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### Can information be locked up? Informed trading ahead of macro-news announcements

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# Can information be locked up? Informed trading ahead of macro-news announcements\*

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# Can information be locked up? Informed trading ahead of macro-news announcements

**Abstract** – U.S. government agencies routinely allow pre-release access to macroeconomic data to accredited news agencies under embargo agreements. Using high frequency data, we find evidence consistent with informed trading during news embargoes of the Federal Open Market Committee’s (FOMC) scheduled announcements. The E-mini S&P 500 futures’ average abnormal order imbalance is statistically significant and in the direction of subsequent policy surprises. Our estimates of pre-release informed trades’ dollar profits range between \$4.5 and \$210.5 million when aggregated across all markets and FOMC’s surprise announcements that we examine. Notably, we find no evidence of informed trading immediately prior to FOMC’s news embargoes or during lockups ahead of nonfarm payroll, CPI, and GDP data releases.

**Keywords:** Media Lockup; News Embargo; Informed Trading; FOMC Announcement; Macroeconomic News

**JEL Codes:** E59; G14; G18; K29

# 1 Introduction

Does granting selected parties early access to value-relevant information pose the risk of giving some investors an unfair advantage? Finance academics and regulators have long debated this issue in the corporate context. For instance, firms' practice of providing some professionals with early access to earnings news was questioned and ultimately banned under Regulation Fair Disclosure (Reg FD).<sup>1</sup> Similarly, equity analysts' practice of 'tipping' large clients ahead of recommendation changes led to private litigation and internal guidelines of major brokerage firms forbidding such practice.<sup>2</sup> We examine similar questions that have recently emerged surrounding the release of macro-news.

Macro-news have economy-wide implications that affect asset prices across several markets.<sup>3</sup> Attesting to the importance of macro-news, U.S. government agencies typically provide accredited news outlets with pre-release access to the information under *embargo agreements*. The accredited journalists receive the data prior to the public release (typically in *press lockup facilities*) to allow time for clarifying questions and preparing reports, but cannot disclose the information until the scheduled release. However, recent investigations raise concerns about lockup practices and highlight the potential for information leakage that would give some traders an unfair, if not illegal advantage, akin to trading on corporate insider information.<sup>4</sup>

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<sup>1</sup>See Weber (2000a, 2000b), Shiller (2000), SEC (2000), Hasset (2000), Bushee, Matsumoto, and Miller (2004), Duarte, Han, Harford, and Young (2008).

<sup>2</sup>See Irvine, Lipson, and Puckett (2007), Goldstein, Irvine, Kandel, and Wiener (2009), Christophe, Ferri, and Hsieh (2010), Busse, Green, and Jegadeesh (2012), Kadan, Michaely, and Moulton (2014).

<sup>3</sup>The evidence shows that the release of macro-news affects prices in equity markets (e.g., Pearce and Roley (1985), French and Roll (1986), Ederington and Lee (1993), Veronesi (1999), Flannery and Protopapadakis (2001), Bernanke and Kuttner (2005), Vega (2006), Andersen et al. (2007), Tetlock (2010)), bond markets (e.g., Pearce and Roley (1985), French and Roll (1986), Ederington and Lee (1993), Veronesi (1999), Flannery and Protopapadakis (2001), Gurkaynak, Sack, and Swanson (2005a), Vega (2006), Tetlock (2010)), and foreign exchange markets (e.g., Urich and Wachtel (1984), Fleming and Remolona (1999), Balduzzi et al. (2001), Andersen et al. (2003), Pasquariello and Vega (2007)). Recent work by Savor and Wilson (2013, 2014) and Lucca and Moench (2014) documents systematic unconditional return patterns in equity markets during the days around macro-news announcements.

<sup>4</sup>These concerns led to the tightening of lockup security requirements and recently prompted the Inspector General of the U.S. Department of Labor to recommend discontinuing the use of press lockups. Among others, see also *The Wall Street Journal* reports "A Probe on Data Releases Is Revived" in April 2013; "FBI Finds Black Boxes That Control Government Data Are Vulnerable" and "Deutsche Borse's News Service for Traders Draws Scrutiny of Investigators" in August 2013; "Labor Department Panel

In this paper, we examine for the first time the potential informed trading during macro-news embargo periods. Given the importance of macro-news and the widespread use of news embargoes, understanding the consequences of these practices is important to ensure market integrity. In particular, we use high frequency data to investigate whether there is informed trading during lockup periods ahead of macro-news releases previously shown to have the largest impact on market prices. These include the announcements of the Federal funds target rate by the Federal Open Market Committee (FOMC), as well as the releases of data on nonfarm payroll and consumer price index (CPI) by the Department of Labor (DOL), and on the gross domestic product (GDP) growth by the Bureau of Economic Analysis (BEA) between September 1997 and June 2013.

Consistent with some traders exhibiting an informational advantage, we find robust evidence of informed trading activities across several markets during lockup periods ahead of monetary policy announcements by FOMC. In particular, we document significant abnormal order imbalances that are in the direction of the subsequent policy surprises. The economic magnitude of our results is significant. Back-of-the-envelope calculations suggest that the aggregate dollar profits of lockup-related informed trades ahead of FOMC's surprise announcements range between \$4.5 and \$210.5 million across all the markets that we examine.

Notably, we find no evidence of informed trading prior to the start of FOMC's lockup periods. Moreover, we find no evidence of informed trading ahead of announcements by other government agencies, although their post-release informational value is comparable to the FOMC's announcements. This evidence jointly suggests the existence of a systematic link between informed trading activities and the FOMC's embargo practices.

Our tests rest on the tenet that, to capitalize on pre-release access to macro-news, an investor would want to trade an instrument that has high systematic, but low idiosyncratic risk exposure. Moreover, the instrument needs to be available for trading prior

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Calls for Ending Lockup for Jobs Data" in January 2014; and *CNBC* report "News organizations respond to Fed lockup questions" in September 2013. Most recently, potential leakages from the Federal Reserve were at the center of investigations suggesting Goldman Sachs Group Inc. and Medley Global Advisors received confidential information ahead of its public release, see for example *Bloomberg News* report "Fed Leak Tipped Traders to Historic Stimulus Move, Prompted Secret Inquiry" in December 2014.

to the macro-news release time and have sufficient liquidity to minimize trading costs and price impact. The E-mini S&P 500 futures (ES) meets these criteria across all the announcements that we study. Hence, we use it as our main testing security. In supplemental tests, we also examine the E-mini Nasdaq 100 futures, the SPDR S&P 500 ETF, the PowerShares QQQ ETF tracking the Nasdaq 100 index, the US treasury futures, and the gold futures.<sup>5</sup>

In a semi-strong efficient market (Fama (1970)), an investor can profit on pre-disclosure private information, if the private signal implies a valuation different from market expectations. The greater this difference, the more likely it is that the investor would trade and profit. Therefore, it is critical for our purposes to measure pre-release market expectations in order to identify the information content of macro-news announcements. For the Federal funds target rate, we measure market expectations using the implied interest rate from Federal funds futures traded at the Chicago Mercantile Exchange (CME) similar to Kuttner (2001) and Bernanke and Kuttner (2005). For nonfarm payroll, CPI, and GDP announcements, there are no traded instruments from which to infer market expectations. Thus, we rely instead on economists' forecasts from the Blue Chip Economic Indicators Survey to classify an announcement as a surprise.

In our tests, we follow existing studies of equity analysts' tipping (e.g., Irvine, Lipson, and Puckett (2007), Christophe, Ferri, and Hsieh (2010)) to identify informed trading activity. Namely, we examine the order imbalances of the testing security prior to the macro-news' releases, defined as the difference between buyer- and seller-initiated trading volumes divided by total trading volume. We measure volume either by number of trades or by dollar amount traded, yielding two metrics of order imbalance. To measure *abnormal* trading activities on announcement days, we use as a benchmark all non-announcement days in the prior 21 trading days or since the last announcement, whichever is fewer. Then, for each type of macro-news release, we compare abnormal order imbalances around surprise and non-surprise announcements. Our empirical strategy ultimately exploits the systematic variation across announcement vs. non-announcement

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<sup>5</sup>We only use these securities in our supplemental tests because the other futures contracts are significantly less liquid than the ES and the ETFs are only available during stock market trading hours - i.e., prior to FOMC announcements.

days as well as across surprise vs. non-surprise announcements.

Our tests yield several important results. First, across various markets that we examine, we find evidence of informed trading activity prior to FOMC’s surprise announcements and this activity is exclusively concentrated in the window immediately before the scheduled release - i.e., lockup period. In the case of E-mini S&P 500 futures, for instance, the abnormal order imbalances are 8.4%-9.4% higher for FOMC’s surprise announcements compared to non-surprise ones. Similar patterns emerge when we examine the E-mini Nasdaq 100 futures, the SPDR S&P 500 ETF, or the PowerShares QQQ Nasdaq 100 ETF. In contrast, we find no evidence of informed trading in the thirty minutes prior to the start of FOMC lockups, nor do we find differences in trading activity during FOMC lockups ahead of non-surprise announcements versus non-announcement days.

In contrast to FOMC’s announcements, we find no evidence of informed trading ahead of DOL or BEA announcements. This is particularly relevant, given that government investigations focused on the permeability of the DOL’s lockup facilities since at least 2011. At that point, Need to Know News (NTKN), a news media organization founded in 2004 and granted press credentials in 2006, was alleged of leaking information and ultimately banned from DOL’s lockups.<sup>6</sup> In supplemental tests we examine whether our results vary around 2006, but find that our inferences are robust across subperiods.

In light of our baseline results, we focus on FOMC’s announcements in our subsequent analysis. First, we zoom in on the lockup window and divide this period into three ten-minute windows. The evidence indicates that the informed order imbalances in E-mini S&P 500 futures are mostly concentrated in the last twenty minutes prior to the scheduled release, particularly the [-20, -10] window. Second, we examine the robustness of our results to controlling for discrepancies between scheduled and actual release times of the FOMC policy announcements (e.g., Flemming and Piazzesi (2005), Lucca and Moench (2014)). In particular, using the earliest time of press reports available on Factiva, we continue to find robust evidence of informed trading activity in the window [-20,-10].<sup>7</sup>

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<sup>6</sup>See “Deutsche Borse’s News Service for Traders Draws Scrutiny of Investigators”, *The Wall Street Journal*, August 12, 2013, by Brody Mullins and Scott Patterson.

<sup>7</sup>This holds whether we define “0” as the actual release time or the earliest of the actual and scheduled release times.

Third, we show that our inferences are robust to using stricter definitions of target rate policy surprises or the actual magnitude of the unexpected target rate policy. Similarly, accounting for the Federal Reserve’s announcements of Quantitative Easing measures since November 2008 does not affect our main inferences. Fourth, we repeat our baseline tests conditional on the direction of the policy surprise and find evidence of asymmetric effects. Specifically, informed trading occurs mainly before good news - i.e., unexpected rate cuts. Short-sale constraints in the stock market may account for this asymmetry, because they limit the ability of liquidity providers in the futures market to hedge their positions. It is also possible that informed traders use limit orders more heavily ahead of bad news surprises (e.g., Baruch, Panayides, and Venkataraman (2014)), which would prevent us from correctly identifying informed trades in this case. Lastly, when we examine other markets, we find evidence of informed trading activity in E-mini Nasdaq 100 futures, S&P 500 and Nasdaq 100 ETFs, and 2-Year Treasury futures.

To conclude our analysis, we examine the price impact of pre-release trading activities and the corresponding potential profits that privately informed traders may have enjoyed. Specifically, similar to the analysis of Irvine, Lipson, and Puckett, (2007), we examine the relation between pre-release order imbalances and returns over various windows. Although surprise announcements are not associated with statistically significant pre-release cumulative abnormal returns using actual announcement times, we do in fact find that pre-release order imbalances are significantly correlated with contemporaneous returns, consistent with informed trading. Back-of-the-envelope calculations indicate that informed trades executed during the FOMC lockups earn substantial profits. Assuming informed trades are liquidated five, ten, or thirty minutes after the announcement, the informed traders’ aggregate dollar profits across all surprise announcements and markets that we examine range between \$4.5 and \$210.5 million.<sup>8</sup>

Our analysis contributes to the ongoing policy debate about lockup practices by testing whether macro-news lockups are associated with informed trading. While our evidence is consistent with information leakage during FOMC’s lockup periods, admittedly

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<sup>8</sup>The lower bound assumes only the order imbalance fraction of the trading volume is informed, whereas the upper bound assumes informed traders take the right position in each recorded transaction.



we are unable to identify the exact information channel due to data limitations. The systematic link between the timing of FOMC’s embargoes and informed trading activities is consistent with information leaking directly from the news media with pre-release access or from other FOMC insiders with incentives to mimic such behavior. Alternatively, it is also possible that traders with a superior ability to predict FOMC policy surprises trade during lockups. The latter explanation, however, seems at odds with the lack of informed trading immediately prior to the start of FOMC’s lockups when market liquidity is higher, or during lockup windows of other agencies that release valuable information.

Our study makes a unique contribution to the literature on the capital market consequences of macro-news announcements (see footnote 3). Existing studies show that macroeconomic news affect post-announcement market prices. We add to this literature by showing that traders in equity index futures and ETF markets begin trading in the direction of FOMC’s policy surprises during pre-announcement embargoes. Our analysis also complements the recent evidence in Cieslak, Morse, and Vissing-Jorgensen (2014), which suggests that information about FOMC policy may in fact reach market participants well ahead of when the official decisions are set.

Our analysis also complements other recent studies of scheduled macroeconomic announcements (e.g., Savor and Wilson (2013, 2014); Lucca and Moench (2014)). In particular, Lucca and Moench examine the behavior of equity market prices ahead of FOMC’s scheduled releases. They document an unconditional run-up of 49 basis points in the S&P 500 index during the 24 hours leading to FOMC’s announcements and conclude that this pattern *is not* driven by *informed* trading. Different from their study, we examine the pre-release effect of FOMC’s policy announcements conditional on their information content and focus on the relatively short lockup period - i.e., 30 minutes, when information leakage is most likely. Our evidence indicates that there *is* in fact systematic *informed* trading ahead of FOMC’s scheduled announcements.

More broadly, our study contributes to the literature regarding the effects of short-lived private information on trading activity and price formation. Consistent with the premise of existing theories (e.g., Hirshleifer, Subrahmanyam, and Titman (1994) and Brunnermeier (2005)), there is mounting evidence that short-lived informational advan-

tages arise in a variety of contexts. For example, some investors appear to enjoy early “tipping” on analyst recommendations (e.g., Irvine, Lipson, and Puckett, (2007); Goldstein, Irvine, Kandel, and Wiener (2009); Christophe, Ferri, and Hsieh (2010); Busse, Green, and Jegadeesh (2012); Kadan, Michaely, and Moulton (2014)). Other (high-speed) traders benefit from early access to news feeds (e.g., von Beschwitz, Keim, and Massa (2013); Hu, Pan, and Wang (2013)) and SEC filings (Rogers, Skinner, and Zechman (2014)). News about sovereign credit ratings appear to reach some market participants well ahead of public announcements (Michaelides, Milidonis, Nishiotis, and Papakyriacou (2014)), and similar evidence is available for policy news regarding regulated industries (Reeb, Zhang, and Zhao (2014)). Adding to this growing body of research, we find evidence of a short-lived information advantage during news embargoes ahead of salient policy announcements of the FOMC.

The remainder of the paper is organized as follows. Section 2 provides the institutional background and develops our main hypothesis. Section 3 describes the data and variable construction. Section 4 presents the results of our empirical analysis and Section 5 concludes.

## **2 Institutional background and testable hypothesis**

Across all information events, the release of macro-news is among those with the largest and widest potential impact on capital markets. Attesting to its importance, government agencies manage tightly the macro-news disclosure process. The agencies have an interest in the timely, wide, and accurate dissemination of macro-data that would enhance the public’s understanding of the information released. To foster this policy goal, it is standard practice to grant accredited news media with pre-release access to macroeconomic data, allowing time for questions and preparation of accurate reports ahead of the official releases. Counter-balancing these benefits is the risk of granting some market participants an unfair (if not illegal) advantage, if such early access is exploited to trade. To ensure a level playing field, government agencies have protocols that impose

news embargoes (or lockups), whereby those who are granted early access to the data would refrain from disseminating the information ahead of the scheduled releases.<sup>9</sup>

In recent years, macro-news embargoes and more generally the security of government data storage facilities have come under scrutiny after internal investigations found severe vulnerabilities.<sup>10</sup> As a result of these investigations, the DOL devised a new set of security procedures and for the first time revoked media credentials for some news agencies suspected of embargo violations (e.g., Need to Know News). Most recently, news reports have indicated that important information about policy decisions of the Federal Reserve may have been leaked. The Fed’s internal investigations seem to suggest that important confidential information reached financial institutions and capital market analysts ahead of the public release during the financial crisis.<sup>11</sup>

The recent events suggest that leakages of macro-news are possible during lockup periods.<sup>12</sup> We aim to assess the implications of this concern by examining whether macro-news lockups are associated with systematically informed trading activities, as measured by order flows, and whether this trading affects the price formation process. In particular, agents with pre-release access to the information would want to trade to capitalize on it. Hence, prior to scheduled macro-news releases, trading activities on securities predominantly exposed to macro factors should reveal the likely presence of informed traders.

Given the previous discussion, we examine whether securities predominantly exposed to macro factors experience abnormal order imbalances in the direction of the subsequent macro-news during media lockup periods.

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<sup>9</sup>See DOL website - <http://www.dol.gov/dol/media/lockupnotice.htm>: “April 10, 2012 Policy Statement and News Organization Agreement”, “Press Lock-Up Summary”, “Testimony of Carl Fillichio, Senior Advisor for Communications and Public Affairs before the Committee on Oversight and Government Reform, United States House of Representatives, June 6, 2012.”

<sup>10</sup>See DOL website - <http://www.dol.gov/dol/media/lockupnotice.htm>: “CleanSweep Red Team Report” and “CleanSweep Mitigation Measures Acceptance Testing.”

<sup>11</sup>See *Bloomberg News* report “Fed Leak Tipped Traders to Historic Stimulus Move, Prompted Secret Inquiry” in December 2014.

<sup>12</sup>Official procedures of the DOL and BEA clearly indicate that the lockup period is thirty-minute, whereas we could not find any official document regarding the length of FOMC lockups. In our tests, we use a 30-minute window for all announcement events and then further zoom in on subwindows within the thirty minutes prior to FOMC announcements.

### 3 Data and variable construction

In this section, we describe the data sources, sample selection, and variable construction.

#### 3.1 Testing securities

We use the E-mini S&P 500 futures (ES) as our main testing security for several reasons. First, the asset underlying ES contracts is the S&P 500 index. Because the underlying asset is a diversified portfolio of large stocks, traders with positions in ES contracts are exposed mostly, if not exclusively, to market-wide risk. Investors with advanced information about economy-wide news would have strong incentives to trade such products to minimize their exposure to idiosyncratic risk. Second, the ES is available for trading almost 24 hours on the Globex electronic platform of the CME.<sup>13</sup> This allows us to examine the trading activities associated with macro-news releases by DOL and BEA, which take place at 8:30 a.m. EST before the U.S. stock market opens. Third, informed traders have strong incentives to trade in deep and liquid markets, so as to minimize their trading costs and price impact. Compared to other index products such as the S&P 500 futures and the SPDR S&P 500 ETF (SPY), the ES is substantially more liquid. According to the CME, the ES market has an average daily volume of over 2.1 million contracts and notional value of \$170 billion in the second quarter of 2013.<sup>14</sup> Moreover, compared to securities such as stocks and ETFs, the ES allows traders to take on higher leverage and pay lower commissions. The initial and maintenance margins of the ES required by the CME are 6.6% and 6% respectively as of December 2014.<sup>15</sup> Therefore, we expect that informed trading prior to macro-news announcements, if any, would be more predominant in the ES compared to other instruments.<sup>16</sup>

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<sup>13</sup>Trading on the CME Globex electronic platform for the E-mini contracts halts between 5:15 p.m.-6:00 p.m. EST every day and between 4:15 p.m. - 4:30 p.m. EST every day except for Sunday.

