How Quickly Do Markets Learn? Private Information Dissemination in a Natural Experiment*

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ABSTRACT

Using data from a unique episode in which the SEC disseminated securities filings to a small group of private investors before releasing them to the public, we provide a direct test of the process through which private information is impounded into stock prices. Because the delay between the time when the filings were privately distributed and when the filings were made public was randomly distributed, our setting provides a rare natural experiment for examining how markets process new private information. We find that it takes minutes—not seconds—for informed traders to incorporate fundamental information into stock prices. We also show that the private investors who had early access to fundamental information profited more, and convey more information into stock prices, when the delay before the filings are released to the public is longer. More importantly, the rate at which information is impounded into stock prices is more correlated with the length of the *predicted* delay before public release than the actual delay, suggesting that informed investors trade strategically. Our study serves as the modern counterpart to Koudijs's (2014a) study on insider trading on eighteenth-century stock exchanges—except, in our case, week-long sailing voyages have been replaced by modern electronic transmission as the conduit for information flows.

INTRODUCTION

For more than two decades, the Securities and Exchange Commission (SEC) has provided investors with access to securities filings containing market-moving information through its Electronic Data Gathering, Analysis, and Retrieval, or EDGAR, system, which is available through the SEC's website. For years, however—unbeknownst to investors, lawmakers, and the public—a small group of private investors have consistently been given early access to these filings before they are released via EDGAR. A government contractor operating a service known as the public dissemination service, or PDS, distributed SEC filings to a small number of paying subscribers moments before they reached the public.[1] In October 2014, the *Wall Street Journal* exposed the issue,[2] drawing immediate demands from several Members of Congress that the SEC examine the problem.[3] Two months later, SEC Chairman Mary Jo White pledged to Congress that the Commission would soon eliminate PDS subscribers' advantage.[4]

While lawmakers' outrage in response to these revelations was understandable, we were more intrigued by a rare opportunity presented by the episode. Before the problem was revealed to the public, Jackson and Mitts (2014) designed and implemented software that allowed us to track the moment when filings reached PDS subscribers and the public EDGAR website. The data effectively give us a lab-like setting for studying how speculators trade on, and how the stock market processes, private information. Specifically, the setting gives us the following two features that are typically not available to researchers in this area.

First, we are able to detect *both* the arrival as well as the nature of private information. While the theoretical literature (pioneered by Glosten and Milgrom (1985) and Kyle (1985)) has developed a

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[1] As described in greater detail below, before this issue was revealed to the public, we subscribed to the PDS service ourselves in order to study the effects of the early dissemination of market-moving information.

[2] Patterson and Tracy (2014) first revealed the PDS advantage to the public. Two of us provided detailed analysis of the timing of the delivery of filings through the SEC's systems that was featured in that article as a critical piece of evidence (Jackson and Mitts, 2014)).

[3] For example, U.S. Senators Tim Johnson and Mike Crapo, the Chairman and Ranking Member of the Senate Committee on Banking, Housing, and Urban Affairs, wrote to SEC Chairman Mary Jo White lamenting the "unequal access" to information provided on SEC-managed systems and demanding that the SEC take steps to "understand and eliminate this disparity."

[4] Chairman White's letter, sent in December 2014, specified that the SEC would, by early 2015, "implement[] an enhancement to our system . . . to ensure that EDGAR filings are available to the public on the SEC website before such filings are made available to PDS subscribers."

thorough framework for how securities prices incorporate private information through the work of informed traders, there are few direct empirical tests of these important theories. That is because private information is, by definition, not public knowledge; thus, neither the timing of its arrival, nor its content, is observable by econometricians. In our setting, we observe the exact time of the arrival of information to a small group of investors (the time at which the filing first reaches PDS subscribers) as well as the nature of the information the investors receive (the content of the filings).

Second, we are able to measure *how long* informed traders have the information before the filings reach the public—that is, we can detect the beginning and the end of the window during which informed traders can take advantage of their information. Critically, as explained below, the duration of the "private window" in our setting varies randomly, allowing us to identify the incorporation of private information in a quasi-experimental setting. Although the SEC claimed that PDS subscribers received filings "at the same time" as filings were posted to the SEC's website, in fact the technical limitations of the EDGAR system led to delays of random length between the time when PDS subscribers received filings and when those filings were posted to EDGAR.[5] The variation in the length of the "private window" in our setting is thus exogenous in the sense that it was beyond the control of all of the parties involved, and thus could not be correlated with any of our variables of interest. This unique source of exogenous variation allows us to draw rare causal inferences about the process through which markets incorporate information into public-company stock prices.

Our study includes three principal findings. First, as one might predict, we find that the profits that accrue to informed traders increase with the length of the delay until the information becomes public. Throughout our entire sample of SEC filings, informed traders earn between six and nine basis points per 100-second delay. The gains are significantly larger, however, for the subset of filings that are especially

[5] As explained below, the length of the delay did depend, in part, upon the volume of filings being submitted to the systems at each point in time. In particular, the delay was longest at approximately 4:00 PM Eastern Standard Time, when markets closed and these systems tended to be overwhelmed by the volume of submissions. The time of day was only a noisy predictor of the length of the "private window," however, which was otherwise randomly distributed.

"newsworthy." These filings, on average, generated a one-day abnormal return of 2% or higher for the small group of private investors who received the filings early.

Second, we find that informed traders take several minutes—not seconds—to impound new fundamental information into stock prices. Contrary to popular intuition driven by the high-frequency trading that has captured headlines, we show that, unlike trading information such as order flow, fundamental information is not incorporated into stock prices in seconds. Indeed, we observe little price impact during the first 100 or so seconds into the "private window," and it takes five to six minutes of trading by informed investors for the price to impound just half of the total effect of the information. In addition, we find that the speed at which stock prices incorporate private information—which serves as a proxy for the aggressiveness with which informed investors trade on their private information—is two to three times higher during the period when informed investors would ex ante expect there to be a "private window," as opposed to unexpected portions of that window. That contrast is consistent with the notion that informed investors engage in strategic trading, attempting to maximize profits by smoothing out the price impact of their trading over the expected time during which they will have an informational advantage (Caldentey and Stacchetti (2010)).

Finally, we analyze whether informed trading leads investors to "overreact" to the public release of information on the EDGAR website because the public is unaware that the information is stale. We find that a significant proportion of the abnormal return we observe after filings are posted to the EDGAR website is reversed during the subsequent four days—but only in cases where the delay between the private and public release of the information was more than 100 seconds. To the extent that the duration of the private window is positively correlated with the staleness of the information when it was released to the public, it is not surprising that the reversal is generally increasing in the length of delay. The lack of a return reversal (reflecting an overreaction) when the delay was brief—that is, when the time between private and public release of the information was 100 seconds or less—suggests that the only reason for the overreaction in other cases was investors' ignorance of the early leakage.

Our study makes a distinct contribution to the vast literature on information and asset pricing by making usually unobservable private information the subject of empirical tests, complementing the common approaches that rely on transaction and order flow information (for a comprehensive survey, see Easley and O'Hara (2003)). Given the fundamental role of financial markets in the aggregation of information and allocation of investment capital (for a detailed survey, see Bond, Edmans, and Goldstein (2012)), our study sheds light on exactly how the stock market performs that role. Importantly, our study complements, but is distinct from, several recent papers that assess the relationship between the distribution of information to investors through the internet and price discovery (Bauguess, Cooney, and Hanley (2013), Drake, Toulstone, and Thornock (2014), Loughran and McDonald (2014)), because the subject of our study is private—rather than public—information.[6]

The recent work most relevant to our study is likely Collin-Dufresne and Fos (2013a) and Koudijis (2014a, b), both of which adopted ingenious research designs to identify the path of private information and the consequent effect on stock prices. Our design differs from that of Collin-Dufresne and Fos (2013a), however, in that the private information in our study relates to the financial and operational—that is, the fundamental—condition of the firm itself. By contrast, the private information studied in Collin-Dufresne and Fos (2013a) is about the *trader*'s intention to intervene rather than about the current state of the firm. As a result, both the creation and duration of the private information are endogenous to the informed trader, which imply critically different strategic behaviors in trading on private information (Collin-Dufresne and Fos (2013b)).

Much more related, however, is Koudijis (2014a, b), which uses boats carrying mail between London and Amsterdam during the 18th century as the conduit for information flow to the stock exchanges in both cities to uncover the strategic behavior of informed trading as well as the relation between information and volatility in securities prices. Like Koudijis, we study how information reaches

[6] Two other recent working papers analyze market responses to private information before its public release (see Hu et al. (2013) and Rogers et al. (2014)). As explained above, however, our setting features random variation in the window during which investors have private information, unlike in Hu et al (2013). Rogers et al. (2014) analyzes the same episode as we do, but that study covers only one of the many types of SEC filings in our sample and does not take advantage of, or mention, the random variation in the private-information window.

and is processed by markets, although we use electronic dissemination as the 21st-century equivalent of boats as transmitters of information. Also like Koudijis, we take advantage of an exogenous source of random variation—in our case, random delays in electronic transmission, and in his, inclement weather that delayed boats at random—to identify how markets process private information. Over the course of the last three centuries, boat journeys that took weeks have been replaced by electronic signals that reach their destinations in seconds as the means for disseminating value-relevant information to investors. We believe that studying similar episodes from these two different eras will offer new insights as to how markets have processed private information in the past—and how they might do so in the future.

I. DATA AND SUMMARY STATISTICS

A. Data

U.S. securities laws impose rigid rules on publicly traded companies that require these firms to disclose material information about themselves to investors in a timely manner. These disclosures are typically provided in the form of securities filings submitted to the SEC. As a result, the SEC has become the central repository for the information that moves markets. Specifically, the SEC's EDGAR system, first launched in the 1990s, is the central portal through which firms can disclose, and investors can retrieve, new information about the firm's fundamental value.

