Flexible Windows and Loadings for Identifying Monetary Policy Surprises

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Abstract

This paper shows that prices in the Eurodollar market gradually adjust to Federal Open Market Committee (FOMC) announcements reach their new level after 45 minutes on average. In addition, volume in the Eurodollar market shifts to longer-dated futures contracts when the Fed relies on forward guidance as its main tool. Based on these two findings, conventional monetary policy surprises with a fixed 30-minute window and constant loadings underestimate the total price change by 20% and incorporates price changes of only the least traded segment of the Eurodollar market for some announcements. To incorporate these insights, I introduce the Volume-based Monetary Policy Surprise (VBS). It features announcement-specific event windows and loadings that are determined by abnormal trading volume around FOMC announcements. The flexible event windows average around 60 minutes but varies substantially, suggesting there is no-one-size-fits-all approach. The flexible loadings move towards the segment of the term structure of interest where the volume is concentrated. The estimated effects of monetary policy are substantially larger. In event studies, the estimated coefficients of monetary policy on the treasury market and stock markets double in size. The VBS also leads to a large negative decline of inflation in vectorautoregressive models of the economy that is absent when instrumenting with conventional measures.

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1 Introduction

A central challenge in monetary economics is identifying the causal effects of monetary policy on financial markets and the economy. The standard approach uses high-frequency "surprises" around Federal Open Market Committee (FOMC) announcements the component of policy decisions that financial markets did not anticipate. These surprises serve as plausibly exogenous instruments because they capture unexpected policy changes that are orthogonal to current economic conditions and have been used extensively in both event studies and structural vector autoregressions.

The conventional methodology, established by Gürkaynak et al. (2005), measures surprises as price changes in interest rate futures over a fixed 30-minute window around FOMC announcements. This approach assumes that markets efficiently incorporate all new information within thirty minutes and that the same window length and asset weights are appropriate for all announcements. The most widely used implementation is the Policy News Surprise (PNS) of Nakamura and Steinsson (2018), constructed as the first principal component of price changes in federal funds and Eurodollar futures with maturities up to 12 months.

However, there are growing concerns that conventional surprise measures systematically understate monetary policy effects, particularly during the era of forward guidance. The PNS exhibits dramatically smaller variation during 2010-2020 precisely when the FOMC expanded its use of forward guidance and introduced regular press conferences compared to earlier periods. This decline is puzzling because the FOMC remained highly active during this period, implementing unconventional policies and providing extensive guidance about future policy paths. Moreover, when conventional surprise measures are used as instruments in structural models, they often yield surprisingly small and statistically insignificant effects on key macroeconomic variables like inflation (Gertler and Karadi, 2015).

This paper addresses two fundamental questions about monetary policy surprise identification. First, how long do markets actually need to process the information contained in FOMC announcements? Second, which interest rate futures contracts contain the most policy-relevant information, and how does this change over time as the FOMC's communication strategy evolves?

To answer these questions, I use comprehensive transaction-level data from the Chicago Mercantile Exchange covering all Eurodollar futures trading from 1988-2022. I propose a novel approach: the Volume-based Surprise (VBS), which uses abnormal trading volume to determine both the optimal window length and contract weights for each individual announcement. The approach builds on a key insight from market microstructure theory: trading volume reveals market participants' incentives to trade on new information (He and Wang, 1995; Kandel and Pearson, 1995; Vives, 2010). When market participants have heterogeneous beliefs about public announcements, volume spikes as they trade toward consensus. The timing of volume normalization reveals when this information processing concludes, while volume concentration across contracts reveals where new information is most policy-relevant.

This approach represents a significant departure from the existing literature on monetary policy surprise measurement. While recent work by Bauer and Swanson (2022) and Miranda-Agrippino and Ricco (2021) has focused on orthogonalizing surprises with respect to predictable components, and Jarociński and Karadi (2020) has emphasized decomposing surprises into information versus policy components, my approach tackles a more fundamental measurement question: whether the conventional assumptions about timing and asset selection are appropriate. By allowing markets to endogenously determine these parameters through volume patterns, the VBS methodology provides a data-driven solution to longstanding measurement challenges.

The Volume-based Surprise delivers two main innovations over conventional approaches. First, it uses *time-varying window lengths* determined by when abnormal trading volume subsides. These windows average 60 minutes for regular announcements and extend to 100 minutes when press conferences provide additional information substantially longer than the standard 30-minute window. Second, it employs *time-varying loadings* that weight contracts based on their relative trading volume, allowing the measure to adapt automatically when market attention shifts across maturities.

Using minute-by-minute trading data spanning 1988-2022, I document two key empirical facts that motivate this approach. First, unlike current-month federal funds futures that price only the announced rate change, Eurodollar futures exhibit *gradual price adjustment*. Prices take an average of 45 minutes to reach their new levels after announcements without press conferences the conventional 30-minute window captures only 80% of the total price adjustment. Second, both *volume and volatility remain abnormally elevated* well beyond the standard window. Trading volume spikes immediately after announcements but remains significantly above normal levels for up to 90 minutes, indicating continued information processing and disagreement resolution among market participants.

These patterns stand in stark contrast to current-month federal funds futures, which exhibit minimal post-announcement trading because their payoffs are determined almost entirely by the announced rate change. The extended adjustment in Eurodollar markets reflects the more complex information content of FOMC communications, which includes not only current policy decisions but also signals about future policy paths that affect longer-maturity contracts.

The Volume-based Surprise reveals substantially larger monetary policy effects than conventional measures across multiple dimensions. In Treasury market event studies, a one-standard-deviation contractionary VBS surprise raises 10-year yields by 3.4 basis points compared to 0.9 basis points using the PNS. The VBS explains between 8% and 32% of the variation in daily Treasury yield changes during 2003-2022, compared to just 2% to 15% for the PNS. For equity markets, the VBS implies that contractionary policy reduces stock prices by 4.4% versus 2.2% using conventional measures, with R-squared increasing from 3% to 15%.

Most importantly for macroeconomics, the VBS resolves the puzzling finding that high-frequency monetary policy shocks have little effect on inflation. Using the VBS as an instrument in a structural vector autoregression over 1988-2020, I find that a contractionary monetary policy shock reduces inflation by 0.10 percentage points after 12 months, with the response statistically significant at the 90% level and following the expected hump-shaped pattern. In sharp contrast, the same specification using conventional surprise measures yields an inflation response that is both economically small and statistically indistinguishable from zero. This difference has important implications for our understanding of monetary policy transmission and the design of optimal policy.

The divergence between the VBS and conventional measures has grown dramatically over time, reflecting the evolution of FOMC communication practices. During 1988-2003, before the introduction of regular forward guidance, the conventional PNS explains 85% of VBS variation. However, from 2004 onwards a period encompassing the zero lower bound, quantitative easing, and the introduction of press conferences this explanatory power falls to just 52%.

I decompose this growing divergence into two distinct sources. First, *longer window lengths* account for 30% of VBS variation in the later period. This component captures information revealed during press conferences and the market's slower processing of increasingly complex FOMC communications. Second, *time-varying loadings* that shift toward longer-maturity contracts explain an additional 18% of VBS variation. During periods of forward guidance, particularly around the zero lower bound, trading volume concentrates in contracts with maturities between 2-3 years as markets focus on signals about future policy normalization rather than near-term rate changes.

