# 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 information 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. Moreover, the information contained in the abnormal order imbalances about subsequent policy surprises predicts the S&P 500's abnormal returns following FOMC announcements. We estimate that pre-release informed trades' profits range between $4.5 and $210.5 million when aggregated across all markets and FOMC announcements that we examine. Notably, we find no evidence of informed trading prior to the start of FOMC news embargoes or during lockups ahead of nonfarm payroll, PPI, 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? Financial economists 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).[1] 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.[2] 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.[3] 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 (often 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 these 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.[4]

[1]See Weber (2000), Shiller (2000), SEC (2000), Hasset (2000), Bushee, Matsumoto, and Miller (2004), Duarte, Han, Harford, and Young (2008).

[2]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).

[3]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)).

[4]These concerns led to tightening of lockup security protocols and even prompted the Inspector General of the U.S. Department of Labor to recommend discontinuing press lockups – see *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 Calls for Ending Lockup for Jobs Data" in January 2014. Potential leakages from the Federal Reserve were also at the center of attention – see *CNBC* report "News organizations respond to Fed lockup questions" in September 2013 and *Bloomberg News*

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 scheduled announcements of the Federal funds target rate by the Federal Open Market Committee (FOMC), the releases of nonfarm payroll and producer price index (PPI) data by the Department of Labor (DOL), and of gross domestic product (GDP) growth data 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 news embargoes ahead of scheduled monetary policy announcements by the FOMC. In particular, we document significant abnormal order imbalances that are in the direction of the subsequent policy surprises. Moreover, we find that the information contained in lockup-related trading activity about subsequent policy surprises predicts the market reaction to the actual release of FOMC statements. 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 surprise announcements range between \$4.5 and \$210.5 million across all the markets that we examine.[5]

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

report "Fed Leak Tipped Traders to Historic Stimulus Move, Prompted Secret Inquiry" in December 2014.

[5]We use the label "surprise announcements" for scheduled announcements whose information content deviates significantly from expectations.

risk exposure. Moreover, the instrument needs to be available for trading prior 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) meet 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.[6]

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 larger this difference, the more likely it is that a privately informed investor would trade and profit. Therefore, it is critical for our purposes to measure pre-release market expectations 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, PPI, 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 identify surprise announcements.

We adopt a two-pronged empirical strategy to test the hypothesis that some traders are privately informed ahead of macro-news' public announcements. In the first part of our analysis, we test whether the information in macro-news that may be privately available to some traders explains pre-announcement market activities, similar in spirit to existing studies on equity analysts' tipping (e.g., Irvine, Lipson, and Puckett (2007), Christophe, Ferri, and Hsieh (2010)). Like in those studies, we identify informed trading by the order imbalances of the testing security, 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

[6]Other futures contracts are significantly less liquid than the ES and the ETFs are only available prior to FOMC announcements.

is fewer. Then, for each type of macro-news release, we test for differences in abnormal order imbalances around surprise and non-surprise announcements. This empirical strategy ultimately exploits the systematic variation in market activity across announcement versus non-announcement days as well as across surprise versus non-surprise announcements.

Our first set of tests yields several important results. First, across various markets that we examine, we find evidence of informed trading activity prior to FOMC surprise announcements and this activity is 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 7.75%–8.73% higher for FOMC 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, the PowerShares QQQ Nasdaq 100 ETF, or 2-Year Treasury futures. Tellingly, we find no evidence of informed trading prior to the start of FOMC news embargoes, nor do we find differences in trading activities during FOMC embargoes ahead of non-surprise announcements versus non-announcement days.

In contrast to FOMC announcements, we find no evidence of informed trading ahead of DOL or BEA announcements. This is particularly relevant, given that government investigations focused predominantly on the DOL lockup practices since at least 2011. At that point, Need to Know News (NTKN), a news media organization with press credentials since 2006, was alleged of leaking information and ultimately banned from DOL lockups.[7] In supplemental tests we examine whether our results vary with NTKN's news media accreditation, but find that our inferences are robust across subperiods.

In light of our baseline results, we focus on FOMC policy releases in the remainder of our analysis. First, we zoom in on the pre-release period and divide it 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 assess the robustness of our results to controlling for discrepancies between official and actual release times of the FMOC policy

[7]See "Deutsche Borse's News Service for Traders Draws Scrutiny of Investigators", *The Wall Street Journal*, August 12, 2013.

announcements (e.g., Flemming and Piazzesi (2005), Lucca and Moench (2015)). Using the earliest time of reports available on Factiva, we continue to find evidence of informed trading activity in the window [−20,−10]. Third, we show that our inferences are robust to using stricter definitions of target rate policy surprises or the actual unexpected target rate policy, and to accounting for the Federal Reserve's announcements of Quantitative Easing measures since November 2008. Lastly, we find that informed trading occurs mainly before good news – i.e., unexpectedly low target rates. Short-sale constraints in the stock market may account for this asymmetry by limiting the ability of liquidity providers in the futures market to hedge 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 the last part of our analysis, we change our testing strategy by adopting the perspective of uninformed market participants. In particular, we examine whether pre-release order imbalances contain information about subsequent FOMC policy surprises that can predict the reaction of market prices to the actual policy announcements. We conduct this analysis in two steps. In the first step, we test whether pre-announcement trading predicts FOMC policy surprises. Then, in the second step, we examine whether the fitted policy surprise systematically predicts the market reaction to FOMC public announcements.

Consistent with informed trading, we find that there is a significant association between abnormal order imbalances observed during FOMC embargoes and subsequent policy surprises. In contrast, the pre-embargo trading activity and the pre-release market returns and volatilities have no predictive power. Moreover, the information contained in lockup-related trading activity about FOMC policy surprises consistently predicts the S&P 500 index reaction to the actual policy announcements over various post-announcement windows. Taken together, this evidence provides strong support to the hypothesis that there is informed trading during FOMC news embargoes.

Our study contributes to the ongoing policy debate about lockup practices by testing whether macro-news lockups are associated with informed trading. While the results are consistent with information leakage during FOMC news embargoes, admittedly we are

unable to identify the exact information channel due to data limitations. The systematic link between the timing of FOMC 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 embargoes. This explanation, however, seems at odds with the lack of informed trading during lockups of other agencies or immediately prior to the start of FOMC embargoes when liquidity is higher and informed traders could gain an early advantage (e.g., Holden and Subrahmanyam (1992), Back, Cao, and Willard (2000)).

Our analysis 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 policy surprises during pre-announcement embargoes. This evidence complements the empirical findings in Cieslak, Morse, and Vissing-Jorgensen (2014), which suggest that information about FOMC policies in fact reach market participants well ahead of when the official decisions are set.

Our study is also related to recent analyses of scheduled macroeconomic announcements (e.g., Savor and Wilson (2013, 2014); Lucca and Moench (2015)). In particular, Lucca and Moench examine the behavior of equity market prices ahead of FOMC 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 announcements and conclude that this pattern *is not* driven by *informed* trading. Different from their study, we examine the pre-release effect of FOMC policy announcements conditional on their information content and focus on a relatively short pre-announcement window – i.e., 30 minutes, when information leakage is most likely. Our evidence indicates that there *is* in fact systematic *informed* trading ahead of FOMC scheduled releases.

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 advantages 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 (2015)), 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 hypotheses. Section 3 describes the data and variable construction. Sections 4 and 5 present the empirical results, and Section 6 concludes.

# 2 Institutional background and testable hypotheses

Among information events, the release of macro-news is one of those with the largest and widest potential impact on capital markets. Attesting to its importance, government agencies manage tightly the 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. Counterbalancing 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 official release time.[8]

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.[9] 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 - see footnote 4. 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.

The recent events suggest that leakages of macro-news ahead of scheduled releases are possible.[10] We aim to assess the implications of this concern by examining whether macro-news embargoes are systematically associated with informed trading activities, as measured by order flows, and how this trading is related to 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 privately informed traders.

We follow a two-pronged approach to test the hypothesis that some traders exploit private information ahead of scheduled macro-news announcements. First, following the literature on 'tipping' (e.g., Irvine, Lipson, and Puckett (2007), Christophe, Ferri, and Hsieh (2010)), we examine whether the information content of macro-news explains the trading

[8] 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."

[9] See DOL website – *http://www.dol.gov/dol/media/lockupnotice.htm*: "CleanSweep Red Team Report" and "CleanSweep Mitigation Measures Acceptance Testing."

[10] Official protocols of the DOL and BEA clearly indicate that the lockup period is thirty-minute, whereas no official protocols describe FOMC news embargoes. 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.

activity observed during news embargoes prior to the public announcements. In these tests, the underlying question is whether there are market participants who systematically react to – i.e., trade on – private information signals about upcoming announcements. Then, we take the perspective of uninformed market participants (and econometricians) and investigate whether lockup-related trading activity may be used to extrapolate valuable information about subsequent macro-news announcements. In particular, we test whether the information contained in pre-announcement market activity systematically predicts the subsequent reaction of market prices to the public release of macro-news.

# 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.[11] 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

[11]Trading on the CME Globex electronic platform for the E-mini contracts halts between 5:15 p.m. and 6:00 p.m. EST every day and between 4:15 p.m. and 4:30 p.m. EST every day except for Sunday.

billion in the second quarter of 2013.[12] 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.[13] Therefore, we expect that informed trading prior to macro-news announcements, if any, would be more predominant in the ES compared to other instruments.[14]

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 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).[15]

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.[16] 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.

[12]See CME Group Leading Products: Q2 2013 publication, available at *http://www.cmegroup.com /education /files/cme-group-leading-products-2013-q2.pdf.*

[13]See CME website at $http://www.cmegroup.com/trading/equity-index/us-index/e-mini-sandp500_performance_bonds.html$.

[14]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, making it harder for econometricians to detect abnormal activities.

[15]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.

[16]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.

## 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 PPI (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.

[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.[17] Then, to estimate the expected Federal funds target rate, we use the average implied 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.[18]

[17]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.

[18]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

In our main analysis we depart from the method developed in Kuttner (2001) because the latter defines FOMC 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 Figures 2 and 3 (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 lockups. Nonetheless, we also examine the robustness of our results to using alternative surprise definitions including Kuttner's (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.[19] 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 policy surprise is as large as 45.5 bp. Panels B, C, and D report similar statistics for nonfarm payroll, PPI, 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

the detailed information about the implied and actual Federal fund rate.

[19]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.

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 identify surprises that would in fact provide a privately informed investor with profitable trading opportunities. In particular, for each announcement type, we construct a categorical variable, *SUR*, that equals one (negative one) when the surprise exceeds certain thresholds and is good (bad) news for the stock market, and zero otherwise.

In our baseline tests for FOMC announcements, we set the thresholds at ±12.5 bp because the minimum adjustment in the Federal funds target rate is 25 bp. Hence, $SUR_{\text{FOMC}}$ is equal to one (negative one) when the announced FOMC target rate is at least 12.5 bp below (above) the futures-implied rate.[20] However, since the inception of the recent financial crisis, the Federal Reserve adopted additional policy measures whose announcements were potentially salient. 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 QE programs. In robustness tests, we control for the information content of QE-related announcements using the daily change in the yields of the ten-year treasury, following Gagnon et al. (2011), Krishnamurthy and Vissing-Jorgensen (2011), and Hamilton and Wu (2012). Specifically, we first calculate the standard deviation of the daily change in the yields during the ten trading days prior and

[20]The FOMC has announced target rate ranges since October 19, 2008. For the corresponding 38 FOMC policy announcements, we use the following method to identify salient surprises: if the future-implied rate is above the upper bound (below the lower bound) of the announced target rate range by at least 12.5 bp, $SUR_{FOMC}$ is equal to one (negative one), and zero otherwise.

the ten trading days following each announcement. Then, if the magnitude of the change on the announcement day exceeds 1.75 times the rolling-window estimate of its standard deviation, we classify it as a surprise.[21]

For the macro-news announcements by DOL and BEA, we rely on economists' forecasts to identify salient surprises. Specifically, in our baseline tests, we first calculate the forecasting error for each announcement as the ratio of the actual value and the median economist forecast minus one:

$$FE_t = \frac{Actual\_announcement\_value_t}{Median\_forecast_t} - 1. \tag{1}$$

Then, we divide the current forecasting error by the rolling window standard deviation of forecasting errors over the previous 24 months to arrive at a standardized forecasting error:

$$SFE_t = \frac{FE_t}{\sigma^{FE}_{t-24,t-1}}. \tag{2}$$

If the absolute standardized forecasting error exceeds 1.65, we classify it as a surprise announcement and the associated $SUR_{DOL/BEA}$ is set to one (negative one) for good (bad) news. We classify nonfarm payroll and GDP (PPI) announcements as good news if the corresponding forecasting error is positive (negative), and bad news otherwise. For robustness, we also experiment with alternative definitions of salient surprises. For instance, we adopt alternative cutoffs for standardized forecasting error (e.g., 1.75 or 2), or compare actual values to the minimum and maximum of economists' forecasts. Our inferences do not vary across the different methods.

[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

[21] 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.

other announcement types, there are no obvious time-series patterns in the distribution of surprises. Overall, surprise announcements account for ten to fifteen percent 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 (2015), there is a clear (unconditional) return run-up before FOMC announcements and this pattern arises long before the start of FOMC 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 each of the four announcement types to assess whether our surprise measures are economically sensible. Each figure shows the cumulative returns starting one hour before non-surprise ($SUR$=0, dashed line) and surprise ($|SUR|$=1, solid line) announcements. To account for the opposite effect of good and bad news, we revert the sign of returns around bad news surprise announcements so that the solid line always corresponds to good news.

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 FOMC news embargoes, there is no difference between price patterns associated with surprise and non-surprise announcements. Then, 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, PPI, 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]

To confirm that the return dynamics in Figure 2 is not confined to the index futures market, we plot the minute-by-minute return in the underlying S&P 500 index during the same event window in Figure 3. Since underlying index returns are only available during the stock market trading hours, we plot the cumulative returns only for FOMC announcements. We obtain high frequency S&P 500 index data between September 9, 1997 and March 1, 2011, which include all 25 surprise but only 82 non-surprise announcements in our full sample. Notwithstanding the smaller number of non-surprise announcements, the return patterns in Figure 3 closely follow those in Panel A of Figure 2.

[Figure 3 about here]

## 3.3 Measurement of informed trading

Informed trading is not directly observable. Following the microstructure literature, we assume that traders require immediacy of execution to exploit an information advantage, which seems sensible in our context where the potential advantage is fairly short lived. Hence, we measure informed trading activity by 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.[22] We use two measures of imbalance, *OIN* and *OID*, where volume is defined as number of trades and dollar trading volume, respectively.

[22]By requiring immediacy, informed traders would tend to use orders that consume liquidity such as market orders, giving rise to imbalances between buyer- and seller-initiated trading volumes. Therefore,

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.[23] Because the data are only stamped to the second and there can be multiple transactions in one second, we calculate the volume-weighted price for each second and then apply the tick rule to the bulk of transactions occurring in the same second.[24] For the two ETF securities, we obtain the quote data in addition to the transaction data from the TAQ database and adopt the Lee and Ready (1991) algorithm to determine 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 thirty-minute window starting one hour before the scheduled announcement, [−60,−30]; the following thirty minutes ending at announcement, [−30,0]; and the one-hour post-announcement period, [0,60]. For each window, we compute the corresponding order imbalance as the difference between the total buyer- and seller-initiated volumes divided by total trading volume. We also calculate the order imbalances in the same trading hour windows of non-announcement days in the 21 trading days prior to the current announcement or since the last announcement, whichever is fewer. Then, we examine the differences in market activity between announcement ($ANN$=1) and non-announcement ($ANN$=0) days, as well as surprise ($SUR$=±1) and non-surprise ($SUR$=0) announcement days. Table A3 of the Internet Appendix reports

researchers typically use "order imbalance" and "trade imbalance" interchangeably (e.g., Blume, Mackinley, and Terker (1989); Chan and Fong (2000); Chordia, Roll, and Subrahmanyam (2002); Barber and Odean (2008); Heston, Korajczyk, and Sadka (2010); and Ben-David et al. (2013)).

[23]These are trades reported late, which account for less than 0.001% in the full sample and in fact zero since 2003. Including them in our tests does not materially affect our analysis.

[24]Our trade signing algorithm follows the bulk volume test suggested by Easley, Lopez de Prado, and O'Hara (2012, 2013) to measure information asymmetry and toxicity in the order flow. Although one could use either volume or time bulk, we choose the latter because Panayides, Shoh, and Smith (2014) and Chakrabarty, Pascual, and Shkilko (2015) show that the time bulk tick test outperforms the bulk volume test and other traditional algorithms such as the tick test, quote test, and Lee and Ready (1991) test in liquid markets.

summary statistics for each variable in our analysis.

# 4 Results

## 4.1 Trading activity around macro-news announcements

In this section we present the evidence pertaining to the hypothesis that trading activity during macro-news embargoes reflects private information about upcoming releases. We begin by examining visually the typical trading activity taking place around macro-news announcements. Similar to Figure 2, in Figures 4 and 5, 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 4 about here]

[Figure 5 about here]

In Figures 4 and 5, 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 4 and 5 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 4 reports the ordinary least squares (OLS) coefficient estimates from these models.