<sup>14</sup>See CME Group Leading Products: Q2 2013 publication, available at <http://www.cmegroup.com/education/files/cme-group-leading-products-2013-q2.pdf>.

<sup>15</sup>See CME website at [http://www.cmegroup.com/trading/equity-index/us-index/e-mini-sandp500\\_performance\\_bonds.html](http://www.cmegroup.com/trading/equity-index/us-index/e-mini-sandp500_performance_bonds.html).

<sup>16</sup>Although we predict that absolute activity of informed traders would be higher in the ES, it is not obvious that their relative activity in the same market also would be higher in the presence of liquidity-based trading. In fact, informed traders may have more opportunities to hide behind liquidity orders,

In addition to the ES, we also examine other futures products: the E-mini Nasdaq 100 futures (NQ), the 2-Year and 10-Year US Treasury futures, and the gold futures. Furthermore, since FOMC's releases take place during trading hours, for these announcements we also examine the two most liquid equity index ETFs: the SPDR S&P 500 ETF (SPY) and the PowerShares QQQ ETF (QQQ, tracking Nasdaq 100 index).<sup>17</sup>

The CME introduced the ES contracts on September 9, 1997. In our tests, we use the full history of the ES' time-stamped (to the second) transaction-level data up to June 30, 2013. The NQ contracts started trading on June 21, 1999, and again we obtain the full history of transaction-level data up to June 30, 2013. The US Treasury futures data begin on January 2, 2004 and the gold futures data go back to December 1, 1999.<sup>18</sup> In our tests, we focus on the front-end futures contracts, because they are typically the most liquid contracts. We obtain transaction-level data on the ETFs (SPY and QQQ) from the NYSE Trade and Quote (TAQ) database. SPY's transaction-level data are available for the entire sample period, whereas QQQ began trading only on March 10, 1999. Like the futures data, our ETF TAQ data also end on June 30, 2013.

### 3.2 Surprise in macroeconomic announcements

In this paper, we investigate the scheduled announcements by three agencies that adopt lockup practices ahead of those releases: the Federal Open Market Committee (FOMC), the Department of Labor (DOL), and the Bureau of Economic Analysis (BEA). We focus on the announcements of four types of macro-news: the Federal funds target rate (FOMC), the nonfarm payroll (DOL), the CPI (DOL), and the GDP (BEA). For each announcement type in the period between September 9, 1997 and June 30, 2013, we collect the announcement date and time, as well as the actual announcement. Table 1 provides further institutional details about these events.

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making it harder for econometricians to detect abnormal activities.

<sup>17</sup>It is possible that informed traders are also active in over-the-counter (OTC) markets. However, given the lack of data for these markets, we have to limit our analysis to exchange-traded products.

<sup>18</sup>We obtain transaction data from the CME Globex only while the pit trading on these products started earlier. We choose to examine the electronic trading data because of liquidity reasons.

[Table 1 about here]

To gauge the information content of macro-news announcements, it is critical to measure market expectations prior to the scheduled releases. The difference between market expectations and announced values represents the news that market prices should impound upon announcement. We adopt two different approaches to infer market expectations, depending on the macro-news type. For the Federal funds rate announcements by the FOMC, we rely on the Federal funds futures traded at the CME, in the spirit of Kuttner (2001) and Bernanke and Kuttner (2005). On each trading day, there are multiple Federal funds futures contracts with different maturity dates. We first calculate the implied interest rate for the rest of the life of each contract at the end of each trading day.<sup>19</sup> Then, to estimate the expected Federal funds target rate, we use the mean implied spot rate across all available contracts, weighting each contract by its daily trading volume. The difference between the expected Federal funds rate on the day before the FOMC announcement and the announced target rate is our measure of the surprise. There are 126 FOMC announcements in our sample.<sup>20</sup>

In our main analysis we depart from the method developed in Kuttner (2001) because the latter defines FOMC's policy surprises based on post-announcement information (i.e., Federal funds futures prices) not available during the lockup window. Instead, our method provides an ex ante measure of policy surprises based on information actually available to parties with lockup access. As discussed below, the evidence in Figure 2 (and Table A2 of the Internet Appendix) shows that announcement returns are significantly correlated with our surprise measures. Therefore, our measure contains information that is valuable (*and possible*) for a trader to possess during FOMC's lockups. In subsequent tests, we explore the effect of using alternative surprise definitions including Kuttner's

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<sup>19</sup>The 30 day Federal funds futures are settled against the average daily Fed funds overnight rate for the delivery month. For futures in the current month, the implied rate at the end of day  $k$  is  $1/(n-k)(n * R_k - \sum_{i=1}^k r_i)$ , where  $n$  is the number of days in the month,  $R_k$  is the quoted rate on the future contract, and  $r_i$  is the realized Fed overnight rate. For contracts in the following months, the implied rate is the same as the quoted future rate.

<sup>20</sup>There were in fact 127 announcements during our sample period, but we drop April 29, 2009, because trading on the Federal funds futures market drained after April 17. Table A1 in the appendix tabulates the detailed information about the implied and actual Federal fund rate.

(2001) method.

For the macro-data announcements by the DOL and BEA, there are no traded instruments from which we can directly infer market expectations. Thus, we rely instead on the distribution of economists' forecasts in the Blue Chip Economic Indicators Survey to infer market expectations (i.e., median economist forecast). During our sample period, there are 189 scheduled releases for each announcement type of the DOL and BEA.

For each announcement type, Table 2 provides summary statistics of the expected and actual values, their difference, and the absolute value of the difference.<sup>21</sup> Panel A shows that the average futures-implied Federal funds rate is 2.734%, while the average target rate announced by the FOMC is 2.679%. The average and median difference between the two rates is arguably small, at less than 4 basis points (bp). The average (median) absolute difference is somewhat larger, 8.3 (5.9) bp. There is, however, substantial variation across announcements and, in the extremes, the FOMC's policy surprise is as large as 45.5 bp. Panels B, C, and D report similar statistics for nonfarm payroll, CPI, and GDP announcements. There is large variation in the announcement surprises in each panel. Comparing actual announcement and the absolute difference in each panel, we find that the 'relative' announcement surprise is much smaller for the FOMC events compared to the other events. This may be due to the fact that we use a continuously updated measure of expectations based on market prices of Federal funds futures for FOMC events, whereas we must rely on a relatively stale measure of expectation based on economists' surveys for the other events.

[Table 2 about here]

The magnitude of the surprise matters to traders because it directly affects the potential value of access to private information about the corresponding announcement. Indeed, small surprises should not induce much informed trading, because the anticipated price update may be too small to offset the trader's transaction costs. Therefore, to conduct meaningful tests, we need to identify those surprises that would in fact provide

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<sup>21</sup>Since October 19, 2008, the FOMC has announced ranges for the target rate, rather than a single figure. In these cases, we use the mid-point of the range to calculate the reported statistics.

a privately informed investor with a profitable trading opportunity. To this end, for each announcement type, we construct an indicator variable,  $SUR$ , that equals one when the surprise exceeds certain thresholds and zero otherwise. For the FOMC announcements, in our baseline tests, we set the thresholds at  $\pm 12.5$  bp because the minimum adjustment in the Federal funds target rate is 25 bp. Hence,  $SUR_{FOMC}$  is equal to one whenever the FOMC announcement surprise is outside the  $\pm 12.5$  bp range.<sup>22</sup>

It is important to note that, since the inception of the recent financial crisis, the Federal Reserve adopted additional policy measures and the corresponding announcements soon became more salient than the traditional Federal funds target rate announcements. In November 2008, the Federal Reserve began its Quantitative Easing (QE) programs, i.e., large-scale open-market purchases of assets such as treasuries and mortgage-backed securities, to reduce borrowing rates. Together with the scheduled announcement of the Federal funds target rate, the corresponding press releases routinely provided information about the Federal Reserve’s stance regarding its QE programs.

In our robustness tests, as in prior studies (e.g., Gagnon et al. (2011), Krishnamurthy and Vissing-Jorgensen (2011), and Hamilton and Wu (2012)), we identify the information content of QE-related announcements by the resulting daily change in the realized rate of the ten-year treasury on the FOMC announcement day. Specifically, we first calculate the standard deviation of the daily change in the realized rate during the ten trading days prior and the ten trading days following each announcement. Then, if the magnitude of the realized rate change on the announcement day exceeds 1.75 times the rolling-window estimate of its standard deviation, we classify it as a surprise.<sup>23</sup>

For the macro-news announcements by DOL and BEA, it is less obvious how to define large surprise announcements. It seems reasonable that the surprise in an announcement

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<sup>22</sup>The FOMC adopted a new policy of setting a range for the target rate since October 19, 2008. For the corresponding 38 FOMC announcements, we use the following method to identify significant surprises: if the future-implied rate is above the upper bound or below the lower bound of the announced target rate range by at least 12.5 bp,  $SUR_{FOMC}$  is equal to one, and zero otherwise. Our results are robust, if we use instead the difference between the futures-implied rate and the the target range midpoint to define surprises.

<sup>23</sup>Our results do not change materially, if we use five- or three-year treasuries, or if impose more stringent requirements on the magnitude of the standardized daily change in treasury rates on the announcement day, e.g., greater than 2 standard deviations.



would be more salient to investors when the announced values fall in the tails of the economist forecasts' distribution. Thus, in this study, we set  $SUR_{DOL/BEA}$  equal to one when the announced value is outside the 10th and 90th percentiles of economists' forecasts and zero otherwise. For robustness, we also experiment with alternative definitions of surprises. For instance, we use the minimum and maximum forecasts as the thresholds or standardize the announcement surprise by the rolling-window standard deviation of the same macro variable and require it to be beyond some threshold, e.g., 1.75 or 2. Our inferences do not vary across the different methods.

Our baseline tests do not differentiate between good and bad news surprises. However, unexpected increases in the Federal funds rate or the CPI and unexpected decreases in the nonfarm payrolls or GDP convey an immediate negative signal to capital market participants (e.g., Andersen et al. (2003), Bernanke and Kuttner (2005)). In these instances, we reverse the signs of the order imbalances and returns of the testing securities so that all surprise announcements should be associated with positive abnormal order imbalances and returns in the presence of informed trading. Then, in our last set of tests, we separate good and bad news surprises to assess whether they have an asymmetric impact on trading activity and returns around macro-news announcements.

[Table 3 about here]

Table 3 shows the annual breakdown of the number of events based on the surprise announcement indicator, SUR. Out of 126 FOMC events, 25 are classified as surprise announcements that are mostly concentrated in the first half of the sample period. For the other announcement types, there are no obvious time-series patterns in the distribution of surprises. Overall, surprise announcements account for one quarter to one third of the total sample of 189 announcements by the DOL or BEA.

Before proceeding with our main tests centered on trading activity, we examine the return patterns of our main testing security (E-mini S&P 500 futures) around macro-news announcements. We begin by plotting the average minute by minute cumulative returns from 9:30 a.m. on the day before the announcement to 4 p.m. on the announcement day, in Panels A-D of Figure 1. To facilitate comparisons, the cumulative returns for different

announcement types are plotted against the same scale in the four panels. Consistent with Lucca and Moench (2014), there is a clear (unconditional) return run-up before FOMC announcements and this pattern arises long before the start of FOMC's lockup periods. In contrast, we find no clear evidence of price run-ups before the announcements by the DOL and BEA, consistent with Savor and Wilson (2013, 2014).

[Figure 1 about here]

In Panels A-D of Figure 2, we zoom in on the two-hour window around the four types of macro-news announcements to assess whether our surprise measures are economically sensible. In each panel, we plot the cumulative returns starting one hour before non-surprise announcements (SUR=0) using a dashed line and before surprise announcements (SUR=1) using a solid line. Across all event types, surprise announcements are associated with a larger price impact than non-surprise announcements, consistent with surprises conveying new information to market participants. However, the timing of the returns around the official releases are notably different across event types. On the one hand, Panel A of Figure 2 shows that, during the thirty minutes preceding the FOMC lockup period, there is no difference between price patterns associated with surprise and non-surprise announcements. However, the two return-paths begin to diverge notably during the lockup period and continue to do so following the official release time. Moreover, FOMC surprise announcements are associated with greater post-announcement return volatility. On the other hand, Panels B-D of Figure 2 show that there is little, if any difference between cumulative returns associated with non-surprise and surprise announcements prior to the official release of nonfarm payroll, CPI, and GDP data by the DOL and BEA. Moreover, although BEA and DOL surprise announcements are associated with relatively large price jumps following the official releases, there are no notable differences in the post-announcement return volatility between non-surprise and surprise announcements after the initial jump.

[Figure 2 about here]

### 3.3 Measurement of informed trading

Informed trading is not directly observable. Assuming informed traders use market orders to exploit their information advantage, we examine the order imbalance in the testing security defined as  $(B-S)/(B+S)$ , where B (S) is the aggregate buyer-initiated (seller-initiated) trading volume. We use two separate measures of order imbalance, OIN and OID, where volume is defined as number of trades and dollar trading volume, respectively.

The transaction-level data from the CME do not flag the direction of the transaction nor do they contain matched quotes. Therefore, we rely on the tick rule to assign trade direction. Namely, a transaction is classified as buyer-initiated (seller-initiated), if the transaction price is above (below) the last different transaction price. We exclude out-of-sequence trades from the analysis. Because there can be multiple transactions in one second and the data are only stamped to the second, we first calculate volume-weighted price for each second and then apply the tick rule to the bulk of transactions occurring in the same second.<sup>24</sup> We also calculate futures returns using the volume-weighted prices to reduce measurement error. For the two ETF securities, we obtain the quote data in addition to the transaction data from the TAQ database and adopt Lee and Ready (1991) algorithm to determine the trade direction. Namely, we compare the transaction price to the midpoint of the bid and ask quotes and, if the transaction price is above (below) the midpoint quote, it is classified as buyer-initiated (seller-initiated). In instances where the transaction price is equal to the midpoint, we instead use the tick rule to identify the direction of the trade.

In our baseline analysis, we examine three event windows: the pre-lockup period from one hour before to half an hour before a macro-news scheduled announcement,  $[-60,-30]$ ; the lockup period from half hour before to the scheduled announcement,  $[-30,0]$ ; and the post-lockup one-hour period following the scheduled release,  $[0,60]$ . For each event window, we compute the corresponding order imbalance as the difference between the

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<sup>24</sup>In a recent study, Panayides, Shohfi, and Smith (2014) find that the bulk tick test outperforms the traditional Lee and Ready algorithm and other trade signing algorithms when the market is dominated by high frequency trading.

total buyer- and seller-initiated volumes scaled by total trading volume. Table 4 reports the mean, standard deviation, and median for each measure of informed trading in each event window. Since we later examine the price impact, we also include the cumulative returns in each event window. The table includes summary statistics for the benchmark measures, which we estimate using the same trading hour windows during the 21 trading days prior to the current announcement or since the last announcement, whichever is fewer. Each panel in Table 4 shows summary statistics for the variables of interest during the control days (ANN=0), the non-surprise announcements (SUR=0), and the surprise ones (SUR=1). Overall, there are large differences between these groups, especially during the [-30,0] lockup period. In the next section, we formally test for differences in the order imbalance measures across the three sets of trading days.

[Table 4 about here]

## 4 Results

### 4.1 Trading activity around macro-news announcements

In this section we present the evidence pertaining to our main hypothesis. We begin by examining visually the typical trading activity taking place around macro-news announcements. Similar to Figure 2, in Figures 3 and 4, we plot the minute-by-minute order imbalance based on number of trades (OIN) and dollar volume (OID), respectively, for the two-hour period around the four announcement types. Across the board, the order imbalance evidence in the two figures is consistent with the return patterns documented in Figure 2.

[Figure 3 about here]

[Figure 4 about here]

In Figures 3 and 4, Panel A shows that for FOMC events the order imbalance is small and largely random before lockups for both surprise and non-surprise announcements.

During pre-release lockups, however, most minutes' order imbalances tend to be in the direction of the subsequent announcement surprise (above the zero line) and larger in magnitude. In contrast, during the same period, the order imbalances of non-surprise announcements continue to be scattered and small. Following both surprise and non-surprise announcements, the order imbalances become smaller also as a result of higher aggregate trading volumes consistent with lower information asymmetry and uncertainty. Panels B-D of the same figures focus on DOL and BEA releases. Consistent with the return plots, there are no obvious patterns in the pre-release order imbalances associated with surprise or non-surprise announcements.

Overall, Figures 3-4 reveal notable differences in trading activity across surprise and non-surprise announcements during lockup periods ahead of FOMC announcements. To assess the statistical significance of these differences, we regress the two order imbalance measures, OIN and OID, for each event window (i.e., [-60,-30], [-30,0], and [0,60]) on the announcement and surprise indicators. Table 5 reports the ordinary least squares (OLS) coefficient estimates from these models.

Panel A of Table 5 reports the regression results for FOMC announcements. Columns 1 and 2 focus on the pre-lockup window (i.e., [-60,-30]). The evidence shows that neither ANN nor SUR are associated with significant market activity in the ES before FOMC lockups. To gauge the differences between surprise announcements and non-announcement days, we report the results of Wald tests in the last two rows of each column - the first row reports the sum of ANN and SUR coefficients and the second row reports the corresponding  $p$ -value. The results of these tests are not statistically significant at conventional levels, suggesting that there is no difference in market activities between surprise announcement days and non-announcement ones.

[Table 5 about here]

Columns 3 and 4 report results for the lockup period, i.e., window [-30,0]. The ANN dummy coefficient estimate is not significant in either column, indicating that FOMC non-surprise announcements are not associated with abnormal trading activities during the lockup. However, the SUR dummy coefficient estimate is significant in both models,

indicating that there are significantly more market orders executed in the direction of the subsequent surprise than those in the opposite direction. In particular, the SUR coefficient estimates in Columns 3 (OIN model) and 4 (OID model) are equal to 8.43 and 9.37, with  $t$ -statistics of 3.76 and 3.25, respectively. Hence, the number and dollar volume of market orders executed in the direction of the subsequent surprise exceed those in the wrong direction by 8.43% and 9.37% of the total volume, respectively. Given that the typical order imbalance is less than one percent in this highly liquid market, these magnitudes are economically large.

It is also noteworthy that the apparent differences in trading activity between the pre-lockup, i.e., [-60,-30], and lockup, i.e., [-30,0], windows are large and statistically significant, as shown formally in Table A3 of the Internet Appendix. This evidence suggests that informed traders start trading more aggressively only after the information contained in the FOMC's policy announcement is supplied to accredited news agencies, prior to its release.

Columns 5 and 6 of Panel A focus on market activities in the one hour following the official FOMC releases. We find that the post-release abnormal order imbalances associated with FOMC surprise announcements are not significantly different from those associated with non-surprise announcements. Overall, the evidence is consistent with information leakage during media lockup periods, whereby informed investors take advantage of the information in FOMC announcements by trading actively in the ES market.

