprise.

$$CAR_{i,d-1,d+1} = \sum_{j=d-1}^{d+1} (r_{i,j} - E(r_{i,j})) \tag{4}$$

where, $r_{i,j}$ is return of stock i on day j, and $E(r_{i,j})$ is the market-model predicted return of stock i on day j. Therefore, $E(r_{i,j}) = \beta_0 + \beta_1(r_{m,j})$, where $r_{m,j}$ is the return of $Nifty\ 50$ index on day j and β_1 is the market beta of the stock.

Using the two surprise proxies, we created two dummy variables ($Ex-ante\ Surprise$ and $Ex - Post\ Surprise$) that categorize an EA into surprise or no-surprise. $Ex - ante\ Surprise$ and $Ex - Post\ Surprise$ takes the value 1 if the SUE and $CAR_{d-1,d+1}$ of a particular EA fall in the first and the fourth quartile of their respective distribution and 0 otherwise.

3.4. Volatility and volume pattern around EA

To examine the influence of the regulation over the price discovery process during the quarterly EA, we use high-frequency data sampled at a 1-minute frequency. For each EA, we identified the exact minute at which the financial results were broadcasted through the exchange. This is used as a reference point for our analysis. The time gap (in minutes) between any given time and the announcement time ($minute\_of\_the\_day - announcement\_minute$) is referred to as $Relative\_min$. Thus, the $Relative\_min$ would be negative, zero, and positive for period before, at, and after the EA, respectively. Our variables of interest – volatility ($|ret\_1|$), and $Standardized\ Volume$ ($StdVol\_1$) are estimated at minute frequency.

As a first cut analysis, we plotted the mean of $|ret\_1|$ and $StdVol\_1$ at different $Relative\_min$ over all EAs before and after the regulation change (referred as two sub-samples). To examine the influence of the regulation change over the information leakage

before EA, we use the Bai and Perron (2003) approach to endogenously identify the structural break in the minute-wise mean series of $|ret\_1|$ and $StdVol\_1$ for the two subsamples. We set the segment size to be 15% of the sample size and a cap of maximum of two breakpoints for each subsample. Figure 1 shows the plot and breakpoints (vertical dotted line) identified by Bai and Perron (2003).

3.5. Influence of regulation over information leakage

We examine the influence of regulation over the information leakage before EA. We take the high-frequency data at 30-minute frequency[8] and constructed relative time dummies. We restricted our sample to a 2-hour time window before the EA. Thus, we construct four relative time dummies ($\Delta t_{[-120,-91]}$, $\Delta t_{[-90,-61]}$, $\Delta t_{[-60,-31]}$ and $\Delta t_{[-30,-1]}$). Our dependent variables are proxies of information leakage, i.e., return volatility and volume. To examine the impact of the new regulation, we use the model mentioned below:

$$\begin{aligned} Information\ leakage\ proxy_{i,q,\Delta t} = \alpha &+ \beta_1 \Delta t_{[-120,-91]} + \beta_2 \Delta t_{[-90,-61]} + \beta_3 \Delta t_{[-60,-31]} \\ &+ \beta_4 \Delta t_{[-30,-1]} + \gamma Post\_Reg + \delta_1 \Delta t_{[-120,-91]} \times Post\_Reg \\ &+ \delta_2 \Delta t_{[90,-61]} \times Post\_Reg + \delta_3 \Delta t_{[-60,-31]} \times Post\_Reg \\ &+ \delta_4 \Delta t_{[-30,-1]} \times Post\_Reg + \epsilon_{i,q,\Delta t} \end{aligned} \tag{5}$$

where $Information\ leakage\ proxy_{i,q,\Delta t_i}$ is represented by the two proxies —$|ret\_30_{i,q,\Delta t}|$ and $StdVol\_30_{i,q,\Delta t}$. $\Delta t_{[-120,-91]}$, $\Delta t_{[-90,-61]}$, $\Delta t_{[-60,-31]}$ and $\Delta t_{[-30,-1]}$ represents relative time period dummy. Table 1 provides the detail of variables used in the study. We estimate the above model (Equation 5) separately for both our dependent variables. In an alternate specification, we also include firm-level fixed effects in Equation 5, and re-estimate the model for the two independent variables separately.

[8] We use 30-minute frequency to minimize the number of relative time dummies. Bernile et al. (2016) have followed similar method. Even taking data at a lower frequency does not affect our results.

As a robustness test, we altered the above specification and conducted our analysis using time dummy variables at 10-minute frequency. We restricted our sample to a 2-hour time window before and after the EA. Our regression specification is given below:

$$Information\ leakage\ proxy_{j,q,\Delta t_i} = \alpha + \sum_{i=-12}^{i=12} \beta_i \Delta t_i + \epsilon_{j,q,\Delta t_i} \tag{6}$$

where $Information\ leakage\ proxy_{j,q,\Delta t_i}$ is represented by the two proxies – $|ret\_10_{j,q,\Delta t_i}|$ and $StdVol\_10_{j,q,\Delta t_i}$. Δt_i represents relative time period dummy variable that equals 1 for i^{th} 10-minute time interval relative to EA and 0 otherwise (see Table 1 for more detail). We estimate the above model (Equation 6) separately for before- and after-regulation subsamples. In an alternate specification, we also include firm-level fixed effects in Equation 6, and re-estimate the model for two subsamples separately.

3.6. Prediction of surprise from pre-EA returns

To examine whether the pre-EA trading activity contains information about the impending announcement and whether the informativeness of the trading activity has decreased after the regulation, we use pre-EA returns to predict the subsequent surprise embedded in the EA. For this, we use two proxies $CAR_{d-1,d+1}$ and SUE (subsection 3.3) to extract the surprise embedded in the EA. We divide the pre-announcement time period into two time intervals —$t_{[-120,-31]}$ and $t_{[-30,-1]}$. For every EA, we use the stock returns for the two time periods separately ($Ret_{[-30,-1]}$ and $Ret_{[-120,-31]}$) to predict the surprise embedded in the impending EA. To analyze the difference in predictive power before and after the regulation change we estimated the below mentioned regression for before-regulation and after-regulation subsamples separately:

$$Sur_{i,q} = \beta_1 Ret_{i,q,[-30,-1]} + \beta_2 Ret_{i,q,[-120,-31]} + \delta_i + \epsilon_{i,q} \tag{7}$$

Where, $Sur_{i,q}$ represents the two proxies of earnings surprise – $CAR_{i,q,d-1,d+1}$ and $SUE_{i,q}$, and δ_i represents firm-level fixed effects. In an alternate specification, we interacted a $Post\_Reg$ dummy variable with $Ret_{[-30,-1]}$ and $Ret_{[-120,-31]}$. This model helps us check

the statistical significance of the reduction in the explanatory power. Specifically, we use the following regression model:

$$\begin{aligned} Sur_{i,q} = {} & \beta_1 Ret_{i,q,[-30,-1]} + \beta_2 Ret_{i,q,[-120,-31]} + \beta_3 Post\_Reg \\ & + \beta_4 Ret_{i,q,[-30,-1]} \times Post\_Reg + \beta_5 Ret_{i,q,[-120,-31]} \times Post\_Reg \\ & + \delta_i + \epsilon_{i,q} \end{aligned} \tag{8}$$

Where, $Sur_{i,q}$ represents the two proxies of earnings surprise – $CAR_{i,q,d-1,d+1}$ and $SUE_{i,q}$, $Post\_Reg$ is a dummy variable that equals 1 for EA after the new regulation was in force and 0 otherwise, and δ_i represents firm-level fixed effects.