When a company submits a securities filing to the SEC, the filing is distributed to three locations. First, the filing becomes available on the SEC's public file transfer protocol (FTP) server. Second, a private contractor detects new filings located on the FTP server and, through a service known as the public dissemination service, or PDS, distributes the filing to a small group of about forty subscribers at a cost of approximately $15,000 per year. Finally, the filing is uploaded to the SEC's EDGAR system, which is available to the investing public through the SEC's website. While in theory these systems should operate simultaneously, in fact technical limitations of these systems led to random delays between the time when filings were distributed to PDS subscribers and when they were made available to the public on EDGAR. Thus, investors with access to the SEC's FTP server, or with a PDS subscription, received filings before other investors could access those filings on the SEC's EDGAR website. The length of the delay ranged from a few seconds to as long as several minutes.[7]

Our study builds on previous work by two of us that collected a detailed dataset including the exact timestamps when filings were posted to the FTP server, distributed to PDS subscribers, and made available on the EDGAR website a sample of recorded exact timestamps when filings were released on the FTP system and the EDGAR website from June 25 to October 15, 2014; our data for delivery of filings to PDS subscribers begins on August 1, 2014.[8] Using the overlapping part of the sample, we found that the FTP and PDS timestamps are almost identical with differences of no more than a few seconds. As such, we use the FTP timestamp as a proxy for the time advantage of the "early informed" in order to preserve a larger sample. Thus, for purposes of our study, sophisticated investors could become a member of the early informed either by directly accessing the FTP site or subscribing to the PDS service by paying approximately $15,000 per year.

This group of informed investors is expected to be small relative to the number of all market participants. While early access via FTP was technically challenging, and PDS subscriptions were granted only to about forty paying subscribers. There is anecdotal evidence suggesting that some of these PDS subscribers were wire services,[9] but end-users likely did not have real-time access to the original filings. The wire services disseminate news in real time in the form of quick summaries of the original filing, but the time it takes to write and post new articles would easily offset the PDS time lead over EDGAR. With respect to early access via FTP, the SEC has not provided data on the number of users of

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[7] As noted above, the *Wall Street Journal* revealed the existence of the delay on October 28. Based on additional research by two of us (Jackson and Mitts, 2014), the *Journal* reported several days later that the delay had substantially narrowed after initial reports of the delay were made public (Ackerman et al., 2014).

[8] Our data for delivery to PDS subscribers begins on August 1, 2014, and continues through the end of the sample period. We obtained the EDGAR website timestamp by monitoring the RSS version of the "Latest Filings" feed that the SEC provides to the public. The FTP timestamp was obtained by querying the FTP server for the "last modified" date of the filing. The PDS timestamp was obtained by recording the exact time a filing was delivered to the PDS subscription maintained by Jackson and Mitts (2014). We also recorded the timestamp indicating when each filing was "accepted" by the SEC, which likely reflects the time when the filing was uploaded to the SEC before it is disseminated through FTP and the SEC's website.

[9] The SEC declined to provide a list of subscribers. According to news reports (Patterson 2014; Ackerman et al. 2014), the group of PDS subscribers include several major financial news and data providers, including Dow Jones Newswire and Morningstar, Inc.

the FTP server at any single point in time. In general, utilizing the FTP server to detect unexpected filings is technically difficult, as an interested investor would be required to navigate to the server directory associated with a particular firm. Because it is difficult to know ex ante which firms will file unexpected or unscheduled filings—which constitute about 95% of our sample—we think that the number of investors with early access to filings via FTP is relatively small.[10]

B. Sample

Our entire dataset starts with 101,555 filings public companies made with the SEC from June 25, 2014 to October 15, 2014, with the exception of July 15, 2014, as technical difficulties with connecting to the SEC's systems prevented us from collecting data on that day. As most of these filings were made by firms whose shares are not traded on a public exchange, our sample consists of only those filings made by publicly traded firms. Moreover, we remove filings that arrived to the EDGAR website prior to the FTP server, which occurs infrequently but happened occasionally because of the random nature of the FTP-EDGAR delay. We also remove filings that occur within one day of a previous filing by the same issuer. These additional filters reduce our sample to 42,619 filings.[11]

For each filing, we obtain individual trades in the issuer's primary shares from the NYSE TAQ database, beginning at the FTP timestamp and concluding at 10 minutes following the EDGAR website timestamp. Restricting the sample further to filings having at least one trade in the TAQ data during the time lag between the FTP and EDGAR timestamps further reduces the sample size to 3,394 filings, or about 8% of the total filings by public companies during our sample period. This small percentage was due to two causes: First, most of the filings involve issuers with low trading volume throughout the day;

[10] It is possible, however, to observe the "file created" date ex post and thereby identify the time that a filing is deposited on the FTP server—and this is how the authors obtained the FTP timestamps. After the delay in SEC filing release was publicly revealed, the authors' requests to FTP servers were almost always denied during the day with the error message that the maximum number of allowed clients (50) were already connected. The fact that earlier requests were never denied indicates that few people were attempting at the FTP during our sample period, and that more investors started to pursue the FTP when its advantage was discovered and when the PDS advantage diminished at the same time.

[11] To determine whether a firm is publicly traded, we search for an entry for the firm in the CRSP and Compustat table that links an entity's CIK to its exchange ticker.

second, in most of the remaining cases the random delay was too short for the early informed to react before the information becomes public on the EDGAR website. For example, the median delay for filings without a trade between the FTP and EDGAR timestamps was 22 seconds, compared to 151 seconds among filings with at least one trade during the FTP-EDGAR gap.

Filings with trades between the FTP timestamp, but before the public release of the information on EDGAR, constitute our key sample for most of the analyses described below. This sample include 140 different filing types, where the most common are Form 8-K (timely disclosure of material corporate events), Form 4 (disclosure of insider trading; current U.S. securities law requires insiders to provide such disclosure within 48 hours of each trade), and Schedule 13D (disclosure of beneficial ownership with an intention to influence corporate control or policies, within 10 days from crossing the 5% threshold). The three form types combined make up 56.1% of the sample. Moreover, a great majority (94.7%) of the filings in our sample are non-scheduled, that is, they are contingent on circumstances rather than coming out at pre-set frequency (such as 10-Q and 10-K). This is important for our analyses because it implies that it is difficult for the market to discern leakage without knowing that a certain filing is forthcoming.

To set the stage, we define the following key points in the timeline of events:

[Insert Figure 1 here.]

t_1 : The PDS/FTP timestamp, or the time when the "early informed" receive the information.

t_2 : The EDGAR timestamp, or the time when the filing information becomes public. The difference $(t_2 - t_1)$ is thus the "private window," or the time lag during which the information remains private.

t_3 : A time proxy for the end of the period (t_2, t_3) during which public investors trade on the information revealed by the SEC filing.

t_4 : A time proxy for the time by which the stock price fully incorporates the new information, including adjusting properly from potential initial over-/under-reaction.

C. Summary statistics

Table 1 reports the distribution of the *Delay*, $(t_2 - t_1)$, in seconds, of the full sample as well as separately for the three major file types. The median delay for the full sample is 26 seconds, with an interquartile range of 7 to 172 seconds. The distributions are highly right-skewed, leading to both mean and variance values that are not representative of the sample. Unless otherwise specified, we impose an additional filter for sample inclusion that *Delay* must not exceed 466 seconds, or the 90th percentile value of the full sample. Trimming the extreme outliers not only limits the influence of extreme observations but also takes into account the possibility that the monitoring script may have periodically "hung" due to server overload, introducing erroneous delays into the data. We believe that the top decile reflects a conservative estimate of delays that are likely to be erroneous, but our results are robust using a lower cutoff such as 300 seconds. The last two rows report the truncated mean (131 seconds) and standard deviation (129 seconds), which reflect the central and dispersion tendencies of the trimmed sample.

[Insert Table 1 here.]

While the time lag between early and public release of filings is largely random, it does seem to be affected by the volume of submissions and traffic at the SEC's EDGAR servers. In fact, there is quite a distinct pattern of delay in relation to time of the day. Figure 2 demonstrates the daily pattern with an average plot of $(t_2 - t_1)$ by hourly bins from 6:00am to 9:00pm. The average delay reaches its peak (about 242 seconds) right after 4:00pm EST, the closing of the formal market of the trading day, presumably a time with high traffic causing delays in transmission of filings to the public EDGAR servers.

[Insert Figure 2 here.]

It is worth noting that trades take place before the market opening at 9:30am and continue after the close of the market at 4:00pm. The after-hour trades, including preopen (8:00 – 9:30am) and post close (4:00 – 6:30pm), are not a recent phenomenon as trades have been regularly executed on electronic communications networks (ECNs) for decades. For example, Barclay and Hendershott (2003) document that among the 250 highest volume stocks on Nasdaq in 2000, about 2.5% of the trading volume occurs pre-open and another 5.5% post-close. Pre-open and post-close trades account for 4.0% and 9.9% of our final sample. Our sample's over-representation of after-hours trades is consistent with Barclay and Hendershott's (2004) finding that adverse selection in trading starts higher in the early day, decreases over the course of the regular trading day, and increases immediately following the close of the market.

The variables of central interest to this study are the abnormal returns earned during various time windows. For an overview, we plot in Figure 3 the histogram of the average abnormal return during the private window, (t_1, t_2), where the benchmark return is that of the SPY, the most liquid exchange-traded fund (ETF) tracing the S&P 500 index. That is, $AR(t_1,t_2) = E_i[R_i(t_1,t_2) - R_m(t_1,t_2)]$. The sample is restricted to all filings for which there is at least one trade during the $(t_2 - t_1)$, i.e., trades containing some information content. The mean is essentially zero (–0.005 basis points), and the standard deviation is 35 basis points (after winsorizing at the 1% extremes). Figure 3 shows that the abnormal returns are roughly symmetric and have fatter tails than a comparable normal distribution.

[Insert Figure 3 here.]

II. RESULTS

A. Trading Profitability by the Early Informed

A1. Regression analysis

Given the "private window" that some trading participants enjoy via early access to SEC filings, the first natural question to explore is the profitability that such an opportunity offers for the informed traders. To this end, we compute the abnormal returns during the random intervals between the time of early access by the subscribers (the FTP time, or t_1) and the time of public release of the same filing (the public server time, or t_2), and relate them to length of delay, conditional on the sign of the ex post returns that incorporate the public digestion of the news.

In this analysis, the dependent variable is $AR_i(t_1,t_2)$, the abnormal returns (in basis points) of stock i during the time window (t_1,t_2) when information remains private, where i is the index for a stock whose issuer posts a SEC filing. The benchmark return is that of SPY, the exchange-traded fund (ETF) for the S&P 500 index portfolio. The choice of SPY over a broader based market portfolio reflects the need to have an instrument with sufficient trading liquidity at high frequencies. Given our interest in assessing how information is disseminated through trading, we include in this analysis only observations where stock *i* posts at least one transaction during the interval (t_1, t_2) in the TAQ trading data.