Panels B, C, and D report the results of the analysis for the release of nonfarm payroll, CPI, and GDP data by the DOL and BEA. Consistent with the patterns in Figures 2-4, we find no statistically significant evidence of informed trading in the ES market during lockup periods ahead of those announcements.

## 4.2 Subperiod analysis

In this subsection, we investigate whether there is a structural break in our baseline results around 2006. This is when a news agency accused of leaking information, Need to Know News, was granted access to the lockup rooms. In particular, we augment our

baseline regression models by adding a dummy variable, POST, which takes a value of one for observations in or after 2006 and zero otherwise. We also interact POST with the ANN and SUR dummies to gauge the change in the effect of surprise announcements on trading activities during lockups. Table 6 reports the OLS estimation results.

[Table 6 about here]

In summary, the coefficient estimates of the SUR indicator remain largely unchanged and the interaction terms are not statistically significant in most specifications. These results are not consistent with the notion that Need to Know News exacerbated information leakage before FOMC announcements or facilitated informed trading before the BEA or DOL announcements. The (lack of) evidence for the latter announcement types, however, should be interpreted with caution. It is possible that a systematic lack of liquidity in the index futures markets may limit the informed traders' ability to capitalize significantly on information leakages ahead of DOL and BEA announcements. To assess this possibility, Figure 5 plots the average number of trades and dollar volume in the ES market for every minute of a trading day. Panels A, B, C, and D correspond to the full sample, the non-announcement, the non-surprise announcement, and the surprise announcement days, respectively. Across the four panels, it is clear that the futures trading volume is substantially lower when the stock market is closed (before 9:30 a.m. and after 4:00 p.m.). Hence, even if a trader has private information as early as 8 a.m., it may be hard to capitalize on it in the futures market without drawing the attention of regulators and other investors.<sup>25</sup> In contrast, the typical market liquidity is much higher during FOMC lockups, which can facilitate informed trading activities.

[Figure 5 about here]

Since we find evidence of informed trading only prior to the FOMC announcements, we focus on these events in the rest of the paper.

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<sup>25</sup>Relatedly, it is possible that informed trading ahead of DOL and BEA official data releases would target other markets that we are not able to examine due to data limitations. For instance, given that macro-news also affect exchange rates, it may be optimal for informed investors to trade in the OTC FX market, the largest round-the-clock financial market in the world.

### 4.3 Zooming in on the lockup window

In this subsection, we divide the FOMC lockup window into three ten-minute periods (labeled [-30,-20], [-20,-10], and [-10,0]) and examine the informed trading activity within each sub-window. Table 7 reports the results.

[Table 7 about here]

Panel A of Table 7 reports the OLS estimates using the baseline model. The estimates in Columns 1 and 2 show that there is no abnormal order imbalance in the first ten minutes of the lockup period. Although the coefficient estimate of SUR is fairly large (greater than 4) in both columns, it is not statistically significant. In contrast, the results in Columns 3 and 4 indicate that there is a large and significant informed order imbalance before surprise announcements in the window [-20,-10]. Specifically, the estimated coefficients on SUR are 7.05 and 9.94 in the OIN and OID regressions with  $t$ -statistics of 1.89 and 2.18, respectively. In the last ten minutes leading to the announcement, the ES's informed order imbalance becomes slightly smaller in magnitude and only marginally significant. In Panel B of Table 7, we repeat our pre- and post-2006 analysis for the three ten-minute sub-windows. We find similar evidence for the pre- and post-2006 periods, except that in the last ten-minute sub-window, there are large and significant informed order imbalances in the pre-2006 period, but no significant informed order imbalance in the post-2006 period.

### 4.4 Scheduled vs. Actual FOMC release time

Earlier studies (e.g., Lucca and Moench (2014), Fleming and Piazzesi (2005)) indicate that media reports about FOMC's announcements may in fact become publicly available minutes ahead of the scheduled time. Although such practice itself seems in contrast with the spirit of a lockup, it is not what gives rise to concerns about violations that would provide some traders with an unfair (private) advantage.

To assess whether early public releases of FOMC announcements affect our baseline



results, we collect the earliest release time of media reports and newswires available on Factiva.<sup>26</sup> Then we repeat our analysis using the media reports' (*actual*) release time instead of the scheduled announcement time. The media reports are only stamped to the minute. Hence, to be conservative, we assume the information reaches the market in the first second of the actual release minute. Table A1 in the appendix reports details about the scheduled and actual release times for each FOMC announcement in our sample. On average, the actual release occurs about two and half minutes earlier than the scheduled time, even though often the actual time is few minutes later.

Not having information on the reasons for the release time discrepancy, we use two methods to account for this discrepancy in our analysis. First, we assume the media lockup always lasts for thirty minutes and the starting time is half an hour before the actual release time. Panel A of Table 8 reports the results using this event time definition. There is statistically significant order imbalance in the first twenty minutes of the lockup period but not in the last ten minutes. Overall, the abnormal order imbalance in the lockup period before surprise announcements is 5.79 to 7.98 percent higher with  $t$ -statistics above 2.5. Alternatively, to account for potential delays in the release of media reports, we also define the announcement time as the earlier of the scheduled and actual time. Panel B reports the results of this analysis. We continue to find that the average order imbalance during lockups ahead of surprise announcements is highly significant.

Next, we assume that the media lockup always starts thirty minutes before the scheduled release time but may end early. Hence, the length of each lockup period can vary. We report the results of the corresponding regression analysis in Panels C and D. Since the first twenty minutes of this alternative lockup window are the same as those under the original definition, the order imbalance before surprise announcements in the second ten-minute window is always significant as in our baseline analysis. In both panels, there is no evidence of significant informed trading in the last sub-window. Overall, like in the baseline tests, the order imbalance during the whole lockup period is always abnormally high and statistically significant. Therefore, it does not appear that the abnormal activ-

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<sup>26</sup>In particular, we collect all newswires and reports from *Dow Jones News Service*, *Reuters*, and *Associated Press* during the two hours around the scheduled release time.

ities documented in our baseline tests are due to the early (public) media reports about FOMC policy announcements.

## 4.5 Robustness

In this section, we present the results of several tests that we perform to assess the robustness of our baseline analysis. First, we repeat our regression analysis using alternative definitions of surprise announcements and report the results in Table 9. We begin by using alternative thresholds to identify significant surprises. In particular, we set the SUR indicator equal to one, if the absolute value of the announcement surprise is above 17.5 bp (Panel A) or above 20 bp (Panel B). Increasing the surprise threshold reduces the number of surprise announcements to only 20 in Panel A and 17 in Panel B. We focus on the media lockup period starting thirty minutes before the scheduled release time because our earlier results indicate that abnormal order imbalances are concentrated in this period. We define the release time 0 as the scheduled time in Columns 1 and 2, the actual time in Columns 3 and 4, and the earlier of the two in Columns 5 and 6. Consistently across all columns, we find that the effect of SUR on the order imbalances during FOMC lockups is statistically significant in line with our baseline results. Alternatively, in Panel C, we use the absolute value of the announcement surprise, AbsDiff, instead of the surprise indicator, SUR. The results are again statistically significant and consistent with our earlier findings.

[Table 9 about here]

In Panel D, we measure the expected Federal funds rate using only Federal funds futures contracts expiring within three months to address the concern that longer term futures may contain irrelevant information about the approaching FOMC meeting. We use again the baseline definition of SUR and the number of surprise announcements reduces to 16 using this method. Nonetheless, we still find significant abnormal order imbalance during the lockup period before surprise announcements regardless of the release time, scheduled or actual.

In Panel E, we adopt a different strategy to measure FOMC’s announcement surprises. Specifically, we rely on the information reflected in the realized ES’ announcement returns to determine the extent to which the FOMC’s announcements surprise market participants. Because informed trading during the lockup period potentially contributes to price discovery, we calculate announcement returns over the window  $[-30, 1]$ , where 0 is the actual announcement time. Using this alternative approach, consistent with the earlier evidence, we find that the relation between order imbalances – whether measured by number of trades or dollar volumes – and realized announcement returns is statistically significant during the lockup period.

In Panel F, we use the Kuttner (2001) method to measure unexpected rate changes. By this method, there are only four announcements in our sample where the unexpected rate change is greater than 12.5 bp. Not surprisingly, given the low power of the test, the corresponding abnormal trading imbalances observed during the lockup window are not statistically significant, even though the coefficient estimate on the SUR dummy is positive and large relative to the ANN dummy coefficient. To gain further insights on these four announcements, Table A4 in the Internet Appendix reports the corresponding order imbalances. The evidence shows that there are very large order imbalances in the direction of the subsequent policy surprise in three out of the four events.

The evidence in Gurkaynak, Sack, and Swanson (2005b, GSS) suggests that FOMC’s announcements contain two distinct signals that market participants react to: the current rate target as well as the future direction of the FOMC’s policy. In Panel G, we rely on their method to identify target and path surprises. Given that it is less obvious how to classify events into surprise and non-surprise announcements using the GSS method, we use the actual continuous surprise measures in our tests. We find that the GSS current target rate surprise is not significantly related to order imbalances in the lockup window. Instead, it is the GSS policy path surprise that explains the systematic variation in abnormal trading activity during FOMC’s lockups. The coefficient estimate suggests that increased selling pressure in E-mini futures is associated with unanticipated tightening policy paths. This evidence supports the notion that there are informed traders establishing positions during FOMC’s lockups to take advantage of the news contained in the

impending announcements.

In Panels H and I, we further examine the different effects that information about current and future target rate policy has on informed trading during FOMC's lockups. Specifically, we redefine our baseline surprise measure by separating the current and non-current future contracts. In line with the results in Panel G, we find that there is little abnormal trading activity associated with the surprise measure based on current Federal funds rate futures. Instead, the abnormal trading activity associated with surprise announcements measured with respect to longer term contracts is large and statistically significant. Nonetheless, our baseline results indicate that using both current and longer term futures identifies surprises that are associated with greater abnormal activity, both statistically and economically.

Next, we examine the sensitivity of our results to changes in the definition of policy surprises during the QE period - i.e., October 2008-June 2013. During this period, the FOMC announced target rates in the form of a range, rather than a point estimate. In Panel A of Table 10, we use the midpoint of the range, rather than its lower and upper bounds, to define surprises. For the period before October 2008, we retain the same baseline definition of surprise announcement used in Table 5. Adopting this approach increases the number of FOMC surprise announcements to 38. Although our inferences remain unchanged, the economic and statistical significance of our results decreases somewhat, suggesting that the additional surprise events add noise to our tests.

During the QE period, in addition to its target rate policy, the FOMC announcements contained arguably important information about the Federal Reserve's large-scale asset purchase programs (i.e., QE<sub>1</sub>, QE<sub>2</sub>, and QE<sub>3</sub>). This additional information in FOMC releases may contaminate our baseline definition of surprise announcements. To address this concern, in Panel B of Table 10, we use the realized changes in the 10-Year treasury rates to define surprises after October 1, 2008, while keeping the same definition based on Federal funds target rates before that date. When we use this alternative approach to define surprise announcements for the QE period, our main inferences remain the same.

[Table 10 about here]

## 4.6 Asymmetric impact of macro-news on informed trading?

A natural question is whether good and bad news associated with FOMC announcements have the same effect. To investigate this issue, we use two separate dummies: *Bad*, which equals one when the announced Federal funds target rate is above the expectation by at least 12.5 bp and zero otherwise, and *Good*, which equals one when the announced Federal funds target rate is below the expectation by at least 12.5 bp and zero otherwise. Based on this classification, of the 25 surprise announcements, six are bad news surprises ( $Bad = 1$ ) and 19 are good news surprises ( $Good = 1$ ). We replace the SUR dummy with these two separate indicators in our baseline regressions. Table 11 reports the OLS regression results for the E-mini S&P 500 futures.

[Table 11 about here]

The evidence in Table 11 suggests that the impact of FOMC surprises on informed trading activity during lockups is asymmetric. On the one hand, we find large and statistically significant positive order imbalances during lockups ahead of good news surprises, with magnitudes ranging from 6.98% to 12.89% depending on the definition of release time and the measure of trading activity. On the other hand, for bad news surprises, we find no abnormal selling pressure in the lockup window, possibly due to the small sample size.

A potential explanation for the asymmetric effect of good and bad news may be the existence of short-sale constraints in the underlying stock market. Such constraints would affect the ability of liquidity providers in the futures markets to hedge their positions and thus limit privately informed traders' ability to trade. Another possibility is that informed traders rely on limit orders ahead of bad news surprises, rather than market orders - as in Baruch, Panayides, and Venkataraman (2014). This, in turn, would prevent us from correctly identifying the direction of their trades based on conventional empirical methods (i.e., the tick-rule or the Lee and Ready (1991) algorithm).

## 4.7 Price impact

In this subsection, we investigate the price impact of informed trading around the FOMC announcements. If uninformed investors expect informed trading during lockups, then prices should incorporate the information in the order flow and the corresponding abnormal returns would provide a measure of informed trading. In contrast, if informed trading is regarded as unlikely and/or it is difficult for uninformed traders to observe the order flow and extract the price information, prices may not immediately reflect the information. To examine this issue, we replace the dependent variable in our baseline regressions with cumulative returns and report the results in Table 12.

[Table 12 about here]

In Panel A of Table 12, we define 0 as the scheduled release time. Columns 1 to 3 report the results separately for the pre-lockup, lockup, and post-lockup periods similar to Table 5, while Columns 4 to 6 repeat the analysis for the three ten-minute subwindows during the lockup. The coefficient estimates on ANN are largely insignificant across all columns except the last one. The SUR coefficient estimate is significantly positive in the lockup period, Column 2, but not so before or after the lockup. The large price run-up of 22.15 bp is associated with a  $t$ -statistic of 4.05, consistent with active informed trading only during the lockup period. Columns 4 to 6 show that the large price run-up occurs mainly in the last few minutes leading to the announcement. Given the discrepancy between scheduled and actual release times, in Panel B, we define 0 as the actual release time and find that the large price run-up disappears. The post-announcement return is large but not statistically significant. Panel C shows similar results when we define 0 as the earlier of the scheduled and the actual release time.

In summary, we find no evidence of significant price run-ups prior to the public release of surprise FOMC announcements. Considering the significant abnormal order imbalance documented earlier, this result suggests that informed traders are able to trade without moving the market and earn most of their profits after the announcement. Importantly, the price run-up difference in Panels A and B shows that a few minutes' information

advantage can in fact result in large potential profits.

The lack of significant abnormal returns in the lockup window may be because the announcement dummies do not reflect the different levels of informed trading and thus do not capture the contribution of the latter to price discovery. To examine this conjecture, we investigate the relation between informed order flow and price discovery following the analysis of Irvine, Lipson, and Puckett (2007) in the context of analysts' tipping. Specifically, in Table 13, we regress the order imbalance during the 126 FOMC's lockup periods on the contemporaneous return and the subsequent return measured at one, five, ten, or thirty minutes after each actual announcement. Regardless of the measure of order imbalance and the definition of announcement returns, the results consistently show two patterns. First, the contemporaneous price impact of the order imbalance is always positive and significant. For example, in Column 1, the coefficient estimate of the contemporaneous return is 62.89 with a  $t$ -statistic of 2.90. Second, none of the subsequent announcement returns is significantly associated with the order imbalance during the lockup although the sign is generally negative. Overall, this evidence is consistent with informed trading during FOMC lockups contributing to contemporaneous price discovery as microstructure theory would suggest.

[Table 13 about here]

## 4.8 Other testing securities

In this subsection, we turn our attention to the abnormal trading activities that may take place in other asset markets. For the reasons explained in the previous section, we examine the trading activity in the E-mini Nasdaq 100 futures (NQ), the SPDR S&P 500 ETF (SPY), the Power-Shares QQQ ETF (QQQ), the 2-Year US Treasury Note futures (TU), the 10-Year US Treasury Note futures (TY), and the gold futures (GC) during the lockup period. Specifically, we repeat our main tests using these additional securities and present the results in Table 14.

[Table 14 about here]

The starting time of the lockup is always set to thirty minutes before the scheduled release time and the ending time is the scheduled time in Columns 1 to 3, the actual time in Columns 4 to 6, and the earlier of the two in Columns 7 to 9. The table reports results for abnormal returns in addition to order imbalances. Similar to our main testing security (ES), Panels A, B, and C show that there are significant informed order imbalances in other equity-related markets (NQ, SPY, and QQQ) during FOMC lockups. In the treasury futures market, the short-term contract experiences significant abnormal order imbalance during the same period but the long-term contract does not show any evidence of informed trading. We do not find informed trading in the gold futures market either. Although the patterns across all markets is similar to those documented for the ES, the results are somewhat less significant both statistically and economically. This, in turn, is consistent with the premise of our analysis that liquidity is a major concern of traders that may have a short-term information advantage, even though they may spread their trades across several markets.

## 4.9 Informed traders' profits

To gauge the economic significance of informed trading activity during FOMC lockups, we estimate the hypothetical profits of informed trades executed ahead of the 25 surprise announcements in our baseline analysis. For this purpose, we assume informed traders receive the information thirty minutes before the scheduled release time and trade in the direction of the policy surprise until the news becomes public - i.e., earliest release time of press reports. We compute the profit for all trades executed in each second using the volume-weighted trade price and choose three arbitrary times at which the traders may unwind their positions: five, ten, and thirty minutes after the actual release time.

We follow two different approaches when aggregating informed trades' profits to obtain a lower bound and an upper bound. The lower bound of our estimate assumes that the informed traders use market orders and only the imbalance portion of the trading volume that we observe reflects informed traders' activity. The upper bound assumes that there is an informed trader behind every transaction executed during the lockup



window, be it via a market order or a limit order.

Panel A of Table 15 presents summary statistics of the informed traders' profit estimates in the E-mini S&P 500 futures. The lower bound of the profits for pre-release informed trades executed during the average lockup prior to a surprise announcement is \$139,398 (\$347,761) assuming the positions are liquidated five (thirty) minutes after the actual release. The upper bound of the estimated profits is notably larger. The average upper bound per surprise announcement is as high as 8.3 million dollars when we assume informed traders unwind their positions ten minutes after the news becomes public. When aggregated across all FOMC surprise announcements, the profit estimates range between 2.5 and 207.5 million dollars on the S&P 500 futures market alone. Panel B of Table 15 provides similar estimates of trading profits across all the markets that we examine. Although the estimates in Panel B are generally larger than those in Panel A, the difference is not very large, indicating that the activity in the E-mini S&P 500 futures market dominates that in other markets, consistent with the premise of our analysis.

[Table 15 about here]

## 5 Conclusion

In this study, we use high frequency trading data to investigate whether there is informed trading ahead of macro-news announcements. We find robust evidence of informed trading, as measured by order imbalance of equity index futures and exchange-traded funds, during the lockup periods ahead of FOMC announcements. Based on our estimates across all the markets that we examine, the aggregate dollar profits of informed trades during lockups prior to FOMC surprise announcements range between \$4.5 and \$210.5 million.

The evidence of informed trading during FOMC's lockups is consistent with information leakage directly from the news media or from other insiders mimicking such behavior. It is also possible that some investors have superior ability to predict and trade ahead

of impending macro-news announcements. Nonetheless, it is noteworthy that such activity would correspond systematically and exclusively with the media lockup periods of FOMC's policy announcements. Overall, our evidence demonstrates at the very least the existence of a systematic link between informed trading activities in capital markets and the FOMC's embargo practices.