3.7. Price discovery around EA

We examine the influence of regulation over the price discovery process around EA using weighted price contribution (WPC) that measures the informativeness of the stock price, and weighted price contribution per trade ($WPCT$) that measures the information content of each trade. Specifically, we use WPC and $WPCT$ as defined by Barclay and Hendershott (2003) and has been used in past EA studies (Jiang et al., 2012). We divide the period starting from 120 minutes before the EA to the market close into six time intervals based on *Relative_min* (variable is defined in subsection 3.4). The start and end time (in *Relative_min* for the six time intervals are $[-120, -61]$, $[60, -31]$, $[-30, -1]$, $[0, 30]$, $[30, 60]$, and $[61, close]$. For each quarter and each period i, we define the WPC_i and $WPCT_i$ as given below:

$$WPC_i = \sum_{s=1}^{S} \left[\left(\frac{|RET_s|}{\sum_{s=1}^{S} |RET_s|} \right) \times \left(\frac{RET_{i,s}}{RET_s} \right) \right] \tag{9}$$

$$WPCT_i = WPC_i / \sum_{s=1}^{S} \left[\left(\frac{|RET_s|}{\sum_{s=1}^{S} |RET_s|} \right) \times \left(\frac{NT_{i,s}}{NT_s} \right) \right] \tag{10}$$

where, $RET_{i,s}$ is logarithmic return during period i for stock s, RET_s is logarithmic

return of stock s between $t = -120$ till the close of market on the same day, $NT_{i,s}$ is total number of trade during period i for stock s, and NT_s is the total number of trade in stock s between $t = -120$ till the market close. This exercise gave us the time series of WPC_i, and $WPCT_i$ at quarterly frequency for every period. To analyze the influence of regulation over the price discovery process around EA, we compare the mean value of WPC_i and $WPCT_i$ before and after the new regulation using the difference-in-mean test (t-test).

3.8. Information Leakage Around Surprise

An investor can profit from the pre-disclosed private information in a semi-strong efficient market (Fama, 1970). The value of the private information would be more if it implies a valuation differential from the market expectations. That is, a private information about the outcome of an impending EA would be much more valuable to a privately informed investor if announcement is a surprise. Therefore, the probability of trading on private information would be high in the case of EA having earnings surprise than in an EA having no surprise. We examine the influence of regulation over the information leakage (volatility pattern) around EA with earnings surprise (surprise-EA). We identify an EA as a surprise-EA if the $CAR_{d-1,d+1}$ or SUE of that EA fall in the first or fourth quartile of their respective distributions. We divide the pre-EA period into two parts —$t_{[-120,-31]}$ and $t_{[-30,-1]}$. The absolute return (proxy of information leakage) during the two periods are used as dependent variables in our model. To check if the regulation influence the leakage of information around surprise EA, we interact $Surprise_{i,q}$ dummy with $Post\_Reg$ dummy in our regression model. Specifically, we estimate below mentioned regression equation.

$$\begin{aligned} Volatility_{i,q,\Delta t} = \beta_1 Surprise_{i,q} + \beta_2 Post\_Reg + \beta_3 Surprise_{i,q} \times Post\_Reg \\ + \delta_i + \epsilon_{i,t} \end{aligned} \tag{11}$$

where, $Volatility_{i,q,\Delta t}$ represents $|Ret_{[-1,-30]}|$ and $|Ret_{[-31,-120]}|$, $Surprise_{i,q}$ represent

Ex-ante Surprise or *Ex-Post Surprise* dummies, and *Post_Reg* is a dummy variable that equals 1 for EA after the regulatory intervention and 0 otherwise.

4. Results and discussion

4.1. Volatility and volume pattern around EA

Figure 1 shows the plot of mean volatility and standardized volume around the EA at 1-minute frequency. The vertical lines show the structural breakpoints identified by using Bai and Perron (2003) approach and horizontal lines around the vertical lines show the confidence interval (95%) of each breakpoints.[9] A close look at the plots reveal following observations. First, both volatility and standardised volume before the EA have shifted to the right after the implementation of regulation, i.e., pre-announcement volatility and volume pick-up has been delayed. Second, before the EA, while there are two structural breaks in the mean volatility plot at $Relative\_min = -48$ *and* -18 in the before-regulation subsample, there is only one structural break in the after-regulation subsample at $Relative\_min = -18$. The standardized volume plots show qualitatively similar breakpoints. Third, the post-EA reaction has become more pronounced. Both volatility and volume lines have a bigger spike just after the EA in the after-regulation subsample than the before-regulation subsample. The increase in trading volume and volatility when the timing of EA is not known ex-ante, can be interpreted as the effect of leakage of price sensitive information rather than speculative trading which need not be concentrated just prior to EA. Furthermore, we see a shift in the increase in the trading volume and volatility after regulatory change. This indicates that the leakage induced trading picks up pace no earlier than an hour prior to EA before the regulation change time period and the pick up shifts to 30 minutes before the EA after regulatory change. Thus, the plots provide preliminary evidence of the delay in the arrival of earnings related information in the market.

[9] For few breakpoints confidence interval (CI) is missing because Bai and Perron (2003) approach does not provide CI for those breakpoints

Insert Figure 1 here

4.2. Influence of the regulation over information leakage

The results from our regression model, specified in subsection 3.5, used to quantify the shift in volatility and volume pre-EA are reported in Table 4. As mentioned, we estimate Equation 5 for our two dependent variables, ($|ret\_30|$, and $StdVol\_30$) separately. The regression models were estimated without (columns (1) & (3) Table 4) and with (columns (2) & (4) Table 4) firm-level fixed effects. Columns (1) and (2) show results when $|ret\_30|$ is used as the dependent variable in Equation 5, and column (3) and (4) show the results with $StdVol\_30$ as the dependent variable in Equation 5. We restricted our sample to a 2-hour time window before the EA.