The key independent variable is *Delay*, which is $t_2 - t_1$ in seconds. We adopt both a short and a long window, (t_2, t_3), to allow the market to digest new information from the public release of the filings after t_2, resulting in two abnormal return measures capturing the information content of the filings for the short term. Henceforth we denote $t_3 = \{t_2 + 10\,\text{min}, d_1\}$ as the point of time when we record the new value of the security after the market digests the publicly released information. The two resulting measures, $AR_i(t_1, t_2 + 10\text{min})$ and $AR_i(t_1, d_1)$, represent abnormal returns from the early access time to 10 minutes after the public release, or to the market close of the following day.

Table 2 reports results from various permutations. To start with, Panel A shows the relation between $AR_i(t_1, d_1)$ and *Delay*, conditional on positive and negative news, where the latter is simply classified by the sign of $AR_i(t_1, d_1)$. In both directions, for every 100 seconds of incremental delay, the private informed traders gain additional 6.2 –8.6 basis points in profits. The magnitude of the gain is stable across all specifications, whether or not we include controls for file types and daily fixed effects, and are all statistically significant at the 1% level.

[Insert Table 2 here.]

Needless to say, all filings are not equal in their newsworthiness. As we increase the hurdle for positive/negative news classification by requiring $AR_i(t_1, d_1)$ to be more than 0.5%, 1%, and 2% in absolute value, the coefficients on *Delay* (with full controls) increases smoothly and monotonically, from 7 to 26 basis points per 100 second delay for positive news, and from 9 to 25 basis points for negative news. The results reported in Panel B of Table 2 are conditional on a positive/negative news hurdle of +2% or −2%. All specifications indicate that trading profitability significant increases with the length of delay; moreover, early access to negative information is more profitable than positive information. With full controls, every 100 second delay is associated with 16-21 basis points of additional abnormal returns for positive news; and the corresponding figure for negative news, 26-28 basis points, is about 50% higher.

To a large extent, the profitability opportunities for the early informed does not depend on the eventual equilibrium stock price that the market settles at one day after the public release of the information. Instead, the early informed can always front run the trades by the late informed—who were likely not aware of their information disadvantage. We thus consider an alternative positive/negative news classification using $AR_i(t_1, t_2 + 10\text{min})$, the abnormal returns during the shorter window until 10 minutes after the public release. This interval is meant to provide just enough time for the early informed to unwind their positions by trading against the late informed shortly after the information becomes public.

Results using this short window are reported in Panels C and D of Table 2. Using the sign of $AR_i(t_1, t_2 + 10\text{min})$ as classification of positive/negative news, the coefficients on *Delay* are stable, ranging from 7-9 basis points per 100 seconds' delay, and are all significant at the 1% level. If we use a more stringent cutoff $|AR_i(t_1, t_2 + 10\text{min})| > 1\%$[12], the coefficients rise to 36-94 basis points (significant at the 5% level or less), suggesting substantially higher profit opportunities from early access to more informative filings.

A2. Nonparametric analysis

Results in Table 2 offer a full picture, under a variety of specifications, of the average rate of profitability which is assumed to progress linearly with the time of delay. To entertain a non-linear relation, taking into account that it might take some (short) time before the market price incorporates private information, we resort to nonparametric analyses by running standard kernel regressions of the abnormal return, $AR(t_1, t_2)$, on the delay, $t_2 - t_1$, conditional on the nature of the news as proxied by the sign and magnitude of the ex post abnormal return, $AR(t_1, t_3)$. Panels A and B of Figure 4 provide a

[12] We opt for 1% rather than 2% as the threshold for "extreme" news because the subsample of observations with absolute abnormal returns greater than 2% is too small for reliable statistical analysis.

visualization of the cumulative trading profitability as the time advantage enjoyed by the early informed prolongs, separately for "extreme" positive and negative news using the $|AR_i(t_1, d_1)| > 2\%$ cutoff. The shapes of the graphs using only the sign of $AR_i(t_1, d_1)$ are similar with flatter slope.

[Insert Figure 4 here.]

The solid lines in the figures are the nonparametric regressions of $AR_i(t_1, t_2)$ versus *Delay* using the standard Gaussian kernel function, and the dotted lines represent the 90% confidence intervals obtained using bootstrapping with replacement. Several patterns emerge that are incremental to what one can learn from the regressions in Table 2. First, there is little price movement during the first 100 second of delay even for this sample of newsworthy events (such that the news will generate 2% or more in absolute abnormal returns after the public fully absorbs the news). This "inaction" region is somewhat surprising given all the attention given to high-frequency trading where informed trades and their price impact could occur on a millisecond scale.

Thus, the informed trading analyzed in our context is distinct from high-frequency trading, and there are two possibilities for the inaction at the short end of the delay. The first explanation is that it takes time (up to minutes and not seconds) for even the most sophisticated speculators to process new information about the fundamental value of a firm, which is distinct from information advantage from the knowledge of order flows. This possibility explains the finding of Rogers, et al. (2014) that the early informed traders react faster to information in Form 4 because Form 4 essentially reveals the order flow from the insiders. The direction of the trades in a Form 4 could be retrieved instantly, while assessing the nature of information disclosed in a Form 8-K takes more time. Alternatively, it may take up to 1 – 2 minutes before the informed trades are detected by market makers. This is also plausible given that a great majority (95%) of the filings analyzed in our sample are unscheduled. Hence, it might take time for market makers to form a certain level of belief regarding order flows from the early informed.

Second, impounding of private information seems to be saturated around the 5^{th} – 6^{th} minute for both positive and negative news. In fact, there seems to be a reversal after six minutes for the positive news subsample (though the scanty data density around that range does not allow use to conclude with statistical confidence). Delays beyond five minutes are uncommon and likely unexpected. As such, strategic training may occur, such that the full price impact is obtained during the first few minutes, and additional trades are not as profitable. Section II.B will analyze such strategic trading in more detail.

Analogous to Panels A and B of Figure 2, Panels C and D plot the nonparametric relation between abnormal returns during the private window against the length of delay using the $|AR_i(t_1, t_2 + 10\text{min})| > 1\%$ to classify positive or negative news. The patterns are similar except that the total trading profits are almost twice as larger. The higher profitability conditional on ex post returns in a shorter time window is expected because the filings are more likely to be the sole driver of price movement during the ten-minute window than the one-day window.

The combined results in Table 2 and Figure 4 affirm a robust opportunity for profitable trading by market participants who gained early access to firms' SEC filings. If we assume that they can trade in the right direction when the ex post abnormal return $AR_i(t_1, t_2 + 10\text{min})$ is greater than 1% in absolute terms (empirically, 81.4% of the time $AR_i(t_1, t_2)$ and $AR_i(t_1, t_2 + 10\text{min})$ have the same sign), and that they initiate a trade right after t_1 and unwind right after t_2, the early informed would potentially be earning an abnormal return of 75 and 160 basis points for a 100 and 200 second delay for positive news, and around 120-170 basis points for a 100-200 second delay for negative news. Both are significantly different from zero even under the low-power nonparametric tests. The total trading profits potentially come from two sources: foreknowledge of the change in the fundamental value of the firm conditional on the news, and overreaction of the late informed who are not aware of the stale nature of the news at public release (to be analyzed in detail in Section II.C). The magnitude of the returns is sizable considering the duration for the arbitrage. Such opportunities also abounded during our sample period: Out of 77 trading days during our sample period alone, there are 113 filings that incurred absolute abnormal returns of more than 1% during the $(t_1, t_2 + 10\,\text{min})$ window and a delay in public release of more than 100 seconds.

B. Information Dissemination and Strategic Trading

B.1. Information dissemination and length of delay

After establishing the trading profitability of the early informed, we now shift our focus from the speculators to the market to assess the speed at which stock prices reflect private information from speculators. We use the abnormal returns during the (t_1, t_3) window ($AR_i(t_1, d_1)$ or $AR_i(t_1, t_2 + 10\text{min})$) to capture the information content of a filing. A longer time window allows adequate time for the market to digest the new information but also allows other information events to confound the effect of the particular filing under study. Therefore, consistency across the results using both measures will give us more confidence.

In this analysis, the dependent variable becomes the ratio $AR_i(t_1, t_2) / AR_i(t_1, t_3)$, which measures the proportion of the "total information content" of a particular filing that is impounded into the stock price during the window when the information remains private. To ensure that the "total information content" is meaningful, we restrict the sample to filings for which $AR_i(t_1, t_3)$ is at least 0.5% in either direction. Setting t_3 to be $t_2 + 10\text{min}$ or d_1 , 72.4% or 53.6% of the observations have positive values of $AR_i(t_1, t_2) / AR_i(t_1, t_3)$. Assuming that the market correctly assesses at least the directional change in the firm value based on the new SEC filing by t_3 , then a negative value of $AR_i(t_1, t_2) / AR_i(t_1, t_3)$ indicates that informed trading, if exists, does not overcome noise trades to have a price impact; in other words, noise, rather than information, drives the stock prices during the private window. Our default specification thus retains the negative values of $AR_i(t_1, t_2) / AR_i(t_1, t_3)$, effectively interpreting noise as "negative information." An alternative method is to censor the negative values of the ratio as zero by treating noise as simply "non-information." Both specifications produce qualitatively similar results but the method we utilized has greater statistical power. The independent variables are the same as in Table 2, where the independent variable of key interest is *Delay,* or the duration of time when information remains private. Results are reported in Table 3.

[Insert Table 3 here.]

Panel A of Table 3 analyze the sample of "modest" news, i.e., $|AR_i(t_1,t_3)|>0.5\%$. As a percentage of the total return from t_1 to d_1, every 100 second delay is associated with 2.8 – 2.9 percentage points increase in private information dissemination; and the speed increases to 10.2 – 12.2 percentage points if we shrink the end point to $t_2+10\min$ during which we are reasonably sure that the SEC filing in consideration is the only information event. All these coefficients are highly statistically significant at the 1% level.