Recent government investigations and media attention has focused on the possibility that some news agencies would violate news embargoes of government agencies such as DOL. However, we find no evidence to support those concerns for the asset markets that we can examine in conjunction with the release of nonfarm payroll, CPI, and GDP data. Notwithstanding, it is worth noting that the lack of evidence in the futures market does not prove absence of information leakage. Admittedly, it is possible that informed trades are routed to other markets that are more liquid during after-hour trading - e.g., OTC FX market, which we cannot analyze due to data limitations. We leave further analysis of this issue to future research.

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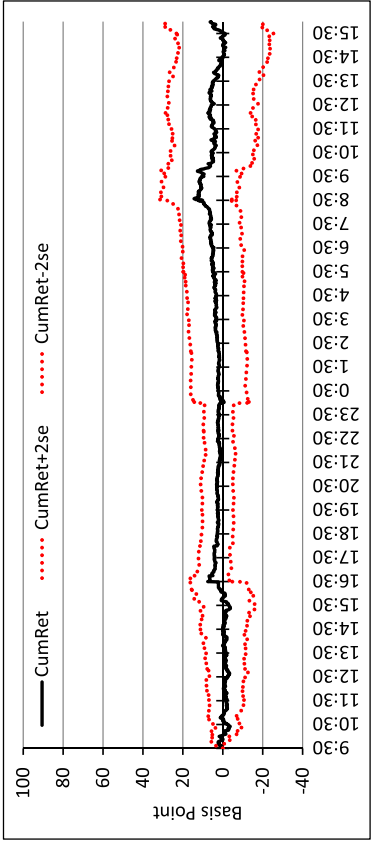
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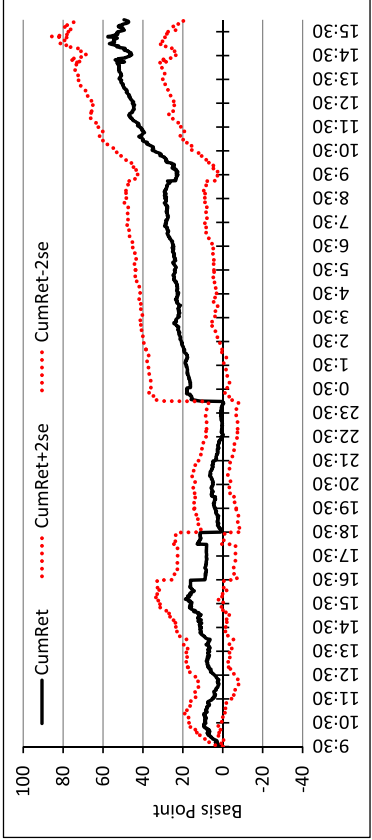
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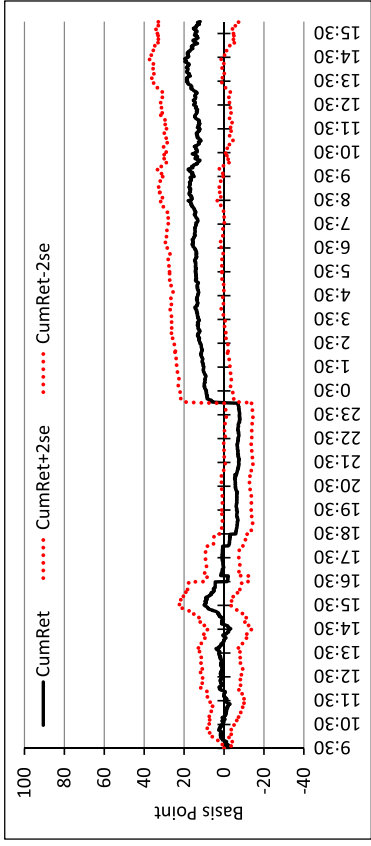
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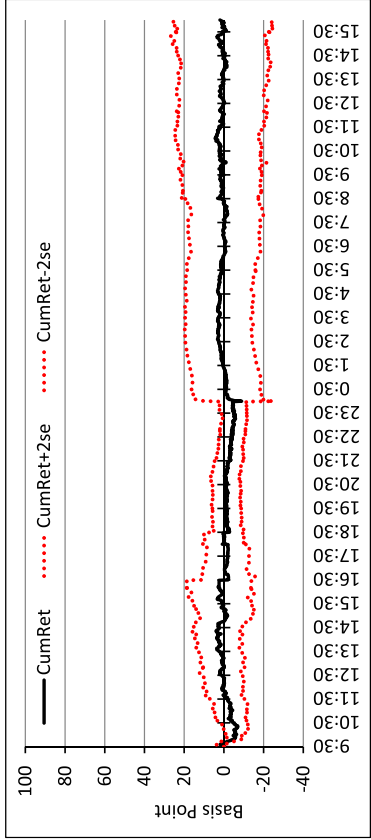
(a) FOMC



(b) Nonfarm payroll



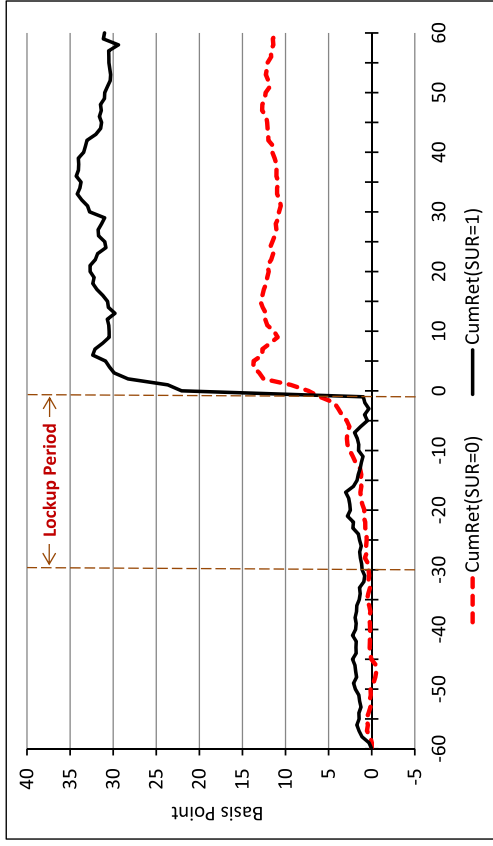
(c) CPI



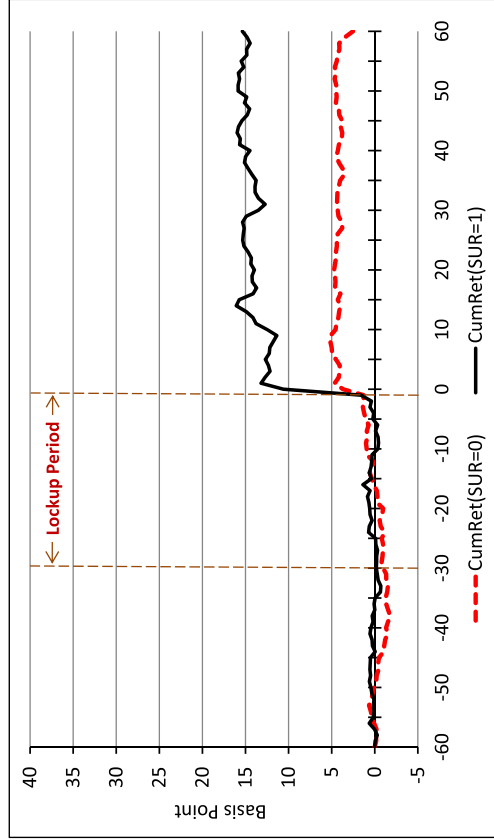
(d) GDP

Figure 1: Cumulative returns around macroeconomic announcement days

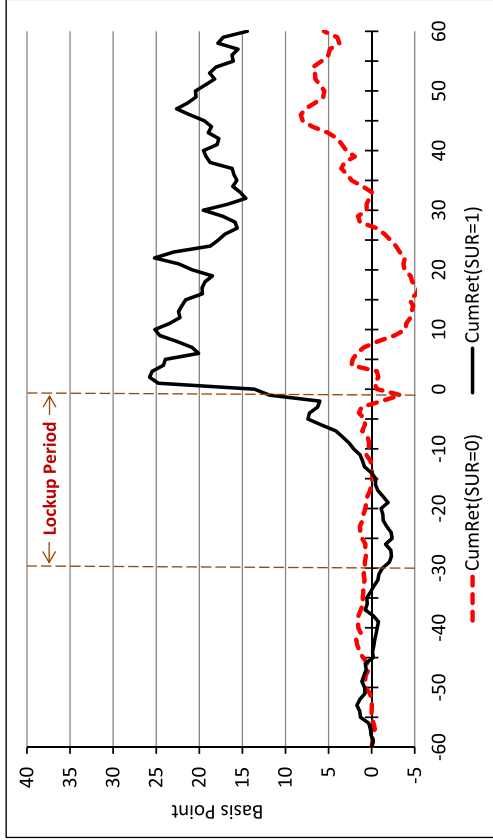
This figure plots the minute-by-minute cumulative returns in the E-mini S&P 500 futures from 9:30 a.m. EST of the day before the macroeconomic announcement day to 4 p.m. EST of the announcement day. The black solid line is the average cumulative returns of all announcements in our sample. The red dashed lines represent the 95% confidence intervals of the average cumulative returns.



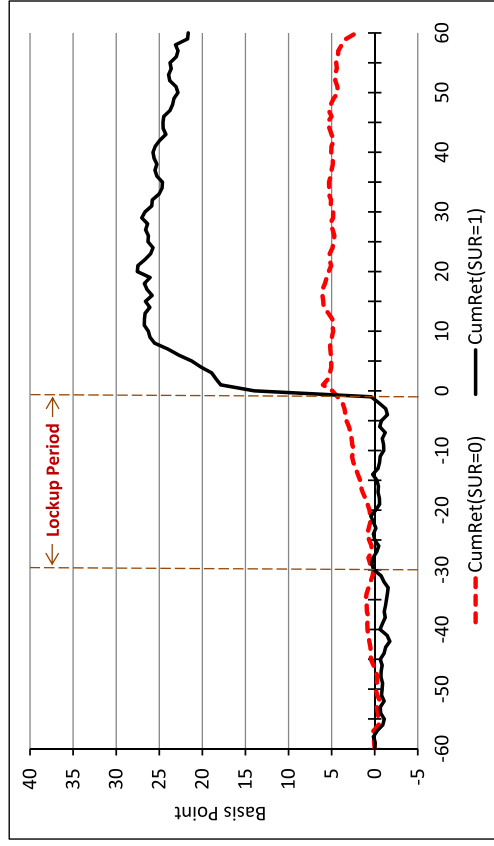
(a) FOMC



(c) CPI



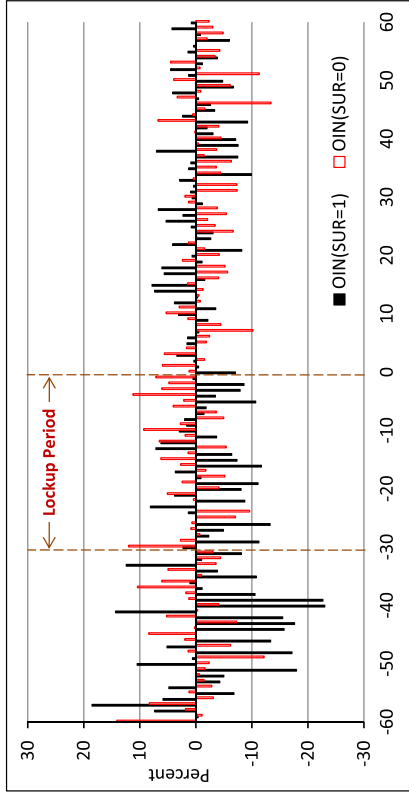
(b) Nonfarm payroll



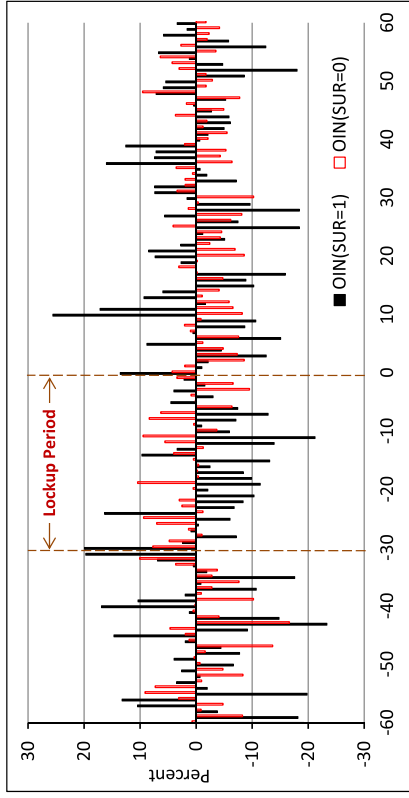
(d) GDP

Figure 2: Cumulative returns in the two hours around the announcement. This figure plots the minute-by-minute cumulative returns in the E-mini S&P 500 futures in the two hours around the macroeconomic announcement. The black solid line is the average cumulative returns of the surprise announcements (SUR=1) and the red dashed line is the average cumulative returns of the non-surprise announcements (SUR=0). “Lockup Period” corresponds to the event window  $[-30, 0]$ , where “0” is the official release time of the macro-news.

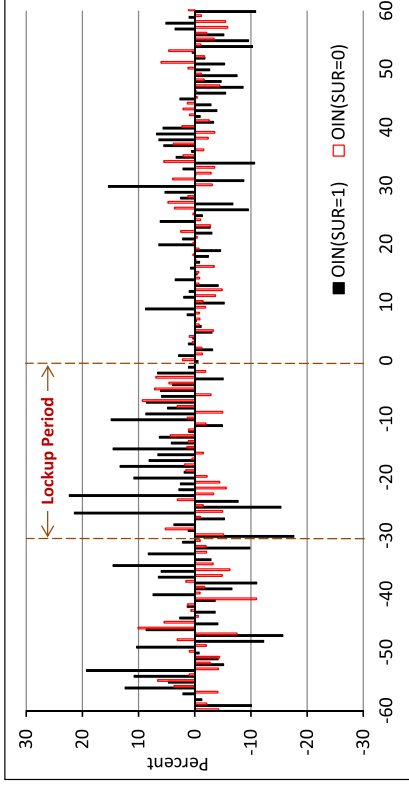




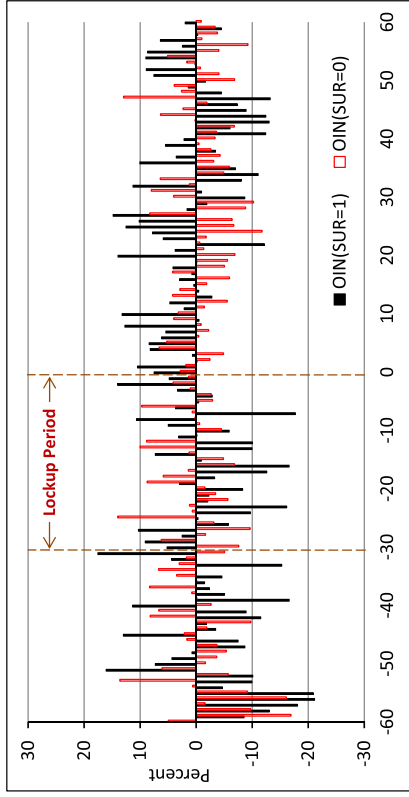
(a) FOMC



(c) CPI

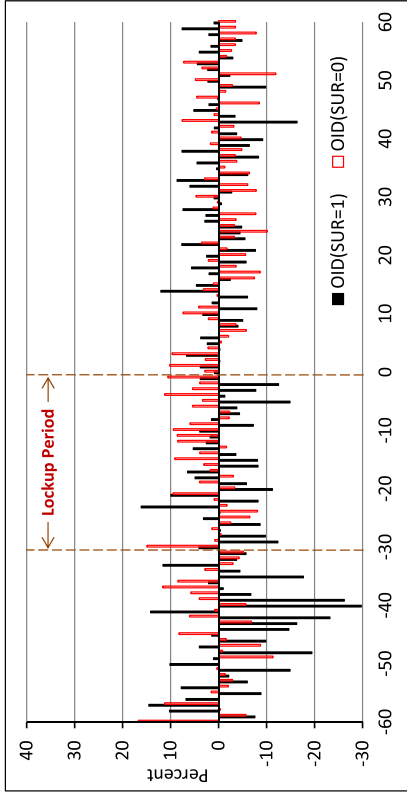


(b) Nonfarm payroll

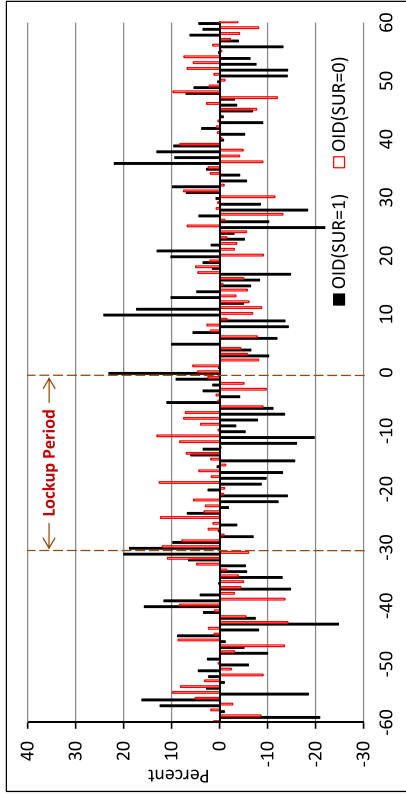


(d) GDP

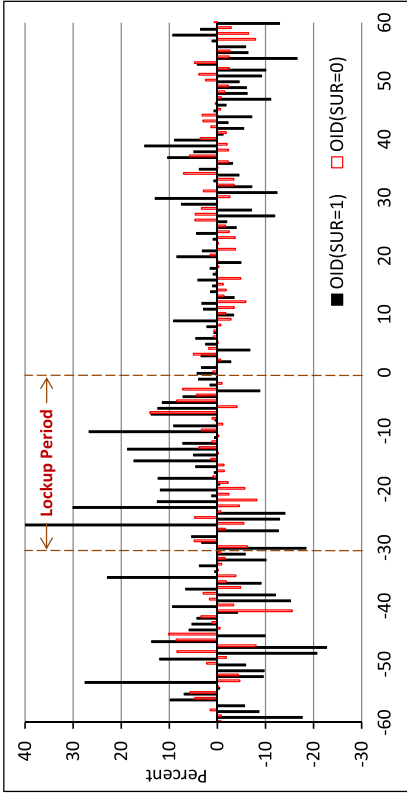
Figure 3: Order imbalance based on number of trades in the two hours around the announcement. This figure plots the minute-by-minute order imbalance based on number of trades (OIN) in the E-mini S&P 500 futures in the two hours around the macroeconomic announcement. The black bar is the average OIN of the surprise announcements (SUR=1) and the red dashed line is the average OIN of the non-surprise announcements (SUR=0). “Lockup Period” corresponds to the event window  $[-30, 0]$ , where “0” is the official release time of the macro-news.