These findings have important implications for monetary policy research and central bank communication. For researchers, the results suggest that many puzzling findings about weakened monetary transmission may reflect measurement error rather than structural economic changes. The VBS methodology could prove valuable beyond monetary policy for measuring surprises around earnings announcements, policy communications by other agencies, or any setting where the optimal event study parameters are unknown ex ante. For policymakers, the results provide evidence that forward guidance and press conferences continue to have substantial market effects even when conventional measures suggest diminished impact.

The remainder of the paper proceeds as follows. Section 2 examines interest rate futures behavior around FOMC announcements and documents the volume patterns that motivate volume-based measurement. Using minute-by-minute data on prices, volume, and volatility, I demonstrate the gradual price adjustment and extended periods of abnormal trading that conventional measures miss. I also examine how trading activity has shifted toward longer-maturity contracts during periods of forward guidance and show that these patterns are robust to concerns about contamination from other macroeconomic news releases.

Section 3 describes the construction of Volume-based Surprises. I detail the methodology for using bootstrapped confidence intervals around expected trading volume to determine announcement-specific window lengths. I then explain how volume-weighted loadings are constructed and demonstrate how they adapt automatically to changes in the FOMC's communication strategy. The section also decomposes the VBS to quantify the separate contributions of flexible window lengths and time-varying loadings relative to conventional approaches.

Section 4 presents the main empirical results comparing VBS to conventional surprise measures. I begin with event studies showing the impact on Treasury yields and equity market returns. I then estimate structural vector autoregressions to trace out the macroeconomic effects of monetary policy shocks, with particular attention to the inflation response that has proven elusive in previous studies. The section also decomposes the VBS into Target and Path components to understand which aspects of monetary policy drive the enhanced results.

Section 5 concludes by discussing the broader implications of volume-based surprise measurement for monetary economics and suggests directions for future research. The findings suggest that market microstructure insights can substantially improve macroeconomic measurement, with potential applications extending well beyond monetary policy to other settings where the optimal event study parameters are unknown ex ante.

Related Literature

Monetary policy surprises have been a key innovation in macro-finance research. Kuttner (2001) proposes studying changes in interest rate futures on FOMC announcement days to isolate unanticipated changes in the federal funds rate. This approach focuses on federal funds futures containing expectations about the current meeting, using a daily window length. Building on this work, Gürkaynak et al. (2005) calculate surprises at longer maturities and, importantly, introduce 30-minute windows around FOMC press releases/interventions. The shift to a 30-minute window addresses the issue of some early 1990s FOMC actions occurring immediately after employment reports, and has since been widely adopted in the literature. The present paper directly contributes to this line of research by relaxing the fixed-length window assumption, instead using trading volume to determine the optimal window length. This approach yields announcement-specific, flexible windows determined by investor behavior.

The study of abnormal volume around public announcements dates back to at least Beaver (1968), who argues that trading volume must result from a lack of consensus among investors about prices. Subsequent research has extended these findings to macroeconomic announcements, with empirical studies using intraday data in the treasury market (Fleming and Remolona (1999), Green (2004)) confirming significant abnormal volume. The work most closely related to this study is Fleming and Piazzesi (2005), which examines the impact of monetary policy announcements on the Treasury market, documenting elevated volume in the Treasury cash market for up to 90 minutes post-announcement. The present paper extends these results to the Eurodollar futures market, focusing on the heterogeneity in volume response around announcements.

Monetary policy surprises have been widely used to study the impact of monetary policy on financial markets and the economy. A primary focus has been the effect on equity markets, with Bernanke and Kuttner (2005) documenting that a 25bp expansionary interest rate surprise raises stock prices by 1%. However, event study regressions for path surprises have been insignificant (Gürkaynak et al., 2005; Lunsford, 2020). This paper contributes by demonstrating that the impact of monetary policy on stock prices is larger when the window length is determined by trading volume in the futures market.

In bond markets, there is ongoing debate about whether monetary policy affects bond term premia. Hanson and Stein (2015) find a substantial impact of changes in the 2-year rate, measured over a 2-day window around FOMC announcements, on bond risk premia. However, Nakamura and Steinsson (2018) argue that these 2-day windows are contaminated by other news and instead use a 30-minute window, finding that the impact of monetary policy on term premia is insignificant beyond a 10-year horizon. The present study shows that the impact of monetary policy on term premia becomes significant when the window length is determined by trading volume in the futures market.

Lastly, a large body of empirical literature, pioneered by Gertler and Karadi (2015), uses high-frequency surprises to proxy for monetary policy shocks in structural VARs. This paper contributes to this literature by demonstrating that improved measurement of the adequate window length has implications for the estimated impact of monetary policy on the economy. Specifically, it leads to a larger response of inflation and output to monetary policy surprises.

2 Interest Rate Futures on the FOMC Announcement Day

The Federal Open Market Committee (FOMC) meets eight times a year to decide on the monetary policy stance of the Federal Reserve. The FOMC announces its decision on the federal funds target rate, which is the interest rate at which banks lend reserves to each other overnight. The announcement is typically made at 2:00 PM Eastern Time, and it is widely anticipated by market participants. During the sample period of November 1988 to December 2022, there were 304 FOMC rate decisions of which 274 are scheduled and 32 unscheduled [1]. Since April 2011, the FOMC has held press conferences four times a year and since 2019 every FOMC announcement is accompanied by a press conference.Therefore, 65 of the scheduled FOMC statements are accompanied by a press conference. Between 1988-1993, there is no information release by the FOMC to the public but instead actions have to inferred from trading desk operations(Cook and Hahn, 1989), while since February 1994 the FOMC provides a statement with the policy action taken during the meeting.

The idea behind the influential (Kuttner, 2001) interest rate surprise measure is to capture the market's reaction to unexpected changes in monetary policy. Fed-funds and Eurodollar futures prices are quoted in the IMM convention where a future that settles h months from now is quoted as $P_{t,h} = 100 - i_{t,h}$, where $i_{t,h}$ is the implied interest rate at time t for the future contract with maturity h. Under general no-arbitrage conditions and assuming risk-neutrality, the implied interest rate of the future contract today is the expectation of the implied interest rate at the end of the contract period:

$$f_{t,h} = \bar{E}_t(it + h) = 100 - P_{t,h}$$

where $f_{t,h}$ is the implied interest rate of the future contract at time t, h is the contract maturity, i_{t+h} is the settlement interest rate at time t+h, and $\bar{E}$ denotes the risk-neutral expectation.