[Table 4 about here]

Panel A of Table 4 reports the results for FOMC announcements. The evidence indicates that there are large differences in market activities during the pre-lockup and lockup windows. In the pre-lockup window, [−60,−30], neither *ANN* nor *SUR* are associated with significant market activity in the ES, as shown in Columns 1 and 2. This is in sharp contrast with the results in Columns 3 and 4 for the lockup window, [−30,0].

While the coefficient estimate on *ANN* is not significant in either column, the *SUR* coefficient estimates in Columns 3 (*OIN* model) and 4 (*OID* model) are positive and statistically significant, with $t$-statistics equal to 3.79 and 3.30, respectively. Hence, there are significantly more market orders executed in the direction of subsequent policy surprises than those in the opposite direction. On average, the number and dollar volume of market orders executed in the direction of subsequent surprises exceed those in the wrong direction by 7.75% and 8.73% of the total volume, respectively. These magnitudes are economically large, given that the typical order imbalance is less than one percent in this highly liquid market.

The large differences in trading activity between the pre-lockup, i.e., [−60,−30], and lockup, i.e., [−30,0], windows are also statistically significant, as shown formally in Table A4 of the Internet Appendix. This evidence suggests that informed traders start trading more aggressively only after the information contained in the FOMC 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, PPI, and GDP data by the DOL and BEA. Consistent with the patterns in Figures 2, 4, and 5, we find no statistically significant evidence of informed trading in the ES market during lockup periods ahead of those announcements.[25]

## 4.2 Subperiod analysis

Between 2006 and 2011, a news agency accused of leaking information, Need to Know News, had access to the lockup rooms. In this subsection, we examine whether our baseline results vary with the news media accreditation of Need to Know News. In particular, we augment our baseline regression models by adding a dummy variable, *NTKN*, which takes a value of one for observations between 2006 and 2011, and zero otherwise. We also interact *NTKN* with *ANN* and *SUR* to gauge the change in the effect of surprise announcements on trading activities during lockups. Table 5 reports the OLS estimation results.

[Table 5 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,

[25] In Table A4 of the Internet Appendix, we stack the three event windows into the same regression model and obtain similar results.

Figure 6 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.[26] In contrast, the typical market liquidity is much higher during FOMC lockups, which would facilitate informed trading activities.

[Figure 6 about here]

Given that our baseline evidence is consistent with informed trading only prior to FOMC announcements, we focus on these events exclusively in remainder of our tests.

## 4.3 Zooming in on FOMC news embargoes

Anecdotal evidence suggests that the embargo practices surrounding FOMC policy releases were less stringent than those of other government agencies. In particular, the FOMC embargoes would typically be shorter than thirty minutes and the actual news reports would often come out minutes ahead of the official release time (e.g., Lucca and Moench (2015), Fleming and Piazzesi (2005)). In this subsection, we examine how these institutional features of the FOMC news embargo practices affect our baseline results.

We begin by investigating the timing of FOMC pre-announcement trading activities. Specifically, we repeat our baseline tests after partitioning the FOMC thirty-minute pre-announcement window into three ten-minute periods (i.e., [−30,−20], [−20,−10], and [−10,0]). Table 6 reports the results of this analysis.

[26]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 foreign exchange (FX) market, the largest round-the-clock financial market in the world.

[Table 6 about here]

The estimates in Columns 1 and 2 of Table 6 indicate that there is no abnormal order imbalance in the first ten minutes of the 30-minute window leading to scheduled FOMC announcements. Although the coefficient estimate of *SUR* is fairly large (greater than 3) 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 7.36 and 9.32 in the *OIN* and *OID* regressions with $t$-statistics of 2.12 and 2.21, respectively. In the last ten minutes leading to the announcement, we continue to find significant abnormal order imbalances in the ES markets, although the economic magnitude is somewhat smaller.[27]

Next, we examine whether the early public dissemination of FOMC policy announcements affects our baseline inferences. While the fact that FOMC releases may in fact become publicly available minutes ahead of the scheduled time seems at odds with the spirit of news embargoes, it does not itself raise concerns about violations that would provide some traders with an unfair (private) advantage.

To conduct this analysis, we collect the earliest release time of media reports and newswires available on Factiva.[28] Then, we repeat our tests using the media reports' (*actual*) time-stamp instead of the official release time. Since the news reports are only stamped to the minute, we assume that the information reaches the market in the first second of the actual release minute, to be conservative.[29] On average, the actual release occurs about two and half minutes earlier than the scheduled time, although the actual time is often few minutes later.

Not having information on the reasons for the release time discrepancy, we use various

[27]In Table A5 of the Internet Appendix, we repeat the analysis for the three ten-minute sub-windows conditional on NTKN's presence and find no evidence that the latter is associated with greater informed trading activity.

[28]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.

[29]Table A1 in the Internet Appendix provides details about official and actual release times for each FOMC scheduled announcement in our sample.

methods to account for this discrepancy in our analysis. To conserve space, however, Table 7 reports only the most conservative of these methods, while Table A6 of the Internet Appendix includes all the others.

[Table 7 about here]

In Table 7, we define the announcement time as the earlier of the scheduled announcement time and the time-stamp of the earliest available news report. Overall, although the point estimates are slightly different compared to our baseline results, the inferences are similar. The order imbalance during the thirty minutes prior to FOMC announcements continues to be abnormally high in the direction of policy surprises and statistically significant. Moreover, the abnormal market activity appears to pick up and be especially high during the second ten minutes of the 30-minute pre-announcement window. The results in Table A6 support similar inferences. Therefore, it does not appear that the abnormal activities documented in our baseline tests are affected by early (public) media reports about FOMC policy announcements.

## 4.4 Additional Robustness Tests

In this subsection, we discuss the results of several tests that we perform to assess the robustness of our baseline evidence. In all cases, these tests focus on the thirty minute window prior to the official or actual release time of FOMC policy announcements. To conserve space, we tabulate the results in the accompanying Internet Appendix.

In Table A7 of the Internet Appendix, we repeat our regression analysis while using alternative definitions of surprises announcements. First, we use more stringent thresholds to identify salient target rate policy surprises: $\pm 17.5$ bp in Panel A and $\pm 20$ bp in Panel B, which reduce the number of surprise announcements to 20 and 17, respectively. In Panel C, we use the actual value of the policy surprise, $DIFF$, instead of the categorical variable, $SUR$. Across all specifications and surprise definitions, we consistently find that lockup-related order imbalances are significantly related to FOMC policy surprises in line with our baseline results.

In Panel D, we measure the expected target 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 upcoming FOMC policy meeting. Using our baseline definition of *SUR*, the number of surprise announcements is reduced to 16, but we continue to find significant lockup-related abnormal order imbalances in the direction of FOMC policy surprises.

In Panel E, we change our strategy to measure FOMC policy surprises and rely on the realized ES' announcement returns to determine the extent to which market participants are surprised by FOMC announcements. Because lockup-related informed trading may contribute to price discovery, we calculate returns over the window $[-30, 1]$, where 0 is the actual announcement time. In line with earlier results, the relation between lockup-related order imbalances – whether measured by number of trades or dollar volumes – and the surprise embedded in realized announcement returns is statistically significant.

In Panel F, we use Kuttner's (2001) method to measure unexpected target 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* variable is positive. Moreover, the evidence in Gurkaynak, Sack, and Swanson (2005b, GSS) suggests that FOMC announcements contain two distinct signals to which market participants react: the current target rate as well as the future direction of FOMC policy. In Panel G, we use their method to identify target and path policy surprises. In these tests, we use the actual surprise measures because it is less obvious how to identify salient events based on GSS. Consistent with the evidence in Panel F, we find that lockup-related order imbalances are not significantly related to the current target policy surprise. In contrasts, it is the target policy path surprise that explains the systematic variation in abnormal trading activity during FOMC news embargoes. The coefficient estimate suggests that increased buying pressure in E-mini futures is associated with unanticipated loosening policy paths. This evidence supports the notion that there are informed traders establishing positions

during FOMC news embargoes to take advantage of complex information 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 lockups. Specifically, we redefine our baseline surprise measure by separating the current and non-current Federal funds rate futures 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.

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 single rate. In Panel A of Table A8, 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 4. 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 the target rate policy, the FOMC announcements contained arguably important information about the Federal Reserve's large-scale asset purchase programs (i.e., $QE_1$, $QE_2$, and $QE_3$). This additional information in FOMC announcements may contaminate our baseline definition of surprise announcements. To address this concern, in Panel B of Table A8, we use the realized changes in the 10-Year treasury yields to define surprises after October 1, 2008, while keeping the same definition based on Federal funds target rates before that date. Using this alternative approach to identify surprise announcements for the QE period does not affect our main inferences.

## 4.5 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* categorical variable with these two separate indicators in our baseline regressions. Table 8 reports the OLS regression results for the E-mini S&P 500 futures.

[Table 8 about here]

The evidence in Table 8 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).

## 4.6 Other testing securities

In this subsection, we turn our attention to trading activities on other asset markets during FOMC news embargoes. 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). Table 9 reports the results of this supplemental analysis.

[Table 9 about here]

Similar to our main testing security (ES), Panels A, B, and C show that there are significant order imbalances in the direction of FOMC policy surprises during news embargoes in other equity index markets (NQ, SPY, and QQQ). In the treasury futures market, the short-term, 2-year, contract experiences significant abnormal order imbalances during the same pre-announcement window, while we find no evidence of informed trading in the long-term, 10-year, contract. Similarly, we find no evidence of informed trading in the gold futures market. 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 is consistent with the premise of our analysis that liquidity is a major concern for traders with a short-term information advantage, even though they may desire spreading their trades across several markets.

Easley, O'Hara, and Srinivas (1998) suggest that informed traders may prefer trading options, if liquidity is high enough. In light of this, we also examine the trading activity in S&P 500 index options (SPX) during FOMC news embargoes. We obtain options transaction data from the CME and again infer the trade direction using the bulk tick test. Then, we estimate the options order flow by aggregating the directional delta exposure in the options contracts following Hu (2014). Although the SPX order imbalance is large and in the direction of policy surprises during the thirty minutes prior to FOMC announcements, it is not statistically significant. According to Easley, O'Hara, and Srinivas (1998), two reasons may explain the lack of directional trading in SPX options. First, the options

market liquidity during the FOMC news embargoes is not high enough to allow informed trading to be profitable. Indeed, during that window, there is virtually no activity in the options market in 33 of the 126 FOMC announcement days. Second, index futures provide high enough leverage to informed traders, which reduces the desirability of option trading. Nonetheless, options markets do in fact provide a unique opportunity for traders who may be aware of the impending arrival of FOMC policy surprises. Specifically, options allow for volatility trading, which can be profitable if post-announcement stock market volatility is expected to increase due to FOMC policy surprises, in line with Brunnermeier (2005). Consistent with this logic, we indeed find that volatility trading is systematically larger during the 30-minute window that precedes the announcement of FOMC policy surprises, as shown in Table A9 of the Internet Appendix.

# 5 Information content of lockup-related trading

Our earlier tests presume some traders have private information about upcoming FOMC announcements. Therefore, their information set would contain the policy surprise prior to trading, i.e., the surprise is exogenous to privately informed traders. To outside observers (including econometricians), however, the policy surprise measure is an *ex post* realization vis-à-vis the market activity that occurs during the news embargoes ahead of FOMC public announcements.

In our last set of tests, we take the perspective of uninformed market participants (and econometricians) and investigate whether lockup-related trading activity contains value-relevant information about upcoming announcements. In particular, first, we test whether the observed pre-announcement trading activity predicts FOMC policy surprises. Then, we examine whether the information contained in pre-announcement market activity about FOMC policy statements systematically predicts market prices' reaction to the public release of those statements. Lastly, we conclude our analysis of the information content of market activity during FOMC news embargoes by gauging the hypothetical profitability of the corresponding trades.

## 5.1 Does pre-announcement trading predict policy surprises and subsequent market reaction?

Heston, Korajczyk, and Sadka (2010) show that order flows and returns in the same trading hour across days are autocorrelated due to institutional trading. Therefore, to conduct our tests, we first calculate the abnormal order imbalance (return) in each announcement day's event-window by subtracting the average order imbalance (return) during the same trading window of the previous five non-announcement days. Then, we estimate the following model:

$$\begin{aligned} SUR =& \beta_0 + \beta_1 OI_{t-1,t-x} + \beta_2 OI_{t-x-1,t-y} + \beta_3 Ret_{t-1,t-x} + \beta_4 Ret_{t-x-1,t-y} \\ &+ \beta_5 Ret^2_{t-1,t-x} + \beta_6 Ret^2_{t-x-1,t-y} + \epsilon, \end{aligned} \tag{3}$$

where $OI_{t-1,t-x}$ is the order imbalance based on either number of trades or dollar volume during the pre-announcement window of length $x$ minutes, $OI_{t-x-1,t-y}$ is the order imbalance during the window of length $y-x$ minutes ending $x$ minutes prior to FOMC announcements, and $Ret$ and $Ret^2$ are the corresponding windows' S&P 500 abnormal returns and squared abnormal returns, respectively.[30] Panel A of Table 10 reports the OLS estimates of model (1), with the coefficients $\beta_1$–$\beta_6$ multiplied by 100.

[Table 10 about here]

The evidence in Table 10 is consistent with our earlier results. Regardless of the trading volume measure, the coefficient estimate on the imbalance during the window immediately preceding the FOMC scheduled announcements is positive and statistically significant at least at the 5% tolerance level. In contrast, the coefficient estimates on the imbalance in the earlier half-hour window and the other control variables are not significantly different from zero. Therefore, the lockup-related trading activity alone appears to contain information

[30] Since we only have ES' transaction prices, we use the underlying cash index returns to avoid autocorrelation induced by the bid-ask bounce, which may result in severely spurious returns using high frequency data. For completeness, we repeat our tests using ES transaction price-based returns and obtain similar results.

about impending FOMC policy surprises, whereas earlier trading or pre-announcement market movements displays no predictive power.

The results are robust when we lengthen the pre-lockup window to 60 minutes, in Columns 3 and 4, and progressively shorten the news embargo window to 20, 15, and 10 minutes, in Columns 5–10. Nonetheless, in line with our earlier inferences, the evidence indicates that a large portion of the informed trading activity prior to scheduled FOMC announcements is concentrated in the subwindow $[-20,-10]$.

Next, we turn to the question of whether the information contained in lockup-related order imbalances about FOMC policy surprises is in fact value-relevant. If the pre-announcement trading contains valuable private information, then the fitted policy surprises should predict the market reaction to the public release of FOMC statements.

In Panel B of Table 10, we examine the relation between the fitted surprise from the models in Panel A, $FSUR$, and the S&P 500's abnormal returns, $Ret_{t,t+z}$, over various post-announcement windows, with $z$ ranging from one to sixty minutes. The evidence shows that the fitted policy surprise is a strong predictor of the market index returns immediately following the corresponding announcements, i.e., when $z$ equals one. This relation weakens as we extend the return calculation window, consistent with the greater post-announcement volatility shown in Figures 2 and 3. Nonetheless, $FSUR$ retains its predictive ability in most specifications, suggesting that informed traders would have enough time to lock in profits from positions established prior to announcement – especially those established in the pre-announcement window $[-20,-10]$.

In Tables A10 and A11 of the Internet Appendix, we assess the robustness of the evidence in Table 10 when we change the definition of the release time or partition the pre-announcement window into shorter subwindows. Those results are in line with the evidence in Table 10. Overall, we find robust evidence that ES order imbalances during FOMC news embargoes contain information about subsequent policy surprises and this information is value-relevant when it becomes public. This combined results support the hypothesis that there is privately informed trading during FOMC news embargoes.

## 5.2 How profitable is pre-announcement informed trading?

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 only and the uninformed market orders are well balanced so that the imbalance 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.

[Table 11 about here]

Panel A of Table 11 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, if 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 11 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. Aggregated across all markets, the estimated informed profits range between 4.5 and 210.5 million dollars

during the sample period. This suggests that the activity in the E-mini S&P 500 futures market dominates that in other markets, consistent with the premise of our analysis.

# 6 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. Consistent with this conclusion, the information contained in the abnormal order imbalances about impending policy surprises predicts the market prices' reaction to the actual FOMC announcements. Our estimates suggest that the aggregate 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 news embargoes 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 window prior to FOMC policy announcements. This evidence suggests the existence of a systematic link between informed trading activities and the FOMC embargo practices.

