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Run EDGAR Run: SEC Dissemination in a High-Frequency World

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ABSTRACT

We describe the process through which the Securities and Exchange Commission (SEC) makes filings "publicly available." For a sample of Form 4 (insider trade) filings, we show that, during the period we examine, the majority of filings are available to paying subscribers of the SEC's public dissemination system (PDS) feed before they are posted to the EDGAR website, and so provide subscribers and their clients with a private advantage. We show that this advantage translates into an economically significant trading advantage, and prices, volumes, and spreads respond to the news contained in filings beginning around 30 seconds before public posting. These findings indicate that

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[Correction added on 11/23/2017, after first online publication: EDGAR has been changed to SEC in several places.]

the SEC dissemination process does not always provide a level playing field and that the meaning of publicly available information in capital markets is no longer simple or obvious. In response to our study, the SEC launched an investigation and agreed to eliminate the PDS timing advantage.

JEL codes: G14; G28; M41

Keywords: event study; insider trading; high-frequency trading (HFT); EDGAR; SEC dissemination; SEC filings

1. Introduction

Because the U.S. Securities and Exchange Commission (SEC) regulates the disclosure of most news about companies, it is important to understand the process through which the SEC disseminates mandated disclosures. To test market efficiency, researchers need to know when news becomes publicly available—the more precise this information, the more powerful the test.[1] We use Form 4 filings that report insider trades by officers and directors to provide evidence on the process through which public company filings are disseminated by the SEC's EDGAR system, and so become publicly available. We address three questions. First, we ask whether the SEC provides certain market participants with access to filings before they are made publicly available. Second, to the extent that these market participants do have early access to filings, we ask whether this allows them to earn economically significant returns by trading on the news. Third, to the extent that early access provides a material trading advantage, we examine whether the length of the timing advantage matters or whether it is sufficient to have the news before other traders.

The mechanics of dissemination become especially critical in a world where trading advantages are measured in fractions of a second. In a widely publicized example, Thomson-Reuters sold advance access to the University of Michigan's Consumer Sentiment Index, a closely watched indicator of consumer spending. Certain clients paid Thomson-Reuters to access the data two seconds before its release to the full set of Thomson-Reuters clients, who in turn received it before its public release (the first set of clients received the feed at 9:54:58 a.m. Eastern time while regular clients received the feed at 9:55:00 a.m.; the news was posted to the university website at 10:00:00 a.m.).[2] While a two-second advantage seems short, the high-frequency trading (HFT) literature shows that trading advantages

[1] Fama [1991, p. 1607] writes that "[t]he cleanest evidence on market-efficiency comes from event studies, especially event studies on daily returns. When an information event can be dated precisely . . . event studies can give a clear picture of the speed of adjustment of prices to information."

[2] "Traders Pay for Early Peek at Key Data," *The Wall Street Journal*, June 12, 2013. For other examples, see "SEC Reviews How ISM Releases Manufacturing Data," *Wall Street Journal*, June 27, 2013; "Financial Information Groups Face NY Probe," *Financial Times*, July 9, 2013; "Peeking Early: A Continuing Kerfuffle over Releases of Privately Sourced Data," *The Economist*,

measured in milliseconds (or even microseconds) are economically valuable (Goldstein, Kumar, and Graves [2014], Budish, Crampton, and Shim [2015], Jones [2013], O'Hara [2015]).[3] The HFT traders we spoke to indicate that, conditional on obtaining the information first, the length of private advantage is not important because positions can be established within microseconds. While the casual observer may assume that the SEC dissemination process through EDGAR is effectively instantaneous, we show that, during the period we examine (March 1, 2012 to December 31, 2013), the process from upload to posting typically takes around 36 seconds (median). We further show that the news is available to certain intermediaries and investors before it is posted to the public EDGAR website: for 57% of insider purchases, filings are available to at least one PDS (public dissemination service) subscriber before they are posted to the EDGAR website.[4] This proportion is a lower bound on the relative frequency of private advantage because we have data from only one of approximately 40 PDS subscribers.[5]

We show that, when the PDS feed is first, prices, volumes, and spreads move 15–30 seconds before the news is posted to the EDGAR site. We also show that, when the PDS feed is first and results in both private and public trading, a return of 28 basis points (during a window that averages 81 seconds in length) is available to the informed traders, which is economically significant for HFT firms.[6] This implies that, during the period we examine, the process through which filings are disseminated via EDGAR provides certain intermediaries and their clients with a timing advantage and that some market participants trade and profit on this advantage. In response to our study, Mary Jo White, the SEC Chair, announced plans on December 19, 2014, to enhance the system to "ensure that EDGAR filings are available to the public on the SEC [EDGAR] website before such filings are made available to PDS subscribers."[7]

We focus on Form 4 filings of insider trading information because these filings are simple, homogeneous disclosures that are informative to market participants. In addition, the implications for price are clear without the

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September 7, 2013; and "Fed Probes for Leaks Ahead of Policy News," *Financial Times*, September 24, 2013.

[3] A millisecond is one-thousandth of a second; a microsecond is one-millionth of a second.

[4] We provide details on EDGAR and the PDS in section 2. Our data are from a single PDS subscriber that receives two feeds. We show that at least one of these feeds "beats" the EDGAR post in 57% of cases for insider purchases, and that both of the feeds beat the EDGAR post time in 53% of cases. Numbers are very similar for insider sales.

[5] See "Fast Traders Are Getting Data from SEC Seconds Early," *Wall Street Journal*, October 29, 2014.

[6] There is evidence that HFT margins are very small, and that these firms make money by trading large volumes very quickly. Goldstein, Kumar, and Graves [2014] report that an HFT firm makes only 0.1 cents per share traded.

[7] Refer to the letter from SEC Chair, Mary Jo White. Available at http://freepdfhosting.com/1f49e3046a.pdf (last accessed March 1, 2017).

need for additional information or analysis, which facilitates our tests of trading advantage.[8] The SEC requires Form 4s to be filed within two business days of the insider's trade. Brochet [2010] finds that insider purchase filings result in positive abnormal returns at the release date. We also know that prices continue to drift after the filing so that outsiders can earn abnormal returns by trading on news about insiders' trades (e.g., Jaffe [1974], Seyhun [1986], Lakonishok and Lee [2001], Jeng, Metrick, and Zeckhauser [2003], Ravina and Sapienza [2010], Jagolinzer, Larcker, and Taylor [2011], Cohen, Malloy, and Pomorski [2012]).[9] Because insider sales are less informative (Rogers [2008], Brochet [2010]), our market tests focus on insider purchases.

Other types of SEC filings such as earnings announcements (reported on Form 8-K filings) and periodic reports (reported on Form 10-Qs and 10-Ks) are often preempted by other, more timely sources of information, and so are less likely to move prices. As a result, the pricing implications are less clear *a priori*, which hinders tests of pre-event information leakage, an important part of our analysis. It is also possible that the timing of these filings is strategically managed as part of managers' disclosure and reporting strategies, potentially complicating our analysis, which is focused on understanding the mechanics of the SEC's dissemination process. Nevertheless, when we extend our baseline analysis to other filing types (including 8-K, 10-Q, and 10-K filings), we again find that a majority of filings are available to at least one PDS subscriber before being posted to EDGAR.

Market participants who subscribe to the PDS feeds are unlikely to trade on all filings, but instead use sophisticated algorithms to identify insider trades that are more likely to move prices. Rather than trying to guess how the algorithms work, we look at actual trades to identify filings that are most likely to have been traded on by a PDS subscriber. To do this, we identify filings with at least one trade immediately around the time of the PDS feed but before the EDGAR post (private trade) and at least one trade within a minute after the EDGAR posting (public trade). Of the average 101 bps accruing between the acceptance of a Form 4 by the SEC and the close of the market that day, we find that approximately 28% of this return is only available to privately advantaged traders.[10] These returns occur

[8] Form 4 filings convey the company name and symbol, identity and role of insider, date of trade, trade type, trade size, trade price, total trade value, and total holdings of the insider.

[9] Seyhun [1986] reports cumulative abnormal returns of 3.0% over the 100 days after insider purchases. Using a sample drawn from 1986 to 2007, Cohen, Malloy, and Pomorski [2012] show that the abnormal returns associated with the trades of "opportunistic" insiders (who are more likely to trade based on information) are 9.8% over a 12-month period after the trade.

[10] For these trades, prices continue to drift by another 160 bps over the next nine days. This additional return is available to outsiders trading on public news. Given the HFT preference for short holding periods, we focus on the filing-day return.

over an average of 81 seconds and are likely to be economically meaningful to HFT traders.[11]

We also find a private advantage outside of market hours. Prices respond in advance of the EDGAR posting with even larger returns (based on quotes) relative to the within-market hours sample. However, markets are substantially less liquid in the after-hours market and the volume response ahead of the EDGAR posting is muted compared to our results for filings made during the trading day.

Our evidence shows that certain parties purchased access to material news about companies in advance of its public release, and that some of these parties (and/or their clients) traded on this news. This seems inconsistent with the SEC's espoused goal to provide a "level playing field" to all investors. It is less clear whether this practice harms investors or the market as a whole. To answer this question requires an assessment of the costs and benefits of this form of "tiered disclosure." These costs and benefits are similar to those discussed in policy debates about the efficacy of prohibitions on insider trading and Regulation FD, as discussed by Haeberle and Henderson [2016].[12]

On one hand, some argue that this type of early access provides incentives to market participants to obtain and trade on private information, improving price formation. On the other hand, the fact that market participants are differentially informed (and know this) can adversely affect liquidity and price formation, and perhaps even discourage disadvantaged investors from participating in the market. Apart from these economic arguments, regulators may have their own reasons to want to ensure that markets are "fair" for all participants.

After public disclosure, we expect spreads to increase because the interpretation of public signals differs across traders (Kim and Verrecchia [1994], Kandel and Pearson [1995]). Adverse liquidity effects seem less

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[11] Returns can be measured using transaction prices from actual trades or the midpoint of quotes; we use both approaches. Quotes are available for every second of the trading day, making them convenient for short window return tests when trading may not occur. As a result, we use quotes when our tests do not require actual trading. Trade-based returns are useful for knowing the actual transaction prices at different points in time. As a result, we use actual trades when our tests require actual trading. Trade-based returns can be affected by "bid–ask bounce" (e.g., one trade is buyerinitiated and executes at the ask, and the next trade is seller initiated and executes at the bid). Given that returns after insider purchases tend to be positive and drift upwards for at least several days, we expect traders to purchase shares after both private and public signals. Therefore, we do not expect bid–ask bounce to affect our results.

[12] See Manne [1966], Carlton and Fischel [1983], and Leland [1992]. Manne [1966] argues that insider trading provides two benefits. First, he argues that insider trading helps to more quickly move the price of the affected security to the "full information" price. Second, he argues that insider trading is an efficient way of compensating corporate managers for producing information. One could argue that allowing information intermediaries to profit from selling early access to information could similarly provide incentives for private actors to produce value relevant private information, improving market efficiency.

likely to occur in the case of disclosures about Form 4 filings for two reasons: (1) unlike regularly scheduled periodic disclosures such as earnings announcements, Form 4 filings are not predictable and (2) before the results of our work (and contemporaneous work by Jackson and Mitts [2014, JM]) were publicized by the *Wall Street Journal*, most investors did not know that PDS subscribers were getting advance access to filings. Nevertheless, we provide evidence that spreads become elevated at and slightly before the time news is publicly disseminated. We are unable to make definitive statements about the efficacy or harm of this form of tiered disclosure.

Our paper makes several contributions. First, we show that, during the period we study, the SEC process for the dissemination of insider filings (and other types of filings) failed to provide a level playing field: certain market participants received access to insider trading filings submitted to EDGAR before others, and prices, volumes, and spreads moved in the direction of the news in advance of it being posted (and publicly available) on EDGAR. The basic technology underlying EDGAR had been in place for a number of years without significant updating. Our evidence suggests that the SEC's technological infrastructure has not kept pace with the capabilities of traders and market intermediaries.[13]

Second, in a market environment where milliseconds (or even microseconds) provide material advantage, how information is disseminated to market participants becomes critical. As we demonstrate, it is technologically difficult to ensure that all market participants receive information simultaneously, which muddies the definition of what it means for information to be "publicly available." As a result, how companies release and disseminate news through various channels, including their own websites, conference calls, the business press, via social media, etc., matters more today than ever before. Research that examines the details of how corporate news is disseminated, including Blankespoor, Miller, and White [2014], Bushee et al. [2010], and Rogers, Skinner, and Zechman [2016], is likely to become increasingly important in understanding how markets assimilate information. While we show significant movement in prices, volumes, and spreads before insider news becomes publicly available, Rogers, Skinner,

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[13] Our paper, along with contemporaneous work by JM, was prominently covered in a front page article in the *Wall Street Journal* on October 29, 2014, in a story that publicized the fact that EDGAR provided PDS subscribers with a timing advantage ("Fast Traders Are Getting Data from SEC Seconds Early," *Wall Street Journal*, October 29, 2014). Our interactions with the SEC in the early fall of 2014 suggest that it was not aware of the timing advantage available to PDS subscribers prior to seeing our paper. On December 19, 2014, Mary Jo White, the SEC Chair, announced plans to enhance the system and that these enhancements were expected to be in place in the first quarter of 2015 (refer to the letter from SEC Chair, Mary Jo White, available at http://freepdfhosting.com/1f49e3046a.pdf). See also "SEC Plans to Fix Flaw in Distribution System," *Wall Street Journal*, December 26, 2014. The EDGAR Public Dissemination Service—New Subscriber Document (version dated February 23, 2015, p. 3) contains the following statement "[t]he SEC may process the EDGAR data for the SEC website prior to transmitting the data to the PDS."

and Zechman [2016] show that there are nevertheless incremental market effects when Dow Jones disseminates this news *after* it becomes publicly available.

Third, our research contributes to the HFT literature, which we describe in section 2. Most of this research examines policy questions such as whether HFT affects the functioning of the market microstructure in such a way as to be harmful to market liquidity (e.g., Brogaard, Hendershott, and Riordan [2014], Budish, Crampton, and Shim [2015], O'Hara [2015]). Relatively little is known about traders who seek to gain an advantage by obtaining access to news before other traders (Jones [2013]). While some studies show that HFT firms trade based on macroeconomic news (as well as other news that moves the market as a whole), we are not aware of any previous work that addresses firm-specific news.