Panel B raises the stakes, limiting the definition of "extreme" news to $|AR_i(t_1,d_1)|>2\%$ or $|AR_i(t_1,t_2+10\min)|>1\%$. The magnitude of the coefficients on *Delay* is similar to those in the "modest" news sample: 3.2 – 4.0 basis points for every 100 second delay for the long window and 13.0 – 14.4.6 basis points for the short window. Again, all coefficients are significant at the 1% level. Results in Table 3 thus suggest that it takes time to disseminate private information. On average it takes 4 – 5 minutes for the market to incorporate about half of the total information in the private signal acquired by the early informed.

The stable pace of private information dissemination with varying intensity of the signal (i.e., a filing that will move the stock price by at least 0.5% or 2%) is consistent with the standard microstructure models (e.g., Kyle (1985)) where one-half of the inside information is incorporated into the price in a one-period model regardless of the ex ante volatility of the asset value. We thus offer a first study that quantifies the time the market takes to incorporate private information via informed trading. Such estimations have not been available to researchers precisely because the accurate arrival time of private information is, by definition, not observable to researchers (except in the rare case we are analyzing). A similar analysis using public announcement cannot isolate the channel of information impounding through trading because prices usually adjust (by market makers) even in the absence of a trade.

B.2. Strategic trading and predicted vs. residual delay

As in the setting of Koudijs (2014a), the speed at which the early informed speculators trade their private information depends on the expected duration of the private window. In Koudijs (2014a), the duration has exogenous variation—that is, there, weather affects the journey by boats carrying newsletters across the Atlantic. In our setting, the private window has a random stopping time depending on traffic at the EDGAR server. While speculators in our sample could form some expectation about the delay time, for which the single most powerful predictor is the time of the day for t_1 (see Figure 2), the expectation is quite coarse, leaving a large residual variation in the unexpected delay to allow for identifying the strategic behavior.

As an illustration, consider the following hypothetical example. Suppose a PDS subscriber receives a newsworthy SEC filing at 9:00am. At that time of the day, the expected delay is short (around 40 seconds). The speculator should trade as aggressively as possible and will probably reveal her private signal quite promptly. If, however, the actual delay were much longer at 200 seconds, the "unexpected" part of the delay (in this case, 160 seconds) is likely to be a wasted opportunity because the private signal would have been revealed prematurely compared to an optimized scheme with known delay duration of 200 seconds. As an example, consider a scenario where private information arrives around 4:00pm when the expected delay is expected to be more than 200 seconds. In that case, a strategic speculator should trade smoothly in small quantities. If, however, the public release occurs much faster than usual and ends the private window after a mere 60 seconds, then the "residual" delay (120 seconds) would not contribute additional private information dissemination because the process was cut short. In both cases, the prediction is such that $AR_i(t_1,t_2)/AR_i(t_1,t_3)$ should bear a much stronger relation to expected or predicted delay than to unexpected or residual delay.

Table 4 performs this test. Here the regressions are the same as in Table 3, except that the key independent variable *Delay* is replaced by two variables, *Predicted delay* and *Residual delay*. *Predicted delay* is the average delay for the hourly bin in which time t_1 of the i-th event falls. *Residual delay* is the difference between *Delay* and *Predicted delay*. Under all of our specifications, the statistical significance is higher for the coefficients on *Predicted delay* than *Residual delay*, as the former has more crosssectional variation. Under variance decomposition, 39.7% of the total variation in *Delay* is retained by *Predicted delay*.

[Insert Table 4 here.]

Panel A reports the "modest" news sample where $|AR_i(t_1,t_3)|>0.5\%$. Indeed, the coefficients on *Expected delay* are about 4-6 times as large as those on *Residual delay* across all three specifications for $t_3 = d_1$. An F-test on the difference between these coefficients indicates that the pairwise difference is significant at the 1% level in these specifications as well. If we use a shorter window, $t_2 + 10\,\text{min}$ to record the stock price that incorporates the public information, the ratio of the two coefficients is lower, around 2.0 – 2.5, in which case the difference between the two coefficients is only marginally significant (at the 10% level) in two out of the three specifications.

The "extreme" news sample ($|AR_i(t_1,d_1)|>2\%$ or $|AR_i(t_1,t_2+10\,\text{min})|>1\%$) provides similar results. The sample shrinks but both time windows (t_1,t_3) produce coefficients on *Predicted delay* that are notably larger than those on *Residual delay*, with ratios similar to those in Panel A except the last column where estimation with daily fixed effects on a small sample becomes unreliable. The F-tests for the difference in the two coefficients remain significant at the 1% level for $t_3 = d_1$, but are insignificant for $t_3 = t_2$+10 min.

Overall, the results in Table 4 show the early informed trade aggressively based on the time advantage they expect to have—rather than the advantage they actually enjoy. This echoes Koudijs' (2014a) finding that the co-movement between the London and Amsterdam exchanges was significantly higher when the next boat was expected to arrive sooner (depending on the wind and weather conditions), which implies that the speed of information dissemination in Amsterdam depended on how long insiders expected it would take for their private signal to become public.

C. Overreaction to Stale News at Public Release

During our sample period, public investors were likely not aware of the fact that some investors were gaining access to the SEC filings moments before the public release of that information. In fact, the magnitude of the public's surprise was apparent in light of the outrage expressed in the media and by lawmakers upon the revelation of the dissemination delay. As such, investors would most likely not be aware that information made available on EDGAR was already stale by the time the filings reached the SEC's public website. The combination of the investors' late-informed status together with an ignorance of that status predicts that public investors may overreact to the news contained in public releases even if those investors are fully rational. To the extent that the length of the information advantage obtained by the early informed is positively associated with the staleness of news at public release (as shown in Tables 2 to 4), it should also be positively associated with the extent of overreaction.

It is worth noting that overreaction to stale news in our setting is of a different nature from that in Huberman and Regev (2001) and Tetlock (2011). In those two studies, investors treat all information as news without differentiating "printed" from "reprinted" news, i.e., news with either full or partial content that was already described in earlier releases. Thus, the investors in those studies are interpreted to be naïve or unsophisticated in assessing the incremental content of public news. In our setting, investors—even sophisticated ones—were likely unaware of the possibility that some traders could front-run on filings submitted to the SEC—an agency whose stated mission is to create a level playing field all market participants.

Following Tetlock (2011), overreaction to stale news can be tested by showing whether there is return reversal in the "steady state" after the first trading period post public news release, i.e., (t_2, t_3) as previously defined. We now introduce another time point, t_4, to proxy for the "steady state." We set $t_4 = d_5$, the market close five days after the public release (t_2), based on Tetlock's (2011) finding that it takes up to five days for market overreactions to reverse. Figure 1 displays and explains the relation among all the time points, t_1 to t_4. Then the analysis boils down to a regression of $AR_i(t_3, t_4)$ on

$AR_i(t_2,t_3)$ and an interaction term $AR_i(t_2,t_3) \times Delay_i$ where a significantly positive coefficient on the latter is consistent with overreaction due to stale news. Results are reported in Table 5.

[Insert Table 5 here.]

Panel A starts with the full sample. Using the first day close (i.e, $t_3 = d_1$) as the end of the period of the presumed overreaction, the first three columns show that the key coefficients on $Delay_i \cdot AR_i(t_2,t_3)$ are significant (at the 5% level) in a regression that includes $Delay_i$ and $AR_i(t_2,t_3)$ on their own as well as other standard control variables. The coefficients on $AR_i(t_2,t_3)$ are positive but insignificant, indicating no overreaction when the time enjoyed by the early informed is close to zero. Moreover, the coefficients are about 100 times as large as those on the interaction term $Delay_i \cdot AR_i(t_2,t_3)$, indicating that return reversal starts to manifest when the delay exceeds 100 seconds.

It is worth noting that the length of 100 seconds required for overreaction to take place maps nicely to the first 100 seconds of "no action" zone by the early informed identified in Section II.A, and in particular Figure 3. If stock prices on average fail to reflect the new signal possessed by the early informed for the first 100 seconds, there should be no overreaction by the late informed if the time lag between the two groups is no longer than 100 seconds because the news remains "fresh" at the time of public release (t_2). The last three columns of Panel A adopt the ten-minute window for overreaction. The coefficients of $Delay_i \cdot AR_i(t_2,t_3)$ are almost twice as high as those in the first three columns, but are not statistically significant.

Results in Panel B, which focuses on the "extreme" news subsamples, are qualitatively similar to those in Panel A where every 100 seconds is associated with 14% more of the abnormal returns during the (t_2,d_1) window to be reversed during (d_1,d_5). On the other hands, using t_2+10 min as the separator between the overreaction period and reversal period overall does not produce significant results.

The contrast in the statistical significance between setting the end of overreaction period to be d_1 and t_2+10 min suggests that the public investors may continue to overreact to news during the

$(t_2 + 10\min, d_1)$ time window. This conjecture is confirmed by Figure 5, where we plot the cumulative abnormal buy-and-hold returns from the arrival of the private information (t_1) to the market close of the fifth trading day afterwards (d_5), with intermediate time points of interest, t_2, t_2+10min, $d_1,\ldots,d_4$ highlighted. The sample is restricted to observations with a delay of 100 seconds or more (since there is no overreaction when the delay is shorter), and positive/negative news is classified by the sign of $AR(t_1,d_1)$. Interestingly, overreaction is present only for positive news but not for negative news.[13] Importantly, it is indeed the case that the bulk of the overreaction takes place during the $(t_2 + 10\min, d_1)$ time window.

[Insert Figure 5 here.]

The analysis in this section indicates that public investors overreacted to SEC filings containing positive news on the day of the public release, not knowing that the news was already stale when there was a significant delay (above 100 seconds) in its release. The absence of overreaction when the delay was minimal indicates that the investors were not irrational but only ignorant (and rightly so) about the pre-release leakage. Such evidence shows that the early release of SEC filings to a small group of investors hurt the investing public, inflicting more damage than would have been incurred if PDS subscribers' time advantage had been public knowledge.

III. CONCLUSION

Using rare data from an unusual episode in which SEC filings containing market-moving information were disseminated to a small group of investors before the public release of that information, we consider a quasi-natural experiment that provides a direct test of the process through which private information is impounded into stock prices. Contrary to the common public intuition about how quickly "fast" traders can act on new information, we find that it takes time—minutes, not seconds—for informed investors to impound fundamental information into public-company stock prices.