Recent government investigations and media attention mostly 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, PPI, 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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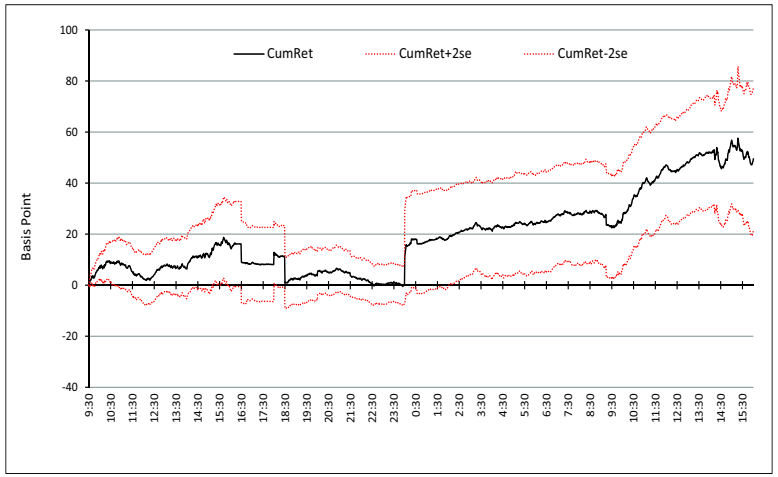
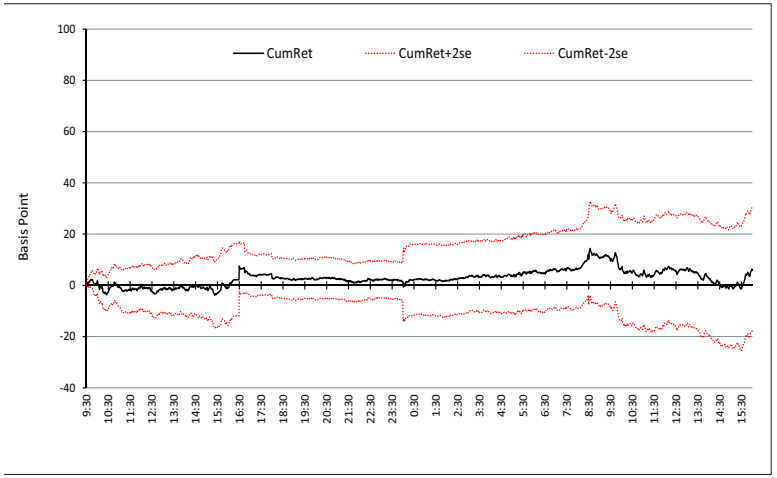
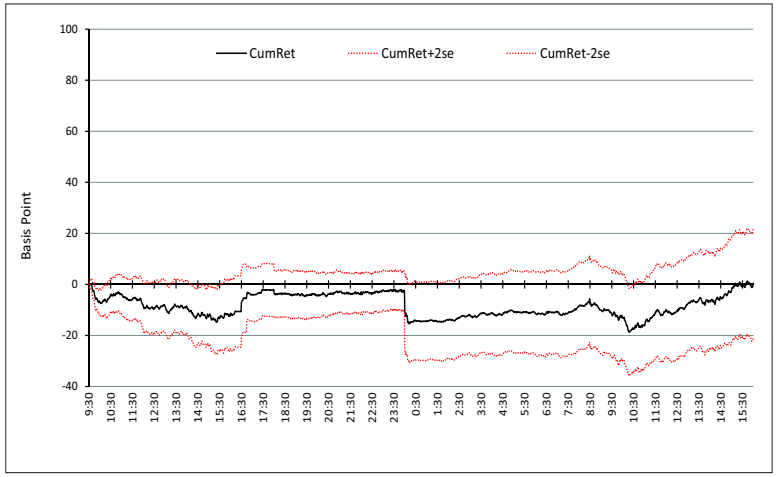


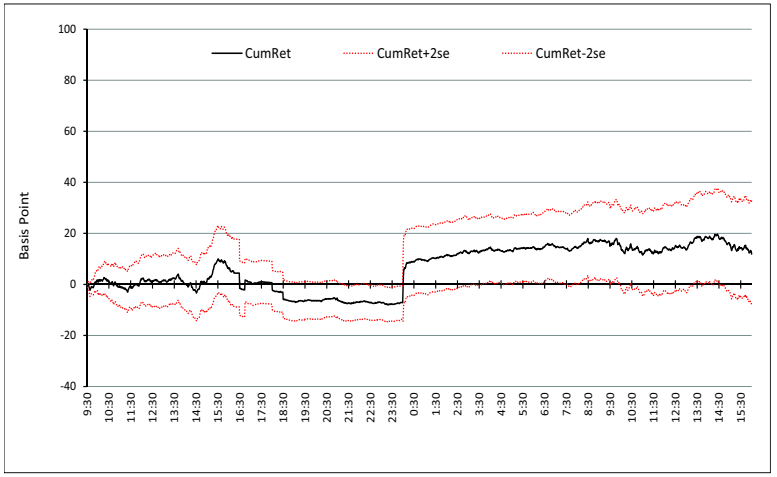

(a) FOMC




(b) Nonfarm payroll



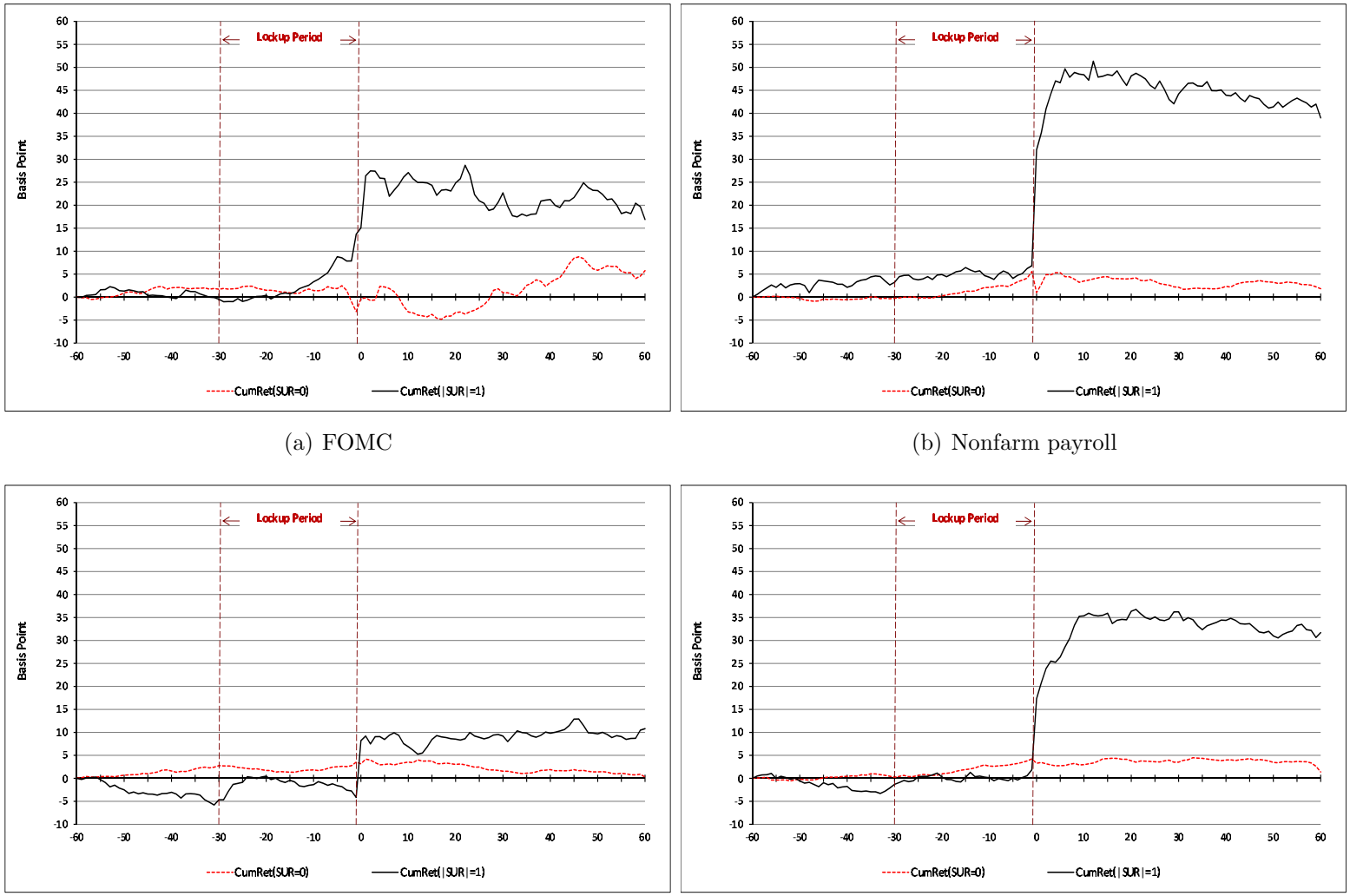

(c) PPI




(d) GDP

Figure 1: Two-day calendar-time unconditional cumulative returns around announcements

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




(a) FOMC

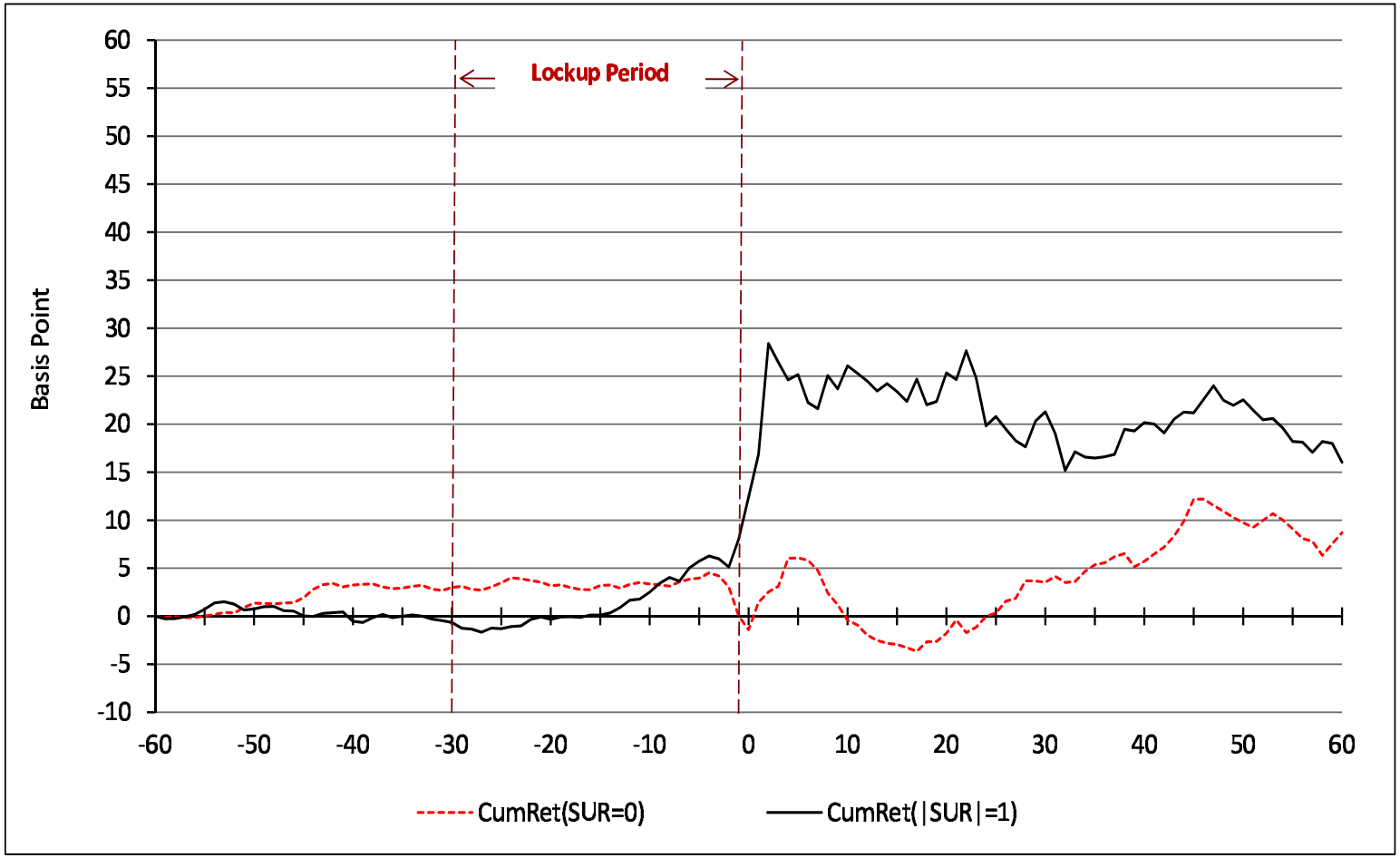
(b) Nonfarm payroll

(c) PPI

(d) GDP

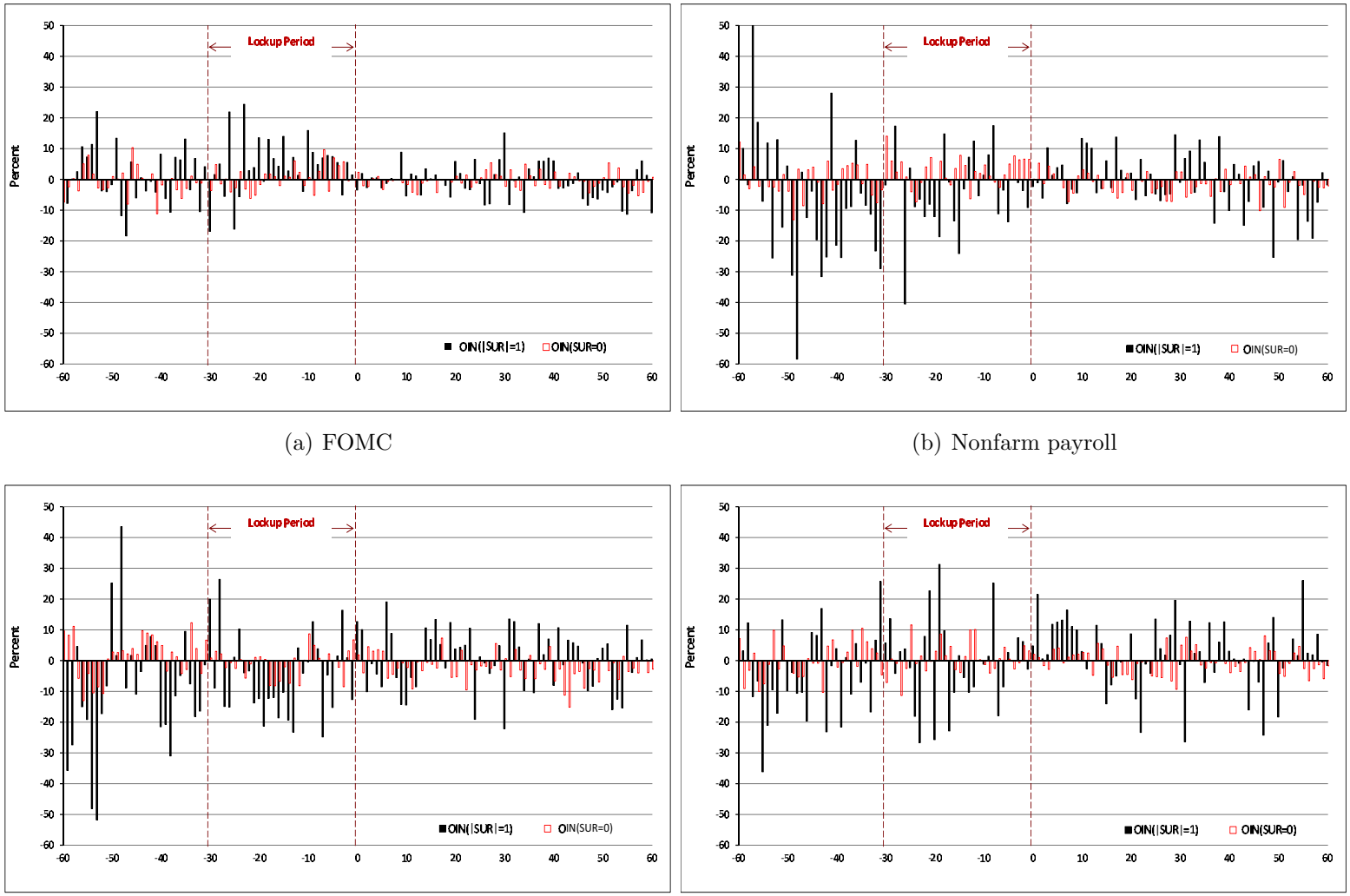
Figure 2: Two-hour event-time conditional cumulative returns around announcements

This figure plots the minute-by-minute cumulative returns of the E-mini S&P 500 futures in the two hours around macroeconomic announcements conditional on their information content. The black solid line represents the average cumulative returns around surprise announcements ($|SUR|$=1) and the red dashed line represents the average cumulative returns around non-surprise announcements ($SUR$=0). "Lockup Period" corresponds to the event window [−30,0], where "0" is the official release time.




(a)

Figure 3: Two-hour event-time S&P 500 conditional cumulative returns around FOMC announcements
This figure plots the minute-by-minute cumulative returns of the S&P 500 index in the two hours around FOMC announcements conditional on their information content. The black solid line represents the average cumulative returns around surprise announcements ($|SUR|$=1) and the red dashed line represents the average cumulative returns around non-surprise announcements ($SUR$=0). "Lockup Period" corresponds to the event window [−30,0], where "0" is the official release time.