Fourth, our findings are important for researchers who conduct event studies of SEC filings, especially when they use intraday data. We show that these filings become publicly available after the time indicated in the filing header and that, in many instances, filings were made available to some market participants between the header time and the time of posting to the EDGAR website. While this may not be an issue for studies that investigate daily effects, researchers who use intraday event times need to consider carefully how to measure when the filing becomes publicly available and exactly what that means. Our evidence shows that filing news is not always simultaneously available to all market participants.

Our work relates to contemporaneous work by JM and Jackson, Jiang, and Mitts [2015, JJM]. Similar to our paper, JM examine whether the SEC provides a timing advantage to certain market participants.[14] JJM use the same setting to provide evidence on the way private information is impounded into security prices. While the conclusions from these papers are broadly similar to those from our study, there are also important differences. First, both JM and JJM find substantially longer delays than our study. JJM also find larger returns for longer delays, inconsistent with our results that returns available to PDS subscribers do not vary with the length of the private advantage. Capturing the actual public posting time with error would likely bias toward finding both longer delays and a relation between return magnitudes and the mis-measured private advantage window length (i.e., the later the proxy for public posting, the longer the delay and the more public return included in the "private" window). The ability to accurately capture the EDGAR public posting time depends on the speed of the computer used, speed of the connection, and efficiency of the program that scrapes the EDGAR website. As we discuss further in appendix A, we are confident about the accuracy of our EDGAR post times for several reasons.

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[14] JM also examine whether the PDS time advantage changed after *Wall Street Journal* coverage of our studies in late October 2014.

Second, JJM use file transfer protocol (FTP) time stamps to proxy for PDS feed times, an important difference from our approach. As we note in appendix A, we find FTP timing advantages are uncorrelated with the timing advantages due to PDS feeds (and that there is little, if any, evidence of trading around FTP post times).

Third, we focus on filings covering insider stock purchases, where the expected direction of the return is known ex ante, which allows us to reliably measure returns actually available to privately informed traders. In contrast, JM and JJM use ex post returns to partition their data into good news and bad news, making it difficult to determine whether investors could actually earn the returns they estimate (they are effectively assuming that all traders had perfect foresight of the sign of returns, which seems unlikely). Thus, while they analyze all filing types (as opposed to our focus on Form 4 filings), this breadth comes at a significant cost.[15]

The next section summarizes the HFT literature, provides more detail on the SEC dissemination process, and presents our research questions. Section 3 describes the data and sample. Section 4 presents our evidence on the timing of the dissemination process, while section 5 presents evidence on the market response and the returns available to advantaged traders. Section 6 concludes and discusses implications.

2. *Our Setting and Research Questions*

A number of analytical papers address how privately informed investors benefit from their information advantage (e.g., Kyle [1985], Foster and Viswanathan [1996], Holden and Subrahmanyam [1992], Back, Cao, and Willard [2000]). Our setting differs from those in these papers in at least three respects. First, investors become privately informed by receiving early access to a public signal. Second, the extent of this timing advantage varies across privately informed traders. Third, most uninformed market participants are likely unaware that informed traders have early access.

2.1 HIGH-FREQUENCY TRADING

A large literature in finance and economics addresses HFT.[16] As described by O'Hara [2015] and Jones [2013], the term high-frequency trader encompasses a number of different trading processes and strategies, the common elements being that trading (1) is done by computers; (2) is

[15] Our sample period differs from that of JM and JJM. Their papers use PDS data for several months beginning in August 2014 while we have 22 months of PDS data, March 2012 through December 2013. As such, we have a longer sample period that does not overlap with theirs, which may also explain differences in results. That being said, the main result—that certain traders have private advantage—is observed in both sets of data for all filing types. Therefore, this result seems robust over the 2012–2014 period, and likely before.

[16] Biais and Woolley [2011], Jones [2013], Goldstein, Kumar, and Graves [2014], and O'Hara [2015] provide summaries.

extremely fast (O'Hara mentions speeds, or more correctly, *latencies*, measured in milliseconds, microseconds, or even nanoseconds); (3) exploits co-location (to minimize latencies; for example, HFT firms that trade U.S. equities are typically located in New York City); and (4) is strategy-based. Goldstein, Kumar, and Graves [2014] point out that HFT represented less than 10% of trading volume on U.S. equity markets in the early 2000s but around 50% by late 2012. Easley, de Prado, and O'Hara [2012] quote a source that indicates that HFT accounts for 70% of the volume on U.S. equity markets since 2009.

A large part of the literature addresses whether HFT is beneficial, and so addresses questions related to liquidity and price discovery. As O'Hara [2015, p. 259] indicates, there is "general, but not universal agreement that HFT market making enhances market quality by reducing spreads and enhancing informational efficiency." Hendershott, Jones, and Menkveld [2011] characterize HFT as a subset of algorithmic traders and conclude that HFT improves price efficiency.

O'Hara points out that, in a high-frequency world, the definition of fundamental information becomes blurred because of the speed of trade. While informed traders still look to profit from information, and other traders seek to learn what informed traders know from market data, the rise of algorithmic trading by machines means that the underlying orders are themselves information. She points out that microstructure models typically define private information as a signal of the asset's underlying fundamental value but that, when trading intervals are measured in milliseconds, information can be order-related as well as asset-related.

This work has three implications for our study. First, the HFT literature indicates that some HFT firms trade on fundamental news, but this is only one of several business models. Goldstein, Kumar, and Graves [2014] describe four broad types of HFT activity: (1) automated liquidity provision (passive market-making); (2) market microstructure strategies (trading the tape), under which HFT firms trade based on information they extract from the order flow to profit from very short term price changes; (3) statistical trading, which exploits arbitrage opportunities across different types of securities; (4) event arbitrage, which is trading based on releases of market-wide (including macroeconomic) and firm-specific news. Consistent with HFT firms receiving information slightly ahead of the market, Brogaard, Hendershott, and Riordan [2014] provide evidence that HFT firms predict price changes over intervals of three to four seconds.

To be successful in event arbitrage, HFT firms seek to be the first to obtain news that moves prices. Jones [2013] discusses the fact that some HFT firms parse firm-specific news to extract signals and take positions on those signals within milliseconds of the information becoming available. However, while the literature suggests that HFT firms likely exploit firm-specific news, there is no direct evidence of such trading. In attempting to understand the fundamental information used by HFT firms to trade, Brogaard, Hendershott, and Riordan [2014, p. 2293] focus on "three types of

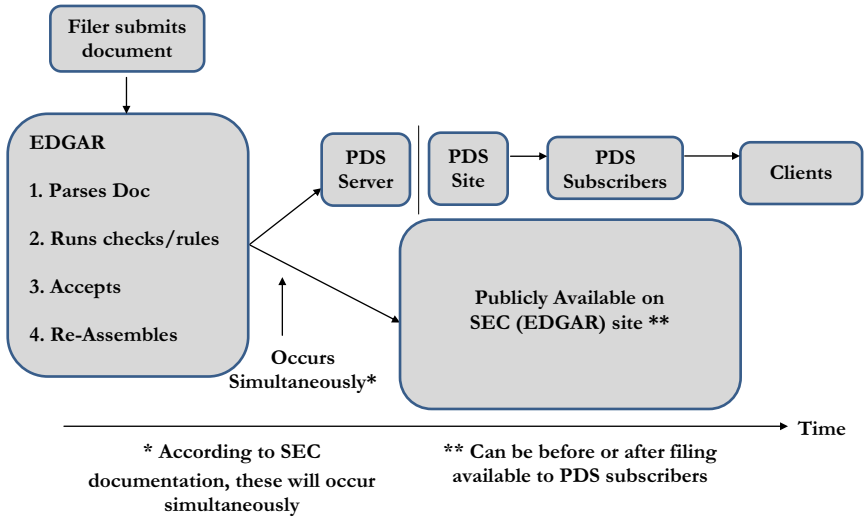

FIG. 1.—The SEC dissemination process.

information identified in prior literature: macroeconomic news announcements, market-wide returns, and imbalances in the limit order book," with the notable omission of firm-specific news.

Second, HFT firms make money by engaging in very high volumes of transactions very quickly; margins on any particular transaction are usually very small. Goldstein, Kumar, and Graves [2014] indicate that the typical net profit margin for an HFT in U.S. equity markets is only 0.1 cents per share traded. Generating even these margins necessitates being faster than other firms to predict and trade on very short-term movements in price or order flow.

Third, HFT activity is strongly related to firm size. Brogaard, Hendershott, and Riordan [2014] report that HFT accounts for 42% of the volume in large stocks and 18% of the volume in small stocks, and observe that the reasons for this are not obvious.

2.2 THE SEC DISSEMINATION PROCESS

The current disclosure regime for Form 4 filings dates from 2002, when the SEC changed its regulations to require that insider transactions be reported within two business days of the trade. Before this, insiders had up to 10 days after the end of the calendar month of the transaction to report the trade, so that trades were often not reported for a month or more (Seyhun [1986]). In June 2003, the SEC required that insider filings be made electronically using EDGAR, so that the information is quickly available to outside investors.

Figure 1 summarizes the SEC dissemination process during the period for which we have data, based on publicly available documents obtained

from the EDGAR website.[17] We supplement the information in figure 1 with conversations with SEC personnel and our data provider (a subscriber to the PDS). The EDGAR site describes the PDS, which aims "to provide the public an accurate, complete and fast method of obtaining all accepted and valid EDGAR filings."[18] A private vendor runs the PDS; the vendor during the period for which we have data (March 2012 through December 2013) was NTT Data. Access to the PDS is subscription based, with fees set by the vendor; these fees were about $15,000 per year in 2014. EDGAR transmits the filing to both the EDGAR website (where it is available to the public) and to the PDS. The PDS transmits the data to paying subscribers. According to the SEC's description of the subscriber service at the time we collected our data, subscribers receive filings that are accepted by EDGAR "at the same time" they are sent to the EDGAR site, with "real-time transmission" of all valid public documents. Thus, at least in theory, the system operates to ensure simultaneous access for all interested parties, whether or not they subscribe to the PDS. Our empirical results do not support this.

The SEC provides further detail about the dissemination process in "EDGAR Public Dissemination Service—New Subscriber Document." The process begins when EDGAR receives a filing that is submitted by an SEC registrant or other filing party. The document is "parsed" to extract key information, and then run through a "rigorous series of syntactic and semantic validation rules" before being accepted by EDGAR. The document is then "reassembled with informative header tags" before being transmitted to the PDS and the EDGAR website. The document states that this process "usually takes no longer than two (2) minutes from the receipt of filing submissions to EDGAR."[19]

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[17] As noted above, the SEC made changes to the EDGAR/PDS in February 2015, at least in part due to the publicity that resulted from our study. Except as otherwise noted, the description we provide here is of the system as it existed prior to the changes made at that time and during the period for which we have data.

[18] Available at http://www.sec.gov/info/edgar/ednews/dissemin.htm (last accessed April 15, 2016). The SEC describes EDGAR as follows: "EDGAR, the Electronic Data Gathering, Analysis, and Retrieval system, performs automated collection, validation, indexing, acceptance, and forwarding of submissions by companies and others who are required by law to file forms with the U.S. Securities and Exchange Commission (SEC). Its primary purpose is to increase the efficiency and fairness of the securities market for the benefit of investors, corporations, and the economy by accelerating the receipt, acceptance, dissemination, and analysis of time-sensitive corporate information filed with the agency." See http://www.sec.gov/edgar/aboutedgar.htm.

[19] All quotes from EDGAR Public Dissemination Service—New Subscriber Document (updated April 1, 2013) at page 3. This document was downloaded from http://www.sec.gov/info/edgar/pdsnewsubscriber.pdf on May 14, 2014. The document was subsequently updated (July 1, 2014) with a new vendor, Attain LLC, but the updated document retains all of the language cited in the text. The document was updated again, on February 23, 2015; the EDGAR website that describes the PDS now states "[t]his document was updated to reflect modifications to the EDGAR system to ensure that EDGAR filings are available to the

Our paper provides evidence on the timeliness of this process. Li, Ramesh, and Shen [2011] provide evidence that the original EDGAR process (circa 1996) had a built-in delay that provided certain intermediaries with a timing advantage of up to 24 hours.[20] This changed in 2002, after which filings were "immediately" made available to the public, with the then-SEC chairman stating that the change ensured that there was a "level playing field" so that investors received "timely information."[21]

After acceptance, EDGAR transmits processed filings to the PDS and EDGAR site. Our discussions with SEC staff indicate that EDGAR initially transmits filings to the PDS and waits for an (automated) acknowledgment of receipt. Once that occurs, EDGAR transmits the filing to the website, where it becomes publicly available. The PDS then begins the process of transmitting filings to the subscribers. According to the subscriber document, transmission to the PDS and the EDGAR site occurs simultaneously; as we show below, this is not, in fact, the case. The PDS server compresses the documents and forwards them through a firewall to the IP addresses of the subscribers' servers. Our understanding is that there are around 40 PDS subscribers, and that the PDS transmits filings to each subscriber feed sequentially in random order. Each of these subscribers has the option of adding a second feed for a marginal cost.

To proxy for the public release of information, most event studies of SEC filings use the date/time the media disseminates the filing or the acceptance date/time stamp in the header of the respective filing on the EDGAR public site.[22] This process worked well when using daily returns, with earnings announcement studies conventionally using days −1 and 0 relative to

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public on the SEC [EDGAR] website *before such filings are made available to the public dissemination [service]* (*PDS*)" (our emphasis).

[20] Li, Ramesh, and Shen [2011, p. 677, note 10] indicate that, when EDGAR was first introduced in 1996, "Level 1" subscribers had immediate access to filings but filings were not posted to the EDGAR site (and so did not become publicly available) for 24 hours.

[21] See "SEC Announces Free, Real-Time Public Access to EDGAR Database" at http://www.sec.gov/news/press/2002-75.htm (last accessed April 15, 2016). This release contains the following quote from then-Chairman of the SEC, Harvey Pitt: "'This latest improvement to the Commission's website will help meet our long-standing goal of providing investors with timely access to information they need to make investment decisions,' Pitt said. 'Through this initiative we are continuing to level the playing field for all investors.'"