We find that the coefficients of $\Delta t_{[-60,-31]}$ and $\Delta t_{[-30,-1]}$ are statistically significant for both the dependent variables in the before-regulation time period, whereas the coefficient of $\Delta t_{[-90,-61]}$ is insignificant (Table 4). This shows that the rise in volatility and volume levels in the before-regulation period happens almost one hour before the EA. In the after-regulation period, we find that the volatility and volume in $t_{[-60,-31]}$ time interval reduces substantially ($\beta_3 + \delta_3$) and in one case becomes almost zero (column (2) of Table 4). We also see a reduction in the volume and volatility during the $t_{[-30,-1]}$ time interval, but the coefficient $\beta_4 + \delta_4$ remains well above zero. We find no change in the behavior of volatility and volume in $t_{[-90,-61]}$ time interval after the regulation. Thus, the results in Table 4 show that there is a delay of 30 minutes in the rise in volume and volatility levels in the after-regulation period as compared to the before-regulation period.

Using the alternate specification given in Equation 6, we test the same hypothesis for robustness purpose. Table A1 and A2 show the regression results of equation 6 for volatility and standardized volume, respectively. Table A1 shows that there is a clear shift of 30 minutes in the arrival of information in the period after the regulation was implemented. In the before-regulation subsample where volatility ($|ret\_10|$) is the dependent

variable, the coefficients of Δt_i for $i > -5$ in column (1) and for $i > -6$ in column (3) of Table A1 are positive and statistically significant. The result is qualitatively similar for the before-regulation subsample when $StdVol\_10$ is considered as the dependent variable. Taken together, our results show that in the before-regulation period, the volatility and volume levels increase around an hour before the EA. For the after-regulation subsample, when volatility ($|ret\_10|$) is used as the dependent variable, we find that the coefficients of Δt_i for $i > -3$ (column (1) and (3) of Table A1) are positive and statistically significant. The result is qualitatively similar for before-regulation subsample where $StdVol\_10$ is the dependent variable. Our results show that in the after-regulation subsample, the volume and volatility start increasing only within 30 minutes before the EA. This period is within the time-frame allowed for the firms to announce earnings after completion of the relevant board meeting.

Insert Table 4 here

4.3. Prediction of surprise from pre-announcement returns

We expect the pre-EA return to predict the surprise embedded in the EA if the increase in volatility and volume before the EA is mainly because of information leakage. However, if the increase is driven mainly by speculation then one would expect the predictive power to be weak. Further, if the regulation curbs the information leakage then we would expect the predictive power to weaken after regulatory change. Accordingly, we would expect β_1 and β_2 of Equation 7 to be positive and significant for before-regulation subsample. Whereas, for after-regulation subsample we expect β_1 to not change but β_2 to weaken or become insignificant.

Table 5 show the results from the regression models. Columns 1 to 4 show the results of regression equation 7. Columns 1 and 2 show results for the before-regulation subsample and column 3 and 4 show for the after-regulation subsample. The results show that, $Ret_{[-30,-1]}$ and $Ret_{[-120,-31]}$ predict both our surprise measures (β_1 and β_2 are

positive and significant) in the before-regulation subsample. Whereas, as expected, in the after-regulation subsample, the explanatory power of $Ret_{[-30,-1]}$ remains almost the same but the explanatory power of $Ret_{[-120,-31]}$ weakens.

To check if the reduction in predictive power for $Ret_{[-30,-1]}$ and $Ret_{[-120,-31]}$ is significant, we estimated the coefficients from the regression model specified in equation 8 (columns 5 and 6). We find that the coefficient of the interaction of $Ret_{[-120,-31]}$ with $Post\_Reg$ dummy is negative and significant, but $Ret_{[-30,-1]}$ with $Post\_Reg$ is negative but not significant. Thus, our results provide us a strong empirical evidence that the predictive power of pre-EA returns reduces significantly in the after-regulation period, particularly of the returns between $t_{[-120,-31]}$. Interestingly, for SUE in the after-regulation period, the coefficient of $Ret_{[-120,-31]}$ (β_2) becomes negative (column 4) indicating loss in the information content of the returns in the corresponding period post regulatory change.

Insert Table 5 here

4.4. Price discovery

To analyze the influence of the new regulation over the price discovery process around EA, we compare the mean values of WPC and $WPCT$ measures for different time intervals for before- and after-regulation subsample. WPC measures the amount of information incorporated into stock price in a particular time interval, whereas $WPCT$ is a proxy of informativeness of each trade during a particular time interval (Barclay and Hendershott, 2003). Table 6 reports the result of our analysis. As observed, the price incorporated within an hour before the EA (time intervals $t_{[-60,-31]}$ and $t_{[-30,-1]}$) decreased in the after-regulation subsample as compared to the before-regulation subsample. The difference is statistically significant. Interestingly, the WPC of $t_{[-60,-31]}$ reduced by about 55% and the WPC of $t_{[-30,-1]}$ reduced by 23%. The WPC immediately after the EA ($t_{[0,30]}$) increased by 44%. In the after-regulation subsample, about 50% of the total

information is incorporated in the prices within 30 minutes of EA. The corresponding figure was 34% for the before-regulation subsample. Thus, the implementation of the regulation has compressed the window of price discovery process.

Regarding $WPCT$, which measure the informativeness of each trade, we find that the informativeness of the trades has reduced for $t_{[-60,-31]}$ time interval, whereas the informativeness of each trade in the period of $t_{[-30,-1]}$ has increased. The changes is statistically significant. Interestingly, the change in the $WPCT$ is not statistically significant for any other interval. These results, alongside the regression result reported in the previous section, indicate that the regulatory change has not only shifted and compressed the period of leakage-induced trading just prior to EA but has also increased the information content of trades close to the EA.

Insert Table 6 here

4.5. Information leakage around surprise

We discuss the result from the regression model specified in Equation 11 that we use to examine the impact of regulatory change on the information leakage which may vary depending upon the extent of surprise element across EA. Table 7 reports the result. We find that in the before-regulation subsample, the coefficients of the proxies of surprise (β_1 of Equation 11) are positive and significant for both the dependent variables ($|Ret_{[-1,-30]}|$ and $|Ret_{[-31,-120]}|$). The result provides empirical evidence of higher volatility in case of EA having higher surprise than EA with low surprise, before the regulatory intervention. However, the interaction between the surprise proxies and *Post_Reg* is negative and significant in the case of *Ex-ante Surprise* (columns 1 and 3). In almost all cases (except column 4), the sum of β_1 and β_3 is either zero or negative. The difference observed in the volatility pick-up before EAs having higher surprise versus EAs having low surprise before regulatory change disappears after the regulatory change. Unlike ex-ante measure of earnings surprise, we find much lower sensitivity of last 30-minutes volatility to the

earnings surprise based on ex-post surprise measure. The impact of regulation on the sensitivity of volatility to ex-post earnings surprise, however, is statistically insignificant though negative.