(a) FOMC

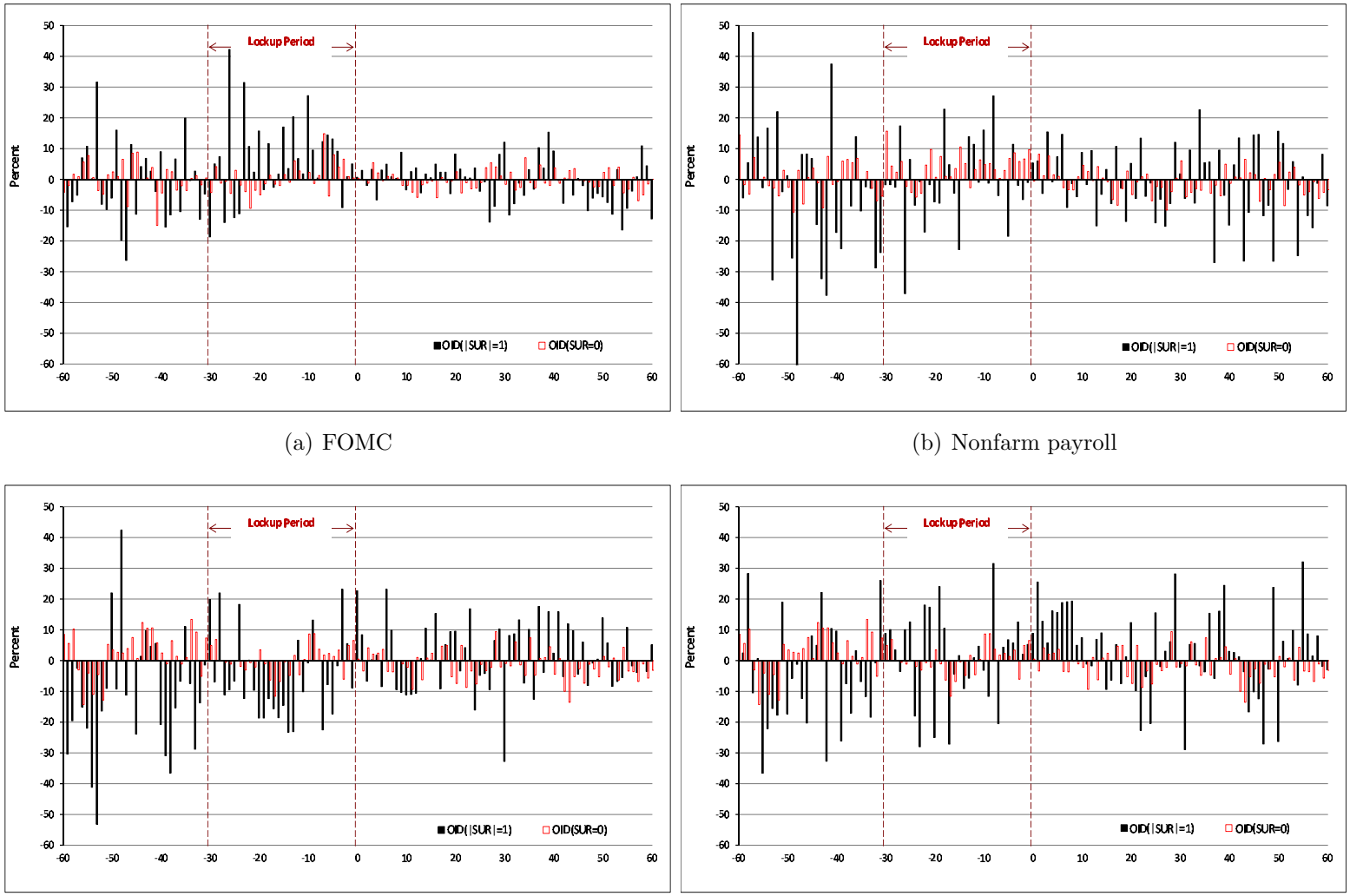
(b) Nonfarm payroll

(c) PPI

(d) GDP

Figure 4: Two-hour event-time order imbalance based on number of trades around announcements

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 macroeconomic announcements conditional on their information content. Black bars represent the average $OIN$ around surprise announcements ($|SUR|$=1) and red bars represent the average $OIN$ around non-surprise announcements ($SUR$=0). "Lockup Period" corresponds to the event window [−30,0], where "0" is the official release time.

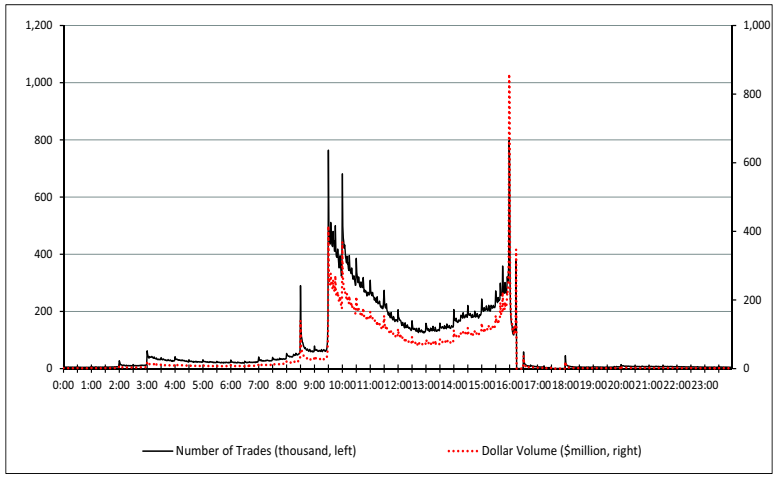



(a) FOMC (b) Nonfarm payroll

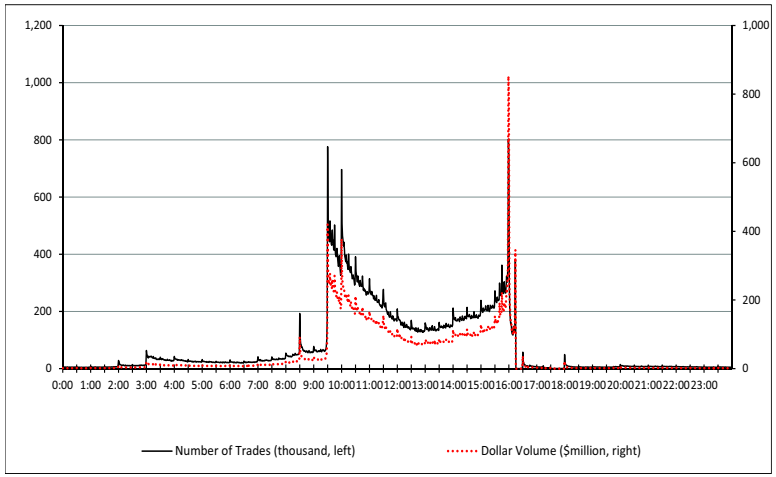
(c) PPI (d) GDP

Figure 5: Two-hour event-time order imbalance based on dollar volume around announcements

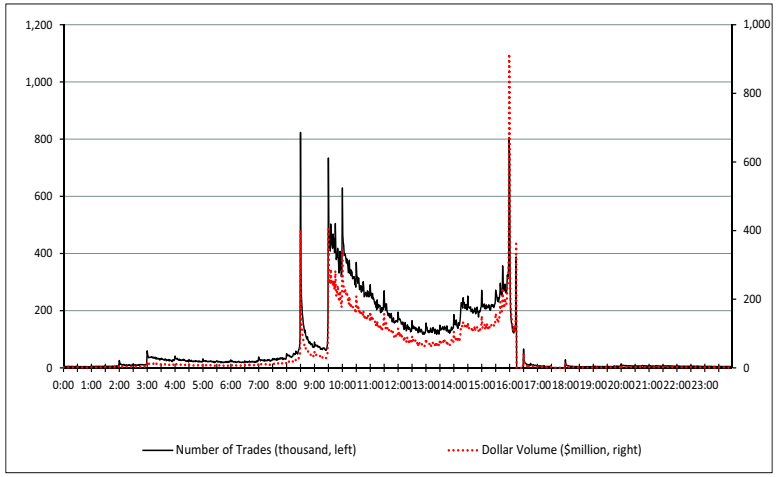
This figure plots the minute-by-minute order imbalance based on dollar volume ($OID$) in the E-mini S&P 500 futures in the two hours around macroeconomic announcements conditional on their information content. Black bars represent the average $OID$ around surprise announcements ($|SUR|$=1) and red bars represent the average $OID$ around non-surprise announcements ($SUR$=0). "Lockup Period" corresponds to the event window [−30,0], where "0" is the official release time.



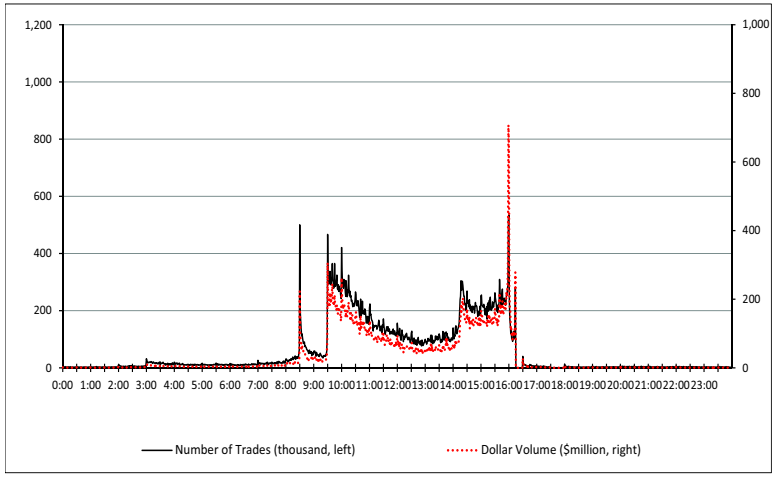

(a) Full sample




(b) ANN=0




(c) SUR=0




(d) $|SUR|$=1

Figure 6: Intraday liquidity in the E-mini S&P 500 futures

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

Table 1: Information about macroeconomic announcements

The table reports institutional details about four types of macroeconomic announcements. $FOMC$, $DOL$, and $BEA$ stand for the Federal Open Market Committee, the Department of Labor, and the Bureau of Economic Analysis, respectively. All times are U.S. 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. |
| PPI | $DOL$ | Monthly | Change | Percent (%) | 8:30 a.m. |
| GDP | $BEA$ | Monthly | Change | Percent (%) | 8:30 a.m. |

Table 2: Summary statistics of macroeconomic expectations and surprises
The table reports sample statistics of the expected ($EXP$) and actual ($ACT$) macroeconomic indicators as well as their differences ($DIFF$) for the period 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 on the day before the policy announcement. The expected values of nonfarm payroll, PPI, and GDP correspond to the medians of the economists' 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 $EXP$ and $ADIFF$ is the absolute value of $DIFF$.

| Statistics | N | Mean | St. dev. | Median | Minimum | Maximum |
|---|---|---|---|---|---|---|
| *Panel A: FOMC* | | | | | | |
| $EXP$ | 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 |
| $ADIFF$ | 126 | 0.083 | 0.099 | 0.059 | 0.000 | 0.455 |
| *Panel B: Nonfarm payroll* | | | | | | |
| $EXP$ | 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 |
| $ADIFF$ | 189 | 70.841 | 67.029 | 59 | 0.000 | 459 |
| *Panel C: PPI* | | | | | | |
| $EXP$ | 189 | 0.189 | 0.458 | 0.200 | −2.000 | 1.600 |
| $ACT$ | 189 | 0.211 | 0.791 | 0.200 | −2.800 | 3.200 |
| $DIFF$ | 189 | 0.022 | 0.463 | 0.000 | −1.300 | 1.600 |
| $ADIFF$ | 189 | 0.343 | 0.312 | 0.300 | 0.000 | 1.600 |
| *Panel D: GDP* | | | | | | |
| $EXP$ | 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 |
| $ADIFF$ | 189 | 0.369 | 0.420 | 0.200 | 0.000 | 3.400 |

Table 3: Annual breakdown of macroeconomic announcements

The table reports the annual number of macroeconomic announcements classified as surprises ($|SUR|$=1) or non-surprises ($SUR$=0) for the period between September 9, 1997 and June 30, 2013. An FOMC announcement is classified as a surprise, if the announced target policy rate deviates from the futures-implied rate by at least 12.5 basis points. For the other macroeconomic indicators, an announcement is classified as a surprise, if the median forecasting error of the Blue Chip Economic Indicators Survey exceeds 1.65 times its two-year rolling window standard deviation.

| | *FOMC* | | *Nonfarm payroll* | | *PPI* | | *GDP* | |
|---|---|---|---|---|---|---|---|---|
| Year | $SUR$=0 | $\|SUR\|$=1 | $SUR$=0 | $\|SUR\|$=1 | $SUR$=0 | $\|SUR\|$=1 | $SUR$=0 | $\|SUR\|$=1 |
| 1997 | 2 | 1 | 3 | 0 | 3 | 1 | 4 | 0 |
| 1998 | 8 | 0 | 11 | 1 | 10 | 1 | 11 | 1 |
| 1999 | 6 | 2 | 10 | 2 | 11 | 1 | 9 | 2 |
| 2000 | 6 | 2 | 11 | 1 | 9 | 3 | 10 | 2 |
| 2001 | 6 | 2 | 10 | 2 | 9 | 3 | 11 | 1 |
| 2002 | 6 | 2 | 12 | 0 | 11 | 1 | 10 | 2 |
| 2003 | 8 | 0 | 11 | 1 | 9 | 3 | 10 | 2 |
| 2004 | 4 | 4 | 10 | 2 | 11 | 1 | 10 | 2 |
| 2005 | 1 | 7 | 12 | 0 | 11 | 1 | 12 | 0 |
| 2006 | 7 | 1 | 12 | 0 | 9 | 3 | 11 | 1 |
| 2007 | 7 | 1 | 10 | 2 | 10 | 2 | 11 | 1 |
| 2008 | 5 | 3 | 10 | 2 | 11 | 1 | 11 | 1 |
| 2009 | 7 | 0 | 9 | 3 | 11 | 1 | 8 | 4 |
| 2010 | 8 | 0 | 12 | 0 | 12 | 0 | 12 | 0 |
| 2011 | 8 | 0 | 11 | 1 | 10 | 2 | 12 | 0 |
| 2012 | 8 | 0 | 12 | 0 | 10 | 2 | 11 | 1 |
| 2013 | 4 | 0 | 6 | 0 | 6 | 0 | 5 | 1 |
| SUM | 101 | 25 | 172 | 17 | 163 | 26 | 168 | 21 |
| Total | 126 | | 189 | | 189 | | 189 | |

Table 4: Futures market imbalances conditional on announcement indicators

This table reports OLS estimates of the relation between event-time order imbalances in the E-mini S&P 500 futures market and announcement day indicators. For each macroeconomic announcement, the sample includes the announcement day ($ANN$=1) and the previous 21 trading days without announcements ($ANN$=0). $OIN$ is 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 using dollar trading volume. Both dependent variables are calculated in three event windows: [−60,-30], [-30,0], and [0,60], where 0 is the official release time of the macroeconomic announcement and the time unit is a minute. The surprise indicator, $SUR$, is equal to 1 (-1) for announcements that convey good (bad) news and 0 otherwise: for FOMC announcements, when the target policy rate is below (above) the futures-implied rate by at least 12.5 basis points; for nonfarm payroll and GDP announcements, when the standardized median forecasting error is above 1.65 (below -1.65); for PPI announcements, when the standardized median forecasting error is below -1.65 (above 1.65). Panels A through D report separate results for announcements on the Federal funds target rate (FOMC), nonfarm payroll, PPI, and GDP, respectively. Robust $t$-statistics are reported in parentheses.

| Period | [−60,−30] | | [−30,0] | | [0,60] | |
|---|---|---|---|---|---|---|
| Model | 1 | 2 | 3 | 4 | 5 | 6 |
| Dependent | *OIN* | *OID* | *OIN* | *OID* | *OIN* | *OID* |
| *Panel A: FOMC* | | | | | | |
| Intercept | 0.113 | −0.336 | −0.492 | −0.590 | −0.154 | −0.154 |
| | (0.47) | (−1.15) | (−2.46) | (−2.28) | (−1.21) | (−0.86) |
| *ANN* | −0.505 | 1.046 | 0.803 | 1.629 | −0.460 | −0.058 |
| | (−0.45) | (0.76) | (0.86) | (1.35) | (−0.77) | (−0.07) |
| *SUR* | −0.586 | −4.863 | 7.751 | 8.728 | 0.007 | 0.176 |
| | (−0.24) | (−1.62) | (3.79) | (3.30) | (0.01) | (0.10) |
| *Panel B: Nonfarm payroll* | | | | | | |
| Intercept | 0.306 | 0.340 | 0.108 | 0.471 | −1.214 | −1.349 |
| | (0.82) | (0.74) | (0.39) | (1.31) | (−6.67) | (−5.50) |
| *ANN* | 0.812 | 1.249 | 2.919 | 4.416 | 1.252 | 1.518 |
| | (0.51) | (0.64) | (2.44) | (2.87) | (1.61) | (1.45) |
| *SUR* | −0.129 | 2.361 | −2.328 | 1.759 | 0.119 | 1.987 |
| | (−0.02) | (0.37) | (−0.60) | (0.35) | (0.05) | (0.59) |