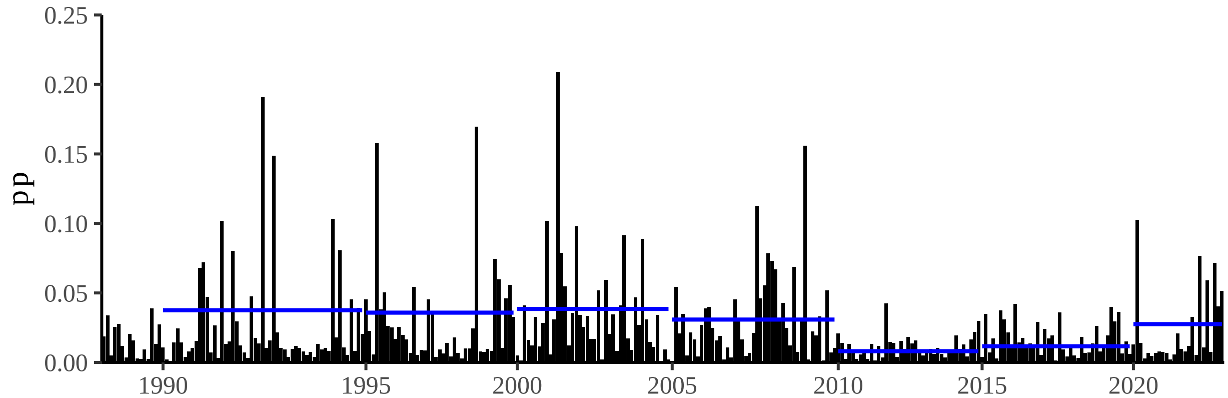
The Kuttner (2001) surprise is defined as the change in the daily close prices of the current-month federal funds futures contract around the FOMC announcement tracks the change in the expected market expectation of the federal funds rate prior to and after the FOMC announcement. Under the assumption that markets do not expect another interest rate decision in the same month, which suggests no residual uncertainty about the contract payoff, and risk-neutrality

$$\begin{aligned} s^{\text{Kuttner}}_{t,x,1M} &\approx f_{t+\overline{x},1M} - f_{t-\underline{x},1M} \\ &= \bar{E}_{t+\overline{x}}[ffr_{1M}] - \bar{E}_{t-\underline{x}}[ffr_{1M}] \\ &= ffr_{t+\overline{x}} - \bar{E}_{t-\underline{x}}[ffr_{t+x}]. \end{aligned}$$

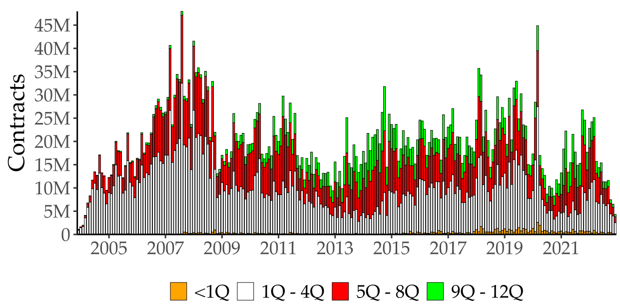
[1] I consider all events that are contained in both (Gürkaynak et al., 2005) and (Bauer and Swanson, 2022)

where $\bar{E}_{t+\bar{x}}[ffr_{1M}] = ffr_{t+\bar{x}}$ since there will be no other FOMC meeting in the same month.[2].

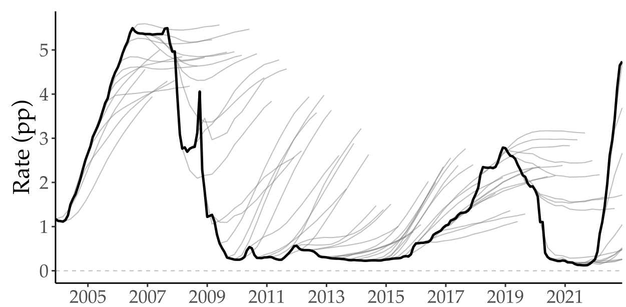
Figure 1: Eurodollar Market



(a) Size of PNS



(b) Monthly Eurodollar Volume



(c) 3M Libor and Futures Curve

Subfigure (a) shows the monthly electronic trading volume in Eurodollar contracts, aggregated by contract maturity. The "Orange" contracts represent all monthly serial contracts in the current quarter, "Whites" denote the four quarterly serials expiring within 12 months, "Reds" denote those expiring within 13-24 months, and "Greens" denote those expiring within 25-36 months. Subfigure (b) shows the 3M USD Libor rate and the futures curve at each quarter-end. Subfigure (c) shows the size of the PNS in black and in blue the standard deviation of the size of the PNS for each 5-year period.

However, over the years the FOMC has changed the way it communicates its decisions to the public with a greater focus on forward guidance and more detailed statements (Campbell et al., 2012; Lunsford, 2020). In addition, from 2010 to 2015 the federal funds rate was effectively zero, limiting the FOMC's ability to use traditional monetary policy tools and in turn the market's surprise to its press releases. To this end, monetary policy surprises often include many asset prices beyond the Kuttner surprise. Let

$$s_{m,x=\bar{x}_m+\underline{x}_m} = \Lambda_m(p_{m,t+\bar{x}_m} - p_{m,t-\underline{x}_m}), \tag{1}$$

where $s_{m,x}$ is a vector of surprises around FOMC meeting m with length k_s at time t with window

[2]This statement is only an approximation since federal funds futures settle on the average effective federal funds rate over the contract month. See Kuttner (2001) on the necessary scaling adjustments under which the surprise captures exactly the difference between the actual federal funds rate and the expected federal funds rate

length x determined by the upper window bound $\overline{x}$ and lower window bound $\underline{x}$,$p_{t+\overline{x}}$ is denotes a vector of prices with dimensionality k_p at the upper window bound and $p_{t-\underline{x}}$ are prices at the lower window bound and Λ_m maps the potentially multi-dimensional price changes to the lower dimensional space of surprises with dimensions of $Lambda_t$ being $k_s \times k_p$.

This involves decisions on the side of the researcher: the choice of the window length x_m, the mapping function Λ_m and which prices to include in $\Delta p_{|\overline{x}-\underline{x}|,m}$. Typically, the window length is fixed across announcements $x_m = x$, the loading matrix $\Lambda_m = \Lambda$ and a fixed set of asset prices $p_{t+\overline{x}}$ and $p_{t-\underline{x}}$ are used. Interest rate futures are choosen in the price vector $p_{t+\overline{x}}$ and $p_{t-\underline{x}}$ which contain the current-month federal funds futures contract (Kuttner, 2001), Eurodollar futures contracts with maturities longer than one month (Gürkaynak et al., 2005; Nakamura and Steinsson, 2018) and can potentially be extended to a set longer-dated interest rate securities (Swanson, 2021) or equity indeces (Jarociński and Karadi, 2020; Lewis, 2023).

A popular measure is the Policy News Surprise (PNS) (Nakamura and Steinsson, 2018) which is a single surprise measure, capturing both, target and path effects. The asset prices contain the Kuttner surprise and Eurodollar futures contracts with maturities up to 12 months, price changes measured at the 30-minute frequency and the loading matrix Λ is determined by Principal Component Analysis [3].

Figure 1a plots the absolute size of the PNS over time, with the blue horizontal line indicating the standard deviation of the PNS over a 5-year fixed window. It shows that the PNS is relatively stable in size at around 4bp but then drops significantly between 2010 to 2020, with small PNS surprises of around 1bp. Therefore, in the exact sample period where the PNS relies on it containing forward guidance information as one of the main tools of monetary policy, the PNS are small compared to any other period.