Insert Table 7 here

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5. Robustness

To show that our results are indeed caused by regulation and not driven due to any other temporal shift, we did placebo regressions analysis using two arbitrary pseudo regulation dates (one before the actual date of implementation and one after it). Specifically, we took June 2, 2014, and December 2, 2016, as regulation implementation dates. We aim to check if the pseudo regulation dates still generated the same results as the actual date. We re-estimate Equation 6 for both volatility and standardized volume with *Post_Reg* dummy defined using pseudo dates rather than the original date.

We first divided our sample into before- and after-regulation subsamples using the original regulation implementation date. Then, we used the pseudo dates for each subsample to determine the value of the *Post_Reg* dummy. For the before-regulation subsample, the value of *Post_Reg* dummy variable is 0 (1) for the period before (after) June 2, 2014. Similarly, for the after-regulation subsample, the value of the *Post_Reg* dummy variable is 0 (1) for the period before (after) December 2, 2016. If our results are driven by regulation change, the coefficient for the interaction term between *Post_Reg* dummy and relative time interval dummies would be insignificant.

Table 8 reports the results of placebo regressions. As observed, for the before-regulation subsample, the interaction coefficients of *Post_Reg* are insignificant for columns 1 and 2 where the dependent variable is proxy of volatility, whereas in columns 3 and 4, where the dependent variable is the standardized volume it is statistically significant but economically insignificant. For our after-regulation subsample, the interaction coefficients

of *Post_Reg* are insignificant in all columns except column 4, where it is statistically significant but economically insignificant. Overall, the results of pseudo regressions confirm that our results are not driven by any other temporal factor.

Insert Table 8 here

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6. Conclusion

Acknowledging the ill-effects of information asymmetry on uninformed traders vis-a-vis informed traders, the regulators have traditionally relied on detection, investigation and prosecution of suspected cases of insider trading. An alternative approach is to speed up disclosure of any information which the insiders may have. As argued by (Park, 2018), there would be no reason to have insider trading regulations in case all inside information is disclosed by the firms and processed by the markets instantaneously. Though it may be unrealistic to expect that the firms and insiders will be able to verify, certify and disclose any price sensitive nonpublic information instantly, it still merits regulatory attention in the form of continuous disclosure regulatory requirements. One such mandatory regulatory intervention was initiated by the Indian capital market regulator, SEBI, requiring listed firms to report their financial results within 30 minutes of the end of the board meeting. This move can be seen as a low-cost device to speed up disclosures (Mahoney, 1995). But this intervention could have had the desired effect of reducing and limiting the information asymmetry between the informed and uninformed traders only if the leakage of information on EA took place after the board meeting. In this paper, we report that the evidence seem to suggest that the leakage relating to information on earnings used to take place after the board meeting. As a consequence of the regulatory intervention, the leakage of information has been restricted to a narrower time period falling within the time period stipulated by the regulator. We also find evidence that the regulatory intervention not only shifted and compressed the heightened market activity just prior to the EA but also increased the information content of such trades done in that narrow

period just prior to the EA. However, the overall much lower information, as indicated by the WPC measure, was leaked before EA after the regulatory change. Consequently, the EA had more information content as indicated by the increase in the WPC measure after the announcement. With this evidence, such a regulatory intervention can be arguably considered a solution to the problem of informed trading that may be difficult for the markets to work out (Stigler, 1971). Privately negotiating a commitment with managers or insiders to curb leakages might be more difficult than the mandatory disclosure regime backed by credible enforcement (Leuz and Wysocki, 2016). Reducing the time window for mandatory disclosures also reduces the cost of surveillance and enforcement as it becomes much easier to detect and investigate any inside trading. Our evidence also indirectly suggests that the firms take the regulations seriously by disclosing the earnings within the stipulated time. This should be of comfort to the Indian regulator which is increasingly recognized as a credible enforcement agency (International Monetary Fund, 2013). Our evidence also sheds light on the rate of flow of information from inside the firm depending upon whether the information is with designated insiders or with a wider set of insiders. We find that the rate of information flow increases dramatically as it becomes available to a wider set of insiders.

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Table 1: Variable Construction Details

Variable Name	Variable Definition	Source
$\|ret\_1\|$	Absolute value of the return in relative one minute time windows with respect to the time of EA.	NSE Trade Book
$\|ret\_10\|$	Absolute value of the return in relative 10-minute time windows with respect to the time of EA.	NSE Trade Book
$\|ret\_30\|$	Absolute value of the return in relative 30-minute time windows with respect to the time of EA.	NSE Trade Book
$StdVol\_1$	Standardized trading volume in relative one minute time window with respect to the time of EA.	NSE Trade Book
$StdVol\_10$	Standardized trading volume in relative 10-minute time window with respect to the time of EA.	NSE Trade Book
$StdVol\_30$	Standardized trading volume in relative 30-minute time window with respect to the time of EA.	NSE Trade Book
$Post\_Reg$	A dummy variable that takes the value 1 for after-regulation time period (i.e post 2015/12/02) and 0 otherwise.	
$\Delta t_{[x,y]}$	A dummy variable that take the value 1 for the time interval between x and y minutes relative to the EA time and 0 otherwise.	
Δt_i	A dummy variable that takes the value 1 when relative 10-minute interval is i and 0 otherwise. For example Δ_{-1} is a dummy variable that becomes one for the first relative 10-minute time slot before EA.	
$Ret_{[x,y]}$	Log returns for the time interval between x and y minutes relative to the time of EA.	NSE Trade Book
$\|Ret_{[x,y]}\|$	Absolute value of returns for time interval between x and y minutes relative to the time of EA.	NSE Trade Book
Ex-ante Surprise	A dummy variable that becomes 1 if the SUE of an EA falls in the first or fourth quartile of the SUE distribution.	CMIE
Ex-post Surprise	A dummy variable that becomes 1 if the $CAR_{d-1,d+1}$ of an EA falls in the first or fourth quartile of the SUE distribution.	CMIE