Table 4 (continued):

| Period | [−60,−30] | | [−30,0] | | [0,60] | |
|---|---|---|---|---|---|---|
| Model | 1 | 2 | 3 | 4 | 5 | 6 |
| Dependent | *OIN* | *OID* | *OIN* | *OID* | *OIN* | *OID* |
| *Panel C: PPI* | | | | | | |
| Intercept | 0.352 | 0.413 | 0.062 | 0.387 | −1.227 | −1.337 |
| | (0.94) | (0.90) | (0.22) | (1.06) | (−6.62) | (−5.41) |
| *ANN* | 2.161 | 4.648 | 0.217 | 1.060 | −0.912 | −0.700 |
| | (1.26) | (2.21) | (0.18) | (0.68) | (−1.15) | (−0.66) |
| *SUR* | 1.933 | 1.210 | −0.806 | 0.267 | −0.342 | 1.947 |
| | (0.43) | (0.22) | (−0.25) | (0.07) | (−0.17) | (0.70) |
| *Panel D: GDP* | | | | | | |
| Intercept | 0.344 | 0.393 | 0.050 | 0.383 | −1.258 | −1.374 |
| | (0.93) | (0.86) | (0.18) | (1.05) | (−6.86) | (−5.59) |
| *ANN* | 0.125 | 2.756 | 1.699 | 3.577 | 1.917 | 1.781 |
| | (0.08) | (1.42) | (1.40) | (2.30) | (2.45) | (1.70) |
| *SUR* | 1.403 | −0.464 | 1.510 | 5.617 | 4.358 | 5.988 |
| | (0.30) | (−0.08) | (0.43) | (1.24) | (1.91) | (1.96) |

Table 5: Futures market imbalances with and without Need to Know News

This table reports OLS estimates of the relation between event-time order imbalances in the E-mini S&P 500 futures market and announcement day indicators conditional on the news media accreditation of Need to Know News. For each macroeconomic announcement, the sample includes the announcement day ($ANN$=1) and the previous 21 trading days without announcements ($ANN$=0). The variables *OIN*, *OID*, and *SUR* are as defined in Table 4. *NTKN* is equal to 1 for observations between January 1, 2006 and December 31, 2011, when Need to Know News had news media accreditation, and 0 otherwise. Panels A through D report separate results for announcements on the Federal funds target rate (FOMC), nonfarm payroll, PPI, and GDP, respectively. Robust $t$-statistics are reported in parentheses.

| Period | [−60,−30] | | [−30,0] | | [0,60] | |
|---|---|---|---|---|---|---|
| Model | 1 | 2 | 3 | 4 | 5 | 6 |
| Dependent | *OIN* | *OID* | *OIN* | *OID* | *OIN* | *OID* |
| *Panel A: FOMC* | | | | | | |
| Intercept | −0.342 | −0.847 | −0.656 | −0.942 | −0.402 | −0.811 |
| | (−1.12) | (−2.28) | (−2.59) | (−2.87) | (−2.48) | (−3.56) |
| *ANN* | −0.607 | 1.420 | −0.161 | 0.776 | −0.685 | −0.725 |
| | (−0.41) | (0.79) | (−0.13) | (0.49) | (−0.88) | (−0.66) |
| *SUR* | 1.907 | −3.382 | 9.709 | 9.643 | 0.582 | 1.598 |
| | (0.66) | (−0.97) | (4.08) | (3.13) | (0.38) | (0.75) |
| *NTKN* | 1.208 | 1.356 | 0.436 | 0.933 | 0.658 | 1.743 |
| | (2.43) | (2.24) | (1.06) | (1.75) | (2.49) | (4.70) |
| *ANN*NTKN* | −0.637 | −1.550 | 1.912 | 2.026 | 0.419 | 1.348 |
| | (−0.27) | (−0.55) | (0.99) | (0.81) | (0.34) | (0.78) |
| *SUR*NTKN* | −10.904 | −7.087 | −6.388 | −0.853 | −1.433 | −3.049 |
| | (−1.79) | (−0.95) | (−1.26) | (−0.13) | (−0.44) | (−0.67) |
| *Panel B: Nonfarm payroll* | | | | | | |
| Intercept | 0.943 | 1.501 | 0.331 | 0.659 | −1.256 | −1.651 |
| | (1.99) | (2.59) | (0.93) | (1.44) | (−5.42) | (−5.29) |
| *ANN* | 0.069 | −0.896 | 3.944 | 5.021 | 1.819 | 1.936 |
| | (0.03) | (−0.36) | (2.58) | (2.56) | (1.83) | (1.45) |
| *SUR* | −2.910 | −0.259 | 0.859 | 1.540 | 2.242 | 1.935 |
| | (−0.41) | (−0.03) | (0.16) | (0.22) | (0.64) | (0.41) |
| *NTKN* | −1.665 | −3.038 | −0.583 | −0.492 | 0.108 | 0.791 |
| | (−2.17) | (−3.24) | (−1.01) | (−0.66) | (0.29) | (1.57) |
| *ANN*NTKN* | 1.654 | 5.403 | −2.435 | −1.667 | −1.295 | −1.110 |
| | (0.50) | (1.33) | (−0.98) | (−0.52) | (−0.80) | (−0.51) |
| *SUR*NTKN* | 5.929 | 4.508 | −5.418 | 1.446 | −3.984 | 0.256 |
| | (0.57) | (0.35) | (−0.69) | (0.14) | (−0.78) | (0.04) |

Table 5 (continued):

| Period | [−60,−30] | | [−30,0] | | [0,60] | |
|---|---|---|---|---|---|---|
| Model | 1 | 2 | 3 | 4 | 5 | 6 |
| Dependent | *OIN* | *OID* | *OIN* | *OID* | *OIN* | *OID* |
| *Panel C: PPI* | | | | | | |
| Intercept | 1.028 | 1.624 | 0.287 | 0.573 | −1.219 | −1.617 |
| | (2.15) | (2.78) | (0.79) | (1.22) | (−5.16) | (−5.13) |
| *ANN* | 1.706 | 1.545 | 0.543 | 0.855 | −2.008 | −1.846 |
| | (0.78) | (0.58) | (0.35) | (0.42) | (−1.97) | (−1.36) |
| *SUR* | 1.629 | 6.584 | −0.925 | 0.092 | −0.364 | 1.628 |
| | (0.29) | (0.96) | (−0.23) | (0.02) | (−0.14) | (0.47) |
| *NTKN* | −1.752 | −3.140 | −0.581 | −0.482 | −0.020 | 0.727 |
| | (−2.27) | (−3.34) | (−0.99) | (−0.64) | (−0.05) | (1.43) |
| *ANN*NTKN* | 1.185 | 8.004 | −0.878 | 0.511 | 2.871 | 2.976 |
| | (0.34) | (1.86) | (−0.35) | (0.16) | (1.76) | (1.37) |
| *SUR*NTKN* | 0.808 | −14.926 | 0.873 | 0.489 | −0.979 | −0.442 |
| | (0.09) | (−1.30) | (0.13) | (0.06) | (−0.22) | (−0.08) |
| *Panel D: GDP* | | | | | | |
| Intercept | 0.925 | 1.459 | 0.248 | 0.521 | −1.298 | −1.716 |
| | (1.97) | (2.52) | (0.69) | (1.12) | (−5.57) | (−5.49) |
| *ANN* | 0.386 | 3.075 | 3.795 | 5.368 | 2.585 | 2.697 |
| | (0.19) | (1.25) | (2.47) | (2.71) | (2.60) | (2.02) |
| *SUR* | 4.436 | 3.763 | 0.353 | 8.756 | 5.033 | 6.190 |
| | (0.79) | (0.54) | (0.08) | (1.58) | (1.80) | (1.65) |
| *NTKN* | −1.520 | −2.787 | −0.519 | −0.360 | 0.105 | 0.894 |
| | (−2.00) | (−2.98) | (−0.89) | (−0.48) | (0.28) | (1.77) |
| *ANN*NTKN* | −0.866 | −1.094 | −5.457 | −4.891 | −1.794 | −2.417 |
| | (−0.27) | (−0.27) | (−2.19) | (−1.53) | (−1.11) | (−1.12) |
| *SUR*NTKN* | −9.562 | −13.434 | 2.290 | −10.442 | −2.356 | −0.907 |
| | (−0.98) | (−1.12) | (0.31) | (−1.08) | (−0.49) | (−0.14) |

Table 6: Further investigation into the pre-announcement window

This table reports OLS estimates of the relation between event-time order imbalances in the E-mini S&P 500 futures market and FOMC announcement day indicators. *OIN*, *OID*, *ANN*, and *SUR* are as defined in Table 4. The dependent variables, *OIN* and *OID*, are calculated separately in three pre-announcement windows: [−30,−20], [−20,-10], and [-10,0], where 0 is the official release time of FOMC announcements. Robust $t$-statistics are reported in parentheses.

| Period | [−30,−20] | | [−20,−10] | | [−10,0] | |
|---|---|---|---|---|---|---|
| Model | 1 | 2 | 3 | 4 | 5 | 6 |
| Dependent | *OIN* | *OID* | *OIN* | *OID* | *OIN* | *OID* |
| Intercept | −0.630 | −0.914 | −0.513 | −0.578 | −0.582 | −0.749 |
| | (−1.88) | (−2.24) | (−1.52) | (−1.40) | (−1.79) | (−1.94) |
| *ANN* | 0.019 | 0.380 | 2.127 | 2.358 | 0.808 | 2.342 |
| | (0.01) | (0.20) | (1.35) | (1.22) | (0.53) | (1.30) |
| *SUR* | 3.095 | 4.453 | 7.362 | 9.318 | 6.560 | 7.493 |
| | (0.90) | (1.07) | (2.12) | (2.21) | (1.98) | (1.90) |

Table 7: Actual FOMC release time

This table reports OLS estimates of the relation between event-time order imbalances in the E-mini S&P 500 futures market and FOMC announcement day indicators, based on the timing of corresponding news reports. First, we collect time-stamped news reports available on Factiva. Then, we define event time 0 as the earlier of the official release time and the earliest news report's time-stamp. For each FOMC announcement in our sample, Table A1 in the Internet Appendix lists the time of scheduled release and earliest news report. *OIN*, *OID*, *ANN*, and *SUR* are as defined in Table 4. The dependent variables, *OIN* and *OID*, are calculated separately in four pre-announcement windows: [−30,0], [−30,-20], [-20,-10], and [-10,0], where 0 is as defined above. Robust $t$-statistics are reported in parentheses.

| 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* |
| Intercept | −0.695 | −0.979 | −0.532 | −0.596 | −0.621 | −0.751 | −0.547 | −0.645 |
| | (−2.04) | (−2.35) | (−1.57) | (−1.44) | (−1.90) | (−1.92) | (−2.71) | (−2.47) |
| *ANN* | −0.035 | 0.422 | 1.987 | 1.911 | 2.907 | 4.640 | 1.584 | 2.244 |
| | (−0.02) | (0.22) | (1.26) | (0.99) | (1.90) | (2.54) | (1.68) | (1.84) |
| *SUR* | 2.396 | 3.201 | 7.803 | 9.424 | 5.184 | 6.571 | 6.020 | 7.492 |
| | (0.69) | (0.75) | (2.25) | (2.23) | (1.55) | (1.64) | (2.91) | (2.81) |

Table 8: Futures market imbalances before positive and negative surprises

This table reports OLS estimates of the relation between event-time order imbalances in the E-mini S&P 500 futures market and FOMC announcement day indicators conditional on the direction of the FOMC policy surprise. *OIN*, *OID*, and *ANN* are as defined in Table 4. The dependent variables, *OIN* and *OID*, are calculated in the pre-announcement window [−30,0]. The event time 0 is the official release time in Columns 1 and 2, the actual time (i.e., earliest news report time-stamp) in Columns 3 and 4, and the earlier of the two in Columns 5 and 6. The policy surprise indicator, *Bad* (*Good*), equals one when the announced Federal funds target rate is above (below) the futures-implied rate by at least 12.5 bp and zero otherwise. Robust $t$-statistics are reported in parentheses.

| Event time | Scheduled | | Actual | | MIN{Scheduled, Actual} | |
|---|---|---|---|---|---|---|
| Model | 1 | 2 | 3 | 4 | 5 | 6 |
| Dependent | *OIN* | *OID* | *OIN* | *OID* | *OIN* | *OID* |
| Intercept | −0.492 | −0.590 | −0.527 | −0.593 | −0.520 | −0.613 |
| | (−2.46) | (−2.28) | (−2.59) | (−2.25) | (−2.55) | (−2.33) |
| *ANN* | −0.021 | 0.492 | 1.239 | 1.250 | 1.009 | 1.172 |
| | (−0.02) | (0.38) | (1.21) | (0.94) | (0.98) | (0.88) |
| *Bad* | 0.005 | 1.980 | −1.436 | 1.945 | −1.217 | 2.081 |
| | (0.00) | (0.37) | (−0.34) | (0.35) | (−0.29) | (0.38) |
| *Good* | 10.764 | 12.887 | 6.982 | 10.903 | 8.019 | 11.803 |
| | (4.33) | (4.00) | (2.76) | (3.33) | (3.16) | (3.60) |

Table 9: Imbalances in other markets prior to FOMC announcements

This table reports OLS estimates of the relation between event-time order imbalances in other markets and FOMC announcement day indicators. Panels A through F report results for 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. *OIN*, *OID*, *ANN*, and *SUR* are as defined in Table 4. The dependent variables, *OIN* and *OID*, are calculated in the pre-announcement window [−30,0]. The event time 0 is the official release time in Columns 1 and 2, the actual time (i.e., earliest news report time-stamp) in Columns 3 and 4, and the earlier of the two in Columns 5 and 6. Robust $t$-statistics are reported in parentheses.

| Period | Scheduled | | Actual | | MIN{Scheduled, Actual} | |
|---|---|---|---|---|---|---|
| Model | 1 | 2 | 3 | 4 | 5 | 6 |
| Dependent | *OIN* | *OID* | *OIN* | *OID* | *OIN* | *OID* |
| *Panel A: E-mini Nasdaq 100 futures* | | | | | | |
| Intercept | −0.117 | −0.246 | 0.140 | 0.104 | 0.140 | 0.104 |
| | (−0.61) | (−0.94) | (1.48) | (0.72) | (1.47) | (0.72) |
| *ANN* | 0.769 | 0.215 | 1.075 | 0.619 | 1.047 | 0.426 |
| | (0.86) | (0.18) | (2.43) | (0.92) | (2.36) | (0.63) |
| *SUR* | 3.469 | 7.777 | 1.239 | 4.623 | 1.528 | 5.237 |
| | (1.84) | (3.01) | (1.33) | (3.25) | (1.63) | (3.68) |
| *Panel B: SPDR S&P 500 ETF* | | | | | | |
| Intercept | 1.029 | −0.147 | 1.166 | −0.578 | 1.166 | −0.578 |
| | (3.59) | (−0.28) | (6.39) | (−1.71) | (6.37) | (−1.71) |
| *ANN* | 2.355 | 2.734 | 2.565 | 2.864 | 2.572 | 2.942 |
| | (1.75) | (1.09) | (2.99) | (1.80) | (2.99) | (1.85) |
| *SUR* | 9.155 | 2.639 | 6.688 | −0.739 | 6.837 | −0.504 |
| | (3.13) | (0.49) | (3.60) | (−0.21) | (3.67) | (−0.15) |
| *Panel C: PowerShares QQQ ETF (tracking Nasdaq 100)* | | | | | | |
| Intercept | 0.031 | 0.117 | 0.339 | −0.420 | 0.339 | −0.420 |
| | (0.10) | (0.25) | (1.74) | (−1.45) | (1.74) | (−1.45) |
| *ANN* | 0.579 | −2.088 | 2.516 | 0.516 | 2.433 | 0.318 |
| | (0.38) | (−0.96) | (2.75) | (0.38) | (2.66) | (0.23) |
| *SUR* | 7.237 | 7.884 | 3.994 | 4.081 | 4.030 | 3.745 |
| | (2.27) | (1.72) | (2.08) | (1.43) | (2.09) | (1.31) |

Table 9 (continued):

| Period | Scheduled | | Actual | | MIN{Scheduled, Actual} | |
|---|---|---|---|---|---|---|
| Model | 1 | 2 | 3 | 4 | 5 | 6 |
| Dependent | *OIN* | *OID* | *OIN* | *OID* | *OIN* | *OID* |
| *Panel D: 2-Year Treasury futures* | | | | | | |
| Intercept | 1.550 | 1.099 | 0.987 | 1.208 | 0.987 | 1.208 |
| | (1.23) | (0.79) | (1.60) | (1.70) | (1.60) | (1.70) |
| *ANN* | −8.060 | −6.920 | −5.203 | −4.505 | −5.499 | −4.496 |
| | (−1.35) | (−1.05) | (−1.77) | (−1.33) | (−1.87) | (−1.33) |
| *SUR* | 11.924 | 17.462 | 14.153 | 17.611 | 14.183 | 17.667 |
| | (0.94) | (1.25) | (2.28) | (2.47) | (2.28) | (2.47) |
| *Panel E: 10-Year Treasury futures* | | | | | | |
| Intercept | 0.426 | 0.280 | 0.473 | 0.154 | 0.473 | 0.154 |
| | (0.80) | (0.49) | (1.99) | (0.56) | (1.98) | (0.55) |
| *ANN* | −1.294 | −0.581 | −1.067 | −0.032 | −0.885 | 0.324 |
| | (−0.52) | (−0.21) | (−0.94) | (−0.02) | (−0.78) | (0.24) |
| *SUR* | 4.619 | 3.276 | 2.560 | 1.366 | 2.784 | 1.332 |
| | (0.87) | (0.57) | (1.07) | (0.49) | (1.16) | (0.48) |
| *Panel F: Gold futures* | | | | | | |
| Intercept | −0.140 | −0.455 | −0.466 | −0.643 | −0.466 | −0.643 |
| | (−0.31) | (−0.83) | (−0.52) | (−0.62) | (−0.52) | (−0.62) |
| *ANN* | −0.637 | −1.558 | 0.053 | −1.441 | −0.022 | −1.384 |
| | (−0.31) | (−0.62) | (0.01) | (−0.22) | (−0.00) | (−0.21) |
| *SUR* | −9.625 | −14.590 | −6.334 | −14.443 | −6.372 | −14.415 |
| | (−1.33) | (−1.66) | (−0.31) | (−0.62) | (−0.32) | (−0.62) |