[22] Griffin [2003] and Li and Ramesh [2009] use the EDGAR filing date in studies of Form 10-Q and Form 10-K filings. Niessner [2014] uses the earlier of the press release date and the EDGAR filing date in her study of the timing of Form 8-K filings. Patell and Wolfson [1982] use announcement times from the Dow Jones News Service (the "Broad Tape") for their study of intraday earnings announcement timing. Most studies of earnings announcements use the Compustat earnings announcement date. Compustat obtains this from "...various news media (such as the *Wall Street Journal* or newswire services)..." (Cohen, Malloy, and Pomorski [2007, p. 156]). Bagnoli, Clement, and Watts [2005] obtain earnings announcement times from Reuters Forecast Pro while Doyle and Magilke [2009] use *Wall Street Journal* Online. Dellavigna and Pollet [2009] take the earliest of the IBES and Compustat earnings announcement dates, which they verify for accuracy using PR Newswire for a small subsample. Hirshleifer, Lim, and Teoh [2009] also follow this approach.

the event date as the event window. For intraday analyses, studies typically use the Dow Jones News Service release time, which provides the time (hour and minute) when the news is transmitted by the wire service. These proxies for the public availability of the news contained in EDGAR filings are reasonable given the questions being asked in these studies (do returns respond to earnings news?) and available data (daily returns or minute-by-minute data for intraday studies). However, given the advent of HFT, it becomes necessary to partition the event window more finely. We consider four points in time, three of which we obtain from a PDS subscriber:

1. EDGAR acceptance time (the time the filing is accepted by the EDGAR system). Acceptance occurs after EDGAR performs certain rudimentary checks on the filing so some time (presumably very short) elapses between when the filing is submitted and when it is accepted. The acceptance time is the "official" EDGAR time stamp that we scrape from the header text of each Form 4 filing in EDGAR.
2. Filing received by PDS Subscriber Feed #1.
3. Filing received by PDS Subscriber Feed #2.
4. Filing first posted to the SEC (EDGAR) website https://www.sec.gov/edgar; we refer to this time henceforth as "posting."[23]

Our data for 2–4 are from a PDS subscriber. Some subscribers obtain a second feed because technical issues sometimes slow dissemination via a given feed (the PDS transmits filings to subscribers sequentially, so having more than one feed hedges against the possibility that a given feed is towards the end of the queue). While our subscriber data set refers to "Feed #1" and "Feed #2" and the SEC's New Subscriber Document refers to "Primary" and "Secondary" feeds, the feeds appear equivalent in our data in that one is not systematically before the other. Each feed is first for approximately 31% of the filings and they are tied for the remaining 38%.[24] Figure 2 presents the distribution of the timing differences, in seconds. The PDS subscriber tracks the two PDS feeds and the EDGAR posting at the millisecond level. We round each of these measures down to the nearest

[23] As far as we know, this time is not available on any publicly available database. We initially obtained these times using real-time "scrapes" of the EDGAR site. We subsequently obtained and used a collection of these times that had been retained by the PDS subscriber for the same window as the PDS feeds they provided to us. They obtained these times by scraping the EDGAR website. Given that this entity's business model depends, at least in part, on obtaining these filings in the timeliest manner possible, they have strong incentives to collect accurate information about when filings become available on the EDGAR website. In addition, the spike we find in the market response at the second of the scrape time when the EDGAR post time is the first dissemination (figure 3) gives additional support to the notion that we have an accurate time for the posting.

[24] We round down to the nearest second and consider the feeds tied if the rounded times are the same.

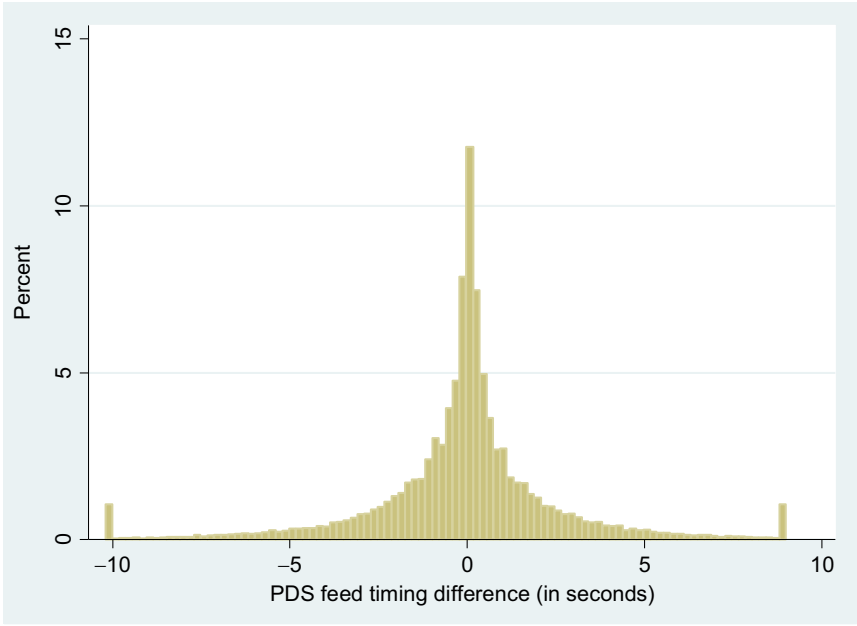

FIG. 2.—Distribution of time differences between the two PDS feeds. The figure plots the distribution of timing differences (in seconds, winsorized at 1% and 99%) between the two PDS feeds. The sample included in the plot are all Form 4 insider trade filings between March 1, 2012 to December 31, 2013 that are unique to a firm within a five-minute window and that we can match to the SEC filing on EDGAR (i.e., line 3 from table 1).

second for all of our tests.[25] Having two feeds provides a substantial advantage because when the feed times differ they often differ by more than a few seconds.

2.3 RESEARCH QUESTIONS

Our tests address three research questions. First, do PDS subscribers obtain a timing advantage vis-à-vis investors who obtain filing information from the public EDGAR site? To answer this question, we provide evidence on the time (in seconds) between when EDGAR accepts a filing and when it is posted to the website. To the extent that there are delays in this process,

[25] Rounding down provides assurance that the information releases did not come before event time $t = 0$ (assuming the NYSE Trade and Quote (TAQ) and PDS subscriber clocks are synchronized). If we alternatively rounded to the nearest second, PDS feeds received in the latter half of the second would be rounded up (e.g., a document received at 10:05:02.57 would be rounded to 10:05:03.00). In a world where some traders can react almost instantaneously, the price, volume, and spread at 10:05:03.00 may already reflect their trading activities. Rounding down ensures that the $t = 0$ price, volume, and spread has not moved as a result of their trading on this PDS feed. Note that certain of our results, discussed below, provide assurance that the TAQ and PDS clocks are synchronized.

we examine factors that explain variation in the delays, including whether "busy" periods (with large numbers of filings) slow the process. We then compare the time a filing is posted to the website to the earlier of the two PDS feeds, our proxy for private availability to PDS subscribers and their clients. Given that our data provider will typically not be the first to receive the filing (i.e., receives the filing after other PDS subscribers), this timing will be biased late in many cases. We use the term "first dissemination" to denote the earliest of times 2, 3, and 4, that is, the first time the information is available to our PDS subscriber via either a PDS feed or the EDGAR website.

Second, we examine whether PDS subscribers (and their clients) obtain an economically significant trading advantage by obtaining early access to the filings. To do this, we analyze intraday (second-by-second) price, volume, and spread data to see whether the market responds to the insider trade news before it is posted to the EDGAR site and becomes publicly available. We then simulate trading strategies actually available to informed market participants such as HFT firms. Specifically, for those instances when the filing is available to PDS subscribers before other market participants (PDS 1st), we identify observations for which trades are made at around the time the news becomes privately available to PDS subscribers (private trade) as well as after the news becomes public (public trade). Under reasonable assumptions, this allows us to compute intraday realized returns available to informed traders and so assess the economic magnitude of these returns.

Third, to the extent that we find that early access to public news provides certain market participants with a material trading advantage, we examine whether the *length* of the timing advantage matters. While it may seem that a longer advantage would naturally be more valuable, our discussions with high-frequency traders suggest that *any* timing advantage is valuable given their ability to take positions almost instantaneously, and that there are large returns to being the winner (getting the information first). We thus use our setting to examine whether the returns available to advantaged traders relate to the length of their timing advantage. Anecdotes from the HFT literature indicate that HFT firms and the intermediaries that cater to them are in an ongoing arms race to reduce the time it takes to access information, so that they can be first.

3. Sample and Data

We provide details of our sample in table 1. We obtain Form 4 filings from Thomson-Reuters, and exclude options trades and trades made by company insiders who are not officers or directors as well as trades made outside of the period from March 1, 2012 to December 31, 2013 (to allow us to match to the PDS subscriber feed data). This results in 97,398 insider trades: 23,128 purchases and 74,270 sales. We then use the insider name and company Central Index Key (CIK) to match to the SEC filing, which reduces the sample to 88,841 trades. To unambiguously associate filings with market effects, we remove observations for which there are

TABLE 1
Sample Construction

	Total Trades	Purchases	Sales	% Purchases
Line 1: Starting sample from T-R (stock not options, Form 4, March 1, 2012 to December 31, 2013, including Officers, Directors, and Committee Members)	97,398	23,128	74,270	23.7
Line 2: Match company CIK and insider name to SEC filings on EDGAR	88,841	19,327	69,514	21.7
Line 3: Restrict to "isolated" Form 4 filings (exclude multiple filings within 15 minutes of each other)	66,110	15,257	50,853	23.1
Line 4: Posted to EDGAR website 9:40 a.m. to 3:30 p.m. Eastern time	21,004	6,727	14,277	32.0
Line 5: With TAQ data	18,721	5,289	13,432	28.3
Line 6: Insider's last transaction price within daily trading range on CRSP	17,960	4,782	13,178	26.6

The table describes sample construction. We begin with all insider filings available from Thomson-Reuters (T-R) from March 1, 2012 through December 31, 2013 (line 1) and merge with Form 4 time stamps from EDGAR, which yields the sample in line 2. We eliminate multiple filings for a given firm within a 15-minute window (line 3) and then restrict the sample to filings posted to the EDGAR website between 9:40 a.m. and 3:30 p.m. on trading days (line 4). We merge this sample with TAQ trading data (line 5). To minimize data errors, we require that the last transaction price falls within the CRSP daily trading range (line 6).

multiple filings for the same firm within a given 15-minute window, which reduces the sample to 66,110 trades. We then match to the data from the PDS subscriber, from whom we obtain the two PDS feed times and the EDGAR post time (no loss of observations).

For our main tests, we restrict attention to trades made between 9:40 a.m. and 3:30 p.m. eastern time to ensure that trades occur during the trading day and avoid beginning and end of day trading effects. This results in the loss of two-thirds of the observations, reducing the sample to 21,004 observations (the majority of trades are filed outside of trading hours). We examine filings in extended market hours for robustness in section 4. We then require that NYSE Trade and Quote (TAQ) data and that the insider transaction price occurs within the daily trading range indicated by the Center for Research in Security Prices (CRSP) data (to remove obvious data errors), resulting in a final sample of 17,960 observations, of which 4,782 (27%) are purchases.

Table 2 provides descriptive information on the sample, after excluding insider sales. We compare the final sample (line 6 of table 1) to the larger

TABLE 2
Descriptive Statistics

	Line 3 Sample			Line 6 Sample (Restrict to Within Trade Hours)			Test of Difference (p-value)	
	N	Mean	Median	N	Mean	Median	Mean	Median
Trade Size ($)	15,257	189,519	17,949	4,782	104,861	16,649	<0.01	0.08
Firm Size ($m)	14,430	3,404	543	4,473	3,690	678	0.20	<0.01
Filing Cluster	15,257	4.75	3.00	4,782	3.09	2.00	<0.01	<0.01
Prior Trade ($)	15,257	510,606	38,000	4,782	257,387	35,464	<0.01	<0.01
CEO	15,257	0.18	0	4,782	0.17	0		0.07
CFO	15,257	0.06	0	4,782	0.06	0		0.93

The table reports descriptive statistics for trade and firm characteristics for insider purchase transactions. Variables are defined in appendix B. p-values are from tests of differences in means (medians) between samples from a two-sided t-test (Wilcoxon rank-sum test). For binary variables, significance is based on p-values from a chi-squared test.

set of observations before we impose the trading day restrictions (lines 3 of table 1). Variable definitions are in appendix B. There are significant differences between insider transactions reported within and outside trading hours. Trade size, the extent to which filings "cluster," and the amount of prior trading by the insider are smaller for filings made within trading hours even though larger firms are more likely to report during trading hours. Median firm size (total assets) is $678 million for trades reported within trading hours compared to $543 million for the line 3 sample that includes all trades. Median trade size is $16,649 for trades reported within trading hours versus $17,949 for the unrestricted line 3 sample. The filing cluster variable indicates that a median of two filings is made in the minute before filing for filings made within the trading day compared to three filings made in the minute before filings in the line 3 sample. Finally, the median prior purchase by the insider is $38,000, but declines to $35,464 for the sample within trading hours.

Compared to other information released by firms, the timing of Form 4 insider trading filings is less likely to be related to the information content of the filing. A large literature examines whether managers strategically time information releases such as earnings announcements, including whether managers strategically delay the release of adverse news to periods when it is likely to receive less attention, including after-trading hours (Patell and Wolfson [1982], Dellavigna and Pollet [2009], Doyle and Magilke [2009], Niessner [2014]).

Most firms have stringent policies that govern trading by corporate officers and board members, and typically handle Form 4 filings in a routine way to ensure compliance with SEC requirements (Bettis, Coles, and Lemmon [2000], Jagolinzer, Larcker, and Taylor [2011]). Consequently, we do not believe that companies or managers strategically manage the timing of Form 4 filings on the basis of their information content (other than, perhaps, to avoid "busy" times or routinely file after trading hours).