Table 2: Descriptive Statistics

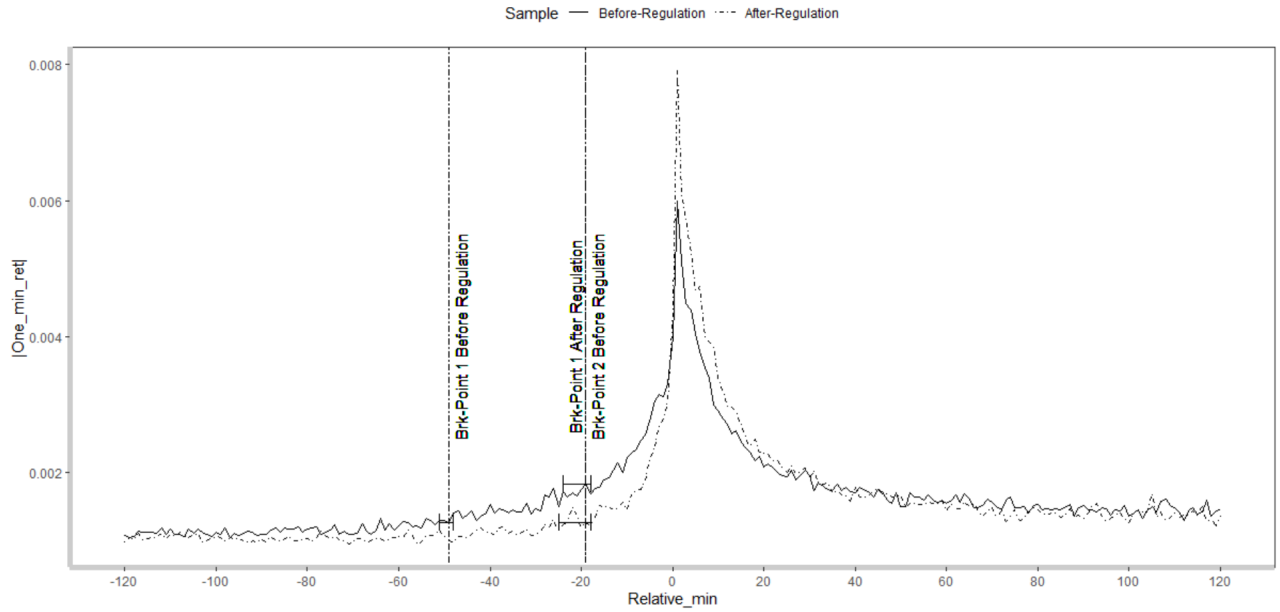
Year	Timing of EA				DMH Surprise EA		
	After Market Hour (AMH)		During Market Hour (DMH)		Ex-ante Surprise	Ex-Post Surprise	Surprise based on both Proxies
	Unique Firm	No of EA	Unique Firm	No of EA			
2013	394	927	386	873	313	352	139
2014	402	1025	356	800	359	369	189
2015	405	1082	353	838	383	411	204
2016	418	1139	353	847	383	365	184
2017	408	1137	342	845	371	369	173

Table 3: Summary Statistics Full Sample

Variable	Mean	St. Dev.	Pctl(25)	Median	Pctl(75)
$CAR_{d-1,d+1}$	−0.041	0.081	−0.084	−0.040	0.004
SUE	0.031	1.088	−0.657	0.075	0.715
$Ret_{[-30,-1]}$	0.0004	0.021	−0.006	−0.0001	0.006
$Ret_{[-120,-31]}$	−0.001	0.015	−0.007	−0.001	0.004
$\lvert Ret_{[-30,-1]}\rvert$	0.012	0.017	0.002	0.006	0.015
$\lvert Ret_{[-120,-31]}\rvert$	0.009	0.012	0.002	0.005	0.011
$\lvert ret\_30\rvert$	0.007	0.011	0.001	0.003	0.008
$StdVol\_30$	−0.080	0.916	−0.521	−0.386	−0.170

Figure 1: Absolute Return (Volatility) and Standardised Volume around EA before and after the regulation change at 1-minute frequency. Table 1 provides the variable definitions.

(a)Absolute Return (Volatility)



(b) Standardised Volume

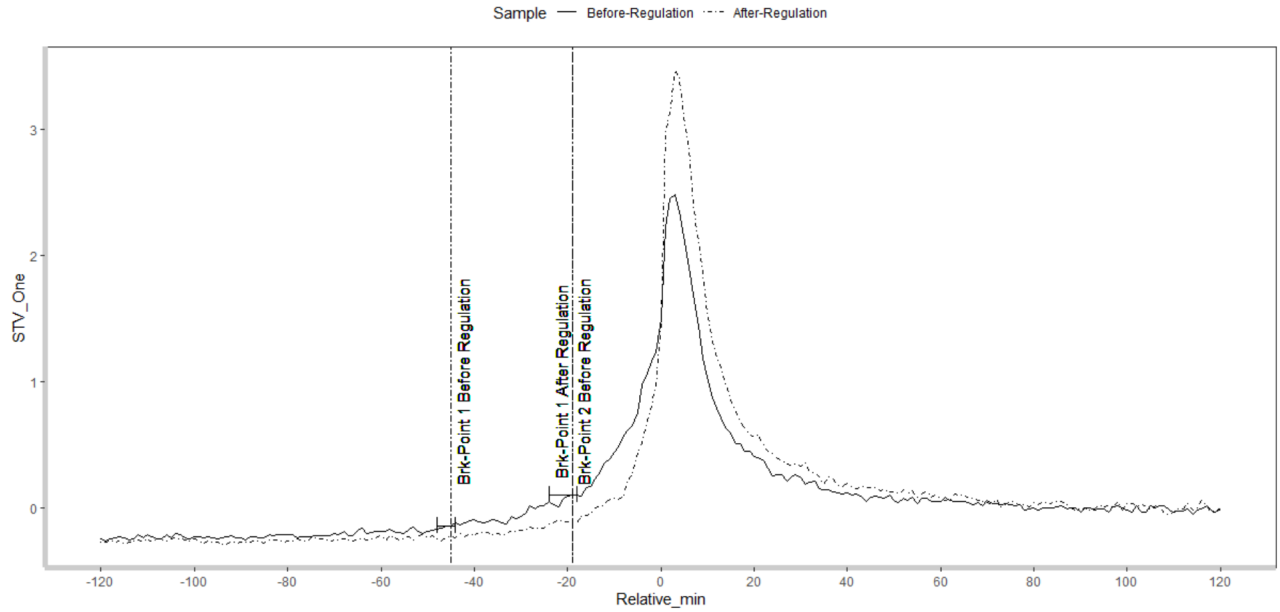


Table 4: Influence of regulation over information leakage

The table shows the regression results of Equation 5. For column (1) & (2) dependent variable us $|ret\_30|$ and for column (3) & (4) dependent variable is $StdVol\_30$. Independent variables are 30-minute relative time dummies. See Table 1 for variable construction details. All fixed effect models have firm level fixed effects and standard error is clustered at firm level. Standard errors are shown in parenthesis. ***, **, and * reflect significance at the 1, 5, and 10% levels, respectively.