Table 10: Predicting FOMC announcement surprises and returns

Panel A reports the OLS estimates of the following model:

$$SUR = \beta_0 + \beta_1 OI_{t-1,t-x} + \beta_2 OI_{t-x-1,t-y} + \beta_3 Ret_{t-1,t-x} + \beta_4 Ret_{t-x-1,t-y} + \beta_5 Ret^2_{t-1,t-x} + \beta_6 Ret^2_{t-x-1,t-y} + \epsilon,$$

where the dependent variable is the FOMC policy surprise as defined in Table 4, and the independent variables include the E-mini S&P 500 futures order imbalances, S&P 500 index return, and the squared index returns measured relative to $t$ (i.e., the official release time). All variables except the surprise indicator are adjusted by subtracting the average value of the corresponding variable during the same time window in the five days prior to the announcement. *OIN* and *OID* are order imbalances calculated using the number of trades and dollar transaction volumes, respectively. Robust $t$-statistics are reported in parentheses. Panel B reports OLS estimates of the relation between the S&P 500's announcement returns, $Ret_{t,t+z}$, and the fitted FOMC policy surprises, $FSUR$, from the corresponding model in Panel A. The $t$-statistics reported in parentheses are calculated using Heckman-correction.

| Period | $x$=30,$y$=60 | | $x$=30,$y$=90 | | $x$=20,$y$=60 | | $x$=15,$y$=60 | | $x$=10,$y$=60 | |
|---|---|---|---|---|---|---|---|---|---|---|
| Model | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Dependent | *OIN* | *OID* | *OIN* | *OID* | *OIN* | *OID* | *OIN* | *OID* | *OIN* | *OID* |
| *Panel A: Predicting announcement surprise* | | | | | | | | | | |
| Intercept | 0.085 | 0.083 | 0.072 | 0.082 | 0.096 | 0.100 | 0.096 | 0.093 | 0.096 | 0.091 |
| | (1.84) | (1.73) | (1.48) | (1.68) | (2.05) | (2.08) | (2.05) | (1.93) | (2.08) | (1.91) |
| $OI_{t-1,t-x}$ | 1.642 | 1.225 | 1.725 | 1.255 | 1.585 | 1.244 | 1.091 | 0.788 | 0.805 | 0.647 |
| | (3.81) | (3.02) | (3.89) | (3.13) | (3.47) | (3.07) | (3.02) | (2.42) | (2.10) | (2.02) |
| $OI_{t-x-1,t-y}$ | 0.336 | −0.098 | −0.390 | −0.660 | −0.140 | −0.413 | 0.645 | 0.212 | 0.744 | 0.235 |
| | (0.96) | (−0.36) | (−0.79) | (−1.64) | (−0.22) | (−0.87) | (1.58) | (0.66) | (1.61) | (0.66) |
| $Ret_{t-1,t-x}$ | 0.036 | 0.068 | −0.034 | −0.007 | 0.034 | 0.056 | 0.430 | 0.494 | 0.548 | 0.536 |
| | (0.14) | (0.26) | (−0.13) | (−0.03) | (0.13) | (0.21) | (1.48) | (1.65) | (1.77) | (1.66) |
| $Ret_{t-x-1,t-y}$ | 0.286 | 0.289 | 0.304 | 0.297 | −0.024 | −0.067 | 0.106 | 0.108 | 0.079 | 0.100 |
| | (1.02) | (0.98) | (1.32) | (1.22) | (−0.14) | (−0.38) | (0.53) | (0.51) | (0.39) | (0.47) |
| $Ret^2_{t-1,t-x}$ | 0.345 | 0.332 | 0.325 | 0.328 | 0.239 | 0.240 | 0.913 | 0.938 | 0.810 | 0.739 |
| | (1.37) | (1.30) | (1.26) | (1.08) | (0.85) | (0.64) | (1.68) | (1.74) | (1.55) | (1.36) |
| $Ret^2_{t-x-1,t-y}$ | −0.372 | −0.184 | −0.363 | −0.190 | −0.061 | 0.025 | −0.080 | 0.033 | −0.177 | 0.038 |
| | (−0.65) | (−0.33) | (−0.91) | (−0.62) | (−0.38) | (0.07) | (−0.30) | (0.05) | (−0.52) | (0.14) |

Table 10 (continued):

| Period | $x$=30,$y$=60 | | $x$=30,$y$=90 | | $x$=20,$y$=60 | | $x$=15,$y$=60 | | $x$=10,$y$=60 | |
|---|---|---|---|---|---|---|---|---|---|---|
| Model | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Dependent | *OIN* | *OID* | *OIN* | *OID* | *OIN* | *OID* | *OIN* | *OID* | *OIN* | *OID* |
| *Panel B: Predicting announcement returns* $Ret_{t,t+z}$ | | | | | | | | | | |
| *z=1* | | | | | | | | | | |
| Intercept | −4.601 | −5.463 | −4.469 | −4.969 | −4.735 | −5.201 | −4.374 | −5.283 | −3.837 | −4.680 |
| | (−1.75) | (−1.94) | (−2.02) | (−2.15) | (−2.01) | (−2.09) | (−1.85) | (−2.05) | (−1.67) | (−1.88) |
| $FSUR$ | 21.682 | 28.780 | 20.600 | 24.713 | 22.788 | 26.626 | 19.403 | 26.881 | 14.983 | 21.922 |
| | (2.56) | (2.95) | (2.63) | (2.99) | (2.89) | (3.01) | (2.52) | (2.89) | (2.06) | (2.41) |
| *z=15* | | | | | | | | | | |
| Intercept | −6.962 | −5.921 | −7.098 | −6.803 | −7.917 | −7.503 | −5.837 | −4.436 | −5.763 | −5.270 |
| | (−1.17) | (−0.92) | (−1.17) | (−1.09) | (−1.33) | (−1.21) | (−0.94) | (−0.65) | (−0.85) | (−0.72) |
| $FSUR$ | 17.759 | 19.185 | 18.877 | 16.444 | 25.617 | 22.213 | 8.975 | 2.558 | 8.367 | 4.305 |
| | (1.99) | (2.02) | (2.01) | (1.78) | (2.36) | (2.07) | (1.05) | (0.10) | (1.16) | (0.96) |
| *z=30* | | | | | | | | | | |
| Intercept | −4.274 | −3.069 | −5.290 | −4.634 | −7.244 | −6.146 | −4.283 | −2.043 | −4.577 | −3.647 |
| | (−0.60) | (−0.42) | (−0.71) | (−0.62) | (−0.98) | (−0.82) | (−0.58) | (−0.26) | (−0.57) | (−0.43) |
| $FSUR$ | 17.131 | 17.211 | 25.494 | 20.093 | 41.577 | 32.542 | 17.809 | 0.624 | 20.228 | 12.576 |
| | (1.90) | (1.88) | (2.18) | (1.97) | (2.01) | (2.19) | (1.66) | (0.02) | (1.69) | (1.38) |
| *z=60* | | | | | | | | | | |
| Intercept | −0.876 | 1.394 | −3.139 | −0.981 | −3.466 | −1.009 | −1.460 | 2.184 | −2.421 | −0.191 |
| | (−0.09) | (0.15) | (−0.33) | (−0.10) | (−0.36) | (−0.10) | (−0.15) | (0.22) | (−0.24) | (−0.02) |
| $FSUR$ | 16.070 | 13.386 | 40.695 | 22.940 | 43.391 | 23.166 | 27.545 | 2.448 | 35.454 | 17.104 |
| | (1.70) | (1.48) | (1.98) | (1.57) | (2.07) | (1.86) | (1.79) | (0.06) | (1.92) | (1.35) |

Table 11: Informed traders' profits around FOMC surprises

This table reports summary statistics for the dollar profits of informed trades executed prior to FOMC surprise announcements. We assume informed traders start accumulating positions thirty minutes before the scheduled announcement time, continue until the actual announcement time, and liquidate their position at the end of five, ten, or thirty minutes after the actual announcement - i.e., $Profit5$, $Profit10$, and $Profit30$ respectively. The lower bounds of the profits, $ProfitT_{lower}$, assume that informed traders use only market orders and uninformed traders submit market orders symmetrically so that the order imbalance is completely determined by informed trading. The upper bounds, $ProfitT_{upper}$, assume that informed traders successfully enter the right position of every transaction during the pre-announcement period using market or limit orders. The trading profits are aggregated across all transactions on the same announcement date and summary statistics are computed across the 25 surprise announcement days.

| Statistic | $Profit5_{lower}$ | $Profit5_{upper}$ | $Profit10_{lower}$ | $Profit10_{upper}$ | $Profit30_{lower}$ | $Profit30_{upper}$ |
|---|---|---|---|---|---|---|
| *Panel A: E-mini S&P 500 futures only* | | | | | | |
| 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 |
| *Panel B: All markets* | | | | | | |
| 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

June 2015

Table A1: FOMC announcement observations

The table lists the detailed information of each FOMC scheduled announcement in our sample. The official time is the scheduled news release time according to the FOMC meeting minutes. The actual time is the earliest release time found from reports on Factiva. *Bottom* denotes the lower bound of the Federal funds target rate and *Up* denotes the upper bound. *ExpRate* (*ExpRate*3*month*) is the futures-implied Federal funds rate on the day before the FOMC policy announcement using all futures contracts (only contracts expiring within three months).

| Date | Official time | Actual time | *Bottom* | *Up* | *ExpRate* | *ExpRate*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 | $Bottom$ | $Up$ | $ExpRate$ | $ExpRate3-month$ |
|---|---|---|---|---|---|---|
| 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 | $Bottom$ | $Up$ | $ExpRate$ | $ExpRate3-month$ |
|---|---|---|---|---|---|---|
| 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

This table reports OLS estimates of the relation between event-time cumulative returns on announcement days and the information in FOMC policy releases for 126 scheduled announcements between September 30, 1997 and June 19, 2013. The announcement returns are calculated in three event windows relative to the scheduled announcement time, 0, for E-mini S&P 500 futures in Panel A, E-mini Nasdaq 100 futures in Panel B, SPDR S&P 500 ETF in Panel C, and 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 announced Federal funds target rate minus the expected rate. The calculation method is described in Subsection 3.2. Robust $t$-statistics are reported in parentheses.

| Variable | Ret[−5,5] | Ret[−15,15] | Ret[−30,30] |
|---|---|---|---|
| *Panel A: E-mini S&P 500 futures* | | | |
| Intercept | −7.918 | −13.324 | −11.461 |
| | (−2.11) | (−2.79) | (−1.77) |
| *Expected* | −39.792 | −23.286 | −29.095 |
| | (−3.01) | (−1.38) | (−1.28) |
| *Unexpected* | −147.485 | −158.107 | −160.762 |
| | (−4.30) | (−3.62) | (−2.72) |
| *Panel B: E-mini Nasdaq 100 futures* | | | |
| Intercept | −10.930 | −15.950 | −21.597 |
| | (−2.15) | (−2.50) | (−2.37) |
| *Expected* | −60.058 | −31.206 | −43.38 |
| | (−3.49) | (−1.45) | (−1.41) |
| *Unexpected* | −213.940 | −221.967 | −287.096 |
| | (−4.65) | (−3.85) | (−3.49) |
| *Panel C: SPDR S&P 500 ETF* | | | |
| Intercept | −6.020 | −13.285 | −8.084 |
| | (−1.55) | (−2.79) | (−1.30) |
| *Expected* | −31.469 | −24.799 | −27.155 |
| | (−2.32) | (−1.49) | (−1.25) |
| *Unexpected* | −139.569 | −159.421 | −154.157 |
| | (−3.98) | (−3.70) | (−2.73) |
| *Panel D: PowerShares QQQ ETF (tracking Nasdaq 100 index)* | | | |
| Intercept | −7.445 | −17.425 | −19.569 |
| | (−1.23) | (−2.63) | (−2.24) |
| *Expected* | −60.972 | −37.748 | −39.666 |
| | (−2.99) | (−1.70) | (−1.35) |
| *Unexpected* | −225.638 | −236.882 | −272.729 |
| | (−4.13) | (−3.98) | (−3.46) |

Table A3: Description of the E-mini S&P500 market around the announcement
This table reports summary statistics for the cumulative returns and order imbalances of the E-mini S&P500 futures around macroeconomic announcement. *ANN*, *SUR*, *OIN*, and *OID* are as defined in Table 4. $ANN$=0 identifies non-announcement days; $SUR$=0 identifies days of non-surprise announcements; and $|SUR|$=1 identifies days of surprise announcements. The event windows are: [−60,−30], from one hour before to half an hour before the official release time; [−30,0], from half hour before to the official release time; and [0,60], from the official 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 good news across all surprises.

| | | Mean | | | Standard deviation | | | Median | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Period | *OIN* | *OID* | *Return* | *OIN* | *OID* | *Return* | *OIN* | *OID* | *Return* |
| *Panel A: FOMC* | | | | | | | | | | |
| $ANN$=0 | [−60,−30] | 0.106 | −0.336 | 0.545 | 12.047 | 14.560 | 24.663 | −0.051 | −0.641 | 0.493 |
| | [−30,0] | −0.494 | −0.590 | −1.103 | 9.942 | 12.941 | 24.527 | −0.338 | −0.808 | −0.081 |
| | [0,60] | −0.155 | −0.154 | 1.131 | 6.458 | 9.083 | 43.485 | −0.147 | −0.429 | 0.702 |
| $SUR$=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 |
| *Panel B: Nonfarm Payroll* | | | | | | | | | | |
| $ANN$=0 | [−60,−30] | 0.306 | 0.340 | −0.310 | 21.347 | 26.174 | 14.894 | 0.000 | −0.004 | 0.000 |
| | [−30,0] | 0.108 | 0.471 | 0.167 | 16.211 | 20.847 | 17.247 | 0.000 | 0.051 | 0.000 |
| | [0,60] | −1.214 | −1.349 | −1.384 | 10.551 | 14.175 | 26.703 | −0.876 | −1.186 | −1.622 |
| $SUR$=0 | [−60,−30] | 0.678 | 0.982 | −0.720 | 19.394 | 23.695 | 12.447 | 0.000 | 0.873 | 0.000 |
| | [−30,0] | 3.066 | 5.078 | 5.673 | 11.932 | 14.297 | 18.202 | 2.761 | 3.656 | 4.987 |
| | [0,60] | 0.177 | 0.431 | −2.526 | 7.042 | 10.527 | 61.707 | −0.273 | −0.393 | 4.242 |
| $\|SUR\|$=1 | [−60,−30] | −0.063 | 2.455 | 3.062 | 20.333 | 26.279 | 14.188 | 3.704 | 4.260 | 2.820 |
| | [−30,0] | −2.149 | 2.046 | 5.905 | 10.765 | 16.663 | 20.843 | −1.393 | 5.836 | 0.000 |
| | [0,60] | 0.121 | 1.997 | 31.682 | 5.208 | 7.099 | 53.803 | −1.818 | 2.980 | 30.731 |

Table A3 (continued):

| | | Mean | | | Standard deviation | | | Median | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Period | *OIN* | *OID* | *Return* | *OIN* | *OID* | *Return* | *OIN* | *OID* | *Return* |
| *Panel C: PPI* | | | | | | | | | | |
| $ANN$=0 | [−60,−30] | 0.352 | 0.413 | −0.260 | 21.371 | 26.147 | 14.754 | 0.000 | 0.007 | 0.000 |
| | [−30,0] | 0.062 | 0.387 | 0.036 | 16.332 | 20.916 | 16.940 | 0.000 | 0.004 | 0.000 |
| | [0,60] | −1.227 | −1.337 | −1.335 | 10.531 | 14.097 | 26.535 | −0.876 | −1.219 | −1.622 |
| $SUR$=0 | [−60,−30] | 2.513 | 5.060 | 2.566 | 20.692 | 23.881 | 15.262 | 1.066 | 7.394 | 2.286 |
| | [−30,0] | 0.308 | 1.455 | 0.431 | 14.355 | 17.854 | 13.767 | 0.437 | 1.923 | 0.000 |
| | [0,60] | −1.961 | −1.922 | −2.416 | 10.861 | 13.503 | 33.293 | −1.862 | −1.380 | −1.399 |
| $\|SUR\|$=1 | [−60,−30] | −7.906 | −11.62 | −4.955 | 16.748 | 26.576 | 12.781 | −7.227 | −13.247 | −4.190 |
| | [−30,0] | −0.870 | −0.067 | 3.185 | 14.748 | 24.466 | 28.143 | 2.153 | −2.241 | 1.619 |
| | [0,60] | 0.151 | 2.417 | 14.134 | 7.744 | 11.101 | 53.300 | −0.818 | 1.690 | 4.830 |
| *Panel D: GDP* | | | | | | | | | | |
| $ANN$=0 | [−60,−30] | 0.344 | 0.393 | −0.310 | 21.180 | 26.001 | 14.926 | 0.000 | 0.009 | 0.000 |
| | [−30,0] | 0.050 | 0.383 | 0.084 | 16.296 | 20.866 | 17.313 | 0.000 | 0.016 | 0.000 |
| | [0,60] | −1.258 | −1.374 | −1.397 | 10.546 | 14.116 | 26.657 | −0.893 | −1.211 | −1.622 |
| $SUR$=0 | [−60,−30] | 1.283 | 3.685 | 0.515 | 19.217 | 24.897 | 14.347 | 0.597 | 1.255 | 0.376 |
| | [−30,0] | 1.478 | 3.418 | 4.037 | 14.285 | 19.760 | 17.369 | 0.659 | 3.170 | 2.479 |
| | [0,60] | 0.477 | 0.015 | −2.816 | 8.749 | 12.476 | 37.286 | −0.092 | −1.069 | −3.629 |
| $\|SUR\|$=1 | [−60,−30] | 1.425 | −0.314 | −3.054 | 19.881 | 23.144 | 19.004 | 2.349 | 0.242 | −0.875 |
| | [−30,0] | 1.593 | 5.806 | 5.502 | 10.027 | 15.563 | 16.404 | 2.128 | 5.569 | 5.428 |
| | [0,60] | 4.390 | 6.007 | 29.972 | 6.987 | 8.142 | 38.171 | 4.110 | 7.062 | 19.902 |