4. Evidence on Timing of Dissemination

To address our first research question, table 3 reports time differences between when the filing first becomes publicly available on the EDGAR website (the EDGAR posting time) and when it is first transmitted to the PDS Subscriber (the time of the earliest of the two PDS feeds). This table reports the distribution of these time differences bucketed in five-second increments.

We tabulate the data for purchases; results for sales are very similar. In the first column, negative differences indicate that the earliest PDS feed occurs before the EDGAR post, meaning that PDS subscribers had the data before it was posted to the EDGAR site; conversely, positive differences indicate that the PDS feed comes after EDGAR posting. Of the 4,782 purchases, 57% are available to the PDS subscriber via one of the PDS feeds before

TABLE 3

Timing Differences Between EDGAR Posting and Earliest of the Two PDS Subscriber Feeds

	Purchases	
Seconds Different	Percentage	Cumulative Percentage
Less than −89	1.40	1.40
−89 to −85	0.13	1.53
−84 to −80	0.08	1.61
−79 to −75	0.10	1.71
−74 to −70	0.08	1.80
−69 to −65	0.02	1.82
−64 to −60	0.04	1.86
−59 to −55	0.15	2.01
−54 to −50	0.17	2.17
−49 to −45	0.21	2.38
−44 to −40	0.17	2.55
−39 to −35	0.33	2.89
−34 to −30	1.25	4.14
−29 to −25	3.53	7.67
−24 to −20	7.36	15.04
−19 to −15	9.39	24.42
−14 to −10	10.16	34.59
−9 to −5	10.98	45.57
−4 to 0 (PDS 1st)	11.54	57.11
1–5 (EDGAR 1st)	11.04	68.15
6–10	9.41	77.56
11–15	7.36	84.92
16–20	4.45	89.38
21–25	3.16	92.53
26–30	2.24	94.77
31–35	1.38	96.15
36–40	0.79	96.95
41–45	0.88	97.83
46–50	0.48	98.31
51–55	0.38	98.68
56–60	0.19	98.87
61–65	0.38	99.25
66–70	0.15	99.39
71–75	0.13	99.52
76–80	0.06	99.58
81–85	0.08	99.67
86–90	0.04	99.71
Greater than 90	0.29	100.00
No. of zeros	3	
No. of observations	4,782	

The table shows the delay, in seconds, between the first PDS feed and EDGAR post for the table 1, line 6 sample. Negative (positive) differences indicate that PDS feed occurs before (after) EDGAR post.

EDGAR posting; the corresponding fraction for sales is 56% (untabulated). Thus, in the majority of cases the filing is available to PDS subscribers before it is publicly available. These numbers are conservative because we have data from one PDS subscriber; other PDS subscribers likely obtain the

information before our subscriber. When one of the PDS feeds beats the EDGAR posting, it is usually the case that both feeds do so: while 57% of the purchase filings are received by at least one feed before the EDGAR posting, 53% are received by *both* feeds before the EDGAR posting (untabulated). When we replicate the analysis for the larger sample of filings, which includes those made outside the trading hours (the table 1, line 3 sample), results are very similar (untabulated).

These delays are economically meaningful. The timing advantage is less than 5 seconds in 11.5% of cases, from 5 to 10 seconds in 11.0% of cases, and more than 10 seconds in 34.6% of cases. These differences provide more than enough time for HFT firms to profit from receiving filing information before others, and challenge the notion that the public dissemination process is a level playing field.

There is no expectation here that the PDS feed should always beat the EDGAR posting time: the service is not intended to provide a timing advantage; the PDS subscribers pay for access and happen in some cases to gain access before EDGAR posting. As discussed in section 2, the SEC's intent is that transmissions to the PDS feeds and posting to the EDGAR site are simultaneous.

We next report on the time that elapses from acceptance by EDGAR to posting on the EDGAR site (see table 4, panel A). For the 4,782 purchases, the mean (median) time from acceptance to EDGAR posting is 40 (36) seconds with a standard deviation of 24 seconds, indicating that there are some large outliers; in some cases, there is a (relatively) long delay in getting the filing posted. Overall, the system processes most filings quickly; it typically takes 30–40 seconds for documents to be posted once they are accepted by EDGAR.

If we look instead at the time between acceptance and first dissemination (i.e., the first time the PDS subscriber receives the filing, either from one of its feeds or from the EDGAR posting), the numbers confirm that dissemination to PDS subscribers often occurs more quickly than posting to the EDGAR site. The mean (median) time to initial dissemination is 30 (30) seconds with a standard deviation of 10 seconds.

When we directly compute the time of private advantage, from when the PDS subscriber first receives the filing, either from one of its two PDS feeds or the EDGAR site directly, to when the filing is posted to the EDGAR site, the mean (median) is 10.5 (3.2) seconds, numbers that are reliably different from zero. For 43% of these observations, the difference is, by definition, zero as the first dissemination is equal to the EDGAR post. In the final row of panel A, we report the time differences between the first PDS feed and the EDGAR posting for the 57% of cases where there is a private advantage. The average advantage to the PDS feed is 18.2 seconds with a median of 13.0 seconds. In the full sample and private advantage subsample, the standard deviations are 22.5 and 27.3, indicating that the delays between first dissemination and EDGAR posting are sometimes large.

TABLE 4
Determinants of Reporting Delays

Panel A: Reporting delays

	N	25th	50th	75th	Mean	SD
Acceptance to EDGAR post	4,782	31.4	36.2	41.6	40.2	23.9
Acceptance to first dissemination	4,782	22.2	30.2	36.4	29.7	10.4
First dissemination to EDGAR post (private advantage): all	4,782	0	3.2	14.9	10.5	22.5
First dissemination to EDGAR post (private advantage): PDS 1st	2,728	6.3	13.0	20.4	18.2	27.3

Panel B: Univariate descriptives

	PDS 1st			EDGAR 1st			Test of Difference (*p*-value)	
	N	Mean	Median	*N*	Mean	Median	Mean	Median
Trade Size ($)	2,728	63,061	16,480	2,054	70,563	17,250	0.11	0.19
Firm Size ($m)	2,556	3,223	668	1,917	3,270	707	0.86	0.92
Filing Cluster	2,728	2.3	2.0	2,054	4.0	4.0	<0.01	<0.01
Prior Trade ($)	2,728	163,332	35,442	2,054	180,221	35,613	0.23	0.63
DJ Coverage	2,728	0.79	1	2,054	0.80	1		0.42
CEO	2,728	0.17	0	2,054	0.17	0		0.48
CFO	2,728	0.06	0	2,054	0.06	0		0.87

(*Continued*)

TABLE 4—*Continued*

Panel C: OLS regressions examining timing differences

	Acceptance to EDGAR Post		Acceptance to PDS Feed #1		Acceptance to PDS Feed #2		First Dissemination to EDGAR Post	
Dependent Variable	Coefficient	*t*-Stat	Coefficient	*t*-Stat	Coefficient	*t*-Stat	Coefficient	*t*-Stat
Intercept	25.270***	3.87	27.318***	4.75	26.979***	4.70	5.124	0.80
Log(1 + *Trade Size*)	0.195	0.60	0.530	1.54	0.494	1.52	−0.151	−0.45
Log(1 + *Firm Size*)	0.309	1.27	0.025	0.24	0.008	0.08	0.287	1.24
Log(1 + *Filing Cluster*)	5.054***	3.82	14.399***	17.86	14.539***	18.31	−3.030**	−2.13
Log(1 + *Prior Trading*)	−0.114	−0.30	−0.445	−1.34	−0.404	−1.30	0.187	0.57
DJ Coverage	−0.044	−0.05	−0.431	−0.61	−0.348	−0.46	0.257	0.33
CEO	0.288	0.37	0.047	0.09	0.018	0.03	−0.107	−0.13
CFO	0.281	0.19	0.308	0.32	0.228	0.26	−0.209	−0.14
Log(1 + *Time Trend*)	2.657	1.64	−3.508	−1.40	−3.370	−1.35	2.847*	1.95
R^2	0.024		0.260		0.260		0.016	
N	4,473		4,473		4,472		4,473	

The table provides descriptive statistics and regression analysis of reporting delays for insider purchase filings. Panel A presents the distributions of reporting delays. Panel B provides univariate comparisons for trade and firm variables based on whether the PDS feeds arrive before the EDGAR posting (PDS 1st) or after (EDGAR 1st). Columns 1, 2, and 3 of panel C examine the delay between EDGAR's acceptance of the document and EDGAR posting, PDS feed #1, and PDS feed #2, respectively. Column 4 examines the time delay between first dissemination (i.e., when the PDS subscriber first receives the information, equal to the earliest of the PDS feeds and the EDGAR posting) and EDGAR posting. All variables are defined in appendix B. *p*-values for tests of differences in means are for a two-sided *t*-test. *p*-values for tests of differences in medians are for a two-sided Wilcoxon rank-sum test. For binary variables, significance is based on *p*-values for chi-squared tests. Regression standard errors are clustered at the year-month level, and ***, **, * indicate 1%, 5% and 10% two-tailed significance, respectively.

It is unclear what delays posting Form 4 filings to the EDGAR site. Based on our understanding of the process, transmission of accepted filings to the EDGAR site should occur as soon as the PDS acknowledges receipt, after which it also begins dissemination to the PDS subscribers. To provide some evidence on why postings to the EDGAR site are delayed relative to their availability to PDS subscribers, panel B of table 4 compares insider purchases partitioned according to whether they are available to PDS subscribers before (PDS 1st) or after (EDGAR 1st) posting to the EDGAR site. We compare trade size (log of 1 + total dollars), firm size (log of 1 + total assets, in millions), prior trading by the insider (log of 1 + total purchase activity, in dollars, for that insider during the previous year), a CEO dummy, a CFO dummy, a Dow Jones coverage dummy, and filing cluster (log of 1 + the number of filings posted to the EDGAR site in the previous 60 seconds).

With one notable exception, the results provide little evidence of systematic differences in the characteristics of filings available to the PDS subscriber before and after they are posted to the EDGAR site. The filing cluster variable is larger for observations for which the filing is posted to the EDGAR site before the PDS feeds arrive, implying that busy periods delay transmission to PDS subscribers more than to the public site; the private advantage is reduced or is less likely to occur in busy times. This impression is reinforced by the regressions we report in panel C. These regressions use the same variables to explain the length of four time lags: from the time of EDGAR acceptance through (1) posting to the website, (2) PDS feed #1, (3) PDS feed #2 as well as (4) from first dissemination (i.e., when the PDS subscriber first receives the filing from its PDS feeds or the EDGAR posting, whichever is first) to EDGAR posting. This last variable is positive when the earliest PDS feed occurs before posting to the EDGAR site and zero when EDGAR posting occurs first. We include a time trend (months) to examine whether the time lags change over our sample period.

These regressions confirm the univariate evidence. The only variable that achieves significance in these regressions is filing cluster, which captures the extent to which a lot of filings are posted to the website in a short period of time (i.e., the EDGAR system is busier). Clusters in filings delay the transmission of the filing to the website and, to a larger extent, to PDS subscribers (the first three specifications have a significantly positive coefficient on the cluster variable).[26] Although clustering slows both the PDS feeds and EDGAR posting, it slows the PDS feeds to a greater degree such that it is less likely that the PDS feeds "beat" posting to the EDGAR site (the coefficient on the cluster variable is significantly negative in the final specification, which indicates a reduction in the timing advantage to PDS subscribers during busier times). For the acceptance-to-EDGAR regression, the coefficient on this variable is around 5 ($t = 3.82$) and the R^2 is 2.4%; in contrast,

[26] Untabulated regression results also suggest that clustered filings increase the gap between EDGAR acceptance and the FTP time stamp.

for the two acceptance-to-PDS feed regressions, the coefficient is around 14 ($t = 18$) and the R^2 is substantially higher at 26%. This is consistent with the clustering of filings playing a more important role in delaying feeds to PDS subscribers, both in absolute terms and relative to the time of EDGAR posting—the PDS process is slower during busier filing periods, reducing the timing advantage of the subscribers. The time-trend variable is positive but only weakly significant, indicating a modest tendency for posting delays to get longer over our sample period. The regressions explain a substantial portion of the variation in the PDS delays (the R^2 is 26%) with the majority of the variation explained by busy times (i.e., the filing cluster).

We also estimate a logit on which PDS feed is first and a regression of the timing difference between the two PDS feeds (untabulated). As noted earlier, each of the PDS feeds is first for 31% of the filings and they are (approximately) tied for the remaining 38%. In the logit specification, only the time trend shows any significance and there is virtually no predictive ability in the model (pseudo $R^2 = 0.006$). In the OLS specification, none of the coefficients are significant and, again, the model has virtually no explanatory power ($R^2 = 0.001$). Thus, it appears that the two feeds are equivalent and differences between the feeds are random.

The results in this section establish that, for our sample of Form 4 filings, PDS subscribers receive the filings before they are posted to the EDGAR website (and so become publicly available) more than half the time. To examine whether these results extend to a less restrictive sample of Form 4 filings and other filing types, we also examine (but do not tabulate) results for a comprehensive set of filings.

Across all SEC filings for our sample period (March 2012 through December 2013), there are 142,443 (261,132) Form 4 filings and 422,454 (385,766) filings of other types made during (outside) trading hours. Similar to what we observe for Form 4s, a large fraction (48%) of other filings occur outside trading hours. For filings made within trading hours, our PDS subscriber receives the filing first 49% (57%) of the time for Form 4 (non-Form 4) filings. For filings made outside of trading hours, the corresponding fractions are 53% (Form 4) and 58% (non-Form 4). Thus, private advantage is not limited to Form 4 filings or to filings made within trading hours.

5. Evidence on Trading Advantage

5.1 EVIDENCE ON TIMING OF THE MARKET RESPONSE TO INSIDER FILINGS

We next provide evidence on when the market responds to the information in the filings. We use three variables to provide evidence on when the market responds to the insider filing news: (1) changes in prices (based on quotes) in event time (percent change in price relative to 60 seconds before dissemination), (2) cumulative abnormal volumes (percent abnormal volume relative to typical volume for the two minutes around the

dissemination), and (3) abnormal spreads (spread relative to spread 60 seconds before dissemination).[27] We provide formal definitions of these measures in appendix B. Each of these variables is measured at one second intervals.[28] We report results for the full sample of 4,782 insider purchases in a series of figures.