[13] One explanation for this asymmetry in reaction to news is the "bad news travels slowly" phenomenon described in Hong, Lim, and Stein (2000), especially when the source of the negative information is the firm.

As one might expect, informed investors profit more—and convey more information into stock prices through their trading—when the delay between private and public revelation of the information is longer. More importantly, information dissemination is much more strongly correlated with the *predicted* length of the delay rather than the *actual* delay, consistent with the notion that informed investors trade strategically, evening out the price impact of their trading. Finally, we show that public investors overreacted to positive news contained in SEC filings, because they were unaware that the information was stale by the time it arrived on the SEC's EDGAR website.

Our study contributes to the relatively scant empirical literature on the process through which private information is incorporated into security prices. We quantify the consequences that investors suffered when certain traders were given early access to market-moving information. The study also serves as a modern counterparty to Koudijis' (2014a) analysis of insider trading during the eighteenth century. Our setting, however, allows us to consider the questions analyzed by Koudijis while replacing week-long sailing voyages with electronic transmission as the conduit through which information travels to markets .

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Figure 1. Timeline of Key Events

t_1 : A SEC filing becomes accessible to the early informed on the Public Dissemination Service (PDS).

t_2 : The same SEC filing becomes publically accessible on EDGAR.

t_3 : Ten minutes after t_2 (i.e., $t_2 + 10\min$), or the market close on the day following t_2 (i.e., d_1). The interval (t_2, t_3) is a proxy for the period during which the public investors trade on the information revealed by the SEC filing.

t_4 : The market close on the 5th day following t_2 (i.e., d_5), a proxy for the time by which the stock corrects any potential overreaction to news.

Figure 2. Average FTP-Public Delay Time throughout a Trading Day

This figure shows the average delay in public release of all filings by public companies during the sample period of June 25, 2014 to October 15, 2014 (excluding July 15, 2014) by hourly intervals throughout a trading day, including the before-market-open and after-market close hours. The delay is calculated as the difference in time, in seconds, from the SEC's public file transfer protocol (FTP) timestamp (a proxy for the actual time that a file reaches the subscribers' Public Dissemination Service (PDS)) to the SEC's Electronic Data Gathering, Analysis, and Retrieval System (EDGAR) timestamp (the actual official time for public release).

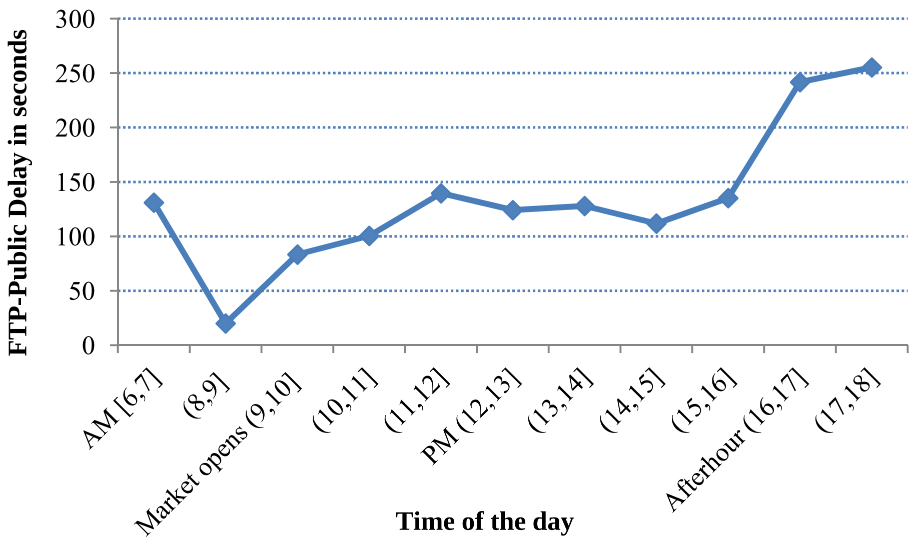


Figure 3. Histogram of Abnormal Returns during the FTP-Public Delay

This figure plots the histogram of the abnormal returns during the FTP-public delay (as defined in Figure 2). The abnormal returns are calculated as the difference between the stock returns of the issuers of the filings and that of the SPY, the most liquidly traded exchange-traded-fund (ETF) tracking the S&P 500 index. The dotted graph represents the hypothetical histogram from a normal distribution.

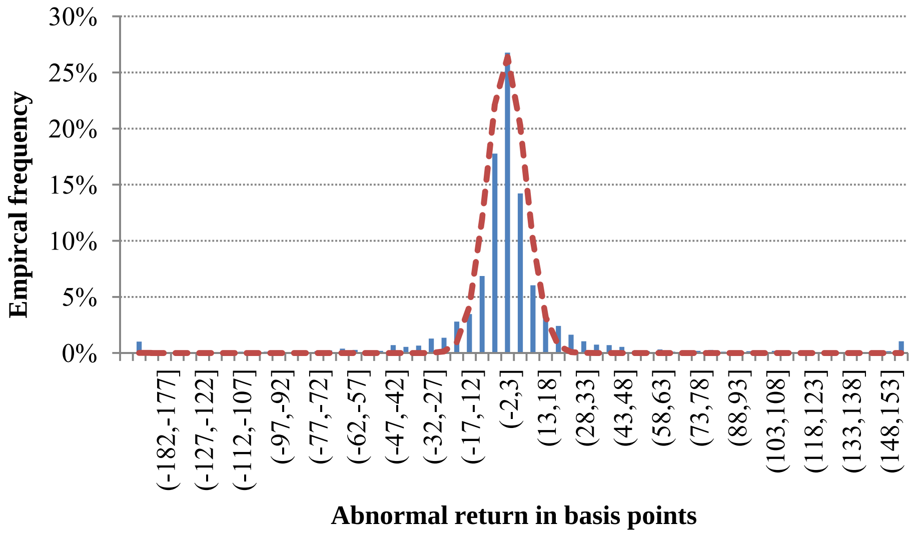
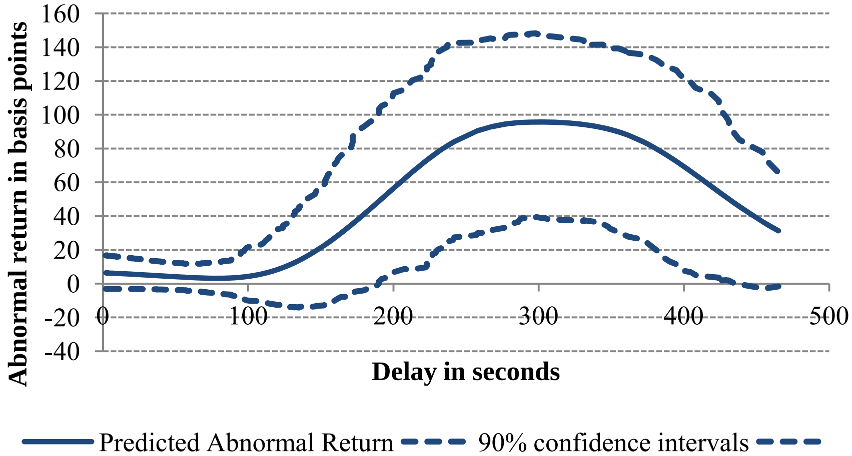


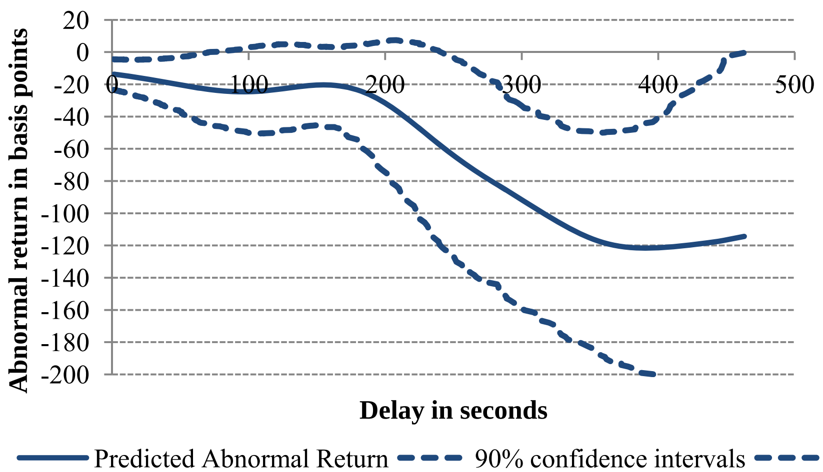
Figure 4. Kernel Regression of Abnormal Return vs. the FTP-Public Delay

This figure plots the kernel regression of the abnormal return, $AR(t_1, t_2)$, as defined in Figure 2, against the length of the FTP-public delay. The four panels separately display results in the subsamples of positive (or negative news), depending on whether $AR(t_1,d_1)$ (or $AR(t_1,t_1$+10 min)) is greater than 2% (or 1%) in absolute magnitude. All kernel regressions adopt the Gaussian kernel with bandwidth of 50. The dotting lines represent 90% confidence intervals by bootstrapping the sample with replacement.