Table A4: Market dynamics around macroeconomic announcements

This table reports pooled OLS regression estimates of the relation between E-mini S&P 500 futures market order imbalances and announcement day indicators, conditional on the timing of the order imbalances. The event windows for each announcement are: [−60,−30], [−30,0], and [0,60], where 0 is the official release time. The dependent variables are the order imbalances calculated using number of trades (*OIN*) or dollar volume (*OID*). *ANN* and *SUR* are as defined in Table 4. *Lockup* is a dummy equal to one for observations in the window [−30,0], and zero otherwise. *Post* is a dummy equal to one for observations in the window [0,60], and zero otherwise. Robust *t*-statistics are reported in parentheses.

| | FOMC | | Nonfarm payroll | | PPI | | GDP | |
|---|---|---|---|---|---|---|---|---|
| Variable | *OIN* | *OID* | *OIN* | *OID* | *OIN* | *OID* | *OIN* | *OID* |
| Intercept | 0.113 | −0.336 | 0.306 | 0.340 | 0.352 | 0.413 | 0.344 | 0.393 |
| | (0.58) | (−1.35) | (1.06) | (0.93) | (1.20) | (1.12) | (1.19) | (1.07) |
| *ANN* | −0.505 | 1.046 | 0.812 | 1.249 | 2.161 | 4.648 | 0.125 | 2.756 |
| | (−0.55) | (0.90) | (0.66) | (0.80) | (1.62) | (2.76) | (0.10) | (1.77) |
| *SUR* | −0.586 | −4.863 | −0.129 | 2.361 | 1.933 | 1.210 | 1.403 | −0.464 |
| | (−0.29) | (−1.91) | (−0.03) | (0.47) | (0.55) | (0.27) | (0.39) | (−0.10) |
| *Lockup* | 1.308 | 0.584 | 2.107 | 3.167 | −1.945 | −3.587 | 1.573 | 0.821 |
| | (1.01) | (0.36) | (1.21) | (1.44) | (−1.06) | (−1.56) | (0.90) | (0.37) |
| *ANN*Lockup* | 0.045 | −1.103 | 0.440 | 0.269 | −3.074 | −5.348 | 1.792 | −0.975 |
| | (0.03) | (−0.67) | (0.25) | (0.12) | (−1.68) | (−2.32) | (1.03) | (−0.44) |
| *SUR*Lockup* | 8.337 | 13.590 | −2.199 | −0.603 | −2.739 | −0.943 | 0.108 | 6.081 |
| | (2.94) | (3.77) | (−0.39) | (−0.08) | (−0.57) | (−0.16) | (0.02) | (0.95) |
| *Post* | 0.593 | 5.039 | 0.248 | −0.374 | −2.276 | 0.737 | 2.956 | 6.452 |
| | (0.21) | (1.40) | (0.04) | (−0.05) | (−0.47) | (0.12) | (0.58) | (1.00) |
| *ANN*Post* | −0.605 | −0.254 | −0.198 | 0.132 | −0.290 | −0.026 | −0.294 | −0.009 |
| | (−2.19) | (−0.72) | (−0.48) | (0.26) | (−0.70) | (−0.05) | (−0.72) | (−0.02) |
| *SUR*Post* | −0.268 | 0.182 | −1.521 | −1.688 | −1.579 | −1.750 | −1.602 | −1.766 |
| | (−0.97) | (0.52) | (−3.72) | (−3.28) | (−3.82) | (−3.37) | (−3.92) | (−3.42) |

Table A5: Abnormal market activity in lockup subwindows

This table replicates the analysis in Table 6 for FOMC announcements, conditional on the news media accreditation of Need To Know News. *OIN*, *OID*, *ANN*, and *SUR* are as defined in Table 4, while *NTKN* is as defined in Table 5. The dependent variables, *OIN* and *OID*, are calculated separately in three pre-announcement windows: [−30,−20], [−20,−10], and [−10,0], where 0 is the official release time of FOMC announcements. Robust $t$-statistics are reported in parentheses.

| Period | [−30,−20] | | [−20,−10] | | [−10,0] | |
|---|---|---|---|---|---|---|
| Model | 1 | 2 | 3 | 4 | 5 | 6 |
| Dependent | *OIN* | *OID* | *OIN* | *OID* | *OIN* | *OID* |
| Intercept | −1.183 | −1.834 | −0.070 | −0.258 | −1.026 | −1.197 |
| | (−2.78) | (−3.55) | (−0.16) | (−0.49) | (−2.50) | (−2.45) |
| *ANN* | 0.884 | 0.931 | −0.043 | 1.064 | −0.578 | 0.785 |
| | (0.43) | (0.37) | (−0.02) | (0.42) | (−0.29) | (0.33) |
| *SUR* | 3.884 | 4.711 | 7.980 | 9.257 | 9.539 | 9.449 |
| | (0.97) | (0.97) | (1.98) | (1.88) | (2.48) | (2.06) |
| *NTKN* | 1.466 | 2.440 | −1.175 | −0.848 | 1.178 | 1.188 |
| | (2.12) | (2.90) | (−1.68) | (−0.99) | (1.76) | (1.49) |
| *ANN*NTKN* | −2.626 | −1.527 | 5.682 | 3.548 | 2.706 | 3.569 |
| | (−0.81) | (−0.39) | (1.74) | (0.89) | (0.87) | (0.96) |
| *SUR*NTKN* | −4.988 | −0.147 | 2.302 | 3.377 | −9.358 | −3.614 |
| | (−0.59) | (−0.01) | (0.27) | (0.32) | (−1.14) | (−0.37) |

Table A6: Scheduled and actual release time

This table replicates the analysis in Tables 4 and 6 using alternative definitions of the FOMC policy announcement time. *OIN*, *OID*, *ANN*, and *SUR* are as defined in Table 4. In Panels A and B, the event time is the time-stamp of the earliest news report available on Factiva. In Panel C, the event time is the earlier of the official release time and the earliest news report time-stamp. In Panel A, the start of the pre-announcement windows is set relative to the corresponding event time. In Panels B and C, the start of the pre-announcement windows is set relative to the official release time. Robust $t$-statistics are reported in parentheses.

| 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* |
| *Panel A: Both time 0 and time t are the actual release time* | | | | | | | | |
| Intercept | −0.472 | −0.618 | −0.749 | −0.793 | −0.578 | −0.635 | −0.545 | −0.581 |
| | (−1.38) | (−1.49) | (−2.21) | (−1.93) | (−1.75) | (−1.60) | (−2.68) | (−2.21) |
| *ANN* | 0.394 | 0.690 | 1.811 | 1.810 | 3.108 | 4.679 | 1.800 | 2.331 |
| | (0.25) | (0.36) | (1.15) | (0.94) | (2.01) | (2.52) | (1.90) | (1.90) |
| *SUR* | 5.698 | 8.802 | 6.465 | 6.492 | 3.472 | 4.977 | 5.912 | 7.781 |
| | (1.63) | (2.07) | (1.87) | (1.54) | (1.03) | (1.22) | (2.84) | (2.90) |
| *Panel B: Time 0 is the scheduled time and t is the actual time* | | | | | | | | |
| Intercept | −0.630 | −0.914 | −0.513 | −0.578 | −0.650 | −0.801 | −0.527 | −0.593 |
| | (−1.88) | (−2.24) | (−1.52) | (−1.40) | (−1.93) | (−1.98) | (−2.59) | (−2.25) |
| *ANN* | 0.019 | 0.380 | 2.127 | 2.358 | 2.694 | 4.263 | 1.663 | 2.233 |
| | (0.01) | (0.20) | (1.35) | (1.22) | (1.72) | (2.26) | (1.75) | (1.82) |
| *SUR* | 3.095 | 4.453 | 7.362 | 9.318 | 4.258 | 5.830 | 5.430 | 7.308 |
| | (0.90) | (1.07) | (2.12) | (2.21) | (1.24) | (1.41) | (2.61) | (2.71) |
| *Panel C: Time 0 is the scheduled time and t is MIN{scheduled time, actual time}* | | | | | | | | |
| Intercept | −0.630 | −0.914 | −0.513 | −0.578 | −0.646 | −0.832 | −0.520 | −0.613 |
| | (−1.88) | (−2.24) | (−1.52) | (−1.40) | (−1.89) | (−2.04) | (−2.55) | (−2.33) |
| *ANN* | 0.019 | 0.380 | 2.127 | 2.358 | 2.621 | 4.332 | 1.529 | 2.234 |
| | (0.01) | (0.20) | (1.35) | (1.22) | (1.65) | (2.28) | (1.60) | (1.82) |
| *SUR* | 3.095 | 4.453 | 7.362 | 9.318 | 5.519 | 7.034 | 6.116 | 7.919 |
| | (0.90) | (1.07) | (2.12) | (2.21) | (1.58) | (1.69) | (2.93) | (2.94) |

Table A7: Alternative surprise definitions

This table replicates Table 4 using alternative definitions for FOMC surprise announcements. The pre-announcement window starts thirty minutes before and ends at: the official 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. *OIN*, *OID*, and *ANN* are as defined in Table 4. In Panels A and B, $SUR$=1 (−1) when the target rate is below (above) the futures-implied rate by at least 17.5 and 20 basis points, respectively. In Panel C, $DIFF$ is the announced minus the expected Federal funds rate. In Panel D, we follow the classification scheme in Table 4 while using only Federal funds rate futures expiring within three months to calculate the expected target rate. In Panel E, $ANNRET$ is the cumulative return of the Emini S&P 500 futures 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. Robust $t$-statistics are reported in parentheses.

| Event time | Scheduled | | Actual | | MIN{Scheduled, Actual} | |
|---|---|---|---|---|---|---|
| Model | 1 | 2 | 3 | 4 | 5 | 6 |
| Dependent | *OIN* | *OID* | *OIN* | *OID* | *OIN* | *OID* |
| *Panel A:* SUR=*1 (−1) if DIFF >17.5 (<−17.5) bp, 20 surprises* | | | | | | |
| Intercept | −0.492 | −0.590 | −0.527 | −0.593 | −0.520 | −0.613 |
| | (−2.46) | (−2.28) | (−2.59) | (−2.25) | (−2.55) | (−2.33) |
| *ANN* | 1.147 | 2.019 | 1.891 | 2.539 | 1.789 | 2.578 |
| | (1.25) | (1.69) | (2.02) | (2.10) | (1.90) | (2.13) |
| *SUR* | 7.172 | 8.047 | 5.231 | 7.043 | 5.848 | 7.456 |
| | (3.18) | (2.76) | (2.28) | (2.37) | (2.54) | (2.51) |
| *Panel B:* SUR=*1 (−1) if DIFF >20 (<−20) bp, 17 surprises* | | | | | | |
| Intercept | −0.492 | −0.590 | −0.527 | −0.593 | −0.520 | −0.613 |
| | (−2.46) | (−2.28) | (−2.59) | (−2.25) | (−2.55) | (−2.33) |
| *ANN* | 1.175 | 2.074 | 1.925 | 2.595 | 1.822 | 2.632 |
| | (1.28) | (1.74) | (2.06) | (2.14) | (1.94) | (2.17) |
| *SUR* | 7.699 | 8.200 | 5.380 | 7.052 | 6.101 | 7.541 |
| | (3.15) | (2.59) | (2.17) | (2.19) | (2.45) | (2.34) |

Table A7 (continued):

| Event time | Scheduled | | Actual | | MIN{Scheduled, Actual} | |
|---|---|---|---|---|---|---|
| Model | 1 | 2 | 3 | 4 | 5 | 6 |
| Dependent | *OIN* | *OID* | *OIN* | *OID* | *OIN* | *OID* |
| *Panel C: Actual policy surprise, DIFF, instead of categorical variable,* SUR | | | | | | |
| Intercept | −0.492 | −0.590 | −0.527 | −0.593 | −0.520 | −0.613 |
| | (−2.46) | (−2.28) | (−2.59) | (−2.25) | (−2.55) | (−2.33) |
| *ANN* | 0.581 | 1.372 | 1.498 | 2.045 | 1.354 | 2.034 |
| | (0.61) | (1.12) | (1.56) | (1.64) | (1.40) | (1.63) |
| *DIFF* | −27.955 | −31.693 | −19.856 | −25.756 | −22.075 | −27.819 |
| | (−3.89) | (−3.41) | (−2.72) | (−2.73) | (−3.01) | (−2.94) |
| *Panel D: Expected target rate from contracts expiring within three months, 16 surprises* | | | | | | |
| Intercept | −0.491 | −0.585 | −0.524 | −0.587 | −0.518 | −0.608 |
| | (−2.45) | (−2.26) | (−2.58) | (−2.23) | (−2.54) | (−2.30) |
| *ANN* | 1.195 | 2.095 | 1.856 | 2.553 | 1.771 | 2.614 |
| | (1.30) | (1.76) | (1.99) | (2.11) | (1.88) | (2.15) |
| *SUR* | 8.418 | 7.363 | 7.001 | 7.080 | 7.454 | 7.172 |
| | (3.35) | (2.26) | (2.74) | (2.14) | (2.91) | (2.17) |
| *Panel E: Surprise based on ES announcement returns* | | | | | | |
| Intercept | −0.524 | −0.584 | −0.530 | −0.541 | −0.513 | −0.562 |
| | (−2.61) | (−2.25) | (−2.62) | (−2.08) | (−2.50) | (−2.14) |
| *ANN* | 11.940 | 13.026 | 6.789 | 6.510 | 7.210 | 6.949 |
| | (4.19) | (3.55) | (2.36) | (1.76) | (2.48) | (1.86) |
| *ANNRET* | 1.637 | 2.525 | 2.369 | 2.953 | 2.152 | 2.875 |
| | (1.79) | (2.15) | (2.57) | (2.49) | (2.31) | (2.41) |

Table A7 (continued):

| Event time | Scheduled | | Actual | | MIN{Scheduled, Actual} | |
|---|---|---|---|---|---|---|
| Model | 1 | 2 | 3 | 4 | 5 | 6 |
| Dependent | *OIN* | *OID* | *OIN* | *OID* | *OIN* | *OID* |
| *Panel F: Kuttner (2001) Method, 4 surprises* | | | | | | |
| Intercept | −0.492 | −0.590 | −0.527 | −0.593 | −0.520 | −0.613 |
| | (−2.45) | (−2.27) | (−2.59) | (−2.25) | (−2.54) | (−2.32) |
| *ANN* | 1.603 | 2.530 | 2.223 | 2.987 | 2.160 | 3.051 |
| | (1.76) | (2.15) | (2.40) | (2.49) | (2.32) | (2.54) |
| *SUR* | 4.832 | 5.899 | 0.844 | 2.384 | 1.035 | 2.496 |
| | (0.97) | (0.91) | (0.17) | (0.36) | (0.20) | (0.38) |
| *Panel G: Gurkaynak, Sack, and Swanson (2005b) Method* | | | | | | |
| Intercept | −0.397 | −0.928 | −0.486 | −0.946 | −0.456 | −0.954 |
| | (−1.34) | (−2.44) | (−1.61) | (−2.41) | (−1.50) | (−2.44) |
| *ANN* | 1.340 | 2.190 | 2.864 | 3.844 | 2.720 | 3.778 |
| | (0.96) | (1.22) | (2.02) | (2.08) | (1.91) | (2.06) |
| *Target* | 0.063 | −0.130 | 0.366 | 0.085 | 0.325 | 0.065 |
| | (0.28) | (−0.46) | (1.61) | (0.29) | (1.42) | (0.22) |
| *Path* | −0.206 | −0.268 | −0.062 | −0.163 | −0.078 | −0.169 |
| | (−2.09) | (−2.12) | (−0.62) | (−1.25) | (−0.77) | (−1.30) |
| *Panel H: Current month contract only, 14 surprises* | | | | | | |
| Intercept | −0.492 | −0.590 | −0.527 | −0.593 | −0.520 | −0.613 |
| | (−2.45) | (−2.27) | (−2.59) | (−2.25) | (−2.54) | (−2.32) |
| *ANN* | 1.545 | 2.553 | 2.187 | 2.998 | 2.123 | 3.064 |
| | (1.69) | (2.16) | (2.35) | (2.49) | (2.27) | (2.54) |
| *SUR* | 1.815 | −0.721 | 1.151 | −0.359 | 1.169 | −0.388 |
| | (0.68) | (−0.21) | (0.42) | (−0.10) | (0.43) | (−0.11) |
| *Panel I: Non-current month contracts, 13 surprises* | | | | | | |
| Intercept | −0.492 | −0.590 | −0.527 | −0.593 | −0.520 | −0.613 |
| | (−2.46) | (−2.28) | (−2.59) | (−2.25) | (−2.55) | (−2.33) |
| *ANN* | 1.200 | 1.996 | 1.956 | 2.558 | 1.860 | 2.586 |
| | (1.30) | (1.68) | (2.10) | (2.12) | (1.98) | (2.14) |
| *SUR* | 5.080 | 6.722 | 3.363 | 5.398 | 3.791 | 5.856 |
| | (3.11) | (3.18) | (2.03) | (2.51) | (2.27) | (2.72) |