Figure 3 shows how these variables change in event time relative to initial posting to the EDGAR site, measured from 60 seconds before posting to 60 seconds after. These two-minute windows are, for the large majority of observations, wide enough to capture the full period from initial acceptance to dissemination via the last of our three possible dissemination events. To assess the effect of the timing advantage, we partition observations according to whether they are available to the PDS subscriber before posting to the EDGAR site (advantaged observations) or not.

We first discuss results for changes in prices (returns) in figure 3, panel A. There is a clear difference between the two sets of observations, with prices moving upward for the advantaged observations beginning around 30 seconds before public posting. Most of the positive return (of around 0.30% for the full two-minute window shown here) occurs before public posting. In contrast, for the nonadvantaged observations, most of the upward shift in price occurs exactly at the time of the posting, with a small upward movement in the few seconds before and additional drift in the seconds after. (The fact that we see this sharp spike at the time of posting provides strong assurance that the measured clock times, including our measurement of the EDGAR post time, are accurate.) The overall price change over the full window is very similar for the two series, suggesting that the information content of the trades is similar (this is also confirmed by return comparisons in table 5). The differences between the two series from at least 30 seconds before public dissemination through one second after are statistically significant (panel D provides *t*-statistics for differences between the series). These results provide clear evidence that the market moves before public dissemination for the advantaged observations.

The results for the volume tests reported in figure 3, panel B, are consistent with those from the returns test. Once again, there is evidence of market response, this time measured as abnormal volume that begins around 30 seconds before public posting for the advantaged observations but noticeably later for the nonadvantaged observations, with a sharp spike at the

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[27] We take cumulative dollar volume from $t = -60$ through event second t less the average volume for the exact same day of the week and time (calculated over the prior 52 weeks), deflated by the average cumulative volume for the entire 120-second window (again calculated over the prior 52 weeks).

[28] Our tests assume that the clocks used by our PDS subscriber and by TAQ are correctly synchronized. This seems reasonable based on the importance to the PDS subscriber of having extremely accurate measurement of time for the Form 4 filings. The tests also assume that there is no delay in recording the quotes using TAQ and (later) trading volumes and spreads. The quote assumption is inconsistent with early work in the microstructure literature (Lee and Ready [1991]) but is supported by more recent tests (Rogers [2008]).

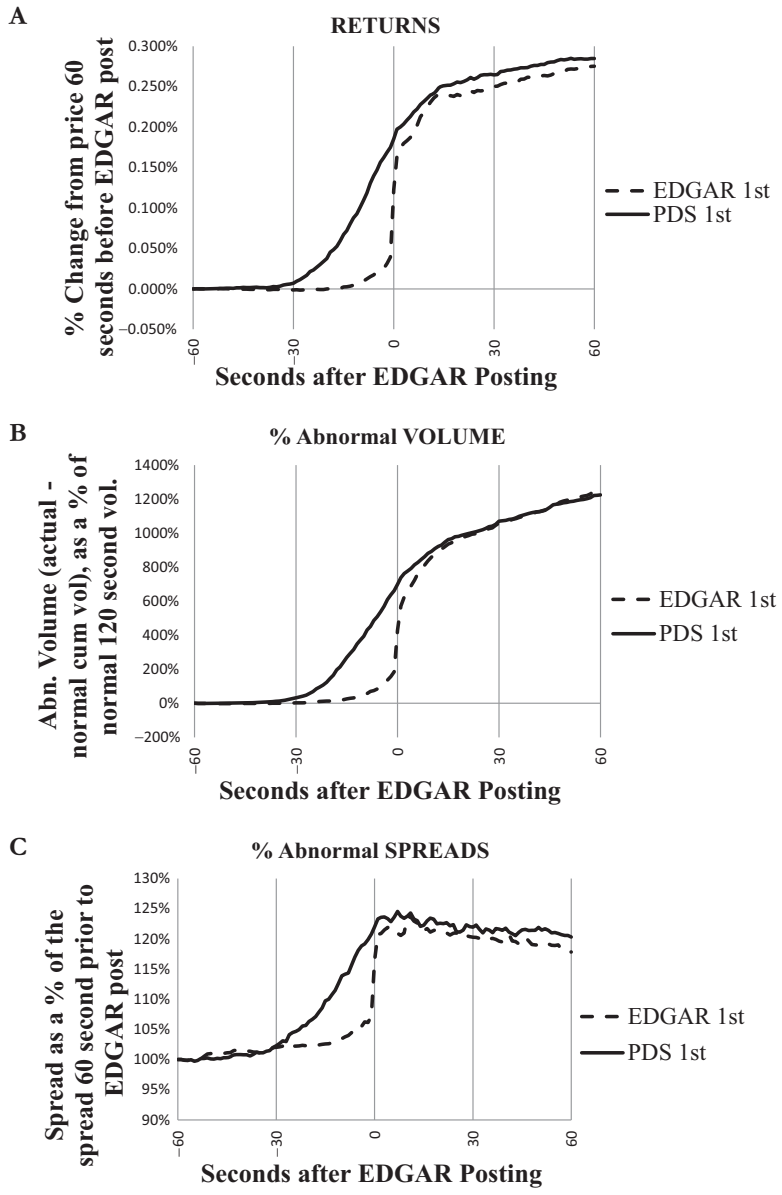

FIG. 3.—Market reactions in "EDGAR Time" based on whether the PDS feeds arrive before or after the EDGAR posting. The figures plot percent returns (panel A), percent abnormal volume (panel B), and percent abnormal spreads (panel C) for a two-minute window around the EDGAR posting. In each panel, the table 1, line 6 sample for insider purchases is divided into those observations where the PDS feed arrives first (i.e., 2,728 observations where the PDS subscriber has a private advantage; PDS 1st) and those for which the EDGAR posting occurs first (i.e., 2,054 observations where the PDS subscriber receives the scraped EDGAR posting as its first source; EDGAR 1st). Panel D provides details on the *t*-statistics of tests of differences between the two samples for the plots in panels A–C. Market reaction variables are defined in appendix B.

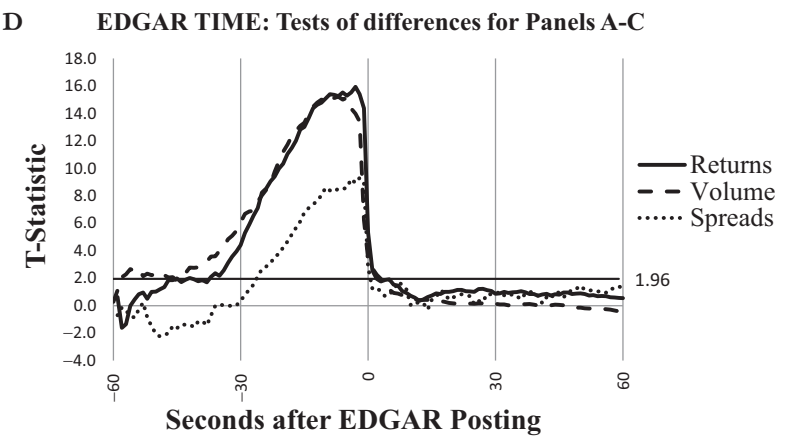

FIG. 3.—*Continued.*

posting time. And once again, the two series merge within 10–15 seconds after the public posting, suggesting that the overall volume response is similar. As with the price differences, differences in volume are statistically significant from more than 30 seconds before public dissemination until just before dissemination (panel D).

Panel C presents the spread results. Similar to the previous figures, these results show that spreads reflect information in the trades noticeably earlier for the advantaged observations relative to the nonadvantaged observations. The fact that spreads, which capture information asymmetry among market participants, jump sharply for the advantaged observations provides additional assurance that the effects we capture are information based and some traders gain a temporary advantage. Note, however, that spreads increase to the same level for both sets of observations, which implies that the higher spreads are due to the arrival of news, consistent with evidence from studies of market liquidity around earnings announcements and the notion that the release of public information can increase information asymmetry because the news is interpreted differently by different market participants (Kim and Verrecchia [1994], Kandel and Pearson [1995]).

Overall, these results present clear evidence that the market responds over a period of about 30 seconds before public posting for the advantaged transactions, consistent with information leakage occurring through the PDS. In contrast, most of the response occurs exactly at the time of public posting for the nonadvantaged transactions. This evidence indicates that the playing field is not fully level, at least for a short time.

An alternative approach is to report the price, volume, and spread changes using different definitions of event time. The next set of tests define time 0 as either: (1) public posting to the EDGAR site (public time), or (2) when the PDS subscriber first receives the information, either from the PDS feeds or the EDGAR posting (first dissemination time). The idea is

to infer from event plots which time is the information event, as measured by the most pronounced "spike" at time 0.

The results of the price test (figure 4, panel A) support the idea that the important informational event is when the filing becomes available to the PDS subscribers, as opposed to when it is posted to the EDGAR site. There is a sharp, distinct price response at time 0 when we define the event as first dissemination time (the earliest receipt by our PDS subscriber). While there is also a time 0 effect when we define the event as the Public Time, it is evident from this plot that a significant portion of the response occurs before time 0, consistent with leakage via the PDS channel for a significant fraction of observations.

The volume results in figure 4, panel B, as well as the spread results in panel C confirm the price results. The most pronounced time 0 spike occurs when time 0 is defined as when the news is first available to PDS subscribers. In contrast, a good part of the reaction occurs before time 0 when it is defined as the EDGAR post time, with something of an incremental spike at time 0, suggesting that there are at least some observations for which EDGAR post time is when the news is first available.

While most of the response occurs at or before time 0, the price and volume charts nevertheless show continued "drift" upwards in prices and volume after the event. Thus, the market adjustment process continues after the end of this two-minute window. Indeed, the evidence from table 5 suggests that, while we clearly document a strong price and market response in this short window around the release of news via EDGAR, this response continues through the end of the trading day and beyond. This drift is consistent with previous evidence on the price movements associated with insider purchases, which shows that the upward drift in prices continues for weeks and months after the time of the trade.

5.2 EVIDENCE ON THE VALUE OF PRIVATE ADVANTAGE

The results to this point indicate that, while the SEC processes filings quickly, typically in about 36 seconds, PDS subscribers have access to more than half of all filings before they are posted to the EDGAR site. We also show that the market responds to the filings before they are posted to the EDGAR website, consistent with some traders trading on this news before it becomes publicly available. We next estimate the economic value of this advantage.

We begin with the understanding that parties subscribing to the feeds are unlikely to trade on all filings, but rather use algorithms to identify more informative filings (i.e., those most likely to move the market price). Rather than trying to guess how the algorithms work, we look for actual trades to identify filings that are most likely to have been traded on by a PDS subscriber. Specifically, we identify filings with (1) at least one trade close to the time of the PDS feed but before the EDGAR post (private trade), and (2) at least one trade within a minute after the EDGAR posting (public trade).

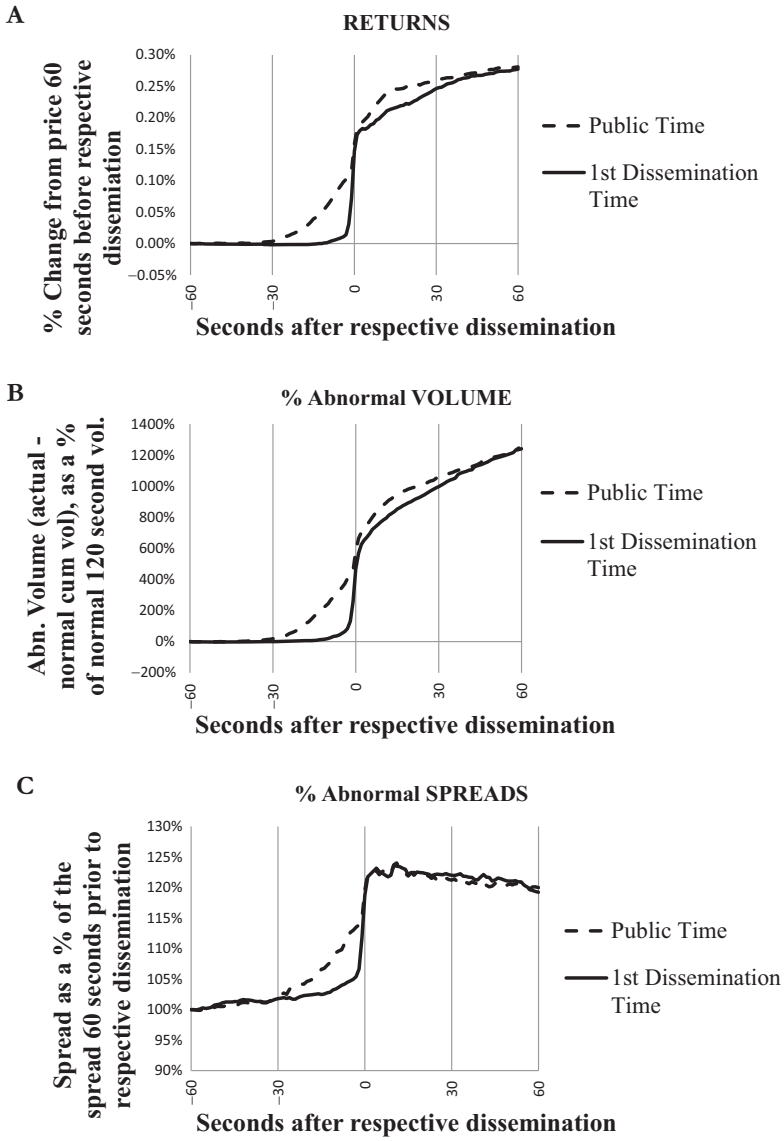

FIG. 4.—Market reactions of the full sample in "1st Dissemination Time" and "Public Time." The figures plot percent returns (panel A), percent abnormal volume (panel B), and percent abnormal spreads (panel C) for a two-minute window around either the EDGAR posting (Public Time) or the first time the PDS subscriber receives the filing (1st Dissemination Time). In each panel, the sample is insider purchases from table 1, line 6. The solid line represents the distribution of the respective market measure centered around the first time the filing is received by the PDS subscriber, equal to the first of the two PDS feeds and the EDGAR posting (i.e., $t = 0$ is the time the PDS subscriber first received the information). The dotted line represents the distribution of the respective market measure centered around the public EDGAR posting (i.e., $t = 0$ is the time the filing appeared on the EDGAR website). Market reaction variables are defined in appendix B.