While this could obviously driven by a structural change in the underlying monetary policy surprise, it is instructive to investigate if using fixed window lengths and fixed loadings are appropriate to identify monetary policy surprises, in particular in the context of forward guidance. The rest of this section is devoted to investigating the empirical regularities in the Eurodollar futures market and how they can give guidance on the choice of window length and loading matrix.

Figure 1b and 1c show the monthly electronic trading volume in Eurodollar contracts, aggregated by contract maturity and the underlying 3M USD Libor rate and the futures curve at each quarter-end, respectively from 2003/11 to 2022/12. While the overall volume in the Eurodollar market moves with the level of the underlying Libor rate and declines after the Global Financial Crisis, the decline is particularly pronounced for Eurodollar contracts with maturities up to 12 months,

[3] Between 1988/11 - 2022/12 the loadings are ENTER HERE

the contracts that are the input to the PNS. Since 2005, the volume in the Eurodollar market shifts towards longer-dated contracts. This suggests that Eurodollar market remains active and liquid. The fan chart of futures curve can explain why. While the level of the 3M USD Libor rate has been low since 2010, the futures curve constantly adjusts its slope in line with the market's expectations about the lift-off from the zero lower bound and the path of future interest rates. These slope changes occur at the long end of the curve which can explain why the PNS suggests the adjustment in the slope does not occur around the FOMC announcement.

Therefore, the evolution of volume and the futures curve suggests that activity in the Eurodollar market has expanded to maturities currently not included in the $\Delta p^{PNS}_{t+\bar{x},t-\underline{x}}$. While these aggregate patterns are informative on the relevant maturities to include in the surprise measure, they do not provide guidance on the choice of window length. To this end, I investigate the behavior of the Eurodollar futures prices and volume around the FOMC announcement press releases in more detail.

Figure 2 shows the cumulative absolute price changes of Eurodollar futures and the Kuttner surprise from 10 minutes before the announcement, the commonly used starting point to measure surprises, to 120 minutes after. Absolute cumulative price change help to shift the focus on the price trajectory conditional on the information released, which can either be positive or negative. In particular, the figure displays $\beta_{t,m\in 0,1}$ and their 99% confidence interval from

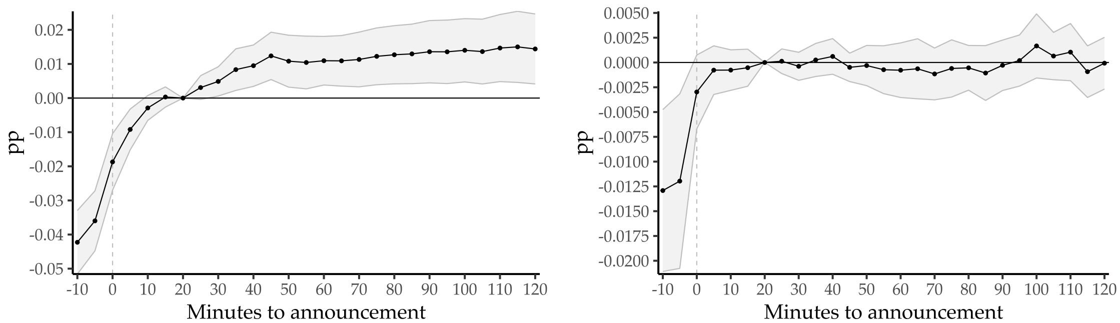
$$(2) \qquad |P_{c,d,t,m=1} - P_{c,d,t=-10,m=1}| = \alpha_{c,d} + \sum_{t=-10}^{t=120} \boldsymbol{\beta_{t,m=1}} \mathbb{1}_t + \epsilon_{c,d,t,m}.$$

The model is first estimated on a sample that contains the 5-minute price changes in a panel of all quarterly Eurodollar contracts with maturities up to 36 months and again estimated the Kuttner surprise respectively. The sample runs from 1994-01-01 to 2022-12-31 and contains all scheduled FOMC announcements where no press conference was held. The coefficients are estimated by OLS and standard errors are clustered at the day level.

There is a 0.9 basis point price change over the 30-minute window in the Kuttner surprise, but this price change is indistinguishable from taking the first price after the FOMC press release, with an average of 0.7 basis points. In contrast, the Eurodollar futures prices initially underreact to the information of the FOMC statement and only gradually converge to the new price. The average cumulative absolute price change is 4 basis points over the first 30 minutes, but crucially, continues to increase by another basis point until it stabilizes at 5 basis points after 45 minutes.

This documents fact number one: asset prices whose payoff are determined by future FOMC decisions, such as Eurodollar futures, underreact to the information in the FOMC statement and only gradually converge to the new price level.

Figure 2: Cumulative Absolute Price Changes



(a) Eurodollar Market **(b)** Kuttner Surprise

The figure shows $\beta_{t,m\in 0,1}$ and their 99% confidence interval from

$$|P_{c,d,t,m=1} - P_{c,d,t=-10,m=1}| = \alpha_{c,d} + \sum_{t=-10}^{t=120} \boldsymbol{\beta_{t,m=1}} \mathbb{1}_t + \epsilon_{c,d,t,m}$$

where d denotes the day, t denotes time and m is a FOMC meeting indicator. The sample runs from 1994-01-01 to 2022-12-31 and contains all scheduled FOMC announcements where no press conference was held. Time t runs from t-10 to t+120, where t=0 indicates the FOMC Statement press release. Prices are sampled at the 5-minute frequency. The coefficients are estimated by OLS and standard errors are clustered at the day level. The coefficients are expressed relative to t=20, which represents the cumulative absolute price change in the 30-minute window of Gürkaynak et al. (2005).

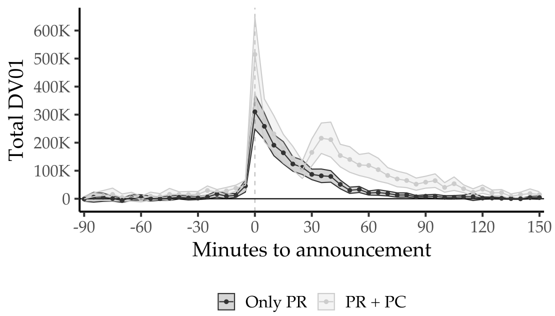
To capture the dynamics of trading volume, I estimate the following model:

$$Volume_{m,d,t} = \alpha_{m,t^{5M}} + \sum_{j=-90}^{j=150,j+=5} \boldsymbol{\beta}_{j,m=1} \mathbb{1}_{t^{5M}=j} \mathbb{1}_{m=d} + \epsilon_{m,d,t}$$

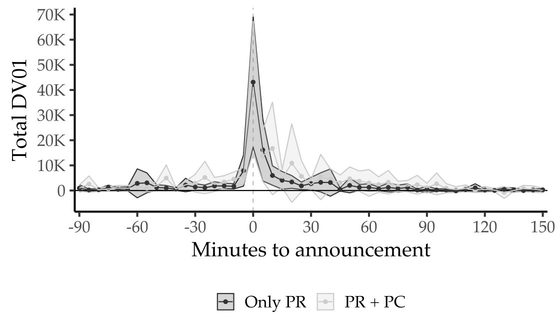
where d denotes the day, t denotes time and m is a FOMC meeting indicator. The model is estimated over our sample where t denotes 1-minute intervals. Therefore, $\beta_{t,m=1}$ can be interpreted as the average 1-minute trading volume in a given 5-minute interval on the FOMC announcement day relative to the average trading volume in the same 5-minute interval on non-FOMC days.