Table A8: Alternative surprise definitions for the QE period

This table replicates Table 4 using alternative definitions for FOMC surprise announcements during the Quantitative Easing (QE) period. The pre-announcement window starts thirty minutes before and ends at: the official 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. *OIN*, *OID*, and *ANN* are as defined in Table 4. In Panel A, we use the mid-point of the target range and the 12.5 bp threshold to define surprise in the QE period. For the announcements before QE, we use the same definition of surprise as in Table 4. In Panel B, we use the realized rate changes in the 10-year treasury yield to define surprise. *SUR* is equal to 1 (−1) if the magnitude of the realized rate change on the announcement day exceeds −1.75 (1.75) times its standard deviation calculated using data from 10 days before and 10 days after the announcement. Robust $t$-statistics are reported in parentheses.

| Event time | Scheduled | | Actual | | MIN{Scheduled, Actual} | |
|---|---|---|---|---|---|---|
| Model | 1 | 2 | 3 | 4 | 5 | 6 |
| Dependent | *OIN* | *OID* | *OIN* | *OID* | *OIN* | *OID* |
| *Panel A: Using the mean of target range as the target rate, 38 observations* | | | | | | |
| Intercept | −0.492 | −0.590 | −0.527 | −0.593 | −0.520 | −0.613 |
| | (−2.46) | (−2.28) | (−2.59) | (−2.25) | (−2.55) | (−2.33) |
| *ANN* | 0.396 | 1.195 | 1.489 | 2.027 | 1.311 | 1.994 |
| | (0.40) | (0.94) | (1.50) | (1.57) | (1.31) | (1.55) |
| *SUR* | 5.848 | 6.469 | 3.558 | 4.652 | 4.117 | 5.125 |
| | (3.35) | (2.87) | (2.01) | (2.03) | (2.31) | (2.23) |
| *Panel B: Using realized rate change, 31 observations* | | | | | | |
| Intercept | −0.492 | −0.590 | −0.527 | −0.593 | −0.520 | −0.613 |
| | (−2.46) | (−2.28) | (−2.59) | (−2.25) | (−2.55) | (−2.33) |
| *ANN* | 1.040 | 1.930 | 1.816 | 2.478 | 1.707 | 2.504 |
| | (1.13) | (1.62) | (1.94) | (2.04) | (1.81) | (2.06) |
| *SUR* | 6.450 | 6.872 | 4.663 | 5.827 | 5.198 | 6.268 |
| | (3.55) | (2.92) | (2.53) | (2.44) | (2.80) | (2.62) |

Table A9: Volatility trading before FOMC announcements

This table reports OLS estimates of the relation between volatility trading activity in the S&P 500 options market and FOMC announcement day indicators. *SUR* and *ANN* are as defined in Table 4. The dependent variables are options' vega order imbalances calculated using both number of trades ($VOIN$) and volume ($VOIV$) during the FOMC pre-announcement window following Holowczak, Hu, and Wu (2014). The pre-announcement window starts thirty minutes before and ends at: the official 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. Robust $t$-statistics are reported in parentheses.

| Event time | Scheduled | | Actual | | MIN{Scheduled, Actual} | |
|---|---|---|---|---|---|---|
| Model | 1 | 2 | 3 | 4 | 5 | 6 |
| Dependent | $VOIN$ | $VOIV$ | $VOIN$ | $VOIV$ | $VOIN$ | $VOIV$ |
| Intercept | 0.006 | −0.001 | 0.014 | 0.015 | 0.014 | 0.015 |
| | (0.51) | (−0.12) | (1.73) | (1.66) | (1.73) | (1.66) |
| *ANN* | 0.020 | −0.054 | 0.016 | −0.055 | 0.011 | −0.063 |
| | (0.34) | (−0.80) | (0.34) | (−1.02) | (0.23) | (−1.16) |
| *SUR* | 0.240 | 0.264 | 0.214 | 0.217 | 0.259 | 0.306 |
| | (1.96) | (1.87) | (2.21) | (1.95) | (2.67) | (2.74) |

Table A10: Predicting announcement surprise and returns using order flow

This table replicates the analysis in Table 10 while using the earlier of the official release time and the earliest news report time-stamp as event time 0. Panel A reports the OLS estimates of the following model:

$$\begin{aligned} SUR =& \beta_0 + \beta_1 OI_{t-1,t-x} + \beta_2 OI_{t-x-1,t-y} + \beta_3 Ret_{t-1,t-x} + \beta_4 Ret_{t-x-1,t-y} \\ &+ \beta_5 Ret^2_{t-1,t-x} + \beta_6 Ret^2_{t-x-1,t-y} + \epsilon, \end{aligned}$$

where the dependent variable is the FOMC policy surprise as defined in Table 4, and the independent variables include the E-mini S&P 500 futures order imbalances, S&P 500 index return, and the squared index returns measured relative to $t$ (i.e., earlier of the official release time and the earliest news report time-stamp). All variables except the surprise indicator are adjusted by subtracting the average value of the corresponding variable during the same time window in the five days prior to announcement. *OIN* and *OID* are order imbalances calculated using the number of trades and dollar transaction volumes, respectively. Robust $t$-statistics are reported in parentheses. Panel B reports OLS estimates of the relation between the S&P 500's announcement returns, $Ret_{t,t+z}$, and the fitted FOMC policy surprises, $FSUR$, from the corresponding model in Panel A. The $t$-statistics reported in parentheses are calculated using Heckman-correction.

| Period | $x$=30,$y$=60 | | $x$=30,$y$=90 | | $x$=20,$y$=60 | | $x$=15,$y$=60 | | $x$=10,$y$=60 | |
|---|---|---|---|---|---|---|---|---|---|---|
| Model | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Dependent | *OIN* | *OID* | *OIN* | *OID* | *OIN* | *OID* | *OIN* | *OID* | *OIN* | *OID* |
| *Stage one: Predicting announcement surprise* | | | | | | | | | | |
| Intercept | 0.085 | 0.087 | 0.074 | 0.086 | 0.093 | 0.099 | 0.089 | 0.087 | 0.091 | 0.084 |
| | (1.79) | (1.78) | (1.50) | (1.77) | (1.94) | (2.07) | (1.83) | (1.76) | (1.94) | (1.75) |
| $OI_{t-1,t-x}$ | 1.671 | 1.363 | 1.771 | 1.516 | 1.628 | 1.529 | 1.138 | 0.948 | 0.916 | 0.862 |
| | (3.90) | (3.43) | (4.04) | (3.90) | (3.58) | (3.89) | (3.09) | (2.73) | (2.67) | (2.69) |
| $OI_{t-x-1,t-y}$ | 0.255 | −0.217 | −0.529 | −0.849 | −0.229 | −0.660 | 0.599 | 0.139 | 0.736 | 0.282 |
| | (0.71) | (−0.78) | (−1.06) | (−2.11) | (−0.35) | (−1.39) | (1.41) | (0.42) | (1.51) | (0.74) |
| $Ret_{t-1,t-x}$ | −0.331 | −0.348 | −0.392 | −0.479 | −0.255 | −0.348 | 0.056 | −0.005 | 0.227 | 0.119 |
| | (−1.09) | (−1.11) | (−1.27) | (−1.54) | (−0.80) | (−1.10) | (0.15) | (−0.01) | (0.53) | (0.26) |
| $Ret_{t-x-1,t-y}$ | 0.288 | 0.285 | 0.335 | 0.341 | −0.020 | −0.054 | −0.034 | −0.020 | −0.086 | −0.088 |
| | (0.93) | (0.89) | (1.38) | (1.34) | (−0.10) | (−0.29) | (−0.16) | (−0.09) | (−0.36) | (−0.35) |
| $Ret^2_{t-1,t-x}$ | 0.209 | 0.296 | 0.240 | 0.120 | 0.169 | 0.008 | 0.112 | 0.304 | −0.132 | −0.166 |
| | (0.75) | (0.69) | (0.69) | (0.54) | (0.25) | (0.00) | (0.13) | (0.42) | (−0.31) | (−0.32) |
| Lag($Ret^2_{t-1,t-x}$) | −0.254 | −0.078 | −0.217 | −0.277 | 0.071 | 0.022 | 0.120 | 0.140 | 0.266 | 0.324 |
| | (−0.52) | (−0.21) | (−0.71) | (−0.64) | (0.19) | (0.02) | (0.16) | (0.27) | (0.47) | (0.67) |

Table A10 (continued):

| Period | $x$=30,$y$=60 | | $x$=30,$y$=90 | | $x$=20,$y$=60 | | $x$=15,$y$=60 | | $x$=10,$y$=60 | |
|---|---|---|---|---|---|---|---|---|---|---|
| Model | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Dependent | *OIN* | *OID* | *OIN* | *OID* | *OIN* | *OID* | *OIN* | *OID* | *OIN* | *OID* |
| *Stage two: Predicting announcement returns z=1* | | | | | | | | | | |
| Intercept | −3.662 | −4.148 | −3.495 | −3.754 | −3.580 | −3.709 | −2.789 | −3.617 | −1.932 | −2.217 |
| | (−1.28) | (−1.39) | (−1.51) | (−1.56) | (−1.41) | (−1.41) | (−1.15) | (−1.32) | (−0.87) | (−0.89) |
| $FSUR$ | 19.360 | 23.363 | 17.988 | 20.119 | 18.688 | 19.746 | 11.378 | 18.193 | 4.328 | 6.671 |
| | (2.13) | (2.35) | (2.18) | (2.47) | (2.17) | (2.16) | (1.71) | (1.80) | (0.93) | (1.07) |
| *Stage two: Predicting announcement returns z=15* | | | | | | | | | | |
| Intercept | −6.188 | −4.740 | −6.156 | −5.632 | −6.506 | −5.688 | −3.348 | −0.498 | −1.328 | 0.456 |
| | (−1.01) | (−0.75) | (−1.01) | (−0.93) | (−1.06) | (−0.92) | (−0.54) | (−0.07) | (−0.19) | (0.06) |
| $FSUR$ | 19.784 | 7.864 | 19.524 | 15.209 | 22.405 | 15.671 | 13.110 | 26.574 | 19.737 | 14.426 |
| | (1.98) | (1.29) | (2.01) | (1.82) | (2.08) | (1.81) | (1.15) | (1.63) | (1.74) | (1.31) |
| *Stage two: Predicting announcement returns z=30* | | | | | | | | | | |
| Intercept | −3.558 | −2.947 | −4.464 | −4.472 | −5.848 | −5.056 | −2.261 | 1.473 | −0.080 | 1.471 |
| | (−0.48) | (−0.41) | (−0.59) | (−0.61) | (−0.76) | (−0.68) | (−0.30) | (0.19) | (−0.01) | (0.17) |
| $FSUR$ | 12.881 | 7.854 | 20.344 | 20.410 | 31.732 | 25.209 | 2.815 | 27.922 | 15.139 | 27.909 |
| | (1.47) | (1.34) | (1.71) | (1.86) | (1.93) | (1.80) | (0.09) | (1.95) | (1.44) | (1.88) |
| *Stage two: Predicting announcement returns z=60* | | | | | | | | | | |
| Intercept | 1.925 | 3.298 | −0.300 | 0.533 | 0.427 | 1.806 | 4.248 | 9.709 | 6.855 | 10.445 |
| | (0.19) | (0.33) | (−0.03) | (0.05) | (0.04) | (0.18) | (0.42) | (0.94) | (0.62) | (0.95) |
| $FSUR$ | 5.789 | 5.515 | 24.097 | 17.241 | 18.114 | 6.768 | 12.668 | 17.614 | 24.120 | 23.671 |
| | (0.87) | (0.65) | (1.67) | (1.48) | (1.46) | (0.89) | (1.32) | (1.39) | (1.24) | (1.46) |

Table A11: Predicting announcement surprise and returns using subperiod order imbalances during lockups

This table replicates the analysis in Table 10 using E-mini S&P 500 order imbalances in three subwindows of the lockup period: [t−30,t−21], [t−20,t−11], and [t−10,t−1], where $t$ is 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. *OIN* and *OID* are order imbalances calculated using the number of trades and dollar transaction volumes, respectively. Robust $t$-statistics are reported in parentheses. Panel B reports OLS estimates of the relation between the S&P 500's announcement returns, $Ret_{t,t+1}$, and the fitted FOMC policy surprises, $FSUR$, from the corresponding model in Panel A. The $t$-statistics reported in parentheses are calculated using Heckman-correction.

| Event time | Scheduled | | Actual | | MIN{Scheduled, Actual} | |
|---|---|---|---|---|---|---|
| Model | 1 | 2 | 3 | 4 | 5 | 6 |
| Dependent | *OIN* | *OID* | *OIN* | *OID* | *OIN* | *OID* |
| *Panel A: Predicting announcement surprise* | | | | | | |
| Intercept | 0.110 | 0.103 | 0.126 | 0.121 | 0.115 | 0.109 |
| | (2.17) | (2.05) | (2.45) | (2.30) | (2.24) | (2.08) |
| $OI_{t-21,t-30}$ | 0.321 | 0.267 | 0.338 | 0.272 | 0.166 | 0.226 |
| | (1.25) | (1.18) | (1.29) | (1.18) | (0.66) | (1.02) |
| $OI_{t-11,t-20}$ | 0.415 | 0.438 | 0.355 | 0.414 | 0.419 | 0.330 |
| | (1.62) | (1.90) | (1.39) | (1.91) | (1.65) | (1.47) |
| $OI_{t-1,t-10}$ | 0.205 | 0.528 | 0.095 | 0.242 | 0.201 | 0.354 |
| | (0.63) | (1.69) | (0.29) | (0.75) | (0.63) | (1.14) |
| $OI_{t-31,t-60}$ | 0.400 | −0.081 | 0.572 | −0.045 | 0.485 | −0.033 |
| | (1.11) | (−0.29) | (1.37) | (−0.14) | (1.25) | (−0.11) |
| $Ret_{t-21,t-30}$ | −0.374 | −0.581 | −0.711 | −0.828 | −0.235 | −0.296 |
| | (−0.74) | (−1.11) | (−1.15) | (−1.33) | (−0.45) | (−0.55) |
| $Ret_{t-11,t-20}$ | −0.178 | −0.326 | −0.004 | −0.080 | −0.170 | −0.285 |
| | (−0.41) | (−0.73) | (−0.01) | (−0.16) | (−0.36) | (−0.59) |
| $Ret_{t-1,t-10}$ | 1.166 | 0.861 | 0.881 | 0.630 | 0.846 | 0.632 |
| | (2.91) | (2.19) | (1.88) | (1.53) | (1.76) | (1.57) |
| $Ret_{t-31,t-60}$ | 0.565 | 0.660 | 0.015 | 0.139 | 0.209 | 0.299 |
| | (1.75) | (2.03) | (0.05) | (0.42) | (0.62) | (0.85) |
| $Ret^2_{t-21,t-30}$ | 0.875 | 0.509 | 3.937 | 3.305 | 3.141 | 2.829 |
| | (0.45) | (0.26) | (1.83) | (1.50) | (1.36) | (1.21) |
| $Ret^2_{t-11,t-20}$ | 1.831 | 2.5 | 0.562 | 0.498 | 1.053 | 1.138 |
| | (1.01) | (1.38) | (0.53) | (0.45) | (0.74) | (0.79) |
| $Ret^2_{t-1,t-10}$ | 1.422 | 1.252 | −1.941 | −1.258 | −1.830 | −1.488 |
| | (1.84) | (1.63) | (−1.07) | (−0.68) | (−1.11) | (−0.89) |
| $Ret^2_{t-31,t-60}$ | −0.832 | −0.644 | −0.124 | 0.026 | −0.147 | −0.055 |
| | (−1.37) | (−1.09) | (−0.23) | (0.05) | (−0.25) | (−0.09) |
| *Panel B: Predicting announcement* $Ret_{t,t+1}$ | | | | | | |
| Intercept | −3.857 | −4.496 | −3.970 | −4.172 | −3.173 | −3.412 |
| | (−1.50) | (−1.57) | (−1.05) | (−1.05) | (−0.97) | (−0.93) |
| $FSUR$ | 25.022 | 20.830 | 16.080 | 17.742 | 19.926 | 18.896 |
| | (2.48) | (2.58) | (1.86) | (1.99) | (1.77) | (1.95) |