TABLE 5
Returns to Insider Purchases

	EDGAR 1st Mean (Median)	PDS 1st Mean (Median)	*p*-value	PDS 1st: Trade Mean (Median)	PDS 1st: No Trade Mean (Median)	*p*-value
No. of observations	2,054	2,728		1,065	1,663	
Returns:						
Private Advantage				0.28%		
				(0.13%)		
Insider Trade to	0.57%	0.30%	0.10	0.29%	0.30%	0.95
EDGAR Accept	(0.06%)	(0.05%)	(0.74)	(0.13%)	(0.00%)	(0.32)
EDGAR Accept to	0.62%	0.57%	0.55	1.01%	0.30%	<0.01
End of Day	(0.35%)	(0.34%)	(0.55)	(0.58%)	(0.18%)	(<0.01)
EDGAR Accept to	2.36%	2.65%	0.58	2.61%	2.68%	0.94
10 Days	(1.33%)	(1.23%)	(0.32)	(1.79%)	(0.96%)	(<0.01)
Insider Trade Size	151,475	105,413	0.21	214,400	35,617	<0.01
	(17,250)	(16,480)	(0.19)	(50,000)	(9,000)	(<0.01)
% Routine Trades	8.4%	9.4%	0.20	5.37%	12.01%	<0.01

This table shows insider trade characteristics and returns to four samples of insider purchase filings based on the sample in line 6 of table 1. The four samples include purchases where (1) the EDGAR post was before the first PDS feed (EDGAR 1st), (2) the first PDS feed was before the EDGAR post (PDS 1st), (3) within the PDS 1st sample there was at least one trade based on the PDS information and at least one trade based on public information (PDS 1st: Trade), and (4) within the PDS 1st sample but missing one or both of the required trades (PDS 1st: No trade). For the PDS 1st: Trade sample, we provide the private advantage returns, defined as the returns accumulating between the first trade in the PDS window and the first trade after the EDGAR post (Returns: Private Advantage). For all four samples, we also provide the returns between the insider trade and the EDGAR acceptance of the Form 4 filing (Returns: Insider Trade to EDGAR Accept), the returns between EDGAR Accept and the end of the trading day (Returns: EDGAR Accept to End of Day), the returns between EDGAR Accept and 10 days later (Returns: EDGAR Accept to 10 Days), the size of the insider's trade, in dollars (Insider Trade Size), and the percent of routine trades using a measure based on Cohen, Malloy, and Pomorski [2012] (% Routine Trades). *p*-values for tests of differences in means are estimated using *t*-tests and *p*-values of tests of differences in medians are estimated using Wilcoxon rank-sum tests. Numbers in parentheses refer to either medians or significance tests of medians.

Ideally, we would observe when the first PDS subscriber receives its feed and look for a trade right after that time; however, we only have data from one PDS subscriber with two feeds. To approximate how much earlier the first feed is likely to be, we investigate when price begins to move (in the expected direction) before either of our PDS feeds. In untabulated results, we find that price begins to move well before our measure of "first dissemination" and the price movement is significantly positive nine seconds prior. This price movement suggests that traders using other feeds often have the ability to trade before our feed. In an attempt to identify the first trade that is likely to be based on PDS feed information, we look for the first trade beginning one second before the significant price movement (i.e., 10 seconds before first dissemination) through the time of EDGAR posting (we evaluate alternative windows for robustness). Having done this, we evaluate the return between the first PDS trade and the first trade occurring within 60 seconds after the EDGAR post.

Table 5 provides return measures and other statistics for various subsamples of the 4,782 purchase observations. We first divide these obser-

vations into those for which the EDGAR posting occurs before the first PDS feed (denoted EDGAR 1st, 2,054 nonadvantaged observations) and those for which at least one of the PDS feeds is first (PDS 1st, 2,728 advantaged observations). We then use the logic identified above to divide these 2,728 observations into those for which we observe at least one likely advantaged trade (PDS 1st: Trade, 1,065 observations) and those we do not (PDS 1st: No Trade, 1,663). We compare the characteristics of these observations to determine whether they differ in ways that we expect if PDS subscribers (or their clients) identify more informative transactions, as expected if HFT firms use this information to trade. First, we compare the size of the insider trade (larger trades are more likely to be informative and hence profitable). Second, we follow the method used by Cohen, Malloy, and Pomorski [2012] to separate insider trades into "routine" (trades that are less likely information based) and "opportunistic" trades; we expect privately advantaged traders to focus on potentially more profitable "opportunistic" trades.[29] We compute returns over various windows to assess the magnitude of the returns available to these traders.

First, there are no reliable differences between the subsets of filings for which the EDGAR posting occurs before or after the first PDS feed in table 5, as expected if filings fall randomly into the two categories. The mean (median) return from the insider trade to acceptance by EDGAR is 57 (6) basis points when EDGAR is first and 30 (5) bps otherwise; these differences are not statistically significant. The mean (median) return from EDGAR acceptance through the end of the trading day is 62 bps (35 bps) when EDGAR is first and 57 (34 bps) otherwise, differences again not statistically significant. If we consider a longer window to get a longer perspective on profitability, the return for the period from EDGAR acceptance through the first 10 trading days after EDGAR filing, the mean (median) returns are 236 bps (133 bps) for the EDGAR first sample and 265 bps (123 bps) otherwise; once again, differences are not statistically significant. These returns are also roughly inline with those observed in longer windows in previous research. Finally, both trade size and the percentage of routine trades are similar across these two main subsamples, with no statistically significant differences.

Our main interest is to compare the two subsets of observations for which the PDS subscriber receives the filing before it is posted to the EDGAR site. Here, we observe differences in the directions we expect if privately advantaged traders identify more informative transactions. Insider trade size is significantly larger for observations where PDS is first and we observe trades in the relevant window: for this subset of 1,065 observations, mean (median) trade size is 214,400 (50,000) shares, compared to 35,617 (9,000)

[29] Similar to Cohen, Malloy, and Pomorski [2012], we classify a trader as a routine trader if she trades in the same direction (buy or sell) and the same month for three consecutive years.

shares for the nontrade subset, differences that are statistically significant at better than 1%. In addition, these trades are significantly less likely to be routine: 5.4% of these trades are routine for the trade subsample compared to 12% for the nontrade subset; once again, differences are statistically significant at better than 1%. This evidence suggests that privately informed traders trade on the most informative and therefore likely most profitable insider trades.

Further confirming this interpretation, the mean return from EDGAR acceptance to the end of the trading day for the trade subset is 101 bps versus only 30 bps for the no-trade subset, differences that are again highly significant (medians are 58 bps and 18 bps, respectively, and are also significantly different).

Finally, we compute a mean (median) privately advantaged return of 28 bps (13 bps), which is the return between the first "private trade" and the first "public trade" following the EDGAR posting. This is approximately 28% of the announcement day return (return from EDGAR acceptance to the close of day price) and occurs in a short period of time; the mean (median) holding period for this return is 81 (49) seconds. We view this as an economically significant private advantage to trading on the PDS feed.

For robustness, we examine alternate private advantage windows beginning five, two, and zero seconds prior to the earliest PDS feed. Using shorter windows increases the probability that we miss the first PDS feed and, thus, the first trade based on the PDS information. When we limit the window to five seconds, we have 1,039 observations with an average private return of 25 bps earned in a mean (median) of 81 (49) seconds. At a two-second window we have 1,023 observations and an average private return of 23 bps earned in a mean (median) of 81 (49) seconds. Finally, at the most conservative (lower bound) estimate of zero seconds, we have 938 observations and an average private return of 11 bps earned in a mean (median) of 79 (49) seconds.

One way of assessing the magnitude of this return is to compare it to the returns reported in other research. Dong et al. [2015, figure 1, p. 2244] report minute-by-minute returns around the public dissemination of earnings announcements. For the pre-Reg FD sample (during regular trading hours), when sophisticated market participants received access to earnings news 15 minutes early, they show a one-minute absolute return of 17 bps. The return that we report above, of 28 bps for an average holding period of 80.6 seconds, seems comparable to their effect. The 28 bps we report corresponds to 28% of the first-day return (101 bps). The number they report corresponds to 51% of the two-day return window.

We can also compare the magnitude of these estimates to those reported by JM. As discussed above, these authors also estimate returns available to PDS subscribers, although using a different approach from ours. Using the full set of EDGAR filings and an ex post measure of the sign of the news, these authors find average returns of from 1 to 2 bps in

absolute value over windows of around 90 seconds. These returns are clearly substantially smaller than ours, and of questionable economic significance. We see this difference in results as validating our approach of focusing on insider purchase filings, for which we know both the sign of the news and that the filings typically convey significant information content.

Another way to gauge the economic significance of our result is to estimate the actual dollar return available from taking a position in the stock based on the private information. For the 1,065 observations in table 5 with privately advantaged trading there are an average of 30 trades (per observation) corresponding to a total of 7,400 shares ($90,000) in the private window. These 30 trades will likely execute at a number of different transaction prices. Practically speaking, HFT firms will not unload these 7,400 shares in a single transaction after public dissemination; on average, it takes approximately four minutes before the public volume equals the private advantage volume. During these four minutes, prices continue to evolve. If all of the purchasers in the private advantage window sold as soon as possible in the public window, their profits would equal the weighted average public transaction price minus the weighted average private transaction price multiplied by the 7,400 shares. This calculation yields an average of $826 per transaction, or $880,000 across the 1,065 observations we investigate.[30] While not large in absolute terms, we see this number as economically plausible given that it is based on only a small fraction of the approximately 1.2 million filings during this time frame. As we discuss in section 2.1, HFT firms trade very large volumes expecting to make small profits on each share traded. Goldstein, Kumar, and Graves [2014] indicate an average net profit margin for HFT firms of around only 0.1 cents per share traded. Our calculation corresponds to a profit of 11 cents per share.

5.3 THE VALUE OF LONGER TIMING ADVANTAGES

Our setting provides a unique opportunity to analyze not just the value of a timing advantage but also the potential value of marginal increases in the timing advantage. At least since Grossman and Stiglitz [1980], theorists have been interested in the implications of a group of investors acquiring information advantages. Empirically, previous work examines whether early access to news results in unusual volume and price movement before its public release (Irvine, Lipson, and Puckett [2007], Dong et al. [2015]). However, the period of private advantage was not observable in these settings. In Dong et al. [2015] their entire sample has a 15-minute advantage

[30] This calculation ignores transaction costs. To the extent that HFT firms demand liquidity in the private window and provide liquidity in the public window, we expect transaction costs (effect of bid–ask spread and net exchange rebates) to be minimal. See Brogaard, Hendershott, and Riordan [2014] for discussion of HFT transaction costs.

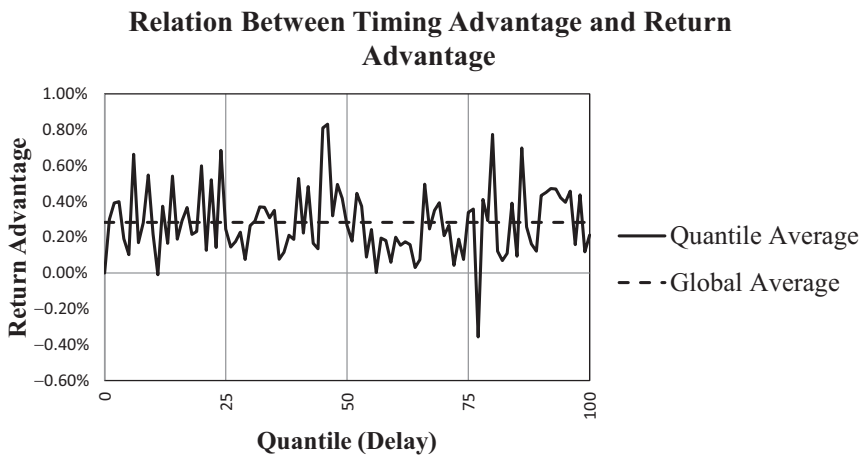

FIG. 5.—Relation between timing advantage and return advantage. The figure shows the average return advantage across 100 quantiles of the delay (difference between the first PDS feed and EDGAR post time). Quantile 1 is the quantile containing the lowest return advantages and quantile 100 contains the highest. The return advantage is the *Private Advantage* returns as calculated in table 5 for the PDS 1st Trade sample (1,065 observations where the PDS feed is before the EDGAR posting and there is at least one trade during the private window).

and Irvine, Lipson, and Puckett [2007] provide evidence consistent with an advantage, but they do not observe when private signals arrive.

Ex ante, it is not obvious whether the value of the timing advantage increases with its length. While it seems intuitive that a longer timing advantage would allow more time to trade and hence be more valuable, Javers [2013] notes that "[i]n the ultra-fast world of high-speed computerized markets, 500 milliseconds is more than enough time to execute trades in stocks and futures that would be affected by the soon-to-be public news. Two seconds, the amount promised to 'low-latency' customers [by Thomson-Reuters], is an eternity." This sentiment is echoed by our discussions with two HFT traders, who argue that what matters is being first rather than the amount of time by which one is first. To test this proposition, we examine whether longer timing advantages translate into larger returns.

Figure 5 plots the returns from privately informed trading, measured in the same way as in table 5, for 100 quantiles of timing delays for the 1,065 observations with at least one privately advantaged trade (the first quantile contains those observations with the smallest timing advantage, while the 100th quantile contains those observations with the longest timing advantages).[31] We plot the average return by quantile. It is clear from

[31] The delay lengths range from 0.5 seconds in quantile 1, to 6.4 seconds in quantile 25, 13.0 seconds in quantile 50, 19.8 seconds in quantile 75, and 242 seconds in quantile 99.

figure 5 that there is no relation between the length of the timing advantage and the magnitude of the trading return.[32] Subject to the caveat that we are extrapolating from our observed PDS feeds to the full set, this test provides clear evidence that the length of the timing advantage is not important—what matters is having a timing advantage, not its length.