Panel (a) and (b) of Figure 3 show the estimated $\hat{\beta}_{t,m\in 0,1}$ and their 99% confidence interval from the model. The coefficients are estimated by OLS and standard errors are clustered at the day level. The figure shows that the trading volume in Eurodollar futures contracts spikes significantly around the FOMC announcement. The average initial spike is an increase in contracts worth 30-50 million in notional value. The trading volume remains elevated for 30 minutes after the FOMC announcement and only returns to its normal level after 90 minutes for non-press conference days and extends to 120 minutes for press conference days. The press conference introduces another shift in the average trading volume to the right, suggesting that new subsequent information is released during the press conference which creates further trading opportunities. This stands in stark contrast to the Kuttner surprise, which shows no significant increase in trading volume around the FOMC announcement beyond the first 10 minutes. There is also no increase in trading volume during the press conference, since all the information about the level of the federal funds rate is already contained in the statement.

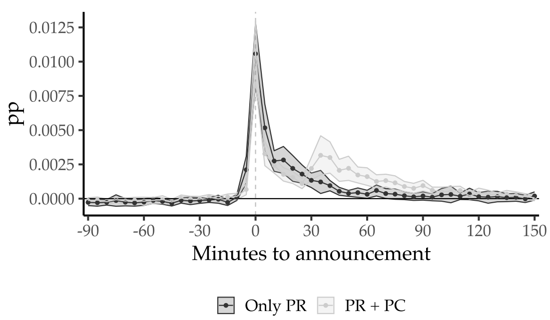
Figure 3: Comparative Analysis of Trading Volume and Price Changes



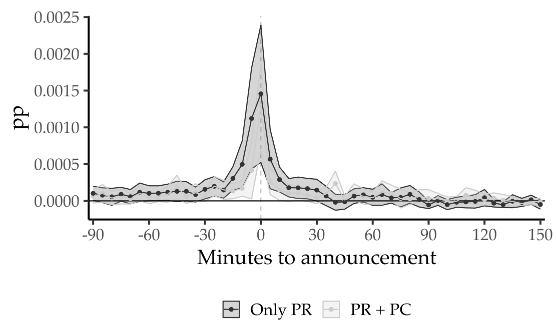
(a) Eurodollar Volume



(b) Kuttner Surprise Volume



(c) Eurodollar Price Volatility



(d) Kuttner Surprise Price Volatility

Panels (a) and (b) show the estimated $\hat{\beta_{t,m\in 0,1}}$ and their 99% confidence interval from

$$Volume_{m,d,t} = \alpha_{m,t^{5M}} + \sum_{j=-90}^{j=150,j+=5} \boldsymbol{\beta}_{j,m=1} \mathbb{1}_{t^{5M}=j} \mathbb{1}_{m=d} + \epsilon_{m,d,t}$$

where d denotes the day, t denotes time and m is a FOMC meeting indicator . Panel (c) and (d) show the estimated $\hat{\beta_{t,m\in 0,1}}$ and their 99% confidence interval from

$$|\Delta P_{c,m,d,t}| = \alpha_{c,m,t^{5M}} + \sum_{j=-90}^{j=150,j+=5} \boldsymbol{\beta}_{j,m=1} \mathbb{1}_{t^{5M}=j} \mathbb{1}_{m=d} + \epsilon_{c,m,d,t}$$

where subscripts are similar to above and c denotes the contract. The coefficients are estimated by OLS. The sample runs from 2004-01-01 to 2022-12-31 and contains all scheduled FOMC announcements and the 30 prior trading days. The vertical line indicates the FOMC announcement at t=0. Standard errors are clustered at the day level.

Volume and price volatility are closely related in most models financial markets under asymmetric information. This is also the case in the Eurodollar market. Panel (c) and (d) of Figure 3 show the average estimated absolute price changes and their 99% confidence intervals, estimate by the following model:

$$|\Delta P_{c,m,d,t}| = \alpha_{c,m,t^{5M}} + \sum_{j=-90}^{j=150, j+=5} \boldsymbol{\beta}_{j,m=1} \mathbb{1}_{t^{5M}=j} \mathbb{1}_{m=d} + \epsilon_{c,m,d,t}.$$

It shows that the average absolute price changes show a remarkably similar pattern to the trading volume. In the first 5 minutes, the average 1-minute price changes are of the order of around 1 bp and then gradually fall until they're back to normal levels after 90 to 120 minutes, depending on whether a press conference is held or not. The average price changes are also significantly larger than the Kuttner surprise, which shows no significant price changes after 20-30 minutes.

This documents fact number two: volume and volatility spike after the FOMC announcement and then gradually return to normal levels. Similar patterns have been documented in corporate earnings announcements (Beaver, 1968; Kandel and Pearson, 1995) and in the government bond market (Fleming and Remolona, 1999).

Taken together, these two facts suggest that while there is a lot of public information released to market participants, with the press release and subsequent press conference as well as the accompanying news coverage, market participants have inherently different beliefs about the implications of the FOMC statement and press conference. If all market participants had the same common priors and would observe the same public information, the no-trade theorem (Milgrom and Stokey, 1982) would imply that there is no reason to trade after the FOMC announcement and markets would incorporate all information into prices (Grossman, 1976). Several rational expectations (He and Wang, 1995; Vives, 1995, 2010) and differences-in-opinion (Kandel and Pearson, 1995; Banerjee and Kremer, 2010) models have been proposed that can lead to trading and volatility around the announcement. A key role play higher-order expectations (Allen et al., 2006; Banerjee et al., 2009; Angeletos and Lian, 2018), which are expectations about the expectations of other market participants. Higher-order expectations can lead to price drift in the presence of asymmetric information, where prices are further away from the fundamental then the average expectation of market participants, and even polarize beliefs in the response to a public signal (Kondor, 2012).

In summary, these models posit that with increased trading intensity and information being incorporated into prices, price informativeness about fundamentals will increase over time. However, all of those models comparative statics in the precision of the public signal, the degree of disagreement among investors, and the speed of information diffusion can all influence the speed of convergence in trading volume and price informativeness, suggesting there is no one-size-fits-all approach to capturing the relevant information in prices. Therefore, the choice of window length around the FOMC announcement should be contingent on the time it takes for market participants to converge in their trading until they have no reason to trade.

3 Volume-Based Surprises

Establishing that market participants take time to resolve all their trading motives around the FOMC press release, I now delve into the implications for identifying monetary policy surprises. The conventional approach to identifying such surprises involves using a fixed window around the FOMC press release and fixed loadings. However, the prior analysis suggests that prices underreact to the information in the FOMC statement and that trading volume spikes significantly around the FOMC announcement.