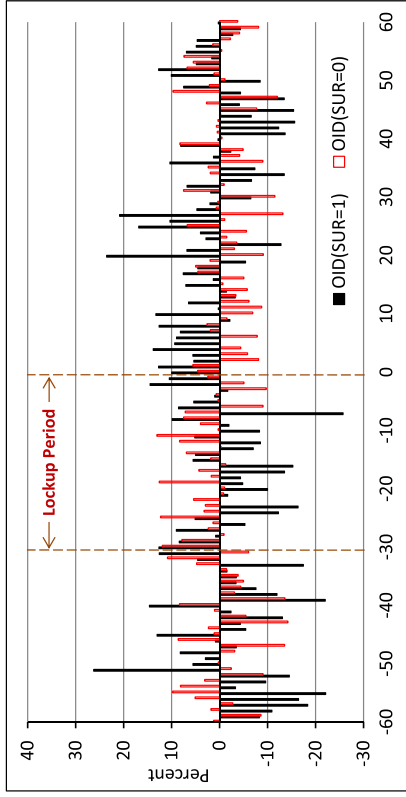
(a) FOMC



(b) Nonfarm payroll

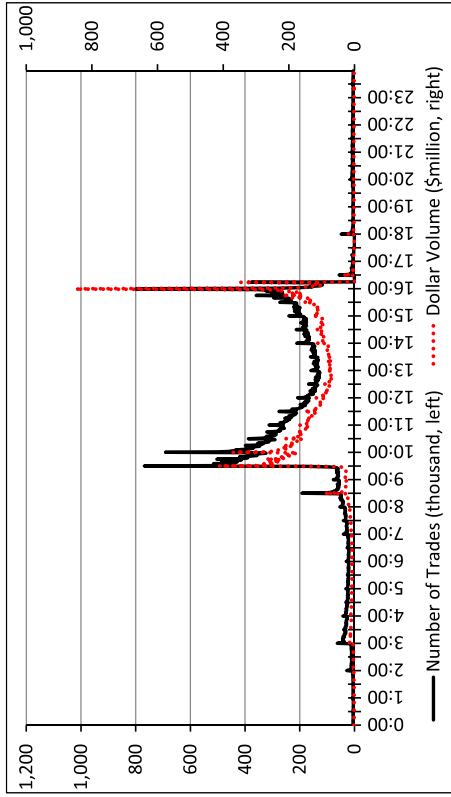


(c) CPI

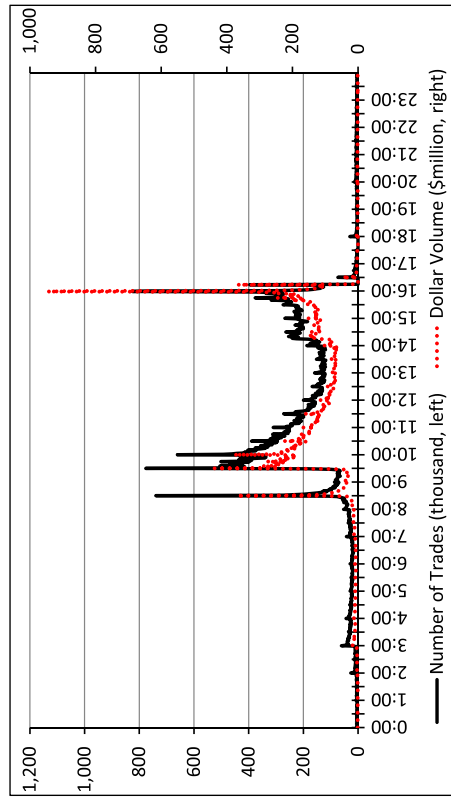


(d) GDP

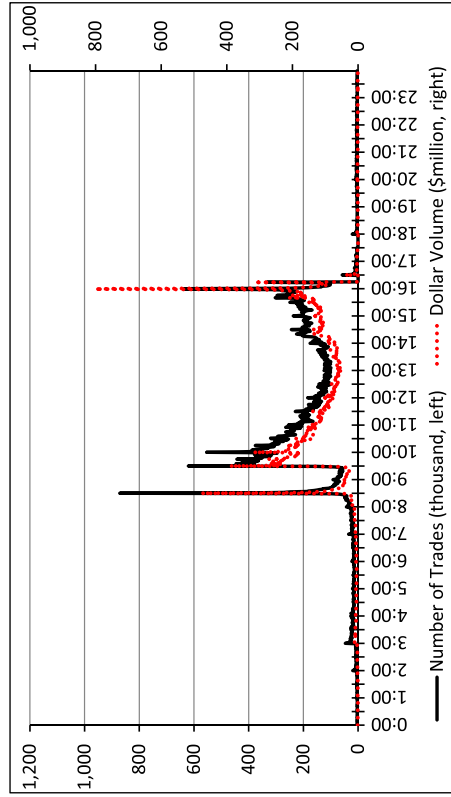
Figure 4: Order imbalance based on dollar volume in the two hours around the announcement. This figure plots the minute-by-minute order imbalance based on dollar volume (OID) in the E-mini S&P 500 futures in the two hours around the macroeconomic announcement. The black bar is the average OID of the surprise announcements (SUR=1) and the red dashed line is the average OID of the non-surprise announcements (SUR=0). “Lockup Period” corresponds to the event window  $[-30, 0]$ , where “0” is the official release time of the macro-news.



(a) Full sample



(b) ANN=0



(c) SUR=0

(d) SUR=1

Figure 5: Intraday liquidity in the E-mini S&P 500 futures

This figure plots the minute-by-minute number of trades and dollar volume in the E-mini S&P 500 futures. The black solid line is the average number of trades (left axis) and the red dashed lines is the average dollar volume (right axis). Panels A, B, C, and D correspond to all trading days (Full sample), the control days (ANN=0), the non-surprise announcement days (SUR=0), and the surprise announcement days (SUR=1), respectively.

Table 1: Information about macroeconomic announcements

The table provides institutional details about the four types of macroeconomic announcements in this study. FOMC, DOL, and BEA stand for the Federal Open Market Committee, the Department of Labor, and the Bureau of Economic Analysis, respectively. All times are Eastern Standard Time.

Announcement	Source	Frequency	Type	Units	Scheduled release time (EST)
Federal Funds Target Rate	FOMC	8 per year	Level	Percent (%)	2:15 p.m. (occasionally 12:30 p.m. or 2 p.m.)
Nonfarm Payrolls	DOL	Monthly	Change	Thousands	8:30 a.m.
CPI	DOL	Monthly	Change	Percent (%)	8:30 a.m.
GDP	BEA	Monthly	Change	Percent (%)	8:30 a.m.

Table 2: Summary statistics of the announcement surprise

The table presents the statistics of the difference between the expected (Exp) and actual (Act) macroeconomic indicators between September 9, 1997 and June 30, 2013. The expected Federal funds target rate is the volume-weighted implied rate from the CME Federal funds futures at one day before the announcement date. The expected values of nonfarm payroll, CPI, and GDP are the median of the economist forecasts from the Blue Chip Economic Indicators Survey. The actual Federal funds target rate after October 2008 is the mid point of the target range. Diff is calculated as Act minus Exp except for the Federal funds target rate after October 2008, which is calculated as the lower bound of the target range minus Exp if Exp is below the lower bound, Exp minus the upper bound if Exp is above the upper bound, and zero otherwise. AbsDiff is the absolute value of Diff.

Statistics	N	Mean	St. dev.	Median	Minimum	Maximum
<i>Panel A: FOMC</i>						
Exp	126	2.734	2.236	2.013	0.071	6.572
Act	126	2.679	2.248	2.000	0.125	6.500
Diff	126	-0.037	0.124	-0.010	-0.450	0.455
AbsDiff	126	0.083	0.099	0.059	0.000	0.455
<i>Panel B: Nonfarm payroll</i>						
Exp	189	82.185	181.112	125	-650	513
Act	189	63.820	201.633	94	-663	519
Diff	189	-18.365	95.911	-13	-330	459
AbsDiff	189	70.841	67.029	59	0	459
<i>Panel C: CPI</i>						
Exp	189	0.204	0.244	0.200	-1.200	0.900
Act	189	0.192	0.325	0.200	-1.700	1.200
Diff	189	-0.012	0.142	0.000	-0.700	0.400
AbsDiff	189	0.101	0.100	0.100	0.000	0.700
<i>Panel D: GDP</i>						
Exp	189	2.583	2.293	2.800	-6.500	8.200
Act	189	2.560	2.352	2.700	-6.300	8.200
Diff	189	-0.023	0.559	0.000	-3.400	1.600
AbsDiff	189	0.369	0.420	0.200	0.000	3.400

Table 3: Annual breakdown of macro announcements

The table presents the time-series distribution of macroeconomic announcements classified as surprise or non-surprise to the market from September 9, 1997 to June 30, 2013. A FOMC announcement is defined as a surprise (SUR=1) if the actual announced target rate deviates from the futures-implied rate by at least 12.5 basis points. For the other types of macroeconomic indicators, an event is classified as a surprise (SUR=1) if the actual value is outside the 10th to 90th percentiles of the economist forecasts from the Blue Chip Economic Indicators Survey.

Year	<i>FOMC</i>		<i>Nonfarm payroll</i>		<i>CPI</i>		<i>GDP</i>	
	<u>SUR=0</u>	<u>SUR=1</u>	<u>SUR=0</u>	<u>SUR=1</u>	<u>SUR=0</u>	<u>SUR=1</u>	<u>SUR=0</u>	<u>SUR=1</u>
1997	2	1	2	1	1	3	4	0
1998	8	0	9	3	5	7	6	6
1999	6	2	8	4	7	5	8	3
2000	6	2	7	5	9	2	7	5
2001	6	2	7	5	10	2	9	3
2002	6	2	12	0	11	1	8	4
2003	8	0	9	3	5	7	8	4
2004	4	4	5	7	7	5	8	4
2005	1	7	9	3	7	5	11	1
2006	7	1	9	3	9	3	9	3
2007	7	1	10	2	12	0	10	2
2008	5	3	6	6	7	5	8	4
2009	7	0	6	6	9	3	8	4
2010	8	0	7	5	11	1	11	1
2011	8	0	7	5	8	4	11	1
2012	8	0	12	0	11	1	9	3
2013	4	0	5	1	3	3	2	4
SUM	101	25	130	59	132	57	137	52
Total	126		189		189		189	

Table 4: Description of the E-mini S&P500 market around the announcement

This table reports the summary statistics of the cumulative returns and order imbalances of the E-mini S&P500 futures around the macroeconomic announcement. For each macroeconomic announcement, the previous 21 trading days are used as control days (ANN=0). In Panel A, an FOMC announcement is defined as a surprise (SUR=1) if the actual announced target rate deviates from the futures-implied rate by at least 12.5 basis points. For the other types of macroeconomic announcements in Panels B, C, and D, an event is classified as a surprise (SUR=1) if the actual value is outside the 10th to 90th percentiles of the economist forecasts from the Blue Chip Economic Indicators Survey. The E-mini S&P 500 futures data from the Chicago Mercantile Exchange (CME) are used to calculate the variables of interest. Return is the cumulative return in basis point calculated using volume-weighted transaction prices. OIN represents the order imbalance defined as  $B-S/(B+S)$ , where B (S) is the number of trades initiated by the buyer (seller). OID is calculated similarly to OIN using dollar trading volume instead of number of trades. Three event periods are examined around the announcement: [-60,-30], from one hour before to half an hour before the scheduled announcement; [-30,0], from half hour before to the scheduled release time; and [0,60], from the scheduled release time to one hour afterwards. For observations in the surprise announcement group (SUR=1), the signs of the return and order imbalance variables are adjusted to reflect the effects of a market-positive surprise.

		Mean			Standard deviation			Median		
	Period	OIN	OID	Return	OIN	OID	Return	OIN	OID	Return
<i>Panel A: FOMC</i>										
ANN=0	[-60,-30]	0.119	-0.308	0.602	12.036	14.574	24.945	0.000	-0.638	0.548
	[-30,0]	-0.527	-0.584	-0.970	10.006	12.944	24.402	-0.434	-0.832	-0.041
	[0,60]	-0.110	-0.094	1.519	6.503	9.105	43.010	-0.142	-0.430	1.116
SUR=0	[-60,-30]	-0.448	0.922	1.970	11.493	15.037	15.648	0.532	1.384	0.000
	[-30,0]	-0.513	-0.098	-5.116	10.025	11.238	24.582	-0.690	-0.285	-1.678
	[0,60]	-0.569	0.094	8.685	4.163	6.506	69.733	-0.309	0.703	9.297
SUR=1	[-60,-30]	-0.790	-4.494	0.323	12.077	19.150	15.687	1.038	-2.492	-2.151
	[-30,0]	7.913	9.268	17.038	11.208	13.538	31.836	9.034	8.680	8.813
	[0,60]	-0.313	0.066	2.607	4.387	7.934	104.141	-0.629	-0.927	0.000
<i>Panel B: Nonfarm Payroll</i>										
ANN=0	[-60,-30]	0.559	0.669	-0.060	21.416	26.203	14.921	0.000	0.059	0.038
	[-30,0]	0.107	0.496	0.173	16.197	20.891	17.346	0.000	0.064	0.010
	[0,60]	-1.324	-1.496	-1.800	10.684	14.249	26.614	-1.055	-1.376	-1.648
SUR=0	[-60,-30]	0.109	1.066	0.573	19.612	23.718	9.972	0.262	0.873	0.000
	[-30,0]	2.475	4.641	5.986	11.778	14.030	13.688	2.583	2.963	6.030
	[0,60]	0.152	1.147	5.305	6.861	10.740	53.624	0.062	0.390	6.728
SUR=1	[-60,-30]	-4.340	-2.850	1.359	18.700	24.259	16.757	-1.653	-4.166	0.000
	[-30,0]	-1.037	-0.619	0.054	12.554	16.445	21.659	-0.008	0.145	-1.916
	[0,60]	0.042	2.170	27.196	7.004	8.835	68.281	0.966	4.809	30.775

Table 4 (continued):

Period	Mean			Standard deviation			Median			
	OIN	OID	Return	OIN	OID	Return	OIN	OID	Return	
<i>Panel C: CPI</i>										
ANN=0	[-60,-30]	0.656	0.773	-0.053	21.330	26.122	14.872	0.000	0.264	0.035
	[-30,0]	0.102	0.480	0.126	16.284	20.905	17.371	0.000	0.053	0.000
	[0,60]	-1.342	-1.477	-1.764	10.695	14.241	26.647	-1.065	-1.352	-1.648
SUR=0	[-60,-30]	-0.409	0.996	-1.933	18.349	22.650	14.981	-2.134	-1.529	-0.394
	[-30,0]	2.121	3.171	2.987	15.006	17.631	12.945	0.510	3.952	1.300
	[0,60]	-0.393	0.009	2.193	7.841	11.213	33.550	-0.901	-0.085	-1.373
SUR=1	[-60,-30]	-1.820	-3.554	-1.440	22.901	29.482	15.453	-2.564	-1.778	0.000
	[-30,0]	0.046	1.210	2.477	14.290	17.129	16.574	1.238	0.754	1.346
	[0,60]	1.312	2.421	14.055	8.660	12.280	43.557	0.683	2.369	9.727
<i>Panel D: GDP</i>										
ANN=0	[-60,-30]	0.575	0.688	-0.062	21.238	26.001	14.954	0.000	0.162	0.043
	[-30,0]	0.061	0.400	0.082	16.267	20.875	17.415	0.000	0.018	0.000
	[0,60]	-1.342	-1.486	-1.745	10.675	14.188	26.585	-1.055	-1.352	-1.639
SUR=0	[-60,-30]	0.745	2.851	0.448	18.739	25.097	14.650	0.429	1.721	0.000
	[-30,0]	1.539	3.426	4.408	14.847	20.133	18.989	0.680	3.544	2.698
	[0,60]	0.243	0.168	-0.542	9.030	12.875	29.258	-0.156	-0.996	-3.910
SUR=1	[-60,-30]	1.390	1.049	-1.185	20.750	24.124	14.960	2.227	0.826	-1.079
	[-30,0]	1.083	1.654	2.358	10.974	17.625	15.355	2.181	5.500	3.005
	[0,60]	3.591	5.917	21.826	6.909	8.527	51.689	2.419	4.339	14.327



Table 5: OLS regressions on announcement type dummies

This table presents OLS regression results in the E-mini S&P 500 futures market. The dependent variables are the order imbalances calculated using both number of trades (OIN) and dollar volume (OID) in three event windows: [-60,-30], [-30,0], and [0,60], where 0 is the scheduled release time. Variables ANN and SUR are defined in Table 4. For observations in the surprise announcement group, the signs of the order imbalance variables are adjusted to reflect the effects of a market-positive surprise. Panels A to D report separate regression results for announcements on the Federal funds target rate, nonfarm payroll, CPI, and GDP, respectively. Corresponding  $t$ -statistics are reported in parentheses. The last row of each panel reports the  $p$ -value of the Wald test that the sum of the coefficients of ANN and SUR equals to zero.

Period	[-60,-30]		[-30,0]		[0,60]	
	1	2	3	4	5	6
Model	OIN	OID	OIN	OID	OIN	OID
<i>Panel A: FOMC</i>						
Intercept	0.126 (0.52)	-0.308 (-1.05)	-0.524 (-2.60)	-0.584 (-2.25)	-0.109 (-0.84)	-0.094 (-0.52)
ANN	-0.574 (-0.47)	1.230 (0.83)	0.012 (0.01)	0.486 (0.37)	-0.460 (-0.71)	0.188 (0.21)
SUR	-0.342 (-0.13)	-5.416 (-1.66)	8.425 (3.76)	9.366 (3.25)	0.256 (0.18)	-0.029 (-0.01)
ANN+SUR	-0.916	-4.186	8.437	9.852	-0.204	0.159
$p$ -value	0.7045	0.155	<.0001	0.0001	0.8743	0.9299
<i>Panel B: Nonfarm payroll</i>						
Intercept	0.559 (1.50)	0.669 (1.46)	0.107 (0.38)	0.496 (1.37)	-1.324 (-7.19)	-1.496 (-6.07)
ANN	-0.450 (-0.24)	0.396 (0.17)	2.368 (1.66)	4.145 (2.25)	1.475 (1.57)	2.642 (2.10)
SUR	-4.448 (-1.33)	-3.916 (-0.96)	-3.512 (-1.40)	-5.260 (-1.63)	-0.109 (-0.07)	1.024 (0.46)
ANN+SUR	-4.899	-3.520	-1.144	-1.115	1.366	3.666
$p$ -value	0.0802	0.3043	0.5862	0.6804	0.3227	0.0472

Table 5 (continued):

Period	[-60,-30]		[-30,0]		[0,60]	
Model	1	2	3	4	5	6
Dependent	OIN	OID	OIN	OID	OIN	OID
<i>Panel C: CPI</i>						
Intercept	0.656 (1.77)	0.773 (1.70)	0.102 (0.36)	0.480 (1.32)	-1.342 (-7.27)	-1.477 (-5.99)
ANN	-1.065 (-0.56)	0.223 (0.10)	2.018 (1.40)	2.692 (1.46)	0.949 (1.01)	1.486 (1.19)
SUR	-1.411 (-0.42)	-4.550 (-1.10)	-2.075 (-0.81)	-1.961 (-0.60)	1.705 (1.02)	2.412 (1.08)
ANN+SUR	-2.476	-4.327	-0.056	0.730	2.654	3.898
<i>p</i> -value	0.3833	0.2140	0.9792	0.7921	0.0602	0.0387
<i>Panel D: GDP</i>						
Intercept	0.575 (1.55)	0.688 (1.51)	0.061 (0.22)	0.400 (1.10)	-1.342 (-7.24)	-1.486 (-6.02)
ANN	0.170 (0.09)	2.163 (0.96)	1.478 (1.05)	3.026 (1.67)	1.585 (1.72)	1.654 (1.35)
SUR	0.645 (0.19)	-1.802 (-0.43)	-0.456 (-0.17)	-1.771 (-0.52)	3.347 (1.94)	5.749 (2.51)
ANN+SUR	0.815	0.361	1.022	1.254	4.933	7.403
<i>p</i> -value	0.7827	0.9207	0.6507	0.6662	0.0008	0.0002

Table 6: Informed trading before and after 2006

This table presents OLS regression results in the E-mini S&P 500 futures market over subperiods before and after 2006. The dependent variables are the order imbalances calculated using both number of trades (OIN) and dollar volume (OID) in three event windows: [-60,-30], [-30,0], and [0,60], where 0 is the scheduled release time. Variables ANN and SUR are defined in Table 4. For observations in the surprise announcement group, the signs of the order imbalance variables are adjusted to reflect the effects of a market-positive surprise. Panels A to D report separate regression results for announcements on the Federal funds target rate, nonfarm payroll, CPI, and GDP, respectively. Post is a dummy equal to one for observations after January 1, 2006 and zero otherwise. Corresponding  $t$ -statistics are reported in parentheses. The last row of each panel reports the  $p$ -value of the Wald test that the sum of the coefficients of ANN\*Post and SUR\*Post equals to zero.