Dependent variable:	$\|ret\_30\|$		$StdVol\_30$	
	Without FE	*With FE*	*Without FE*	*With FE*
	(1)	(2)	(3)	(4)
$\Delta t_{[-90,-61]}$	−0.00001	−0.00005	0.036	0.033**
	(0.0003)	(0.0002)	(0.024)	(0.015)
$\Delta t_{[-60,-31]}$	0.002***	0.001***	0.169***	0.162***
	(0.0003)	(0.0003)	(0.024)	(0.021)
$\Delta t_{[-30,-1]}$	0.008***	0.008***	1.085***	1.074***
	(0.0003)	(0.0005)	(0.024)	(0.036)
$Post\_Reg$	−0.001**	−0.001***	−0.044*	−0.041***
	(0.0004)	(0.0002)	(0.027)	(0.015)
$\Delta t_{[-90,-61]} \times Post\_Reg$	−0.00004	−0.00000	−0.018	−0.015
	(0.0005)	(0.0003)	(0.038)	(0.019)
$\Delta t_{[-60,-31]} \times Post\_Reg$	−0.001***	−0.001***	−0.086**	−0.080***
	(0.0005)	(0.0003)	(0.037)	(0.027)
$\Delta t_{[-30,-1]} \times Post\_Reg$	−0.003***	−0.002***	−0.420***	−0.410***
	(0.0005)	(0.001)	(0.037)	(0.046)
Constant	0.005***		−0.341***	
	(0.0002)		(0.017)	
Observations	16,167	16,167	16,166	16,166
Adjusted R^2	0.077	0.129	0.191	0.207

Table 5: Surprise Prediction

The table shows the regression results of Equation 7 and 8, where pre-EA returns are used to predict the EA surprise. Column (1) to (4) show results of Equation 7 and column (5) and (6) for Equation 8. All columns have firm-level fixed effects and standard errors clustered at firm level. ***, **, and * reflect significance at the 1, 5, and 10% levels, respectively.

	Before-regulation		After-regulation			
Dependent variable:	$CAR_{d-1,d+1}$	SUE	$CAR_{d-1,d+1}$	SUE	$CAR_{d-1,d+1}$	SUE
	(1)	(2)	(3)	(4)	(5)	(6)
$Ret_{[-30,-1]}$	0.718***	8.913***	0.748***	6.537***	0.815***	9.273***
	(0.171)	(1.480)	(0.090)	(1.674)	(0.187)	(1.625)
$Ret_{[-120,-31]}$	1.084***	6.959***	0.668***	−1.136	1.140***	7.034***
	(0.126)	(2.111)	(0.156)	(2.809)	(0.128)	(2.021)
$Post\_Reg$					−0.006*	0.015
					(0.003)	(0.055)
$Ret_{[-30,-1]} \times Post\_Reg$					−0.027	−2.555
					(0.188)	(2.272)
$Ret_{[-120,-31]} \times Post\_Reg$					−0.373*	−9.226***
					(0.198)	(3.535)
Observations	2,072	1,665	1,477	1,410	3,549	3,075
Adjusted R^2	0.406	0.074	0.381	0.065	0.349	0.034

Table 6: Price Discovery Analysis

The table reports the estimated value of WPC (Equation 9) and $WPCT$ (Equation 10) of every period of EA day for before and after-regulation subsamples separately. The 'Difference' column reports the difference of after- and before- regulation subsample WPC or $WPCT$ of a particular period. The t-stats column reports the t-value of difference in mean test.

Panel-A	Weighted Price Contribution (WPC)			
Subsample	Before-regulation	After-regulation	Difference	t-stats
$WPC_{[-120,-61]}$	0.080	0.070	-0.011	-0.868
$WPC_{[-60,-31]}$	0.068	0.030	-0.038	-2.755
$WPC_{[-30,-1]}$	0.224	0.172	-0.053	-1.96
$WPC_{[0,\ 30]}$	0.343	0.495	0.152	3.578
$WPC_{[31,\ 60]}$	0.084	0.092	0.008	0.566
$WPC_{[61,\ close]}$	0.201	0.143	-0.059	-2.548

Panel-B	Weighted Price Contribution Per Trade (WPCT)			
Subsample	Before-regulation	After-regulation	Difference	t-stats
$WPCT_{[-120,-61]}$	1.044	0.960	-0.084	-0.533
$WPCT_{[-60,-31]}$	1.015	0.624	-0.391	-1.837
$WPCT_{[-30,-1]}$	1.357	1.643	0.286	2.26
$WPCT_{[0,\ 30]}$	0.98	1.065	0.086	1.411
$WPCT_{[31,\ 60]}$	0.755	0.714	-0.042	-0.384
$WPCT_{[61,\ close]}$	0.831	0.764	-0.067	-0.785

Table 7: Information Leakage Around Surprise

The table shows the regression results of Equation 11. Column (1) and (2) show the results when $|Ret_{[-120,-31]}|$ is used as the dependent variable, and column (3) and (4) show the results when the dependent variable is $|Ret_{[-30,-1]}|$. All models have firm level fixed-effects. ***, **, and * reflect significance at the 1, 5, and 10% levels, respectively.

Dependent variable:	$\|Ret_{[-120,-31]}\|$		$\|Ret_{[-30,-1]}\|$	
	(1)	(2)	(3)	(4)
Ex-ante Surprise	0.001^{*}		0.004^{***}	
	(0.001)		(0.001)	
Ex-ante Surprise × Post_Reg	-0.002^{**}		-0.004^{***}	
	(0.001)		(0.001)	
Ex-post Surprise		0.001^{**}		0.002^{***}
		(0.001)		(0.001)
Ex-post Surprise × Post_Reg		-0.001		-0.001
		(0.001)		(0.001)
Post_Reg	-0.001^{**}	-0.002^{***}	-0.002^{**}	-0.003^{***}
	(0.001)	(0.001)	(0.001)	(0.001)
Observations	3,479	3,549	3,563	3,627
Adjusted R^2	0.108	0.111	0.094	0.080

Table 8: Placebo Regression

The table reports the regression result of Equation 5. Column (1) - (4) shows the result of before-regulation subsample and column (5)-(6) show the result of after-regulation subsample. For before-regulation subsample pseudo regulation date is assumed as 02/06/2014, and for after-regulation subsample pseudo regulation is assumed as 02/12/2016. All fixed effect models have firm level fixed effects with errors clustered at firm level. ***, **, and * reflect significance at the 1, 5, and 10% levels, respectively.