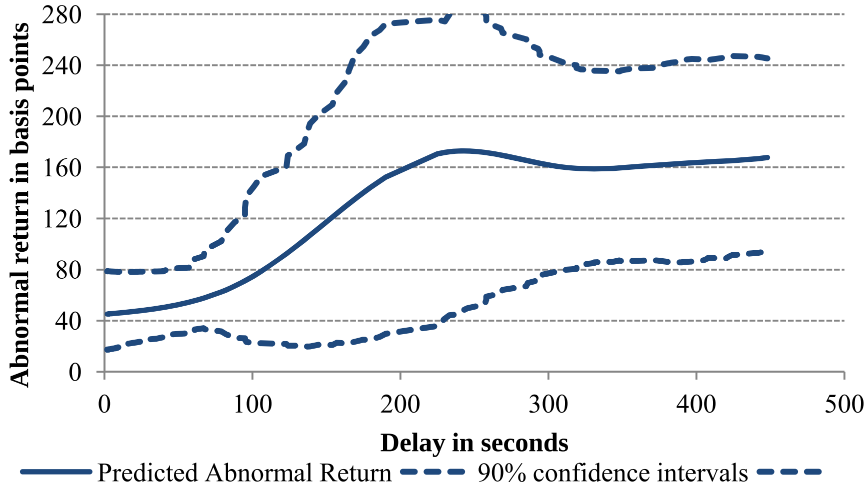
Panel A: Extreme Positive news: $AR(t_1,d_1) > 2\%$



Panel B: Extreme negative news: $AR(t_1,d_1) < -2\%$



Panel C: Extreme positive news: $AR(t_1,t_1+10\text{ min}) > 1\%$



Panel D: Extreme negative news: $AR(t_1,t_1+10\text{ min}) < -1\ \%$

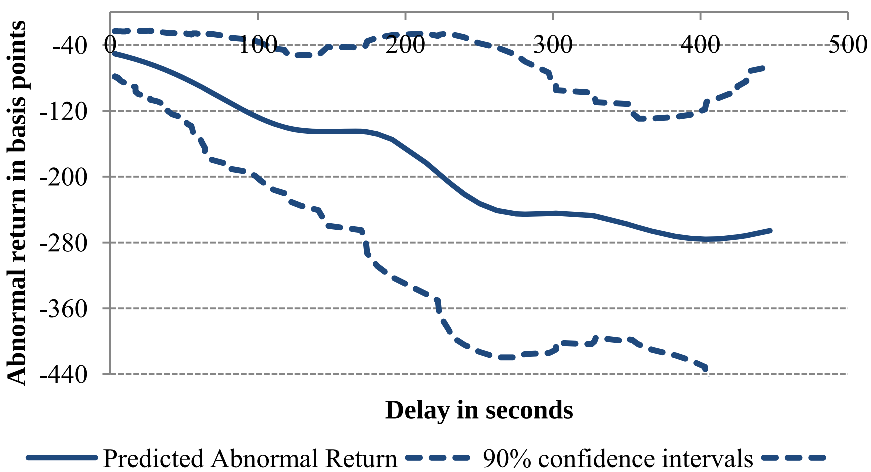
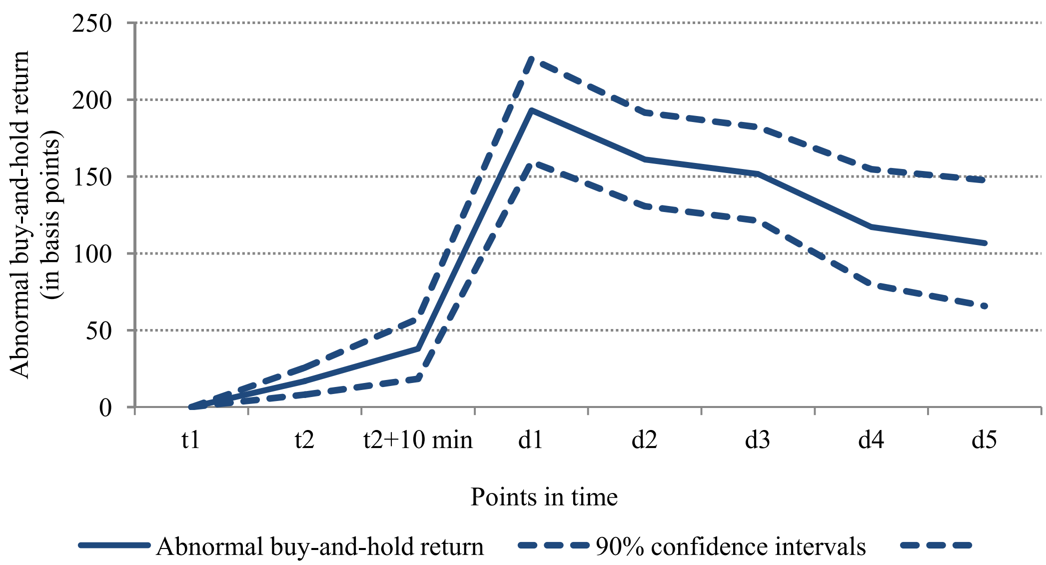


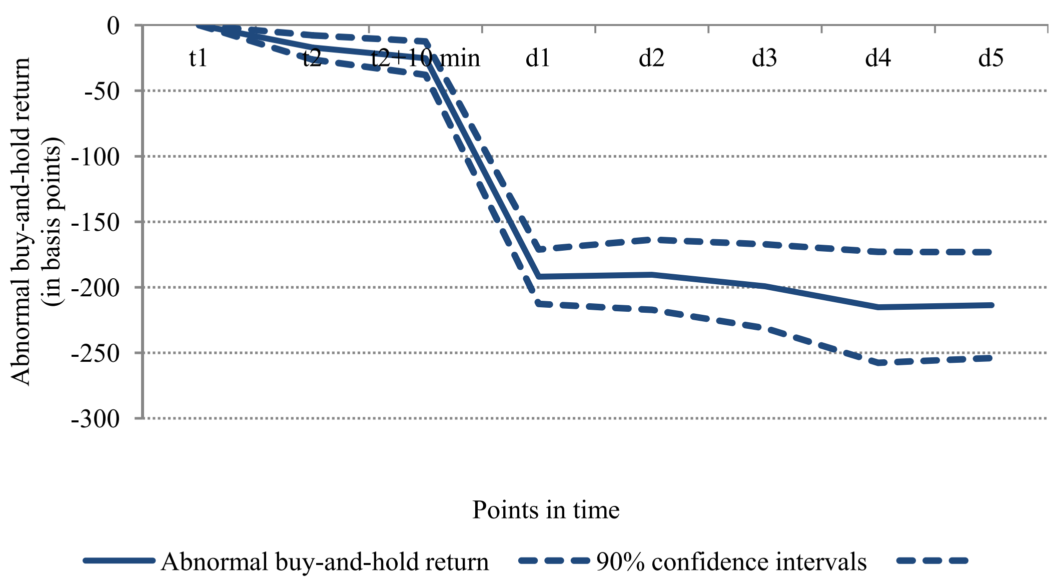
Figure 5. Abnormal Buy-and-Hold Return over Time

This figure plots the abnormal buy-and-hold returns from the arrival of private information to the market close of the 5th day post information. The time points examined (t_1, t_2, t_2+10 min, d_1,…, d_5) are defined and explained in Figure 1. The sample is all panels are restricted to observations with the FTP-EDGAR delay exceeding 100 seconds. Panels A and B use the sample of all news, while Panels C and D focuses on the subsamples of "extreme" news defined as $|AR(t_1,d_1)|$ > 2 %. Panels A and C examine positive news and Panels B and D examines negative news. Positive/negative news is classified by the sign of $AR(t_1,d_1)$. The dotted lines represent the 90% confidence intervals based on the t-statistics of the average returns.

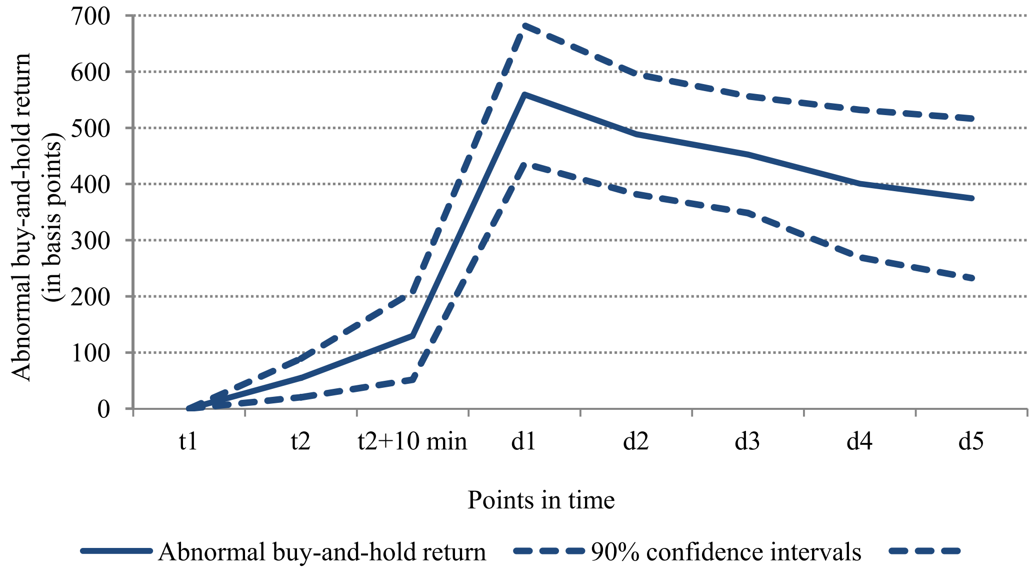
Panel A. Full sample/Positive news



Panel B. Full sample/Negative news



Panel C. Extreme positive news: $AR(t_1,d_1) > 2\%$



Panel D. Extreme negative news: $AR(t_1,d_1) < -2\ \%$

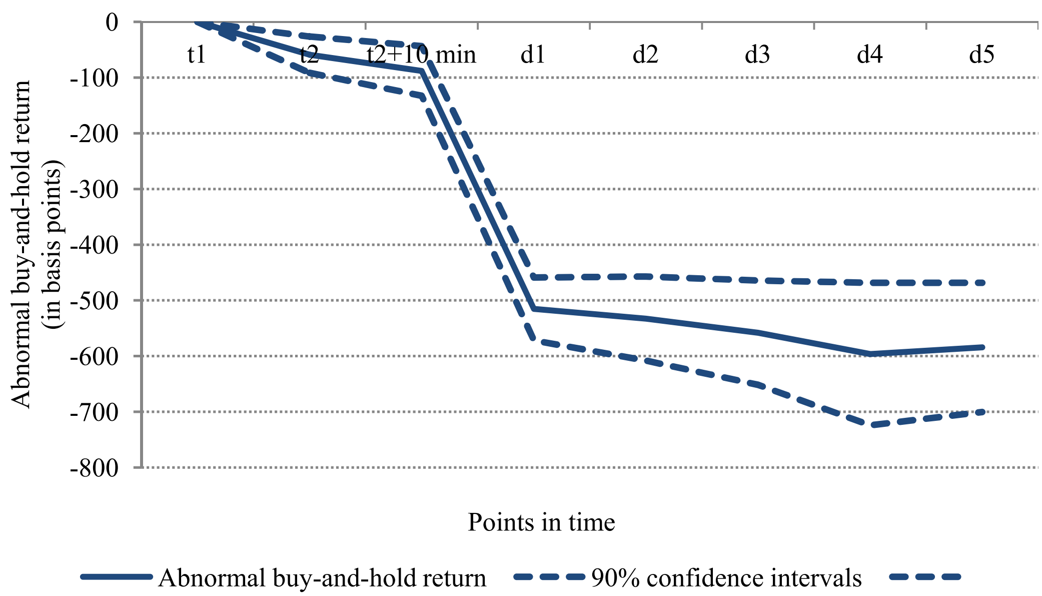


Table 1. Distribution of the FTP-Public Delay

This table reports the summary statistics (mean, standard deviation, and the various percentile values) of the delay in public release of all filings by public companies during the sample period of June 25, 2014 to October 15, 2014 (excluding July 15, 2014). The delay is calculated as the difference in time, in seconds, from the SEC's public file transfer protocol (PFT) timestamp (a proxy for the actual time that a file reaches the subscribers' Public Dissemination Service (PDS)) to the SEC's Electronic Data Gathering, Analysis, and Retrieval System (EDGAR) timestamp (the actual official time for public release. Summary statistics for the full sample, as well as for the top three filing types, the Form 8K, Form 4, and Schedule 13D, are reported. Form 8-K provides timely disclosure of material corporate events, Form 4 discloses transactions by insiders within 48 hours, and Schedule 13D discloses beneficial ownership with an intention to influence corporate control or policies, within 10 days from crossing the 5% threshold.