Period	[-60,-30]		[-30,0]		[0,60]	
	1	2	3	4	5	6
Model	OIN	OID	OIN	OID	OIN	OID
<i>Panel A: FOMC</i>						
Intercept	-0.267 (-0.81)	-0.819 (-2.03)	-0.505 (-1.83)	-0.855 (-2.40)	-0.273 (-1.54)	-0.793 (-3.20)
ANN	-1.611 (-0.90)	1.253 (0.58)	-0.644 (-0.43)	-0.104 (-0.05)	-1.063 (-1.12)	-0.933 (-0.70)
SUR	3.121 (0.97)	-3.415 (-0.87)	10.286 (3.84)	10.486 (3.05)	1.157 (0.68)	2.248 (0.94)
Post	0.837 (1.73)	1.087 (1.85)	-0.041 (-0.10)	0.577 (1.11)	0.349 (1.35)	1.487 (4.12)
ANN*Post	1.839 (0.75)	-0.173 (-0.06)	1.231 (0.60)	1.034 (0.39)	1.085 (0.83)	1.916 (1.05)
SUR*Post	-12.841 (-1.99)	-8.478 (-1.08)	-7.312 (-1.36)	-2.907 (-0.42)	-2.104 (-0.61)	-5.687 (-1.18)
(ANN+SUR)*Post	-11.002	-8.650	-6.081	-1.874	-1.019	-3.771
$p$ -value	0.0678	0.2388	0.2265	0.7720	0.7515	0.4024
<i>Panel B: Nonfarm payroll</i>						
Intercept	1.548 (3.01)	2.158 (3.43)	0.447 (1.16)	0.813 (1.63)	-1.581 (-6.23)	-2.082 (-6.14)
ANN	-1.582 (-0.60)	-1.726 (-0.54)	3.750 (1.90)	5.039 (1.98)	2.399 (1.85)	2.859 (1.65)
SUR	-8.074 (-1.75)	-4.083 (-0.72)	-5.566 (-1.61)	-7.216 (-1.62)	-0.164 (-0.07)	0.183 (0.06)
Post	-2.089 (-2.79)	-3.146 (-3.44)	-0.719 (-1.28)	-0.670 (-0.93)	0.544 (1.48)	1.240 (2.51)
ANN*Post	2.389 (0.63)	4.474 (0.96)	-2.891 (-1.01)	-1.869 (-0.51)	-1.942 (-1.03)	-0.464 (-0.18)
SUR*Post	7.640 (1.14)	0.358 (0.04)	4.309 (0.86)	4.108 (0.63)	0.108 (0.03)	1.776 (0.40)
(ANN+SUR)*Post	10.030	4.832	1.418	2.240	-1.834	1.311
$p$ -value	0.0802	0.3043	0.5862	0.6804	0.3227	0.0472

Table 6 (continued):

Period	[-60,-30]		[-30,0]		[0,60]	
	1	2	3	4	5	6
Model	OIN	OID	OIN	OID	OIN	OID
<i>Panel C: CPI</i>						
Intercept	1.757 (3.42)	2.380 (3.78)	0.484 (1.24)	0.847 (1.69)	-1.583 (-6.20)	-2.081 (-6.11)
ANN	-1.533 (-0.56)	-0.747 (-0.22)	4.370 (2.09)	3.883 (1.45)	1.631 (1.19)	1.095 (0.60)
SUR	-3.154 (-0.72)	-5.787 (-1.07)	-5.393 (-1.60)	-4.853 (-1.13)	0.913 (0.42)	2.999 (1.02)
Post	-2.303 (-3.10)	-3.363 (-3.69)	-0.799 (-1.41)	-0.768 (-1.06)	0.505 (1.37)	1.264 (2.56)
ANN*Post	1.109 (0.29)	2.160 (0.47)	-4.355 (-1.51)	-2.171 (-0.59)	-1.336 (-0.71)	0.611 (0.24)
SUR*Post	4.356 (0.63)	2.911 (0.34)	6.821 (1.28)	6.737 (0.99)	1.833 (0.53)	-0.715 (-0.15)
(ANN+SUR)*Post	5.465	5.071	2.466	4.566	0.498	-0.103
<i>p</i> -value	0.3833	0.214	0.9792	0.7921	0.0602	0.03870
<i>Panel D: GDP</i>						
Intercept	1.521 (2.97)	2.075 (3.30)	0.428 (1.09)	0.680 (1.35)	-1.607 (-6.27)	-2.129 (-6.24)
ANN	2.084 (0.80)	3.795 (1.19)	3.875 (1.95)	6.740 (2.64)	2.817 (2.17)	2.831 (1.64)
SUR	0.083 (0.02)	-2.053 (-0.36)	-2.695 (-0.76)	-2.725 (-0.60)	3.982 (1.72)	6.585 (2.14)
Post	-1.982 (-2.67)	-2.906 (-3.19)	-0.770 (-1.36)	-0.586 (-0.80)	0.555 (1.50)	1.348 (2.73)
ANN*Post	-3.78 (-1.03)	-3.177 (-0.70)	-4.799 (-1.70)	-7.460 (-2.06)	-2.504 (-1.36)	-2.425 (-0.99)
SUR*Post	0.330 (0.05)	-0.461 (-0.05)	4.330 (0.82)	0.861 (0.13)	-1.838 (-0.53)	-2.163 (-0.47)
(ANN+SUR)*Post	-3.450	-3.638	-0.470	-6.599	-4.342	-4.588
<i>p</i> -value	0.7827	0.9207	0.6507	0.6662	0.0008	0.0002

Table 7: Further investigation into the lockup window

This table presents OLS regression results for FOMC announcements. The dependent variables are the order imbalances calculated using both number of trades (OIN) and dollar volume (OID) in three sub-windows of the lockup period: [-30,-20], [-20,-10], and [-10,0], where 0 is the scheduled release time. Variables ANN and SUR are defined in Table 4. For observations in the surprise announcement group, the signs of the order imbalance variables are adjusted to reflect the effects of a market-positive surprise. In Panels A and B, we repeat the analysis in Table 5 and 6 on E-mini S&P 500 futures. Corresponding  $t$ -statistics are reported in parentheses. The last row of each panel reports the  $p$ -value of the associated Wald test.

Period	[-30,-20]		[-20,-10]		[-10,0]	
Model	1	2	3	4	5	6
Dependent	OIN	OID	OIN	OID	OIN	OID
<i>Panel A: Sub-windows during the lockup period</i>						
Intercept	-0.539 (-1.61)	-0.731 (-1.79)	-0.534 (-1.59)	-0.598 (-1.46)	-0.773 (-2.35)	-0.978 (-2.52)
ANN	-1.129 (-0.67)	-0.970 (-0.47)	1.682 (0.99)	0.905 (0.44)	0.813 (0.49)	2.317 (1.18)
SUR	4.444 (1.19)	5.876 (1.30)	7.053 (1.89)	9.936 (2.18)	6.637 (1.82)	6.983 (1.61)
ANN+SUR	3.316	4.907	8.735	10.841	7.450	9.300
$p$ -value	0.3233	0.2294	0.0093	0.0082	0.0236	0.0169
<i>Panel B: Sub-windows before and after 2006</i>						
Intercept	-1.019 (-2.22)	-1.725 (-3.09)	0.060 (0.13)	-0.312 (-0.56)	-1.025 (-2.28)	-1.244 (-2.34)
ANN	0.686 (0.28)	0.819 (0.28)	0.327 (0.13)	0.332 (0.11)	-1.240 (-0.52)	-0.069 (-0.02)
SUR	4.007 (0.91)	4.985 (0.93)	7.514 (1.70)	9.801 (1.81)	10.681 (2.46)	10.474 (2.04)
Post	0.985 (1.47)	2.065 (2.54)	-1.331 (-1.98)	-0.680 (-0.83)	0.558 (0.85)	0.580 (0.75)
ANN*Post	-3.220 (-0.96)	-2.974 (-0.73)	2.391 (0.71)	0.735 (0.18)	3.842 (1.17)	4.154 (1.07)
SUR*Post	-2.251 (-0.25)	1.391 (0.13)	0.442 (0.05)	2.057 (0.19)	-13.091 (-1.49)	-8.928 (-0.86)
(ANN+SUR)*Post	-1.267	3.457	-0.889	1.377	-12.534	-8.348
$p$ -value	0.5131	0.8764	0.7352	0.7849	0.2594	0.6227

Table 8: Scheduled and actual release time

This table presents OLS regression results in the E-mini S&P 500 futures market using different announcement time for FOMC announcements. The dependent variables are the order imbalances calculated using both number of trades (OIN) and dollar volume (OID) during the media lockup period. Variables ANN and SUR are defined in Table 4. For observations in the surprise announcement group, the signs of the order imbalance variables are adjusted to reflect the effects of a market-positive surprise. In Panel A and C, time 0 is the earliest actual release time recorded by the Dow Jones, Bloomberg, and Reuters Newswires. In Panel B and D, time 0 is set to be the earlier of the scheduled and the actual release time. Both Panels A and B investigate three ten-minute subwindows before the event time. Both Panels C and D investigate the event period starting thirty minutes before the scheduled release time so that the last subwindow can be longer or shorter than ten minutes. Corresponding  $t$ -statistics are reported in parentheses. The last row of each panel reports the  $p$ -value of the Wald test that the sum of the coefficients of ANN and SUR equals to zero.

Period	[-30,-20]		[-20,-10]		[-10,0]		[-30,0]	
Model	1	2	3	4	5	6	7	8
Dependent	OIN	OID	OIN	OID	OIN	OID	OIN	OID
<i>Panel A: Time 0 is the actual release time</i>								
Intercept	-0.419 (-1.22)	-0.463 (-1.12)	-0.744 (-2.22)	-0.794 (-1.94)	-0.707 (-2.12)	-0.824 (-2.06)	-0.555 (-2.72)	-0.544 (-2.08)
ANN	-0.825 (-0.48)	-1.060 (-0.51)	1.166 (0.69)	0.331 (0.16)	3.599 (2.13)	5.138 (2.54)	1.328 (1.29)	1.253 (0.95)
SUR	6.901 (1.81)	10.361 (2.25)	6.596 (1.77)	7.484 (1.65)	1.895 (0.51)	2.766 (0.62)	5.791 (2.55)	7.983 (2.74)
ANN+SUR	6.076	9.301	7.762	7.815	5.494	7.904	7.119	9.236
$p$ -value	0.0762	0.0246	0.0209	0.056	0.1002	0.0482	0.0005	0.0004
<i>Panel B: Time 0 is the MIN{scheduled time, actual time}</i>								
Intercept	-0.638 (-1.87)	-0.792 (-1.91)	-0.530 (-1.58)	-0.613 (-1.49)	-0.776 (-2.34)	-0.964 (-2.45)	-0.555 (-2.73)	-0.611 (-2.34)
ANN	-1.018 (-0.59)	-0.834 (-0.40)	1.253 (0.74)	0.180 (0.09)	3.192 (1.90)	4.850 (2.43)	1.046 (1.02)	1.155 (0.88)
SUR	3.672 (0.97)	4.537 (0.99)	7.837 (2.10)	10.540 (2.31)	3.957 (1.07)	4.708 (1.07)	6.068 (2.69)	7.780 (2.68)
ANN+SUR	2.654	3.703	9.09	10.72	7.149	9.558	7.114	8.935
$p$ -value	0.4365	0.3716	0.0069	0.009	0.0314	0.0155	0.0005	0.0006

Table 8 (continued):

Period	[-30,-20]		[-20,-10]		[-10, t]		[-30,t]	
Model	1	2	3	4	5	6	7	8
Dependent	OIN	OID	OIN	OID	OIN	OID	OIN	OID
<i>Panel C: Time 0 is the scheduled release time and t is the actual release time</i>								
Intercept	-0.539 (-1.61)	-0.731 (-1.79)	-0.534 (-1.59)	-0.598 (-1.46)	-0.862 (-2.52)	-1.033 (-2.54)	-0.543 (-2.66)	-0.562 (-2.14)
ANN	-1.129 (-0.67)	-0.970 (-0.47)	1.682 (0.99)	0.905 (0.44)	3.100 (1.80)	4.435 (2.15)	1.255 (1.22)	1.219 (0.92)
SUR	4.444 (1.19)	5.876 (1.30)	7.053 (1.89)	9.936 (2.18)	3.082 (0.81)	4.229 (0.93)	5.309 (2.34)	7.504 (2.57)
ANN+SUR	3.315	4.906	8.735	10.841	6.182	8.664	6.564	8.723
p-value	0.3233	0.2294	0.0093	0.0082	0.0705	0.0338	0.0013	0.0009
<i>Panel D: Time 0 is the scheduled release time and t is MIN{scheduled time, actual time}</i>								
Intercept	-0.539 (-1.61)	-0.731 (-1.79)	-0.534 (-1.59)	-0.598 (-1.46)	-0.854 (-2.46)	-1.071 (-2.60)	-0.535 (-2.60)	-0.589 (-2.24)
ANN	-1.129 (-0.67)	-0.970 (-0.47)	1.682 (0.99)	0.905 (0.44)	2.879 (1.64)	4.378 (2.10)	1.024 (0.99)	1.148 (0.86)
SUR	4.444 (1.19)	5.876 (1.30)	7.053 (1.89)	9.936 (2.18)	4.521 (1.17)	5.546 (1.21)	6.152 (2.69)	8.203 (2.80)
ANN+SUR	3.315	4.906	8.735	10.841	7.4	9.924	7.176	9.351
p-value	0.3233	0.2294	0.0093	0.0082	0.0333	0.0161	0.0005	0.0004

Table 9: Alternative surprise definitions

This table presents OLS regression results in the E-mini S&P 500 futures market with alternative surprise definitions for FOMC announcements. The dependent variables are the order imbalances calculated using both number of trades (OIN) and dollar volume (OID) during the media lockup period. We fix the lockup starting time to thirty minutes before the scheduled release time and the ending time is set to the scheduled release time in Columns 1 and 2, the actual time in Columns 3 and 4, and the earlier of the two in Columns 5 and 6. Variables ANN is defined in Table 4. For observations in the surprise announcement group, the signs of the order imbalance variables are adjusted to reflect the effects of a market-positive surprise. In Panel A, SUR is equal to one when the actual announced target rate deviates from the futures-implied rate by at least 17.5 basis points. In Panel B, SUR is equal to one when the actual announced target rate deviates from the futures-implied rate by at least 20 basis points. In Panel C, ABSDIFF is the absolute value of the difference between the expected and actual Federal funds target rates. In Panel D, we use only the Federal funds rate futures expiring in three months to calculate the expected target rate and the SUR is defined as in Table 4. In Panel E, ANNRET is the cumulative return of the ES from 30 minutes before the announcement to one minute after. Panels F and G use the surprise definitions of Kuttner (2001) and Gurkaynak, Sack, and Swanson (2005b), respectively. Panels H and I use the current month and non-current month Federal funds future contracts to calculate the announcement surprise, respectively. Corresponding  $t$ -statistics are reported in parentheses. The last row of Panels A, B, D, F, H, and I reports the  $p$ -value of the Wald test that the sum of the coefficients of ANN and SUR equals to zero.

Event time	Scheduled		Actual		MIN{Scheduled, Actual}	
	1	2	3	4	5	6
Model	OIN	OID	OIN	OID	OIN	OID
<i>Panel A: SUR=1 if AbsDiff&gt;17.5 bp, 20 surprises</i>						
Intercept	-0.524 (-2.60)	-0.584 (-2.25)	-0.543 (-2.66)	-0.562 (-2.14)	-0.535 (-2.60)	-0.589 (-2.24)
ANN	0.500 (0.50)	1.050 (0.82)	1.552 (1.54)	1.637 (1.26)	1.367 (1.35)	1.633 (1.26)
SUR	7.458 (3.05)	8.152 (2.59)	4.768 (1.93)	6.746 (2.11)	5.523 (2.21)	7.198 (2.25)
ANN+SUR	7.958	9.202	6.32	8.383	6.89	8.831
$p$ -value	0.0004	0.0015	0.0056	0.0044	0.0027	0.0027
<i>Panel B: SUR=1 if AbsDiff&gt;20 bp, 17 surprises</i>						
Intercept	-0.524 (-2.60)	-0.584 (-2.25)	-0.543 (-2.66)	-0.562 (-2.13)	-0.535 (-2.60)	-0.589 (-2.24)
ANN	0.721 (0.73)	1.349 (1.07)	1.756 (1.77)	1.918 (1.50)	1.577 (1.58)	1.915 (1.49)
SUR	7.784 (2.98)	8.046 (2.39)	4.743 (1.79)	6.521 (1.91)	5.594 (2.10)	7.046 (2.06)
ANN+SUR	8.505	9.395	6.499	8.439	7.171	8.961
$p$ -value	0.0005	0.0028	0.0086	0.0082	0.004	0.005



Table 9 (continued):

Event time Model Dependent	Scheduled		Actual		MIN{Scheduled, Actual}	
	1 OIN	2 OID	3 OIN	4 OID	5 OIN	6 OID
<i>Panel C: Use actual difference instead of dummy</i>						
Intercept	-0.524 (-2.61)	-0.584 (-2.25)	-0.543 (-2.66)	-0.562 (-2.14)	-0.535 (-2.60)	-0.589 (-2.24)
ANN	0.614 (0.64)	1.365 (1.11)	1.514 (1.57)	2.014 (1.62)	1.368 (1.41)	2.010 (1.61)
ABSDIFF	-27.955 (-3.87)	-31.693 (-3.41)	-19.856 (-2.71)	-25.756 (-2.73)	-22.075 (-3.00)	-27.819 (-2.94)
<i>Panel D: Use contracts expiring in three months, 16 surprises</i>						
Intercept	-0.523 (-2.60)	-0.579 (-2.23)	-0.541 (-2.65)	-0.556 (-2.11)	-0.532 (-2.59)	-0.584 (-2.21)
ANN	0.698 (0.71)	1.556 (1.23)	1.555 (1.56)	1.978 (1.54)	1.420 (1.42)	2.037 (1.59)
SUR	7.288 (2.71)	6.923 (2.00)	5.104 (1.88)	6.906 (1.97)	5.650 (2.06)	7.009 (2.00)
ANN+SUR	7.986	8.479	6.659	8.884	7.07	9.046
<i>p</i> -value	0.0015	0.0089	0.009	0.0069	0.0059	0.006
<i>Panel E: Use announcement returns</i>						
Intercept	-0.524 (-2.61)	-0.584 (-2.25)	-0.530 (-2.62)	-0.541 (-2.08)	-0.513 (-2.50)	-0.562 (-2.14)
ANN	11.940 (4.19)	13.026 (3.55)	6.789 (2.36)	6.510 (1.76)	7.210 (2.48)	6.949 (1.86)
ANNRET	1.637 (1.79)	2.525 (2.15)	2.369 (2.57)	2.953 (2.49)	2.152 (2.31)	2.875 (2.41)