These conclusions differ from those of JJM. These authors find that the "potential profits" available to informed traders increase with the length of the delay until the information becomes public. As we noted previously, finding larger profits to longer delay is consistent with measurement error in the EDGAR post times such that public post times measured late (slow) have both longer delays and larger returns (i.e., capture more of the market response to the public announcement).[33]

5.4 FIRM-SIZE PARTITION

As discussed in section 2.1, the HFT literature indicates that trading by HFT firms is more prevalent in large firms than small firms (Brogaard, Hendershott, and Riordan [2014]). This provides an opportunity to further test the prediction that HFT firms take advantage of the early release of the insider filings. Specifically, we divide our sample into two approximately equal-sized groups according to whether firms are above or below median market value of equity. This yields a set of "large firms," with mean market value of equity of $4.2 billion (between Brogaard, Hendershott, and Riordan's large and medium firms), and a set of "small firms," with a mean market value of equity of $0.08 billion (smaller than Brogaard, Hendershott, and Riordan's average small firm). We expect there to be substantially more HFT activity in the large firm subsample relative to the small firm subsample.

Table 6 replicates the analysis from table 5 with the large and small firm partition; results for large firms are shown in panel A and for small firms in panel B. The fraction of PDS first observations is very similar across the two subsamples, at about 57%, as expected if the allocation

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[32] We obtain very similar results if we instead use the dollar value of the trades as well as from regressing either the measured return advantage or the dollar value on the length of the timing delay. None of these tests provide any evidence of a relation between the timing and the magnitude of the returns available to privately informed traders.

[33] At the same time as finding larger profits to longer delays, JJM also report "potential profits" of 6–9 bps per 100 seconds, which are substantially smaller than our estimates of the returns available to informed traders. Here there are several problems. First, as discussed in appendix A, the FTP time is uncorrelated with the PDS feed time (JM and JJM assume these times are the same). Second, they assume all PDS subscribers receive the filings simultaneously when, in fact (as we discuss in section 2), they receive the filings sequentially. Finally, their return is on-average, controlling for filing type, while we focus on one particular filing type (Form 4s for insider purchases) that has been established as conveying important, market-moving information.

TABLE 6

Returns to Insider Purchase Split on Firm Size

Panel A: Returns to insider purchases: Large firms

	EDGAR 1st Mean (Median)	PDS 1st Mean (Median)	*p*-value	PDS 1st: Trade Mean (Median)	PDS 1st: No Trade Mean (Median)	*p*-value
No. of observations	1,014	1,377		893	484	
Returns:						
Private advantage				0.26%		
				(0.12%)		
Insider Trade to	0.46%	0.40%	0.72	0.38%	0.45%	0.67
EDGAR Accept	(0.07%)	(0.17%)	(0.34)	(0.16%)	(0.18%)	(0.55)
EDGAR Accept to	0.70%	0.60%	0.10	0.81%	0.19%	<0.01
End of Day	(0.39%)	(0.37%)	(0.30)	(0.49%)	(0.20%)	(<0.01)
EDGAR Accept to	1.19%	1.22%	0.90	1.43%	0.82%	0.08
10 Days	(1.06%)	(1.01%)	(0.85)	(1.05%)	(0.89%)	(0.47)
Insider Trade Size	275,030	181,159	0.20	241,888	69,122	0.01
	(35,651)	(32,948)	(0.09)	(52,888)	(11,882)	(<0.01)
% Routine trades	7.52%	9.92%	0.04	6.30%	16.60%	<0.01

Panel B: Returns to insider purchases: Small firms

	EDGAR 1st Mean (Median)	PDS 1st Mean (Median)	*p*-value	PDS 1st: Trade Mean (Median)	PDS 1st: No Trade Mean (Median)	*p*-value
No. of observations	1,040	1,351		172	1,179	
Returns:						
Private advantage				0.42%		
				(0.23%)		
Insider Trade to	0.38%	0.19%	0.09	−0.15%	0.24%	0.46
EDGAR Accept	(0.04%)	(−0.13%)	(0.16)	(−0.16%)	(−0.12%)	(0.47)
EDGAR Accept to	0.53%	0.55%	0.87	2.02%	0.34%	<0.01
End of Day	(0.29%)	(0.29%)	(0.90)	(1.40%)	(0.17%)	(<0.01)
EDGAR Accept to	2.26%	2.90%	0.51	2.39%	2.97%	0.81
10 Days	(0.83%)	(0.82%)	(0.36)	(0.77%)	(0.82%)	(0.90)
Insider Trade Size	31,009	28,209	0.51	71,686	21,867	<0.01
	(9,498)	(9,627)	(0.68)	(33,335)	(7,826)	(<0.01)
% Routine trades	9.18%	8.91%	0.82	5.8%	10.13%	<0.01

This table is similar to table 5 for the subsamples of large and small firms. The firms in table 5 are divided into large and small firms based on the median firm size (market value of equity). Panel A shows the returns for large firms and panel B shows the returns for small firms. The four samples in each panel include purchases where 1) the EDGAR post was before the first PDS feed (EDGAR 1st); 2) the first PDS feed was before the EDGAR post (PDS 1st); 3) within the PDS 1st sample there was at least one trade based on the PDS information and at least one trade based on public information (PDS 1st: Trade); and 4) within the PDS 1st sample but missing one or both of the required trades (PDS 1st: No trade). For the PDS 1st: Trade sample, we provide the private advantage returns, defined as the returns accumulating between the first trade in the PDS window and the first trade after the EDGAR post (Returns: Private Advantage). For all four samples, we also provide the returns between the insider trade and the EDGAR acceptance of the Form 4 filing (Returns: Insider Trade to EDGAR Accept), the returns between EDGAR acceptance and the end of the trading day (Returns: EDGAR Accept to End of Day), the returns between EDGAR acceptance and 10 days later (Returns: EDGAR acceptance to 10 Days), the size of the insider's trade, in dollars (Insider Trade Size), and the percent of routine trades using a measure based on Cohen, Malloy, and Pomorski [2012] (% Routine Trades). *p*-values for means are estimated using *t*-tests and *p*-values of medians are estimated using Wilcoxon rank-sum tests. Numbers in parentheses refer to either medians or significance tests of medians.

of filings to the PDS is not systematic. Consistent with the notion that HFT firms trade more actively in large firms, the fraction of observations that qualify for our private advantage calculation (PDS first observations with the requisite trades) is substantially higher for the large firm sample (893 observations or 65%) than for the small firm sample (172 observations or 13%). Consistent with table 5 results, we find significant differences between the PDS first subsamples with and without trade data in the direction expected—the former group is characterized by larger insider trade sizes and relatively more "opportunistic" trades, reinforcing the conclusion that traders focus on more informative (and so profitable) trades.

Figure 6 replicates the analyses reported in figure 3 for large and small firm subsamples. Panel A presents results for returns and panel B presents results for abnormal volume. For large firms, differences between the plots for the PDS 1st and the EDGAR 1st observations are clear: the plots of both returns and abnormal volume start moving upwards around 30 seconds before EDGAR posting for the PDS 1st observations, while the plots move almost vertically at 0 for the EDGAR 1st observations, consistent with privately advantaged trading. For small firms, these patterns are evident but not as sharp or pronounced, consistent with less privately advantaged trading in these firms. However, as seen in panel C, there is very little volume traded in the small firms. All of this is what we expect if HFT firms use the PDS feed to gain a private advantage and do so to a greater extent for large firms relative to small firms.

5.5 EXTENDED MARKET HOURS ANALYSIS

Our main tests focus on filings that occur during regular market hours (after we exclude filings around the opening and closing bells). The market is open for extended trading from 4:00 a.m. to 9:30 a.m. and 4:00 p.m. to 8:00 p.m. The SEC accepts filings from 8:00 a.m. to 10:00 p.m. Thus, the weekday period during which the SEC accepts new filings and the markets are open for extended trading is between 8:00 a.m. to 9:30 a.m. and 4:00 p.m. to 8:00 p.m. We examine whether our results extend to filings during these windows. Of the 7,496 insider purchase filings made outside of regular trading hours during our sample period, 6,989 occur during extended trading hours. Using line 5 and 6 sample filters from table 1, we obtain an extended-hours sample of 5,502 observations. The split between EDGAR 1st and PDS 1st is approximately even (EDGAR is first 49.6% of the time and PDS is first 50.4% of the time).

When we repeat the analysis reported in figure 3, panel A, for this set of observations, we obtain very similar results (not reported): there is significant price movement before the EDGAR post time. However, there is little liquidity during this extended trading period: volume is minimal, with zero control period volume for many of our observations. Thus, while our main results on timing continue to hold outside of

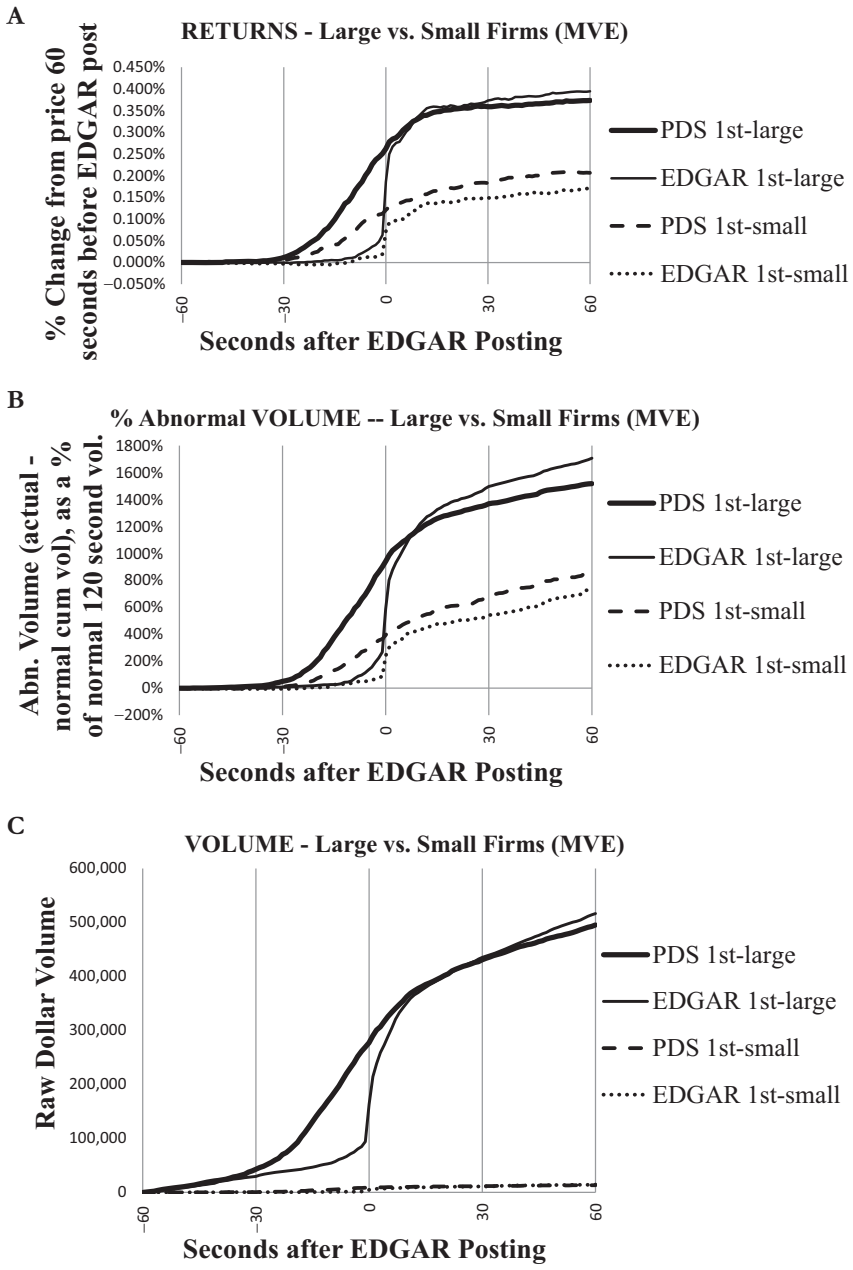

FIG. 6.—Market reactions, split on firm size, in EDGAR Time based on whether the PDS feeds arrive before or after the EDGAR posting. The figures are similar to figure 3 with the sample split at the median of firm size (market value of equity). The plots show percent returns (panel A), percent abnormal volume (panel B), and raw volume (panel C) for a two-minute window around the EDGAR posting. In each panel, the table 1, line 6 sample is divided into those observations where the PDS feed arrives first (PDS 1st) and those for which the EDGAR posting occurs first (EDGAR 1st). Market reaction variables are defined in appendix B.

normal trading hours, it is not clear whether there is sufficient liquidity for market participants to earn significant returns from their timing advantage.

6. *Summary and Conclusions*

We provide evidence on the timeliness of the EDGAR process used by the SEC to publicly disseminate Form 4 insider filings. The timeliness of this process has become critical with the emergence of traders who can take advantage of very small timing differences, sometimes measured in microseconds, between when information becomes available to different market participants. Although we focus on Form 4 filings, the SEC uses the same dissemination process for all regulatory filings, and the timing advantages extend to other filing types.

Our evidence, based on a sample of Form 4 insider trading filings in 2012 and 2013, shows that EDGAR processes these filings quickly, with around a 40-second lag between when filings are accepted by EDGAR and when they are made available to the public on the EDGAR website. We also show that PDS subscribers, who pay for direct access to EDGAR, receive filings before they are available on the EDGAR website more than half of the time (in 57% of cases for insider purchases and in 56% of cases for insider sales). The average period of private advantage is about 10 seconds for the full sample and 18 seconds for the subsample of filings where the PDS feeds are before the EDGAR posting, a relatively long time in the world of HFT. We report evidence—from prices, trading volume, and spreads—that the market responds to the news in advance of its public release. All three measures of trading activity begin to move up to 30 seconds before the filing is made available on the EDGAR site. These findings are hard to reconcile with the notion that the EDGAR process provides a level playing field to investors.

Based on reasonable assumptions, we provide evidence that these timing advantages translate into economically material trading profits. First, we report evidence that traders identify the most informative of those filings they access early. Second, we show that these trades generate trading profits that average around 28 bps over an 81-second period, which we view as economically significant for HFT firms. Finally, we show that the profitability of these trades does not depend on the length of the timing advantage—what matters is getting the information early, not how much of a timing advantage one has.