	Before-Regulation subsample				After-Regulation subsample			
Dependent variable:	$\|ret\_30\|$		$StdVol\_30$		$\|ret\_30\|$		$StdVol\_30$	
	Without FE	*With FE*	*Without FE*	*With FE*	*Without FE*	*With FE*	*Without FE*	*With FE*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Delta t_{[-90,-61]}$	−0.0003	−0.0004	0.047	0.045*	0.0001	0.0001	0.019	0.018
	(0.001)	(0.0003)	(0.038)	(0.024)	(0.0004)	(0.0003)	(0.034)	(0.016)
$\Delta t_{[-60,-31]}$	0.002***	0.002***	0.214***	0.206***	0.0003	0.0003	0.111***	0.109***
	(0.0005)	(0.0004)	(0.037)	(0.034)	(0.0004)	(0.0003)	(0.034)	(0.022)
$\Delta t_{[-30,-1]}$	0.008***	0.007***	1.216***	1.202***	0.005***	0.005***	0.642***	0.640***
	(0.0005)	(0.001)	(0.037)	(0.049)	(0.0004)	(0.001)	(0.034)	(0.043)
Post_Reg	−0.001***	−0.001***	−0.098**	−0.098***	−0.001*	−0.001***	−0.008	−0.008
	(0.001)	(0.0004)	(0.038)	(0.024)	(0.0004)	(0.0003)	(0.034)	(0.018)
$\Delta t_{[-90,-61]} \times$ *Post_Reg*	0.001	0.001	−0.024	−0.025	−0.0003	−0.0003	−0.001	−0.001
	(0.001)	(0.0004)	(0.053)	(0.029)	(0.001)	(0.0003)	(0.048)	(0.023)
$\Delta t_{[-60,-31]} \times$ *Post_Reg*	−0.0005	−0.0003	−0.098*	−0.096**	−0.0001	−0.0001	−0.056	−0.058*
	(0.001)	(0.001)	(0.053)	(0.039)	(0.001)	(0.0004)	(0.047)	(0.031)
$\Delta t_{[-30,-1]} \times$ *Post_Reg*	0.001	0.001	−0.273***	−0.274***	0.0004	0.0004	0.047	0.044
	(0.001)	(0.001)	(0.052)	(0.059)	(0.001)	(0.001)	(0.047)	(0.060)
Constant	0.006***		−0.292***		0.005***		−0.381***	
	(0.0004)		(0.027)		(0.0003)		(0.024)	
Observations	9,488	9,488	9,488	9,488	6,679	6,679	6,678	6,678
Adjusted R^2	0.075	0.127	0.210	0.226	0.066	0.141	0.140	0.165

Annexure

Figure A1: Distribution of during market hour EA

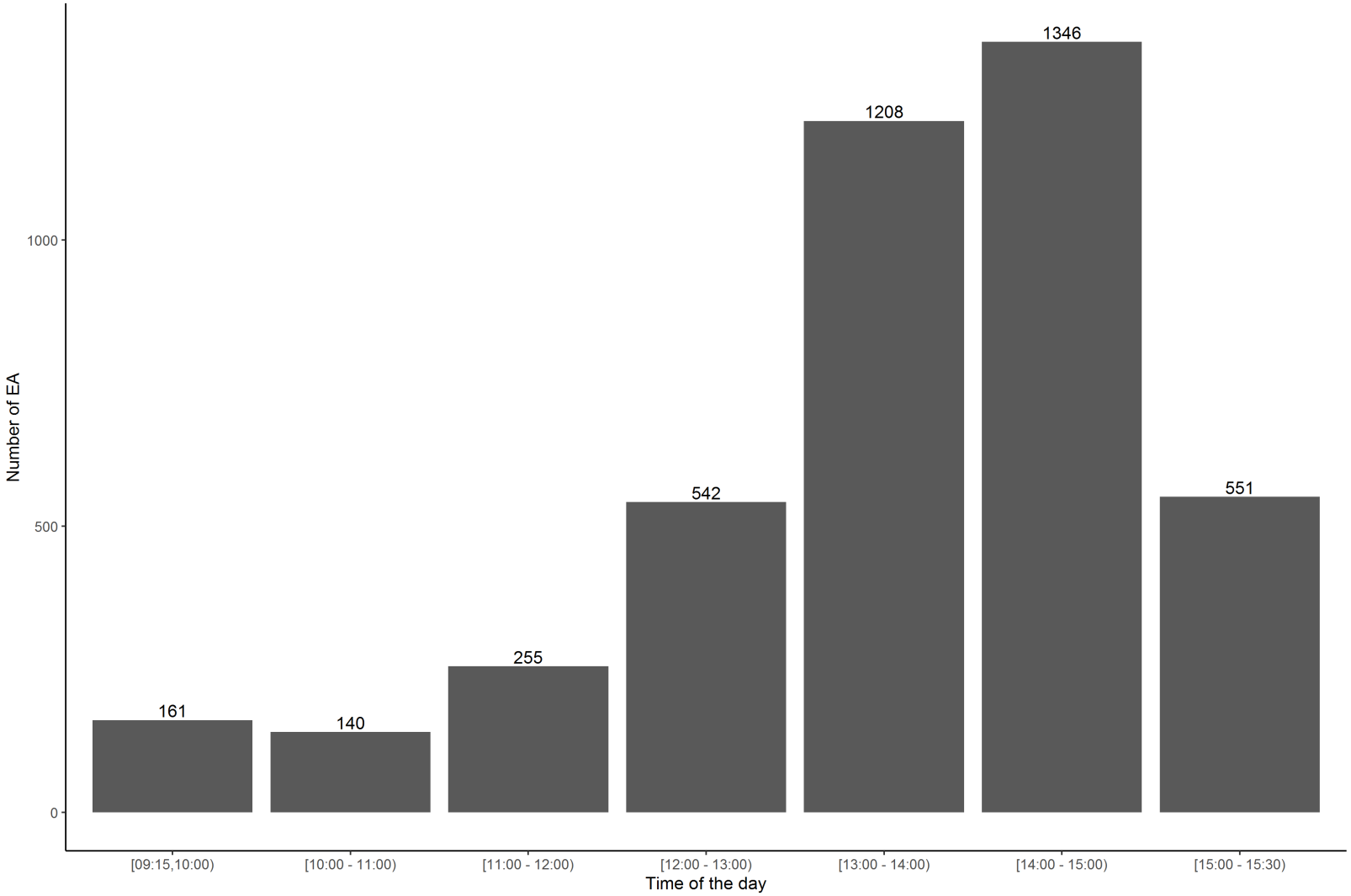


Table A1 : Regression at 10 minute frequency

The table shows regression results of Equation 6 for two subsamples with $|ret\_10|$ as dependent variable. Column (1) and (3) show before-regulation (01/01/2013 - 01/12/2015) and Column (2) and (4) after-regulation (02/12/2015 - 31/12/2017) subsample results. Fixed effect models have firm level fixed effects and standard errors are clustered at firm level. Standard errors are shown in parenthesis. Independent Variables are 10 minute relative time interval dummies. See Table 1 for variables construction details. ***, **, and * reflect significance at the 1, 5, and 10% levels, respectively.