Table 9 (continued):

Event time	Scheduled		Actual		MIN{Scheduled, Actual}	
	1 OIN	2 OID	3 OIN	4 OID	5 OIN	6 OID
<i>Panel F: Use Kuttner (2001) unexpected rate change, 4 surprises</i>						
Intercept	-0.524 (-2.60)	-0.584 (-2.25)	-0.541 (-2.07)	-0.530 (-2.61)	-0.562 (-2.14)	-0.513 (-2.50)
ANN	1.713 (1.84)	2.703 (2.26)	3.070 (2.55)	2.464 (2.63)	3.019 (2.49)	2.243 (2.37)
SUR	3.643 (0.71)	3.779 (0.58)	1.035 (0.16)	2.737 (0.53)	2.015 (0.30)	3.023 (0.58)
ANN+SUR	5.356	6.482	4.105	5.201	5.034	5.266
<i>p</i> -value	0.2868	0.3158	0.3033	0.5279	0.3026	0.4424
<i>Panel G: Use Gurkaynak, Sack, and Swanson (2005b) surprises</i>						
Intercept	-0.397 (-1.34)	-0.928 (-2.44)	-0.486 (-1.61)	-0.946 (-2.41)	-0.456 (-1.50)	-0.954 (-2.44)
ANN	1.340 (0.96)	2.190 (1.22)	2.864 (2.02)	3.844 (2.08)	2.720 (1.91)	3.778 (2.06)
Target	0.063 (0.28)	-0.130 (-0.46)	0.366 (1.61)	0.085 (0.29)	0.325 (1.42)	0.065 (0.22)
Path	-0.206 (-2.09)	-0.268 (-2.12)	-0.062 (-0.62)	-0.163 (-1.25)	-0.078 (-0.77)	-0.169 (-1.30)
<i>Panel H: Use current month contract only, 14 surprises</i>						
Intercept	-0.524 (-2.60)	-0.584 (-2.25)	-0.543 (-2.66)	-0.562 (-2.13)	-0.535 (-2.60)	-0.589 (-2.23)
ANN	1.590 (1.64)	2.444 (1.96)	2.337 (2.38)	2.769 (2.19)	2.265 (2.29)	2.844 (2.24)
SUR	1.050 (0.37)	-2.021 (-0.55)	-0.168 (-0.06)	-1.879 (-0.51)	-0.103 (-0.04)	-1.943 (-0.52)
ANN+SUR	2.64	0.423	2.169	0.89	2.162	0.901
<i>p</i> -value	0.3269	0.9027	0.4261	0.8001	0.4309	0.7979
<i>Panel I: Use non-current month contracts, 13 surprises</i>						
Intercept	-0.524 (-2.60)	-0.584 (-2.25)	-0.543 (-2.66)	-0.562 (-2.14)	-0.535 (-2.60)	-0.589 (-2.24)
ANN	0.586 (0.54)	1.143 (0.82)	1.644 (1.49)	2.087 (1.47)	1.398 (1.26)	1.985 (1.40)
SUR	5.204 (2.67)	6.533 (2.61)	2.639 (1.34)	4.389 (1.73)	3.280 (1.65)	4.979 (1.96)
ANN+SUR	5.79	7.676	4.283	6.476	4.678	6.964
<i>p</i> -value	0.0004	0.0003	0.01	0.0025	0.0052	0.0012

Table 10: Alternative surprise definitions for the QE period

This table presents OLS regression results in the E-mini S&P 500 futures market with alternative surprise definitions for FOMC announcements during the Quantitative Easing (QE) period. The dependent variables are the order imbalances calculated using both number of trades (OIN) and dollar volume (OID) during the lockup period starting at thirty minutes before the scheduled announcement time. The news announcement time is set to the scheduled release time in Columns 1 and 2, the actual time in Columns 3 and 4, and the earlier of the two in Columns 5 and 6. In Panel A, we use the mean of the target range and the 12.5 bp threshold to define surprise in the QE period. For the rest of the sample period, we use the same definition as in Table 5. In Panel B, we use the realized rate changes in the 10-year treasury to define surprise. SUR is equal to one if the magnitude of the realized rate change on the announcement day exceeds 1.75 times the its standard deviation calculated using data from 10 days before and 10 days after each announcement. For observations in the surprise announcement group, the signs of the order imbalance variables are adjusted to reflect the effects of a market-positive surprise. Corresponding  $t$ -statistics are reported in parentheses. The last row of each panel reports the  $p$ -value of the Wald test that the sum of the coefficients of ANN and SUR equals to zero.

Event time	Scheduled		Actual		MIN{Scheduled, Actual}	
Model	1	2	3	4	5	6
Dependent	OIN	OID	OIN	OID	OIN	OID
<i>Panel A: Using the mean of target range as the target rate, 38 observations</i>						
Intercept	-0.524 (-2.60)	-0.584 (-2.25)	-0.543 (-2.66)	-0.562 (-2.14)	-0.535 (-2.60)	-0.589 (-2.24)
ANN	-0.313 (-0.29)	0.132 (0.09)	1.250 (1.13)	1.202 (0.85)	0.971 (0.87)	1.099 (0.77)
SUR	6.459 (3.32)	7.928 (3.17)	3.281 (1.66)	5.814 (2.29)	3.992 (2.01)	6.394 (2.51)
ANN+SUR	6.146	8.06	4.531	7.016	4.963	7.493
$p$ -value	0.0002	0.0001	0.0064	0.0011	0.003	0.0005
<i>Panel B: Using realized rate change, 31 observations</i>						
Intercept	-0.524 (-2.60)	-0.584 (-2.25)	-0.543 (-2.66)	-0.562 (-2.14)	-0.535 (-2.60)	-0.589 (-2.24)
ANN	0.089 (0.09)	0.780 (0.58)	1.410 (1.33)	1.547 (1.13)	1.164 (1.09)	1.484 (1.08)
SUR	6.284 (3.03)	7.086 (2.66)	3.374 (1.61)	5.724 (2.11)	4.107 (1.94)	6.273 (2.31)
ANN+SUR	6.373	7.866	4.784	7.271	5.271	7.757
$p$ -value	0.0004	0.0007	0.0092	0.0021	0.0044	0.0011

Table 11: Market activities before positive and negative surprises

This table presents OLS regression results in the E-mini S&P 500 futures market for FOMC announcements with positive and negative surprises. The dependent variables are the order imbalances calculated using both number of trades (OIN) and dollar volume (OID) during the lockup period starting at thirty minutes before the scheduled announcement time. The news announcement time is set to the scheduled release time in Columns 1 and 2, the actual time in Columns 3 and 4, and the earlier of the two in Columns 5 and 6. Variables ANN is defined in Table 4. We divide the surprise announcements into positive and negative surprises. Bad equals one when the announced Federal funds target rate is above the futures-implied rate by at least 12.5 bp and zero otherwise. Good equals one when the announced Federal funds target rate is below the futures-implied rate by at least 12.5 bp and zero otherwise. Corresponding  $t$ -statistics are reported in parentheses.

Event time Model Dependent	Scheduled		Actual		MIN{Scheduled, Actual}	
	1 OIN	2 OID	3 OIN	4 OID	5 OIN	6 OID
Intercept	-0.524 (-2.61)	-0.584 (-2.26)	-0.543 (-2.66)	-0.562 (-2.14)	-0.535 (-2.60)	-0.589 (-2.24)
ANN	0.012 (0.01)	0.486 (0.37)	1.255 (1.22)	1.219 (0.92)	1.024 (0.99)	1.148 (0.86)
Bad	1.020 (0.24)	-1.785 (-0.33)	0.011 (0.00)	-3.259 (-0.59)	0.240 (0.06)	-3.198 (-0.58)
Good	10.764 (4.30)	12.887 (4.00)	6.982 (2.75)	10.903 (3.33)	8.019 (3.14)	11.803 (3.60)
ANN + Bad	1.032	-1.299	1.266	-2.04	1.264	-2.05
$p$ -value	0.8011	0.8051	0.6806	0.7454	0.7657	0.6974
ANN + Good	10.776	13.373	8.237	12.122	9.043	12.951
$p$ -value	<.0001	<.0001	0.0004	0.0003	<.0001	<.0001

Table 12: Price behavior around the FOMC announcements

This table presents OLS regression results in the E-mini S&P 500 futures market for FOMC announcements. The dependent variables are the returns in different event windows relative to the officially scheduled announcement time 0. The news announcement time  $t$  is set to the scheduled release time in Panel A, the actual time in Panel B, and the earlier of the two in Panel C. Variables ANN and SUR are defined in Table 4. For observations in the surprise announcement group, the signs of the order imbalance variables are adjusted to reflect the effects of a market-positive surprise. Corresponding  $t$ -statistics are reported in parentheses. The last row of each panel reports the  $p$ -value of the Wald test that the sum of the coefficients of ANN and SUR equals to zero.

Event time	[-60,-30]	[-30,t]	[t,60]	[-30,-20]	[-20,-10]	[-10,t]
Model	1	2	3	4	5	6
<i>Panel A: time <math>t</math> is the scheduled time</i>						
Intercept	0.603 (1.22)	-0.970 (-1.97)	1.519 (1.67)	-0.468 (-1.60)	-0.232 (-0.78)	-0.267 (-0.87)
ANN	1.367 (0.55)	-4.146 (-1.67)	7.166 (1.56)	0.159 (0.11)	0.417 (0.28)	-4.715 (-3.05)
SUR	-1.646 (-0.30)	22.154 (4.05)	-6.079 (-0.60)	-0.046 (-0.01)	2.397 (0.72)	19.800 (5.82)
ANN+SUR	-0.279	18.008	1.087	0.113	2.814	15.085
$p$ -value	0.9549	0.0003	0.9049	0.9692	0.3481	<.0001
<i>Panel B: time <math>t</math> is the actual time</i>						
Intercept	0.603 (1.22)	-0.866 (-1.78)	1.196 (0.56)	-0.468 (-1.60)	-0.232 (-0.78)	-0.164 (-0.57)
ANN	1.367 (0.55)	2.915 (1.19)	0.355 (0.03)	0.159 (0.11)	0.417 (0.28)	2.348 (1.61)
SUR	-1.646 (-0.30)	4.060 (0.75)	12.164 (0.51)	-0.046 (-0.01)	2.397 (0.72)	1.693 (0.53)
ANN+SUR	-0.279	6.975	12.519	0.113	2.814	4.041
$p$ -value	0.9549	0.1512	0.5614	0.9692	0.3481	0.1617
<i>Panel C: time <math>t</math> is <math>\text{MIN}\{\text{schedule time, actual time}\}</math></i>						
Intercept	0.603 (1.22)	-0.904 (-1.88)	1.196 (0.56)	-0.468 (-1.60)	-0.232 (-0.78)	-0.201 (-0.72)
ANN	1.367 (0.55)	2.494 (1.03)	0.806 (0.07)	0.159 (0.11)	0.417 (0.28)	1.926 (1.36)
SUR	-1.646 (-0.30)	5.542 (1.04)	10.695 (0.45)	-0.046 (-0.01)	2.397 (0.72)	3.176 (1.02)
ANN+SUR	-0.279	8.036	11.501	0.113	2.814	5.102
$p$ -value	0.9549	0.1466	0.5596	0.9692	0.3481	0.1561

Table 13: Price discovery from informed order flow

This table presents OLS regression results in the E-mini S&P 500 futures market for 126 FOMC announcements. The dependent variables are the order imbalances calculated using number of trades (OIN) and dollar volume (OID). The news announcement time  $t$  is set to the actual time.  $Ret_{lockup}$  is the return during the lockup period starting thirty minutes before the scheduled release time and ending at actual announcement time.  $Ret_{0,n}$  denotes the post-announcement return from the actual release time to  $n$  minutes later. Corresponding  $t$ -statistics are reported in parentheses.

Variable	OIN	OID	OIN	OID	OIN	OID	OIN	OID
Model	1	2	3	4	5	6	7	8
Intercept	0.022 (0.85)	0.052 (1.74)	0.020 (0.79)	0.050 (1.75)	0.019 (0.79)	0.052 (1.79)	0.020 (0.80)	0.050 (1.75)
$Ret_{lockup}$	62.888 (2.90)	53.474 (2.09)	61.927 (2.83)	50.243 (1.99)	60.612 (2.78)	50.493 (1.97)	62.404 (2.83)	48.939 (1.93)
$Ret_{0,1}$	1.424 (0.28)	-0.814 (-0.14)						
$Ret_{0,5}$			-1.011 (-0.23)	-4.813 (-0.97)				
$Ret_{0,10}$					-1.906 (-0.56)	-2.945 (-0.73)		
$Ret_{0,30}$							-0.201 (-0.06)	-4.076 (-1.05)

Table 14: Activities around FOMC announcements in other markets

In this table, we repeat our analysis for FOMC announcements with alternative testing securities. Panels A to F report the results on the E-mini Nasdaq 100 futures, SPDR S&P 500 ETF, PowerShares QQQ ETF (tracking Nasdaq 100), 2-Year US Treasury Note futures, 10-Year US Treasury Note futures, and Gold futures, respectively. The dependent variables are the returns and order imbalances calculated using both number of trades (OIN) and dollar volume (OID) during the lockup period starting at thirty minutes before the scheduled announcement time. The news announcement time is set to the scheduled release time in Columns 1 and 2, the actual time in Columns 3 and 4, and the earlier of the two in Columns 5 and 6. Variables ANN and SUR are defined in Table 4. For observations in the surprise announcement group, the signs of the return and order imbalance variables are adjusted to reflect the effects of a market-positive surprise. Variables ANN and SUR are defined in Table 4. Corresponding  $t$ -statistics are reported in parentheses. The last row of each panel reports the  $p$ -value of the Wald test that the sum of the coefficients of ANN and SUR equals to zero.

Period	Scheduled			Actual			MIN{Scheduled, Actual}		
	1	2	3	4	5	6	7	8	9
Model	OIN	OID	Ret	OIN	OID	Ret	OIN	OID	Ret
<i>Panel A: E-mini Nasdaq 100 futures</i>									
Intercept	-0.172 (-0.89)	-0.297 (-1.13)	-1.918 (-2.39)	0.181 (1.93)	0.124 (0.86)	2.220 (0.74)	0.181 (1.92)	0.124 (0.86)	2.220 (0.74)
ANN	1.080 (1.10)	0.154 (0.11)	-6.075 (-1.49)	1.642 (3.40)	0.842 (1.14)	0.813 (0.05)	1.560 (3.22)	0.521 (0.70)	-0.844 (-0.05)
SUR	2.886 (1.39)	7.904 (2.78)	28.868 (3.34)	0.023 (0.02)	4.018 (2.57)	8.636 (0.27)	0.380 (0.37)	4.858 (3.10)	10.217 (0.31)
ANN+SUR	3.966	8.058	22.793	1.665	4.86	9.449	1.94	5.379	9.373
$p$ -value	0.0326	0.0015	0.0031	0.0499	0.0002	0.6396	0.0066	<.0001	0.6907
<i>Panel B: SPDR S&amp;P 500 ETF</i>									
Intercept	1.029 (3.58)	-0.147 (-0.28)	-0.958 (-1.78)	1.166 (6.38)	-0.578 (-1.71)	0.958 (0.64)	1.166 (6.36)	-0.578 (-1.71)	0.958 (0.64)
ANN	1.513 (1.03)	4.938 (1.82)	-2.951 (-1.07)	2.052 (2.20)	5.527 (3.21)	1.182 (0.15)	2.025 (2.17)	5.590 (3.25)	0.226 (0.03)
SUR	8.373 (2.63)	-0.807 (-0.14)	24.482 (4.10)	5.409 (2.67)	-4.500 (-1.20)	3.685 (0.22)	5.590 (2.75)	-4.286 (-1.14)	5.405 (0.32)
ANN+SUR	9.886	4.131	21.531	7.461	1.027	4.867	7.615	1.304	5.631
$p$ -value	0.0005	0.4350	<.0001	<.0001	0.8683	0.7522	<.0001	0.6871	0.6244
<i>Panel C: PowerShares QQQ ETF (tracking Nasdaq 100)</i>									
Intercept	0.031 (0.10)	0.117 (0.25)	-1.716 (-2.10)	0.339 (1.74)	-0.420 (-1.45)	0.368 (0.16)	0.339 (1.74)	-0.420 (-1.45)	0.368 (0.16)
ANN	-0.258 (-0.16)	-2.939 (-1.23)	-6.462 (-1.54)	1.851 (1.85)	0.001 (0.00)	3.014 (0.26)	1.796 (1.79)	-0.229 (-0.15)	1.505 (0.13)
SUR	7.769 (2.21)	9.720 (1.93)	30.841 (3.48)	3.231 (1.53)	4.547 (1.45)	11.246 (0.46)	3.280 (1.55)	4.343 (1.38)	11.632 (0.48)
ANN+SUR	7.511	6.781	24.379	5.082	4.548	14.26	5.076	4.114	13.137
$p$ -value	0.0163	0.1312	0.002	0.0006	0.0921	0.4711	0.0014	0.0804	0.4799

Table 14 (continued):

Period	Scheduled			Actual			MIN{Scheduled, Actual}		
Model	1	2	3	4	5	6	7	8	9
Dependent	OIN	OID	Ret	OIN	OID	Ret	OIN	OID	Ret
<i>Panel D: 2-Year Treasury futures</i>									
Intercept	1.614 (1.26)	1.212 (0.86)	0.191 (1.11)	0.642 (1.04)	0.951 (1.34)	-0.631 (-1.52)	0.642 (1.04)	0.951 (1.34)	-0.631 (-1.52)
ANN	-9.484 (-1.46)	-8.089 (-1.13)	-0.210 (-0.24)	-6.149 (-1.95)	-5.139 (-1.41)	0.627 (0.30)	-6.478 (-2.05)	-5.135 (-1.41)	0.679 (0.32)
SUR	15.725 (1.14)	20.701 (1.36)	0.513 (0.28)	17.025 (2.54)	19.738 (2.56)	0.095 (0.02)	17.199 (2.56)	19.795 (2.57)	0.067 (0.01)
ANN+SUR	6.241	12.612	0.303	10.876	14.599	0.722	10.721	14.66	0.746
<i>p</i> -value	0.6121	0.3518	0.8542	0.0699	0.034	0.8595	0.0734	0.0333	0.8526
<i>Panel E: 10-Year Treasury futures</i>									
Intercept	0.298 (0.56)	0.136 (0.23)	0.018 (0.05)	0.426 (1.80)	0.063 (0.23)	-1.217 (-1.25)	0.426 (1.79)	0.063 (0.23)	-1.217 (-1.25)
ANN	-1.719 (-0.64)	-0.847 (-0.29)	3.141 (1.78)	-1.134 (-0.93)	0.045 (0.03)	3.954 (0.79)	-0.956 (-0.78)	0.439 (0.31)	4.351 (0.87)
SUR	5.498 (0.96)	3.799 (0.61)	0.736 (0.20)	2.896 (1.12)	1.334 (0.44)	1.217 (0.11)	3.055 (1.18)	1.128 (0.37)	0.861 (0.08)
ANN+SUR	3.779	2.952	3.877	1.762	1.379	5.171	2.099	1.567	5.212
<i>p</i> -value	0.4599	0.5965	0.247	0.4654	0.6085	0.5796	0.3637	0.5602	0.5823
<i>Panel F: Gold futures</i>									
Intercept	-0.308 (-0.69)	-0.617 (-1.12)	-0.255 (-0.43)	-0.954 (-1.08)	-1.085 (-1.05)	1.568 (1.03)	-0.954 (-1.08)	-1.085 (-1.05)	1.568 (1.03)
ANN	-0.634 (-0.30)	-1.354 (-0.52)	-1.572 (-0.56)	0.060 (0.01)	-0.920 (-0.13)	-2.604 (-0.26)	-0.019 (-0.00)	-0.859 (-0.13)	-2.956 (-0.29)
SUR	-8.295 (-1.13)	-11.612 (-1.27)	0.668 (0.07)	-5.234 (-0.25)	-11.397 (-0.47)	1.713 (0.05)	-5.155 (-0.25)	-11.457 (-0.47)	2.065 (0.06)
ANN+SUR	-8.929	-12.966	-0.904	-5.174	-12.317	-0.891	-5.174	-12.316	-0.891
<i>p</i> -value	0.208	0.1392	0.9241	0.8327	0.5984	0.9887	0.7953	0.5956	0.9793



Table 15: Informed traders' profits around FOMC surprises

This table estimates the profits of early informed traders in the 25 surprise FOMC announcements. We assume the informed traders acquire the news at thirty minutes before the scheduled announcement time, accumulate positions until the actual announcement time, and liquidate their position at the end of five minutes, ten minutes, or thirty minutes after the actual announcement. The lower bounds of the profits are calculated assuming that the informed traders use market orders and the resulting imbalance in each second during the lockup is due only to informed trades. The upper bounds are calculated assuming that the informed traders successfully enter the right position behind every transaction using either a market order or a limit order. The trading profits are aggregated across all transactions on the same announcement date and summary statistics are reported for the days. The number in the informed trading profit variables indicate the assumed position closing time after the actual announcement and the 'lower' and 'upper' indicate the side of the boundary.