Consequently, I propose to summarize the surprise in short-term interest markets based on abnormal trading volume in Eurodollar futures. The Volume-based Surprise (VBS) is defined as

$$s^{VBS}_{m,x=\overline{x}_m+10} = \Lambda_m(p_{m,t+\overline{x}_m} - p_{m,t-10}) \tag{3}$$

where the window length x_m is determined by the how long trading volume remains elevated above normal levels and the loadings Λ_m are determined by the relative share of each Eurodollar contract volume of the total contract volume. This approach is easily implementable and only requires access to trading data from the past 30 trading days. Importantly, this allows for the identification of announcement-specific window lengths and loadings, in real time, without the need for complex econometric models.

The underlying idea is to create a baseline of normal expected trading volume that would prevail in the Eurodollar market in the absence of the FOMC announcement. This baseline is then compared to the actual trading volume observed around the FOMC announcement. The window length is defined as the point in time where the trading volume falls back into the normal range.

More formally, let $V_{m,d,t} = \sum_{c=1}^{12} V_{m,d,t,c}$ denote the trading volume of the Eurodollar market in a given minute t on day d and m denotes the FOMC meeting. For each FOMC meeting m, d contains the FOMC annonuncement day $d = m$ and the 30 trading days $m-30 \leq d \geq m$ prior. The following procedure is applied to determine the window length x_m and the loadings Λ_m for each FOMC meeting m:

1. For each 5-minute clock bucket t^{5M}, collect the one-minute volumes

$$\{V_{m,d-i,t}\}_{i=1}^{30,\ t\in t^{5M}}$$

for the 30 business days prior to the announcement. Rather than resample individual minutes i.i.d., we perform a day-level cluster bootstrap (Rao and Wu, 1988):

- Draw 30 trading days with replacement from the 30-day window.
- For each drawn day, include all 5 one-minute observations in that day.
- Compute the overall mean of the pooled one-minute observations.
- Repeat $B = 5{,}000$ times to form the bootstrap distribution of the mean.
- Take the empirical 0.5% and 99.5% percentiles of these bootstrap means, denoted $\widetilde{V}^{\text{Normal},0.005}_{m,t^{5M}}$ and $\widetilde{V}^{\text{Normal},0.995}_{m,t^{5M}}$.

2. Calculate $V5M_{m,d,t} = \frac{1}{5}\sum_{i=0}^{4} V_{m,d,t-i}$ to smooth the trading volume.
3. Define the upper window bound

$$\overline{x_m} = \min\{x \mid x \geq 10 \text{ and } V5M_{m,d,t+w} < \widetilde{V^{\text{Normal}}_{m,d,t}}^{0.995}\},$$

where x are the minutes after the FOMC press release.

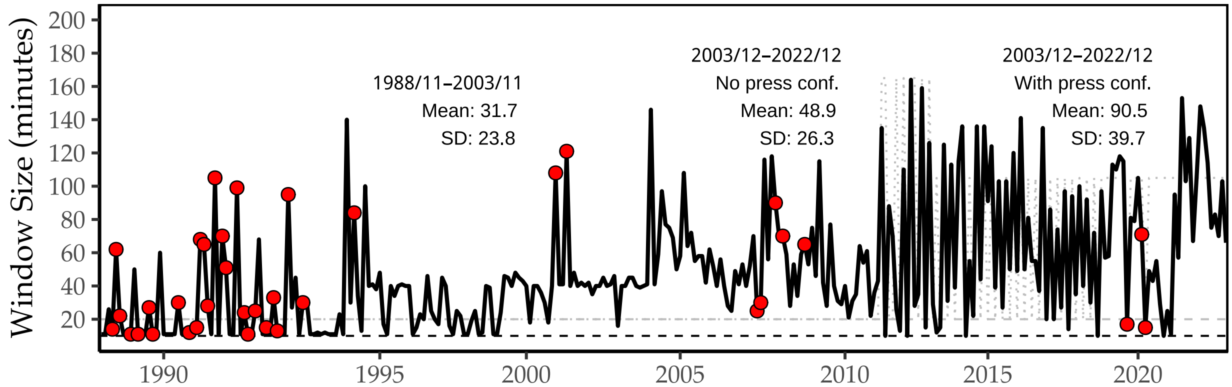
4. If there is a press conference, I check if there is any $t_0 \in [t_{PC}, t_{PC+75}], \forall[t_0, t_0{+}10] \quad V5M_{m,d,t+w} > \widetilde{V^{\text{Normal}}_{m,d,t}}^{0.995}$ from which I restart the search for x.
5. x_m is therefore determined when no new information from the FOMC press release and press conference is incorporated into the trading volume.

This approach delivers three critical insights. The window length $x_m = |\overline{x_m} - \underline{x}|$, the abnormal trading volume $V^{\text{abnormal}}_{m,t} = V5M_{m,t} - \widetilde{V}^{\text{Normal}}_{m,t^{5M}}$, and since all above measures can be linearly combined, the share of each Eurodollar contract volume of the total contract volume $\lambda_{m,d,t,c} = \frac{V_{m,d,t,c}}{V_{m,d,t}}$. It essentially creates the average 1-minute trading volume for a given 5-minute interval t^{5M} over the 30 trading days prior to the FOMC meeting. I implement this procedure for all FOMC meetings m from 1988 to 2024, where volume is the number of transactions between 1988/11-2003/11 and the number of contracts traded between 2004/12 - 2022/12 (see Appendix A).

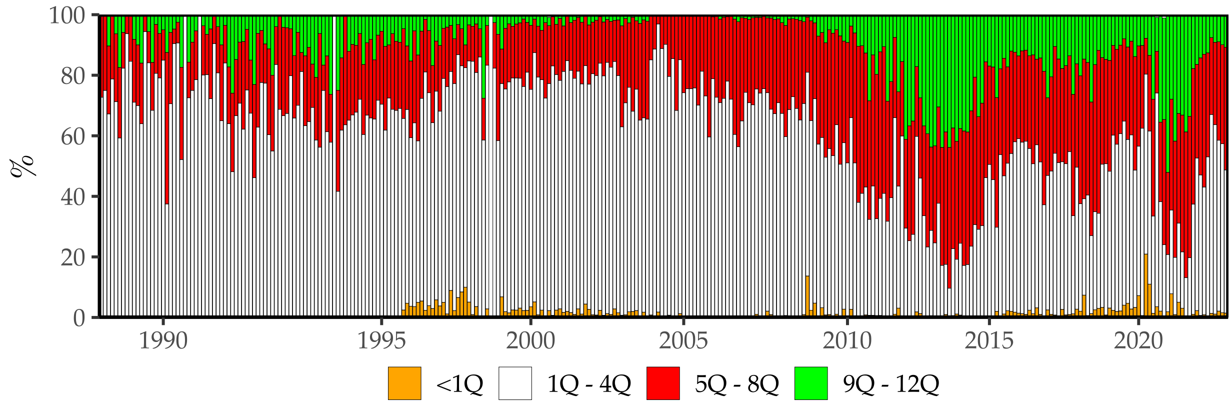
I rely on the non-parametric cluster bootstrap (Rao and Wu, 1988; Davison and Hinkley, 1997) instead create the confidence intervals, the key advantage being that it naturally handles the occurence of zero trading volume in the Eurodollar market, which can occur particularly in early sample periods. I cluster at the day level to account for within-day correlation of the 1-minute trading volume.