	All Files	**Form 8K** (News release)	**Form 4** (Insider trading)	**Schedule 13D** (Activist block formation)
# observations	42,619	7,227	22,219	517
10th percentile	4	3	4	4.6
25th percentile	7	7	7	12
Median	26	33	24	59
75 percentile	172	203	159	231
90 percentile	466	471.4	451	498
Mean	219.52	180.66	233.13	191.21
Standard Deviation	3242.28	425.56	3995.73	375.29
Truncated mean	130.63	145.94	122.67	94.23
Truncated standard deviation	128.80	137.40	125.69	131.10

Table 2. Trading Profitability vs. the Length of the FTP-Public Delay

The timeline (t_1, t_2, and t_3) is defined in Figure 1. In all panels, the dependent variable is $AR(t_1,t_2)$, the abnormal return during FTP-Public delay in basis points. In each panel the full sample is sorted into the "positive news" and "negative news" subsamples depending on the sign of $AR(t_1,t_3)$, the total abnormal return till after the public trading on the news. The key independent variable is *Delay*, the length of the FTP-public delay in seconds. Control variables include filing types and daily fixed effects. In Panels A and B, t_3 is set to be d_1, the market close of the day following the public release of the filing; in Panels C and D, t_3 is set to be t_2+10 min, ten minutes after the public release. In Panels A and C, the sample includes all news; while the "extreme" news sample in Panel B (Panel D) includes all observations where $AR(t_1,t_3)$ is greater than 2% (1%) in absolute value. T-statistics based on standard errors adjusted for heteroskedasticity are reported below the coefficients in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level.

Panel A: All News and $t_3 = d_1$

	(1)	(2)	(3)	(4)	(5)	(6)
	Positive News: $AR(t_1,d_1) > 0$			Negative News: $AR(t_1,d_1) < 0$		
Delay	0.0650***	0.0621***	0.0646***	-0.0857***	-0.0804***	-0.0846***
	(3.02)	(2.98)	(3.43)	(-2.68)	(-2.67)	(-2.63)
Form 8K		14.4765**	11.9615*		-18.2928**	-18.1595**
(News release)		(1.67)	(1.62)		(-1.78)	(-1.78)
Form 4		-1.4707	1.3164		5.0554	-0.0833
(Insider trading)		(-0.41)	(0.37)		(1.27)	(-0.02)
Schedule 13D		3.3194	12.4766		-75.4596*	-94.3357**
(Activist block formation)		(0.13)	(0.52)		(-0.96)	(-1.17)
Constant	0.0638	-2.2882	4.2328	1.8928	4.0464	-8.1833
	(0.03)	(-0.81)	(0.89)	(0.66)	(0.80)	(-0.81)
Daily fixed effects	N	N	Y	N	N	Y
R-squared	0.010	0.015	0.153	0.011	0.021	0.086
Observations	1,208	1,208	1,208	1,315	1,315	1,315

Panel B: Extreme News ($|AR(t_1, t_3)| \geq 2\%$) and $t_3 = d_1$

	(1)	(2)	(3)	(4)	(5)	(6)
	Positive News: $AR(t_1,d_1) > 2\%$			Negative News: $AR(t_1,d_1) < -2\%$		
Delay	0.2057***	0.1988***	0.1603**	-0.2796***	-0.2726***	-0.2581**
	(2.60)	(2.63)	(2.13)	(-2.38)	(-2.45)	(-2.66)
Form 8K		26.1740	36.7084		-27.3287	-42.1265
(News release)		(0.93)	(1.93)		(1.22)	(-0.31)
Form 4		-18.3061	-6.0805		22.5557	-9.4810
(Insider trading)		(-1.12)	(-0.32)		(1.22)	(-0.31)
Schedule 13D		-0.3794	39.8695		-294.3428*	-346.4304**
(Activist block formation)		(-0.01)	(0.82)		(-2.42)	(-2.62)
Constant	0.8983	-1.0633	-13.2046	-0.2433	8.6945	14.7468
	(0.12)	(-0.08)	(-0.44)	(-0.02)	-0.41	-0.49
Daily fixed effects	N	N	Y	N	N	Y
R-squared	0.027	0.038	0.493	0.030	0.049	0.231
Observations	280	280	280	296	296	296

Panel C: All News and $t_3 = t_2 + 10\,\text{min}$

	(1)	(2)	(3)	(4)	(5)	(6)
	Positive News: $AR(t_1, t_2+10\ min) > 0$			Negative News: $AR(t_1, t_2+10\ min) < 0$		
Delay	0.0723***	0.0708***	0.0780***	-0.0926***	-0.0861***	-0.0903***
	(3.16)	(3.19)	(3.52)	(-3.12)	(-3.13)	(-3.01)
Form 8K		-4.6449	-5.1760		-18.9438***	-20.2260***
(News release)		(1.78)	(1.87)		(-1.92)	(-1.99)
Form 4		15.8717**	14.2107**		8.0612	2.5239
(Insider trading)		(-1.27)	(-1.02)		(2.15)	(0.63)
Schedule 13D (Activist block formation)		20.7098	23.6425		-45.0684	-50.4168*
		(0.61)	(0.74)		(-1.09)	(-1.14)
Constant	4.2127**	2.2743	5.3683	-2.4910	-1.4153	-5.8221
	(2.05)	(0.67)	(0.94)	(-0.94)	(-0.32)	(-0.74)
Daily fixed effects	N	N	Y	N	N	Y
R-squared	0.0113	0.0195	0.0964	0.0144	0.0259	0.0992
Observations	1,232	1,232	1,232	1,328	1,328	1,328

Panel D: Extreme News ($|AR(t_1, t_3)| \geq 1\%$) and $t_3 = t_2 + 10\min$

	(1)	(2)	(3)	(4)	(5)	(6)
	Positive News: *AR(t_1, t_2+10 min) > 1%*			Negative News: *AR(t_1, t_2+10 min) < -1%*		
Delay	0.3623**	0.4029**	0.6929**	-0.5811**	-0.6083**	-0.9430***
	(2.71)	(2.69)	(2.78)	(-2.32)	(-2.52)	(-2.91)
Form 8K		9.7966	-7.2389		128.4813	151.8677
(News release)		(0.15)	(-0.11)		(0.70)	(-0.96)
Form 4		-96.8759	-159.2786		54.3543	-132.4667
(Insider trading)		(-1.72)	(-1.63)		(1.91)	(1.25)
Schedule 13D		70.4536	68.8940		-71.4244	-462.5305
(Activist block formation)		(0.48)	(0.72)		(-0.58)	(-2.30)
Constant	47.5460	54.3259	-8.1347	-53.9028	-91.2645	16.4957
	(1.99)	(1.43)	(-0.11)	(-1.63)	(-1.34)	(1.34)
Daily fixed effects	N	N	Y	N	N	Y
R-squared	0.041	0.069	0.515	0.064	0.078	0.535
Observations	103	103	103	94	94	94

Table 3. Information Dissemination and the FTP-Public Delay

The dependent variable in this table is % $AR(t_1,t_2)/AR(t_1, t_3)$, the proportion of total abnormal returns post-public trading that are realized during the private window (t_1,t_2) in percentage points. The timeline of events is defined in Figure 1. The key independent variable is *Delay*, the length of the FTP-public delay in seconds. Control variables include filing types and daily fixed effects. In Panels A, the sample includes "modest" news defined as $AR(t_1, t_3)$ being greater than 0.5% in absolute magnitude. The sample in Panel B consists of "extreme" news where $AR(t_1, t_3)$ is greater than 2% (or 1%) in absolute value. The first three columns of both panels set t_3 to be d_1, whereas the last three columns set t_3 to be t_2+10 min. T-statistics based on standard errors adjusted for heteroskedasticity are reported below the coefficients in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level.