Statistic	Profit5_lower	Profit5_upper	Profit10_lower	Profit10_upper	Profit30_lower	Profit30_upper
<i>Panel A: E-mini S&amp;P 500 futures only</i>						
Mean	139,398	6,112,174	102,725	8,298,398	347,761	5,565,444
Std. dev.	1,844,628	19,173,420	2,316,577	24,673,519	2,698,181	27,264,839
Sum	3,484,953	152,804,346	2,568,122	207,459,944	8,694,020	139,136,109
<i>Panel B: All markets</i>						
Mean	180,179	6,962,984	261,456	8,420,849	256,015	6,280,122
Std. dev.	1,680,259	21,912,198	2,623,964	24,826,879	3,118,885	27,827,551
Sum	4,504,469	174,074,608	6,536,411	210,521,235	6,400,375	157,003,043

## *Internet Appendix*

**Can information be locked up? Informed trading  
ahead of macro-news announcements**

January 2015

Table A1: FOMC announcement observations

The table lists the FOMC announcement sample observations in the study. Associated with each announcement, the official time is the scheduled news release time according to the FOMC meeting minutes. The actual time is the earliest release time found on public news agencies. Bottom denotes the lower bound of the Federal funds target rate and Up denotes the upper bound. Exp Rate is the implied Federal funds rate on the day before FOMC announcement from all of the Federal funds rate futures and Exp Rate 3-month uses only contracts expiring in three months to calculate the implied rate.

Date	Official time	Actual time	Bottom	Up	Exp Rate	Exp Rate 3-month
19970930	14:15:00	14:13:00	5.5	5.5	5.918	5.923
19971112	14:15:00	14:12:00	5.5	5.5	5.595	5.591
19971216	14:15:00	14:15:00	5.5	5.5	5.614	5.612
19980204	14:15:00	14:12:00	5.5	5.5	5.442	5.446
19980331	14:15:00	14:14:00	5.5	5.5	5.57	5.574
19980519	14:15:00	14:13:00	5.5	5.5	5.566	5.548
19980701	14:15:00	14:14:00	5.5	5.5	5.528	5.52
19980818	14:15:00	14:12:00	5.5	5.5	5.484	5.49
19980929	14:15:00	14:12:00	5.25	5.25	5.173	5.179
19981117	14:15:00	14:19:00	4.75	4.75	4.857	4.866
19981222	14:15:00	14:13:00	4.75	4.75	4.727	4.776
19990203	14:15:00	14:12:00	4.75	4.75	4.741	4.741
19990330	14:15:00	14:12:00	4.75	4.75	4.803	4.788
19990518	14:15:00	14:11:00	4.75	4.75	4.833	4.82
19990630	14:15:00	14:15:00	5	5	5.167	5.134
19990824	14:15:00	14:14:00	5.25	5.25	5.25	5.238
19991005	14:15:00	14:12:00	5.25	5.25	5.322	5.322
19991116	14:15:00	14:16:00	5.5	5.5	5.413	5.404
19991221	14:15:00	14:13:00	5.5	5.5	5.661	5.627
20000202	14:15:00	14:14:00	5.75	5.75	5.927	5.895
20000321	14:15:00	14:14:00	6	6	6.065	6.032
20000516	14:15:00	14:13:00	6.5	6.5	6.528	6.5
20000628	14:15:00	14:15:00	6.5	6.5	6.572	6.571
20000822	14:15:00	14:14:00	6.5	6.5	6.541	6.533
20001003	14:15:00	14:12:00	6.5	6.5	6.488	6.488
20001115	14:15:00	14:12:00	6.5	6.5	6.516	6.516
20001219	14:15:00	14:16:00	6.5	6.5	6.288	6.356
20010131	14:15:00	14:14:00	5.5	5.5	5.294	5.332
20010320	14:15:00	14:13:00	5	5	4.886	4.924
20010515	14:15:00	14:15:00	4	4	4.066	4.07
20010627	14:15:00	14:12:00	3.75	3.75	3.641	3.703
20010821	14:15:00	14:13:00	3.5	3.5	3.415	3.465
20011002	14:15:00	14:15:00	2.5	2.5	2.315	2.315
20011106	14:15:00	14:19:00	2	2	2.005	2.008
20011211	14:15:00	14:14:00	1.75	1.75	1.753	1.733

Table A1 (continued):

Date	Official time	Actual time	Bottom	Up	Exp rate	Exp rate 3-month
20020130	14:15:00	14:16:00	1.75	1.75	1.772	1.724
20020319	14:15:00	14:19:00	1.75	1.75	1.982	1.842
20020507	14:15:00	14:14:00	1.75	1.75	1.811	1.758
20020626	14:15:00	14:13:00	1.75	1.75	1.787	1.85
20020813	14:15:00	14:14:00	1.75	1.75	1.625	1.625
20020924	14:15:00	14:12:00	1.75	1.75	1.665	1.665
20021106	14:15:00	14:14:00	1.25	1.25	1.458	1.474
20021210	14:15:00	14:13:00	1.25	1.25	1.24	0
20030129	14:15:00	14:16:00	1.25	1.25	1.181	1.202
20030318	14:15:00	14:15:00	1.25	1.25	1.136	1.179
20030506	14:15:00	14:13:00	1.25	1.25	1.165	1.176
20030625	14:15:00	14:16:00	1	1	0.877	0.899
20030812	14:15:00	14:15:00	1	1	1.094	1.013
20030916	14:15:00	14:19:00	1	1	1.011	1.012
20031028	14:15:00	14:14:00	1	1	1.037	1.005
20031209	14:15:00	14:14:00	1	1	1.087	1.011
20040128	14:15:00	14:14:00	1	1	1.058	1.002
20040316	14:15:00	14:15:00	1	1	1.009	1.003
20040504	14:15:00	14:16:00	1	1	1.115	1.062
20040630	14:15:00	14:18:00	1.25	1.25	1.585	1.404
20040810	14:15:00	14:15:00	1.5	1.5	1.55	1.519
20040921	14:15:00	14:15:00	1.75	1.75	1.907	1.792
20041110	14:15:00	14:15:00	2	2	2.216	2.16
20041214	14:15:00	14:15:00	2.25	2.25	2.428	2.41
20050202	14:15:00	14:12:00	2.5	2.5	2.61	2.546
20050322	14:15:00	14:17:00	2.75	2.75	3.142	2.884
20050503	14:15:00	14:16:00	3	3	3.256	3.094
20050630	14:15:00	14:15:00	3.25	3.25	3.543	3.416
20050809	14:15:00	14:17:00	3.5	3.5	3.95	3.658
20050920	14:15:00	14:17:00	3.75	3.75	3.878	3.765
20051101	14:15:00	14:18:00	4	4	4.34	4.103
20051213	14:15:00	14:13:00	4.25	4.25	4.459	4.369
20060131	14:15:00	14:14:00	4.5	4.5	4.564	4.558
20060328	14:15:00	14:17:00	4.75	4.75	4.969	4.76
20060510	14:15:00	14:17:00	5	5	5.107	5.095
20060629	14:15:00	14:16:00	5.25	5.25	5.335	5.308
20060808	14:15:00	14:14:00	5.25	5.25	5.309	5.305
20060920	14:15:00	14:13:00	5.25	5.25	5.259	5.261
20061025	14:15:00	14:13:00	5.25	5.25	5.266	5.248
20061212	14:15:00	14:14:00	5.25	5.25	5.21	5.236
20070131	14:15:00	14:14:00	5.25	5.25	5.247	5.247
20070321	14:15:00	14:15:00	5.25	5.25	5.2	5.233
20070509	14:15:00	14:15:00	5.25	5.25	5.221	5.244
20070628	14:15:00	14:14:00	5.25	5.25	5.24	5.242
20070807	14:15:00	14:14:00	5.25	5.25	5.217	5.218

Table A1 (continued):

Date	Official time	Actual time	Bottom	Up	Exp rate	Exp rate 3-month
20070918	14:15:00	14:15:00	4.75	4.75	4.73	4.855
20071031	14:15:00	14:15:00	4.5	4.5	4.44	4.501
20071211	14:15:00	14:15:00	4.25	4.25	4.037	4.134
20080130	14:15:00	14:14:00	3	3	3.061	3.079
20080318	14:15:00	14:14:00	2.25	2.25	1.795	1.847
20080430	14:15:00	14:15:00	2	2	2.021	2.017
20080625	14:15:00	14:09:00	2	2	2.164	2.063
20080805	14:15:00	14:13:00	2	2	2.105	2.056
20080916	14:15:00	14:14:00	2	2	1.794	1.795
20081029	14:15:00	14:17:00	0.5	1	0.905	0.907
20081216	14:15:00	14:11:00	0	0.25	0.33	0.33
20090128	14:15:00	14:14:00	0	0.25	0.252	0.23
20090318	14:15:00	14:17:00	0	0.25	0.225	0.225
20090624	14:15:00	14:18:00	0	0.25	0.359	0.229
20090812	14:15:00	14:16:00	0	0.25	0.355	0.198
20090923	14:15:00	14:16:00	0	0.25	0.28	0.185
20091104	14:15:00	14:18:00	0	0.25	0.319	0.154
20091216	14:15:00	14:15:00	0	0.25	0.282	0.171
20100127	14:15:00	14:16:00	0	0.25	0.234	0.138
20100316	14:15:00	14:14:00	0	0.25	0.268	0.195
20100428	14:15:00	14:14:00	0	0.25	0.357	0.217
20100623	14:15:00	14:15:00	0	0.25	0.292	0.204
20100810	14:15:00	14:14:00	0	0.25	0.218	0.177
20100921	14:15:00	14:14:00	0	0.25	0.193	0.185
20101103	14:15:00	14:16:00	0	0.25	0.189	0.175
20101214	14:15:00	14:15:00	0	0.25	0.255	0.182
20110126	14:15:00	14:16:00	0	0.25	0.24	0.172
20110315	14:15:00	14:13:00	0	0.25	0.245	0.139
20110427	12:30:00	12:32:00	0	0.25	0.271	0.115
20110622	12:30:00	12:27:00	0	0.25	0.208	0.109
20110809	14:15:00	14:18:00	0	0.25	0.101	0.085
20110921	14:15:00	14:24:00	0	0.25	0.071	0.069
20111102	12:30:00	12:32:00	0	0.25	0.114	0.085
20111213	14:15:00	14:13:00	0	0.25	0.11	0.092
20120125	12:30:00	12:28:00	0	0.25	0.112	0.085
20120313	14:15:00	14:15:00	0	0.25	0.143	0.116
20120425	12:30:00	12:32:00	0	0.25	0.15	0.135
20120620	12:30:00	12:32:00	0	0.25	0.168	0.167
20120801	14:15:00	14:13:00	0	0.25	0.136	0.14
20120913	12:30:00	12:31:00	0	0.25	0.126	0.128
20121024	14:15:00	14:15:00	0	0.25	0.146	0.149
20121212	12:30:00	12:30:00	0	0.25	0.138	0.142
20130130	14:15:00	14:15:00	0	0.25	0.137	0.133
20130320	14:00:00	14:00:00	0	0.25	0.14	0.143
20130501	14:00:00	14:01:00	0	0.25	0.125	0.125
20130619	14:00:00	14:00:00	0	0.25	0.105	0.103

Table A2: Market reaction to FOMC surprises

The table shows the stock market reaction to the FOMC announcement surprise in the sample of 126 scheduled announcements between September 30, 1997 and June 19, 2013. Reported are the OLS regression results of the announcement returns on the expected and unexpected changes in the target Federal funds rate. The announcement returns are calculated in three event windows relative to the scheduled announcement time defined as time 0 on the E-mini S&P 500 futures in Panel A, the E-mini Nasdaq 100 futures in Panel B, the SPDR S&P 500 ETF in Panel C, and the PowerShares QQQ ETF (tracking Nasdaq 100) in Panel D. Expected is the volume-weighted Federal funds future implied rate on the day before FOMC announcements using all contracts. Unexpected is the actual Federal funds rate minus the expected rate. The calculation method is detailed in Subsection 3.2. Associated  $t$ -statistics are reported in parentheses.

Variable	Ret[-5,5]	Ret[-15,15]	Ret[-30,30]
<i>Panel A: E-mini S&amp;P 500 futures</i>			
Intercept	-7.918 (-2.11)	-13.324 (-2.79)	-11.461 (-1.77)
Expected	-39.792 (-3.01)	-23.286 (-1.38)	-29.095 (-1.28)
Unexpected	-147.485 (-4.30)	-158.107 (-3.62)	-160.762 (-2.72)
<i>Panel B: E-mini Nasdaq 100 futures</i>			
Intercept	-7.918 (-2.11)	-13.324 (-2.79)	-11.461 (-1.77)
Expected	-39.792 (-3.01)	-23.286 (-1.38)	-29.095 (-1.28)
Unexpected	-147.485 (-4.30)	-158.107 (-3.62)	-160.762 (-2.72)
<i>Panel C: SPDR S&amp;P 500 ETF</i>			
Intercept	-7.918 (-2.11)	-13.324 (-2.79)	-11.461 (-1.77)
Expected	-39.792 (-3.01)	-23.286 (-1.38)	-29.095 (-1.28)
Unexpected	-147.485 (-4.30)	-158.107 (-3.62)	-160.762 (-2.72)
<i>Panel D: PowerShares QQQ ETF (tracking Nasdaq 100 index)</i>			
Intercept	-7.918 (-2.11)	-13.324 (-2.79)	-11.461 (-1.77)
Expected	-39.792 (-3.01)	-23.286 (-1.38)	-29.095 (-1.28)
Unexpected	-147.485 (-4.30)	-158.107 (-3.62)	-160.762 (-2.72)

Table A3: Market dynamics around macroeconomic announcements

This table presents pooled OLS regression results in the E-mini S&P 500 futures market using observations in three event windows for each announcement: [-60,-30], [-30,0], and [0,60]. The dependent variables are the order imbalances calculated using both number of trades (OIN) and dollar volume (OID). Variables ANN and SUR are defined in Table 4. Lockup is a dummy equal to one for observations in the lockup window ([-30,0]), and zero otherwise. Post is a dummy equal to one for observations in the post-lockup period ([0,60]), and zero otherwise. For observations in the surprise announcement group, the signs of the order imbalance variables are adjusted to reflect the effects of a market-positive surprise. Corresponding *t*-statistics are reported in parentheses.

Variable	FOMC		Nonfarm payroll		CPI		GDP	
	OIN	OID	OIN	OID	OIN	OID	OIN	OID
Intercept	0.118 (0.61)	-0.325 (-1.31)	0.529 (1.83)	0.623 (1.71)	0.621 (2.14)	0.737 (2.02)	0.592 (2.03)	0.740 (2.01)
ANN	-0.629 (-0.64)	1.197 (0.96)	-0.420 (-0.28)	0.443 (0.24)	-1.030 (-0.70)	0.260 (0.14)	0.153 (0.11)	2.111 (1.16)
SUR	-0.279 (-0.13)	-5.366 (-1.94)	-4.448 (-1.71)	-3.916 (-1.20)	-1.411 (-0.54)	-4.550 (-1.37)	0.511 (0.19)	-1.786 (-0.52)
Lockup	-0.654 (-2.37)	-0.277 (-0.79)	-0.424 (-1.03)	-0.149 (-0.29)	-0.529 (-1.29)	-0.279 (-0.54)	-0.537 (-1.30)	-0.355 (-0.68)
ANN*Lockup	0.659 (0.48)	-0.706 (-0.40)	2.790 (1.33)	3.725 (1.41)	3.059 (1.47)	2.454 (0.94)	1.331 (0.65)	0.930 (0.36)
SUR*Lockup	8.698 (2.83)	14.745 (3.77)	0.936 (0.25)	-1.344 (-0.29)	-0.664 (-0.18)	2.589 (0.55)	-0.986 (-0.26)	0.120 (0.02)
Post	-0.228 (-0.82)	0.228 (0.65)	-1.850 (-4.51)	-2.121 (-4.11)	-1.958 (-4.77)	-2.207 (-4.27)	-1.931 (-4.69)	-2.230 (-4.29)
ANN*Post	0.161 (0.12)	-1.085 (-0.62)	1.893 (0.90)	2.202 (0.84)	1.974 (0.95)	1.219 (0.46)	1.429 (0.70)	-0.454 (-0.18)
SUR*Post	0.544 (0.18)	5.416 (1.39)	4.339 (1.18)	4.940 (1.07)	3.116 (0.84)	6.962 (1.49)	2.575 (0.67)	7.646 (1.58)

Table A4: Order imbalance before surprise events using the Kuttner (2001) method

This table reports the order imbalance in number of trades (OIN) and dollar volume (OID) during the lockup periods preceding four surprise announcements based on the Kuttner (2001) method. The order imbalance is expressed in percentage.

Date	Surprise (bp)	Scheduled		Actual		Min{Scheduled, Actual}	
		OIN	OID	OIN	OID	OIN	OID
11/6/2002	-19	6.562	7.273	6.562	7.273	6.562	7.273
6/25/2003	15	-2.405	-16.572	-2.076	-12.939	-2.405	-16.572
9/18/2007	-15	0.583	-2.517	0.583	-2.517	0.583	-2.517
3/18/2008	17	-9.775	-2.266	-9.463	-3.441	-9.463	-3.441