Figure 4a shows the resulting upper bounds of window lengths $\overline{x}_m$. The grey dashed line in

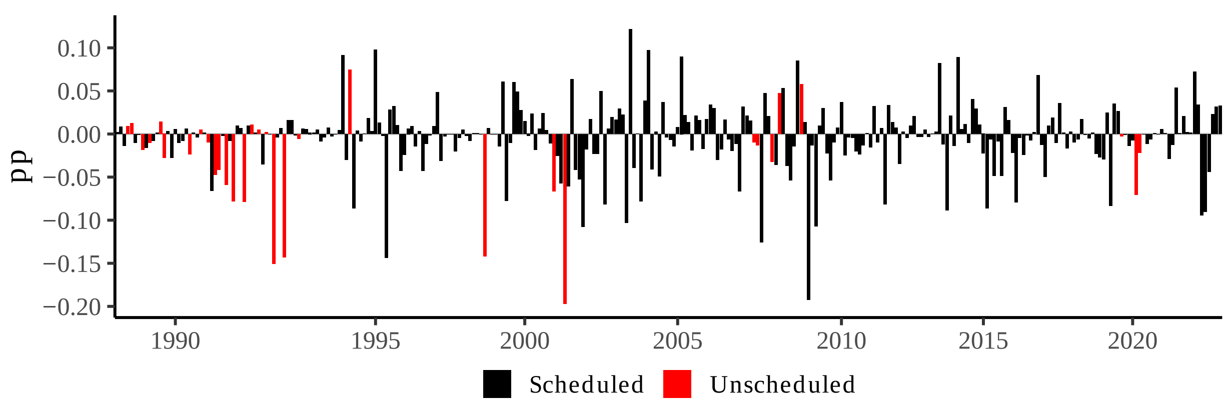
Figure 4: Volume-Based Surprise



(a) Upper Window Bound $\overline{x}_m$



(b) Loadings Λ_m



(c) Volume-based Surprise $\Lambda_m(p_{m,t+\overline{x}_m} - p_{m,t-10})$

The figure shows the announcement-specific window lengths based on abnormal trading volume for the first, fourth and eighth Eurodollar contract. Red dots mark that the window length is based on the first trade that occurs after the FOMC announcement. Grey dots indicate that a press conference took place. The horizontal dashed line marks the 30-minute window length.

the background indicates the upper bound of 20 minutes of the 30 minute window in case only a press statement was released, and an extended window of 105 minutes after the press conference in case it was held. The figure reveals that the estimated average window lengths extends beyond the 30-minute window length, even in the early sample period where these contracts are traded in the Eurodollar pit. The upper average window bound during 1988/11-2003/11 is 35 minutes, with very large outliers around unscheduled announcements and the first ever FOMC press release in 1994/02 which surprised markets. One caveat is that the Eurodollar pit typically closes at 15:00 ET, which allows for a maximum of 45 minutes that is often hit once the FOMC accompanies its monetary policy actions with a press release at 14:15 ET.

With the advent of electronic trading in 2004, the window lengths become longer, with an average of 50 on days without a press conference and 70 minutes on days with a press conference. One particular large outlier is the FOMC announcement on 2020/03/03, which was an unscheduled cut in the federal funds rate by 50 basis points, which surprised markets and led to a large surge in trading volume throughout the trading day.

While press conferences introduce new information (Gómez-Cram and Grotteria, 2022) and therefore makes longer windoe lengths necessary (Acosta et al., 2025), it is striking that the even without new information, the average window length is longer than what the tight 30-minute window (Gürkaynak et al., 2005) would suggest. In addition, the role of press conferences varies significantly over time, with their role being particularly pronounced during 2013 to 2015 and 2020 to 2022, when the Federal Reserve communicates about the lift-off from the zero lower bound (Narain and Sangani, 2023).

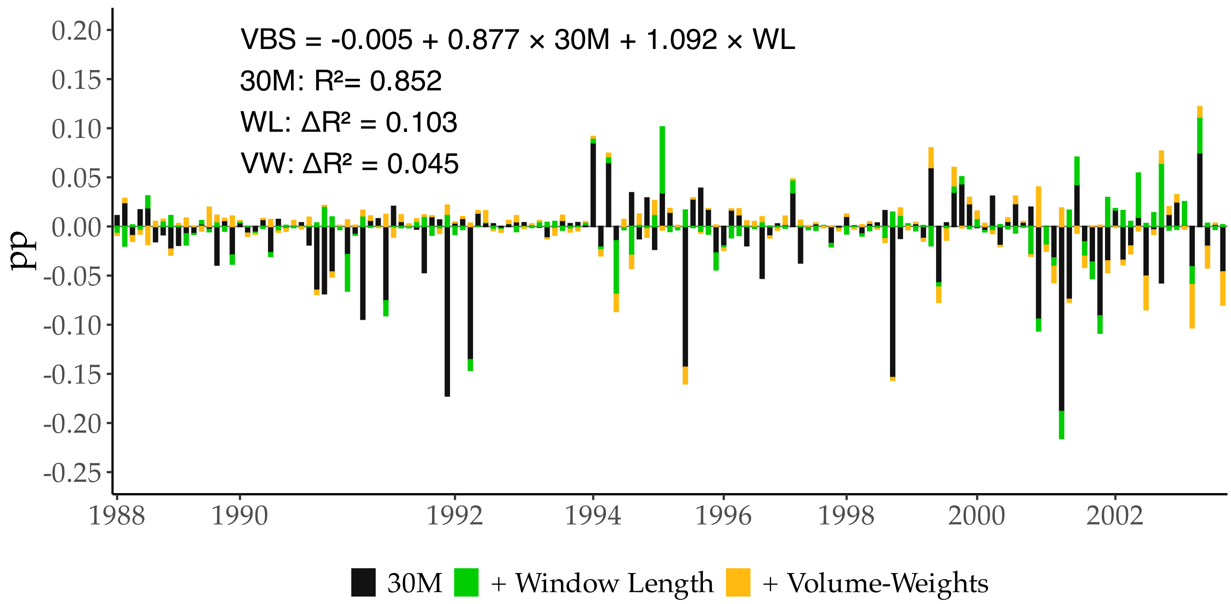
The second panel 4b shows the loadings Λ_m of the volume-based surprise. The loadings are defined as the share of the total Eurodollar market volume that is traded in a given contract c at time t after the FOMC announcement. Within the figure, the loadings are summed up for each bucket of contracts, where the color indicates the horizon bucket. It shows loadings that are stable over time with volume concentrated in the first four quarterly Eurodollar contracts, with the rest mostly being concentrated in the 4th to 8th quarterly contract.