Panel A: "Modest" news: $|AR(t_1, t_3)| \geq 0.5\%$

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	% $AR(t_1,t_2)/AR(t_1, d_1)$			% $AR(t_1,t_2)/AR(t_1, t_2+10min)$		
Delay	0.0286***	0.0280***	0.0282***	0.1202***	0.1224***	0.1017***
	(3.65)	(3.61)	(4.13)	(4.27)	(4.20)	(4.42)
Form 8K		2.3803	1.5601		0.1836	-5.7905
(News release)		(1.18)	(0.76)		(0.02)	(-0.55)
Form 4		-0.5506	0.7156		-8.5014	-6.1352
(Insider trading)		(-0.38)	(0.46)		(-0.91)	(-0.58)
Schedule 13D		1.9370	1.6255		9.1250	2.3628
(Activist block formation)		(0.18)	(0.15)		(0.32)	(0.09)
Constant	-0.8694	-1.2570	15.8353	9.7482**	11.0906*	51.9748***
	(-1.11)	(-1.20)	(1.38)	(2.48)	(1.84)	(3.39)
Daily fixed effects	N	N	Y	N	N	Y
R-squared	0.015	0.017	0.072	0.0557	0.0585	0.2275
Observations	1,694	1,694	1,694	424	424	424

Panel B: "Extreme" news: $|AR(t_1, d_1)| \geq 2\%$ or $|AR(t_1, t_2\text{+10 min})| \geq 1\%$

	(1)	(2)	(3)	(4)	(5)	(6)
	% $AR(t_1,t_2)/AR(t_1, d_1)$			% $AR(t_1,t_2)/AR(t_1, t_2\text{+10min})$		
Delay	0.0404***	0.0400***	0.0325***	0.1117***	0.1264***	0.1253***
	(2.65)	(2.63)	(3.21)	(3.54)	(4.10)	(4.71)
Form 8K		1.3159	1.7868		-8.1323	-9.9725
(News release)		(0.39)	(0.41)		(-0.69)	(-0.70)
Form 4		-2.9562	0.2634		-15.2065	17.2670
(Insider trading)		(-1.13)	(0.10)		(-1.02)	(1.18)
Schedule 13D		13.5381	17.3945		39.3508	62.6343***
(Activist block formation)		(0.93)	(1.32)		(1.18)	(4.12)
Constant	-0.1545	-0.1159	1.6511	13.2959**	15.9172	27.9659
	(-0.12)	(-0.07)	(0.58)	(2.26)	(1.55)	(1.51)
Daily fixed effects	N	N	Y	N	N	Y
R-squared	0.0277	0.0326	0.1543	0.1005	0.1334	0.5908
Observations	576	576	576	197	197	197

Table 4. Information Dissemination and Strategic Trading

The dependent variable in this table is % $AR(t_1,t_2)/AR(t_1, t_3)$, the proportion of total abnormal returns post-public trading that are realized during the private window (t_1,t_2). The timeline of events is defined in Figure 1. The key independent variables are *Predicted delay* and *Residual delay*. *Predicted delay* is proxied for by the average delay for the hourly bin in which time t_1 of the *i*-th event falls. *Residual delay* is the difference between *Delay* and *Predicted delay*. Control variables include filing types and daily fixed effects. In Panels A, the sample includes "modest" news defined as $AR(t_1, t_3)$ being greater than 0.5% in absolute magnitude. The sample in Panel B consists of "extreme" news where $AR(t_1, t_3)$ is greater than 2% (or 1%) in absolute value. The first three columns of both panels set t_3 to be d_1, whereas the last three columns set t_3 to be t_2+10 min. T-statistics based on standard errors adjusted for heteroskedasticity are reported below the coefficients in parentheses. The bottom of the table reports the F-test statistics as well as the associated p-value for the equality of the coefficients on *Predicted delay* and *Residual delay* . *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level.

Panel A: "Modest" news: $|AR(t_1, t_3)| \geq 0.5\%$

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	% $AR(t_1,t_2)/AR(t_1, d_1)$			% $AR(t_1,t_2)/AR(t_1, t_2$+10 min)		
Predicted Delay	0.1011***	0.0957***	0.0910***	0.1667***	0.1544***	0.1765***
	(4.04)	(3.96)	(3.95)	(2.99)	(2.81)	(3.22)
Residual Delay	0.0156***	0.0157***	0.0177***	0.0767***	0.0800***	0.0622***
	(2.68)	(2.70)	(3.02)	(3.78)	(3.87)	(2.89)
Form 8K		2.1154	1.8672		3.4304	-0.4281
(News release)		(1.18)	(1.09)		(0.52)	(-0.07)
Form 4		0.2489	1.2592		-3.5775	-7.5553
(Insider trading)		(0.20)	(0.87)		(-0.51)	(-0.91)
Schedule 13D		2.6050	2.2199		8.7550	-0.3492
(Activist block formation)		(0.25)	(0.21)		(0.31)	(-0.01)
Constant	-10.8808***	-10.7836***	5.8296	2.3686	3.4810	38.9511**
	(-3.45)	(-3.42)	(0.48)	(0.28)	(0.40)	(2.27)
Daily fixed effects	N	N	Y	N	N	Y
R-squared	0.0277	0.0288	0.0869	0.0563	0.0586	0.2506
Observations	1,664	1,664	1,664	406	406	406
Test: Predicted Delay = Residual Delay						
F-statistics	25.6326***	21.1369***	16.1192***	2.7875*	1.6892	2.9691*
p-value	0.0000	0.0001	0.0001	0.0958	0.1944	0.0856

Panel B: "Extreme" news: $|AR(t_1, d_1)| \geq 2\%$ or $|AR(t_1, t_2\text{+10 min})| \geq 1\%$

	(1)	(2)	(3)	(4)	(5)
Dependent variable		$\% AR(t_1,t_2)/AR(t_1, d_1)$		$\% AR(t_1,t_2)/AR(t_1, t_2\text{+10 min})$	
Predicted Delay	0.0825***	0.0744***	0.1023***	0.1733**	0.2160***
	(2.84)	(2.80)	(3.75)	(2.05)	(2.59)
Residual Delay	0.0171**	0.0179**	0.0129*	0.0999**	0.1141***
	(2.35)	(2.51)	(1.84)	(2.49)	(2.77)
Form 8K		2.8092	3.5524*		-8.1802
(News release)		(1.51)	(1.67)		(-0.68)
Form 4		-0.8109	1.7575		-7.9271
(Insider trading)		(-0.51)	(0.90)		(-0.50)
Schedule 13D		15.0770	18.1851		47.2172
(Activist block formation)		(1.06)	(1.44)		(1.42)
Constant	-7.1949*	-7.0597*	-12.2577**	0.2331	-3.6262
	(-1.92)	(-1.84)	(-2.26)	(0.01)	(-0.19)
Daily fixed effects	N	N	Y	N	N
R-squared	0.0433	0.0528	0.2209	0.1095	0.1475
Observations	557	557	557	184	184
Test: Predicted Delay = Residual Delay					
F-statistics	10.9274***	7.2749***	14.8953***	0.5881	0.9625
p-value	0.001	0.0072	0.0001	0.4454	0.3295

Table 5. Overreaction to Stale News and FTP-to-Public Delay

This table analyzes the relation between public investors' overreaction to news and the delay in the public release of news (hence the degree of news staleness). In both panels the dependent variable is the abnormal return during (t_3, t_4), a period post the immediate trading by the public on news release till the price reaches a steady state, in percentage points. Figure 1 describes and explains the various time points. Panel A uses the full sample while Panel B focuses on "extreme news" defined as $AR(t_1, t_3)$ being greater than 2% (or 1%) in absolute value. Both panels set t_4 to be d_5, the market close on the 5th day post news release. The first three columns of both panels set t_3 to be d_1, whereas the last three columns set t_3 to be t_2+10 min. The coefficients of key interest are those of $AR(t_2, t_3)$ * *Delay*. T-statistics based on standard errors adjusted for heteroskedasticity are reported below the coefficients in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level.

Panel A: Full sample

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable		$AR(d_1,d_5)$			$AR(t_2 + 10\ min,d_5)$	
$AR(t_2, t_3)$ * Delay	-0.0013**	-0.0013**	-0.0013**	-0.0028	-0.0028	-0.0027
	(-2.03)	(-2.04)	(-2.14)	(-1.44)	(-1.47)	(-1.54)
Delay	-0.00001	-0.00001	-0.000001	-0.00001	-0.00001	-0.000002
	(-1.10)	(-0.82)	(-0.19)	(-1.51)	(-1.18)	(-0.22)
$AR(t_2, t_3)$	0.1440	0.1373	0.1379	0.4097	0.3998	0.4218
	(1.40)	(1.33)	(1.33)	(0.85)	(0.85)	(0.96)
Form 8K		-0.0035	-0.0019		-0.0064*	-0.0052
(News release)		(-1.28)	(-0.68)		(-1.88)	(-1.59)
Form 4		0.0037**	0.0061***		0.0046**	0.0067***
(Insider trading)		(2.09)	(3.19)		(2.41)	(3.04)
Schedule 13D		0.0308	0.0315		0.0337	0.0386
(Activist block formation)		(1.24)	(1.36)		(1.32)	(1.61)
Constant	-0.0031***	-0.0041***	-0.0054	-0.0035**	-0.0042**	-0.0041
	(-2.59)	(-2.83)	(-1.25)	(-2.38)	(-2.50)	(-0.68)
Daily fixed effects	N	N	Y	N	N	Y
R-squared	0.0175	0.0247	0.1099	0.0076	0.0168	0.0926
Observations	2,424	2,424	2,424	2,566	2,566	2,566

Panel B: Extreme news: | $AR(t_1, d_1)$| ≥ 2% or | $AR(t_1, t_2$+10 min)| ≥ 1%

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable		$AR(d_1,d_5)$			$AR(t_2$ + 10 min,$d_5)$	
$AR(t_2, t_3)$ * Delay	-0.0014**	-0.0015**	-0.0014**	-0.0032	-0.0033	-0.0031*
	(-2.07)	(-2.16)	(-2.45)	(-1.41)	(-1.48)	(-1.65)
Delay	-0.00001	-0.00001	0.000002	-0.00003	-0.00002	0.00002
	(-0.64)	(-0.51)	(0.09)	(-0.89)	(-0.56)	(0.80)
$AR(t_2, t_3)$	0.1478	0.1553	0.1398	0.4726	0.4648	0.5249
	(1.34)	(1.38)	(1.27)	(0.83)	(0.85)	(1.17)
Form 8K		-0.0100	-0.0010		-0.0149	-0.0087
(News release)		(-1.38)	(-0.13)		(-1.58)	(-0.94)
Form 4		-0.0134*	-0.0010		0.0021	0.0135
(Insider trading)		(-1.78)	(-0.13)		(0.25)	(1.44)
Schedule 13D		0.0516	0.0648		0.0693	0.0791
(Activist block formation)		(0.92)	(1.50)		(1.06)	(1.53)
Constant	-0.0081*	-0.0026	-0.0216	-0.0088	-0.0061	-0.0363
	(-1.78)	(-0.52)	(-1.15)	(-1.45)	(-0.91)	(-1.14)
Daily fixed effects	N	N	Y	N	N	Y
R-squared	0.0283	0.0418	0.2434	0.0121	0.0264	0.2317
Observations	557	557	557	197	197	197