Our study raises questions about the meaning of publicly available information in a high-frequency, low-latency world, where trading advantages are measured in milliseconds. In particular, our findings raise important questions for firms and regulators about how information should be disseminated in today's capital markets, especially if the goal is to maintain a "level playing field" for all participants.

APPENDIX A

Discussion of Contemporaneous Working Papers and FTP Times

FTP TIMES: DATA COLLECTION

When a firm submits a filing to the SEC, the file is uploaded to the SEC's FTP site. According to Jackson and Mitts [2014, JM] "after filings are posted to the FTP site, a private third party, through a system known as the public dissemination service (PDS), distributes the filings to selected investors before the filings are released to the public" (p. 1). Jackson, Jiang, and Mitts [2015, JJM] also focus on the potential importance of the FTP server and use the "FTP timestamp as a proxy for the time advantage of the 'early informed' in order to preserve a large sample" (p. 8).[34] The claim raises several important issues. First, if all filings were indeed publicly available on the FTP server prior to being disseminated to paying PDS subscribers, one might argue that the SEC has (at least theoretically) provided a level playing field (i.e., anyone with a computer and some programming knowledge could technically be the first person to find a new filing). Second, if this were true, researchers would not need access to private PDS feeds when researching HFT around SEC filings.

While FTP time stamps are discussed in JM, JJM, and other public documents, it is difficult to know exactly what the time, and stamps represent. Therefore, we evaluate whether the FTP time is a reasonable approximation for our PDS times and whether it could influence our findings. To begin, we scrape the FTP date-times from the FTP server for each Form 4 filing in our line 6 sample from table 1 (we end up with 4,758 observations). The FTP timestamp represents the last time a file was saved (i.e., the original dates and times are overwritten if a filing is subsequently updated or amended by the firm). In light of the overwriting of the date-time field by amendments, we merge the FTP dates with the EDGAR acceptance dates and find that 1.9% of the sample (89 observations) has an FTP date that is not the same as the EDGAR date. In all 89 cases, the FTP date is after the EDGAR acceptance date, consistent with the date-time being overwritten due to an update or amendment. We drop the 89 observations (i.e., excluding the largest outliers) leaving us with 4,669 observations where the FTP date is the same as the EDGAR accept date.

FTP TIME VERSUS ALTERNATE TIMES

We next compare the FTP times to four times—EDGAR accept, first dissemination, first PDS, and EDGAR post. Table A1 shows the differences

[34] JJM state that "FTP and PDS time stamps are almost identical, featuring differences of no more than a few seconds" (p. 8). However, JM provide evidence that these differences are often economically large (at least by HFT standards). In particular, their tables 1 and 2 report mean FTP gaps that are 7.6 (8.2) seconds larger than the mean PDS gaps for all (Form 4) filings. As noted in the introduction, "a few seconds" is a long time in the HFT world.

TABLE A1

Seconds Between FTP Time and Various Other Times

	% FTP 1st	25th	50th	75th	Mean	SD
Panel A: Difference between FTP time						
EDGAR accept	22.0	−3.7	−37.8***	−71.0	−62.3***	471
First dissemination	36.5	1.1	−4.3***	−13.8	−31.4***	470
First PDS	45.7	10.8	−1.8***	−13.5	−24.8***	470
EDGAR post	73.7	2.8	1.1***	−0.5	−17.0***	454
Panel B: Absolute difference between FTP time						
EDGAR accept		17.3	38.8***	71.0	69.8***	470
First dissemination		1.6	7.1***	15.2	34.8***	469
First PDS		5.9	12.2***	20.8	40.1***	469
EDGAR post		1.0	1.8***	6.9	27.1***	453

This table shows time differences, in seconds, between the FTP time and four alternative times: EDGAR acceptance, first dissemination, first PDS, and EDGAR post. Panel A provides signed differences and panel B provides absolute differences. In panel A, positive differences indicate that the FTP time is earlier. The differences are shown for the 4,669 observations with FTP date equal to EDGAR accept date.

***indicates p-value <0.01 based on a paired t-test for means and a Wilcoxon matched-pair sign-rank test for medians.

between the FTP time and each of these alternative times, in seconds. Panel A shows the signed differences in seconds. Consistent with JM and JJM, we use positive time differences to indicate that FTP time is earlier. Panel B shows the absolute differences in seconds. The evidence suggests that the FTP time stamp is not a precise proxy for any of these four measures. While the FTP time stamp is before the EDGAR posting in the majority of cases (73.7%), it tends to be after the other data sources. If a trader could instantaneously find filings on the FTP server, he or she would beat our proxy for first dissemination 36.5% of the time.[35] Of the four times, the closest time to the FTP is actually the EDGAR post—the mean (median) FTP time occurs 17 seconds after (1.1 seconds before) the EDGAR post and has a mean (median) absolute difference of 27.1 (1.8) seconds.

As additional evidence related to the claim by JJM that the "FTP and PDS time stamps are almost identical," we also note that the gap between the FTP and EDGAR post time and the gap between the first PDS post time and EDGAR post have a small but significantly positive correlation of 0.12.

RECONCILIATION TO CONCURRENT STUDIES

JM find that the FTP time was an average (median) of 63 (5) seconds *before* the EDGAR posting for Form 4 filings (table 1) and JJM find that the FTP time was an average (median) of 233 (24) seconds *before* the EDGAR

[35] JJM note that "utilizing the FTP server to detect unexpected filings is technically difficult" (p. 9).

posting for Form 4 filings (table 1). Our gaps are substantially smaller. It is possible that these FTP gaps vary through time as evidenced by JM and JJM finding very different gaps when using somewhat different (yet overlapping) sample periods.

It is noteworthy that the FTP times are scraped from the FTP system and are static over time unless there is an update or amendment for a particular file. In contrast, the EDGAR posting time can only be obtained when the posting occurs (i.e., it cannot be retroactively obtained). The accuracy of the posting time can be affected by the speed of the computer, the speed of connection, and the efficiency of the program that scrapes the EDGAR site in real time. If any of these frictions are substantial, then the recorded EDGAR post time will be overstated (i.e., late). We take comfort in the accuracy of our EDGAR post times for three reasons. First, our source of the information is a PDS subscriber whose business model is based on obtaining the filings as quickly as possible (they reference their EDGAR post times as their third feed, in addition to the two PDS feeds, in conversation). Second, when our EDGAR post time is the first of our three dissemination sources (i.e., it is equal to first dissemination), we see the market reaction spike at the time of the EDGAR posting (refer to figure 3—both price and volume reactions for the subsample where the EDGAR post is first spike at the second of our EDGAR posting). Third, the SEC has never refuted our findings and it has agreed to remedy the issue that we identified.

FTP FILES AS A SOURCE OF HIGH-FREQUENCY (LOW LATENCY) TRADING

Finally, we examine whether there is evidence to suggest that the FTP is actually used by traders. To examine this question, we plot how the market reacts depending on the direction and magnitude of the FTP time versus our proxy for first dissemination time. Before plotting the time differences, we first show the distribution of these differences in table A2. FTP is within one second of first dissemination time for only 13% of the observations and is more than one second slower (faster) for 61% (26%) of the observations.

In figure A1, we divide the sample into three groups based on the magnitude of the (absolute) difference between the FTP and first dissemination times. In the first group, the FTP time and first dissemination time are approximately the same, defined as within one second ("within 1 second"). In the second group, the times are 1–10 seconds apart ("1–10 second diff"), and in the third group the times are more than 10 seconds apart (">10 second diff"). The price reactions are plotted using FTP time (i.e., $t = 0$ is the FTP time). Our expectation is that, if the FTP time is accurate and the FTP system is used for trading, we should see a spike at $t = 0$ for all groups, suggesting that trading occurs when the information becomes available. However, if it is the first dissemination time that is accurate and traded on, then we should only see a spike at $t = 0$ for the observations,

TABLE A2
Differences Between FTP and First Dissemination Times

Seconds Between FTP and First Dissemination	Percentage
% FTP > 1 second before	26%
% FTP within 1 second	13%
% FTP > 1 second after	61%
More	0%
[25, 34)	0%
[15, 24)	3%
[5, 14)	7%
[4, 5)	1%
[3, 4)	2%
[2, 3)	2%
[1, 2)	11%
[0, 1) FTP before first dissemination	10%
[−1, 0) FTP after first dissemination	3%
[−2, −1)	3%
[−3, −2)	3%
[−4, −3)	3%
[−5, −4)	3%
[−15, −6)	26%
[−25, −16)	15%
[−35, −26)	4%
Less	3%
No. of observations	4,669

This table shows the distribution of timing delays, in seconds, between the FTP time and the first dissemination (i.e., the earlier of the first PDS feed and the EDGAR post). Positive differences indicate the FTP arrived first and negative differences indicate the first dissemination was first.

where FTP is approximately equal to first dissemination (i.e., "within 1 second"). It is apparent from the lines in figure A1 that only the observations where the FTP time approximates first dissemination show a spike around $t = 0$.

In figure A2, we divide the group with the greatest difference between FTP and first dissemination times (i.e., the ">10 second diff" group from figure A1) into those observations where the FTP is earlier versus later than the first dissemination time. Our expectation is that, if the market reaction occurs at our measure of first dissemination and not FTP time, the markets will move before the FTP time ($t = 0$) when the FTP occurs later (">10 second late") and will move after the FTP time when the FTP occurs earlier (">10 second early"). These expectations are borne out by the data as we see the market reacting more than 10 seconds after (before) the FTP time for the early (late) group.

In summary, the evidence is consistent with our measure of first dissemination time being the more likely source of trading information and the FTP system being in limited use (if in use at all) by traders. Based on these results, we do not incorporate the FTP timestamp into our main analysis.

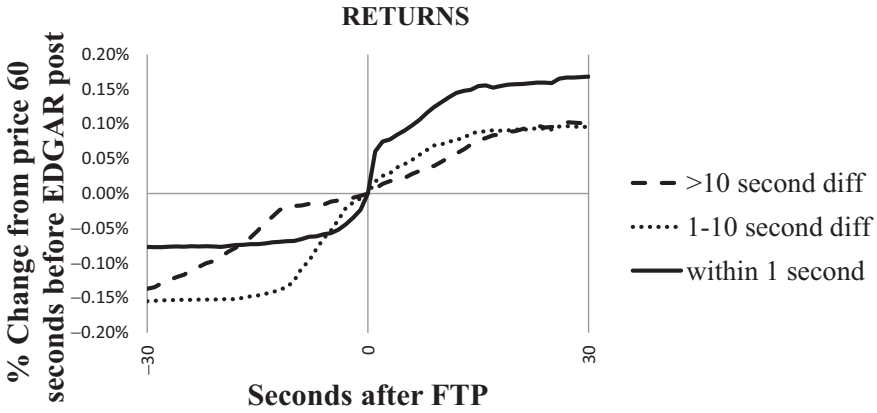

FIG. A1.—Returns around FTP time stamp. This plot shows the returns around the FTP time for three subsets of filings: (1) filings that have an FTP time within one second of first dissemination ("within 1 second"), (2) filings that have an FTP time between 1 and 10 seconds of the first dissemination time ("1–10 second diff"), and (3) filings that have an FTP time more than 10 seconds different from the first dissemination time (">10 second diff").

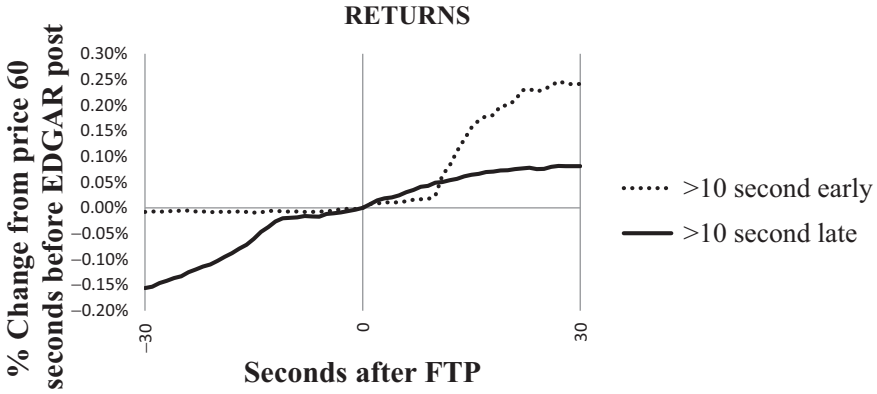

FIG. A2.—Returns around FTP time stamp given large FTP-first dissemination time differences. This plot shows the returns around the FTP time for filings with FTP time more than 10 seconds different from the first dissemination time, split into those where the FTP is early (">10 second early") and those where the FTP is late (">10 second late").

APPENDIX B

Variable Definitions

Independent Variables (Tables)

Note: All continuous variables winsorized at 1% and 99%.

Trade Size	the dollar value of the insider purchase, from Thomson-Reuters
Firm Size	lagged total assets, from Compustat, in millions
Filing Cluster	the number of filings posted to EDGAR in the 60 seconds prior to the Form 4 posting
Prior Trading	the total amount of purchase activity, in dollars, that the insider engaged in during the prior 365 days, from Thomson-Reuters
CEO	1 if the insider is the CEO, 0 otherwise
CFO	1 if the insider is the CFO, 0 otherwise
DJ Coverage	1 if the firm has Dow Jones coverage (per the RavenPack archive) of the Form 4 filing, 0 otherwise; the media coverage is deemed related to the filing if the filing is about the firm, the category is listed as either insider-buy or insider-sell, the relevance score equals 100, and the coverage occurs within 15 minutes following the first dissemination
Time Trend	a measure of chronological time, equal to 1 for observations in the first month of the data and 22 for those in the last month

Market Reaction Variables (Figures)

Returns	the percent change in price between event time and the price 60 seconds prior to dissemination
% Abnormal Volume	cumulative dollar volume from $t = -60$ through event second t less the average volume for the exact same day of the week and time (calculated over the prior 52 weeks), deflated by the average cumulative volume for the entire 120 second window (again calculated over the prior 52 weeks)
% Abnormal Spreads	the percentage of normal spread, measured as (spread at time t)/(spread at 60 seconds prior to dissemination)

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