Dependent variable:	$\|ret\_10\|$			
	Without FE		*With FE*	
	(1)	(2)	(3)	(4)
Δt_{-11}	0.00004 (0.0003)	−0.00002 (0.0003)	0.00002 (0.0001)	−0.00002 (0.0001)
Δt_{-10}	−0.0001 (0.0003)	−0.0001 (0.0003)	−0.0001 (0.0001)	−0.0001 (0.0001)
Δt_{-09}	0.00005 (0.0003)	−0.0002 (0.0003)	0.00001 (0.0001)	−0.0002* (0.0001)
Δt_{-8}	0.00002 (0.0003)	−0.0001 (0.0003)	−0.00002 (0.0001)	−0.0001 (0.0001)
Δt_{-7}	0.0001 (0.0003)	−0.0002 (0.0003)	0.0001 (0.0001)	−0.0002 (0.0001)
Δt_{-6}	0.0004 (0.0003)	0.0001 (0.0003)	0.0004*** (0.0002)	0.0001 (0.0001)
Δt_{-5}	0.001*** (0.0003)	−0.00003 (0.0003)	0.001*** (0.0002)	−0.00003 (0.0001)
Δt_{-4}	0.001*** (0.0003)	0.0002 (0.0003)	0.001*** (0.0002)	0.0002 (0.0001)
Δt_{-3}	0.002*** (0.0003)	0.001** (0.0003)	0.001*** (0.0002)	0.001*** (0.0002)
Δt_{-2}	0.003*** (0.0003)	0.001*** (0.0003)	0.003*** (0.0002)	0.001*** (0.0002)
Δt_{-1}	0.007*** (0.0003)	0.005*** (0.0003)	0.007*** (0.0003)	0.005*** (0.0003)
Δt_{-0}	0.001*** (0.0003)	0.002*** (0.0003)	0.001*** (0.0002)	0.002*** (0.0002)
Δt_{1}	0.011*** (0.0003)	0.014*** (0.0003)	0.011*** (0.001)	0.014*** (0.001)
Δt_{2}	0.005*** (0.0003)	0.006*** (0.0003)	0.005*** (0.0002)	0.006*** (0.0004)
Δt_{3}	0.003*** (0.0003)	0.004*** (0.0003)	0.003*** (0.0002)	0.004*** (0.0002)
Δt_{4}	0.002*** (0.0003)	0.003*** (0.0003)	0.002*** (0.0002)	0.003*** (0.0002)
Δt_{5}	0.002*** (0.0003)	0.003*** (0.0003)	0.002*** (0.0002)	0.003*** (0.0002)
Δt_{6}	0.002*** (0.0003)	0.002*** (0.0003)	0.002*** (0.0002)	0.002*** (0.0002)
Δt_{7}	0.002*** (0.0003)	0.002*** (0.0003)	0.001*** (0.0002)	0.002*** (0.0002)
Δt_{8}	0.001*** (0.0003)	0.002*** (0.0003)	0.001*** (0.0002)	0.002*** (0.0002)
Δt_{9}	0.001*** (0.0003)	0.001*** (0.0003)	0.001*** (0.0002)	0.002*** (0.0002)
Δt_{10}	0.001*** (0.0003)	0.001*** (0.0003)	0.001*** (0.0002)	0.001*** (0.0002)
Δt_{11}	0.001*** (0.0003)	0.001*** (0.0003)	0.001*** (0.0002)	0.002*** (0.0002)
Δt_{12}	0.001*** (0.0003)	0.001*** (0.0004)	0.001*** (0.0002)	0.002*** (0.0002)
Constant	0.003*** (0.0002)	0.003*** (0.0002)		
Observations	51,774	35,620	51,774	35,620
Adjusted R^2	0.078	0.146	0.131	0.196

Table A2: Regression at 10 minute frequency

The table shows regression results of Equation 6 for two subsamples with $StdVol\_10$ as dependent variable. Column (1) and (3) show before-regulation (01/01/2013 - 01/12/2015) and Column (2) and (4) after-regulation (02/12/2015 - 31/12/2017) results. Fixed effect models have firm level fixed effects and standard errors are clustered at firm level. Standard errors are shown in parenthesis. Independent Variables are 10 minute relative time dummies. See Table 1 for variables construction details. ***, **, and * reflect significance at the 1, 5, and 10% levels, respectively.

Dependent variable:	$StdVol\_10$			
	Without FE		*With FE*	
	(1)	(2)	(3)	(4)
Δt_{-11}	0.012 (0.031)	0.017 (0.030)	0.013 (0.012)	0.018* (0.011)
Δt_{-10}	0.009 (0.031)	−0.011 (0.030)	0.010 (0.014)	−0.010 (0.010)
Δt_{-9}	0.017 (0.031)	0.002 (0.030)	0.018 (0.014)	0.004 (0.011)
Δt_{-8}	0.018 (0.031)	0.018 (0.030)	0.020 (0.014)	0.020 (0.013)
Δt_{-7}	0.068** (0.031)	0.019 (0.030)	0.070*** (0.017)	0.021 (0.013)
Δt_{-6}	0.077** (0.031)	0.047 (0.030)	0.080*** (0.019)	0.048*** (0.015)
Δt_{-5}	0.138*** (0.031)	0.047 (0.030)	0.143*** (0.021)	0.049*** (0.014)
Δt_{-4}	0.196*** (0.030)	0.090*** (0.030)	0.203*** (0.023)	0.093*** (0.016)
Δt_{-3}	0.330*** (0.030)	0.155*** (0.030)	0.340*** (0.025)	0.158*** (0.021)
Δt_{-2}	0.576*** (0.030)	0.294*** (0.030)	0.586*** (0.033)	0.297*** (0.028)
Δt_{-1}	1.406*** (0.030)	0.959*** (0.030)	1.418*** (0.050)	0.963*** (0.047)
Δt_{0}	0.013 (0.031)	0.079*** (0.031)	0.013 (0.016)	0.081*** (0.016)
Δt_{1}	2.927*** (0.030)	4.106*** (0.030)	2.941*** (0.060)	4.114*** (0.061)
Δt_{2}	1.185*** (0.030)	1.613*** (0.030)	1.201*** (0.034)	1.624*** (0.034)
Δt_{3}	0.742*** (0.031)	0.981*** (0.030)	0.759*** (0.027)	0.995*** (0.028)
Δt_{4}	0.555*** (0.031)	0.723*** (0.031)	0.575*** (0.024)	0.739*** (0.024)
Δt_{5}	0.460*** (0.031)	0.583*** (0.031)	0.484*** (0.024)	0.602*** (0.023)
Δt_{6}	0.421*** (0.032)	0.531*** (0.032)	0.448*** (0.024)	0.553*** (0.023)
Δt_{7}	0.389*** (0.032)	0.476*** (0.033)	0.419*** (0.024)	0.503*** (0.026)
Δt_{8}	0.339*** (0.033)	0.432*** (0.034)	0.372*** (0.024)	0.463*** (0.023)
Δt_{9}	0.320*** (0.034)	0.409*** (0.035)	0.358*** (0.024)	0.445*** (0.024)
Δt_{10}	0.326*** (0.035)	0.374*** (0.036)	0.368*** (0.026)	0.416*** (0.027)
Δt_{11}	0.310*** (0.035)	0.347*** (0.038)	0.357*** (0.027)	0.394*** (0.027)
Δt_{12}	0.272*** (0.037)	0.370*** (0.040)	0.326*** (0.025)	0.425*** (0.030)
Constant	−0.302*** (0.022)	−0.336*** (0.021)		
Observations	51,774	35,619	51,774	35,619
Adjusted R^2	0.300	0.523	0.302	0.523