At the zero-lower-bound at the end of 2008, the share of the 8th - 12th Eurodollar contracts increases significantly over time and at its peak in 2013 over 40% of the volume is concentrated in this segment. During this period, the share of the 1st - 4th Eurodollar contracts falls below 20% of the total volume. Throughout the rest of the sample, the share of the 8th - 12th Eurodollar contracts remains elevated at least 10% of the total volume. In summary, the Eurodollar market shifts substantially across time towards the contract in which market participants receive the most information from the FOMC communication. Using fixed loadings with contracts only up to the 4th quarterly contract can miss the contracts in which trading is concentrated.

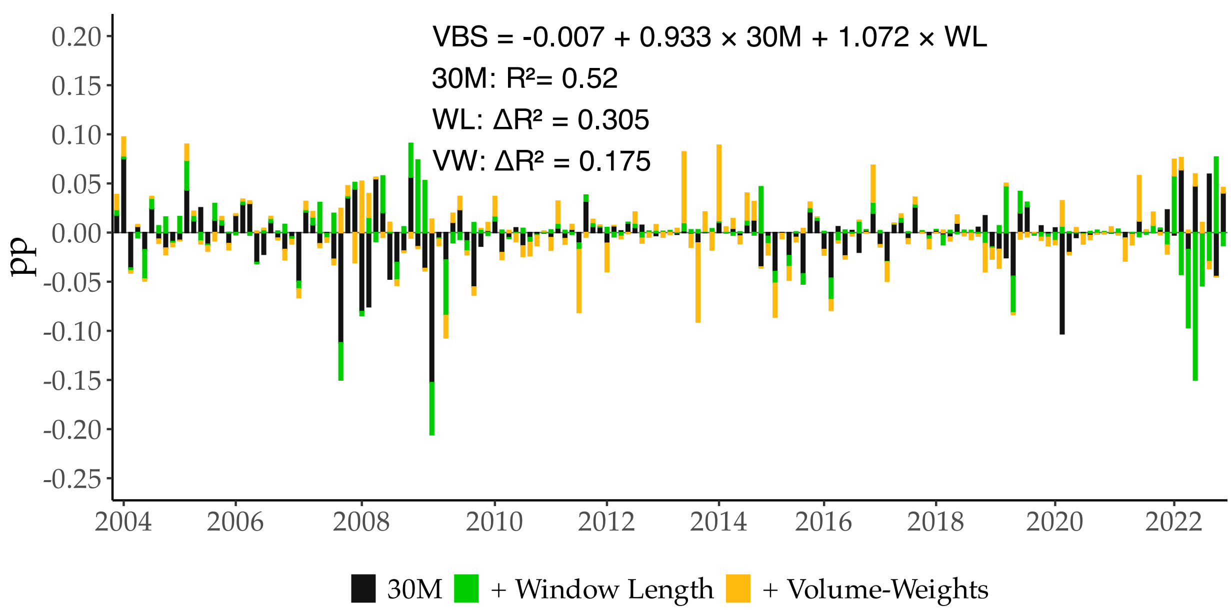
The final panel 4c shows the volume-based surprise, which is the product of the loadings

Figure 5: Decomposing the Volume-Based Surprise

(a) 1988/11-2003/11



(b) 2003/12-2022/12



The figure shows the decomposition of the volume-based surprise into three components. The first component is the 30-minute PNS surprise, which is the standard measure of monetary policy surprises. The second component is the volume-based surprise that is explained by the window length (WL) and the third component is the volume-based surprise that is explained by the volume-weighting (VW). The window length component is the residuals of a regression of the first principle component of the first four Eurodollar futures with flexible window lengths x_m on the 30-minute PNS surprise. The volume-weighting component is the residual variation in the volume-based surprise after regressing it on the PNS and the WL component. The decomposition is implemented separately between 1988/11 - 2003/11 () and 2003/12 - 2022/12.

and the price change in the Eurodollar market. The largest surprises are often on unscheduled FOMC announcements, which is a common feature of any monetary policy surprise measure. Crucially, there are large surprises during 2010 - 2020, which suggests that the Federal Reserve's communication during this period caused repricing in the Eurodollar market.

Does the volume-based surprise capture the same information as the 30-minute PNS? To answer this question, I decompose the PNS surprise into three components in Figure 5 which are obtained as follows. I regress the volume-based surprise on the 30-minute PNS surprise and obtain the residuals which I call "VBS: Unexplained" throughout the paper. The R-Squared of this regression quantifies how much of the variation in the volume-based surprise is explained by the 30-minute PNS surprise.

Secondly, I decompose the VBS: Unexplained into a part that is explained by the window length (WL) and the volume-weighting (VW). The window length component is created from the residuals of a regression of the first principle component of the first four Eurodollar futures with flexible window lengths x_m on the 30-minute PNS surprise. This isolates the additional information that is captured by the volume-based surprise due to just extending the windows. Regressing the VBS on it and the PNS quantifies the variation due to the window length.

The volume-weighting component is the residual variation in the volume-based surprise after regressing it on the PNS and the WL component. This decomposition is implemented seperately between 1988/11 - 2004/11 and 2004/12 - 2022/12.

The decomposition reveals a substantial shift between the VBS and PNS. In the early sample period, up to 84% of the variation in the VBS is explained by the PNS with only 11% of the variation being explained by the window length and 5% by the volume-weighting. This can explain why Gürkaynak et al. (2005) do not find meaningful differences between using their tight window of 30 minutes and their wider window of 60 minutes. The window length leads to differences is when the Federal Reserve starts to introduce press statements in 1994, and the volume-weighting starting from 2002. However, these differences are dwarfed in size by the large easening surprises captured by both surprise measures.

This stands in stark contrast to the later sample period, where only 55% of the variation in the VBS is explained by the PNS, while 28% of the variation is explained by the window length and 17% by the volume-weighting. The volume-weighting component picks up a lot of the movement during zero lower bound period, where there are no large surprises in the PNS. This suggests that the volume-based surprise is capturing information that is not reflected in the PNS during this period. In addition, the window length component shows its importance during the tightening cycle that started in 2022 where a disconnect between the PNS and the VBS, capturing the information during the press conferences if they matter to markets, emerges.

Figure **??** discusses announcements where the decomposition shows large differences between the VBS and PNS or the window lenghts are particularly pronounced. On February 2 1994, the FOMC released a statement, delivering a rationale for its rate hike for the first time in its history. This caught markets by surprise (The New York Times, 1994) and led to a continuous surge in transactions with implied rates of the first Eurodllar contract gradually pushing upwards. However, even though the window is substantially longer the resulting volume-based surprise is very close to the PNS.

On February 1, 1995, the Federal Reserve raised interest rates by 25 basis points which left market participants wondering when the peak of the tightening cycle would be reached (The New York Times, 1994) . The volume-based surprise is substantially larger than the PNS, mainly driven by the longer window length. The FOMC press release introduces a spike in transactions, that is sustained until the close of the Eurodollar pit at 15:00 ET. Implied interest rates of the first Eurodollar contract are quite volatile in the first 20 minutes after the FOMC announcement, but then continue to rise to their new level 10bp above the pre-announcement level.

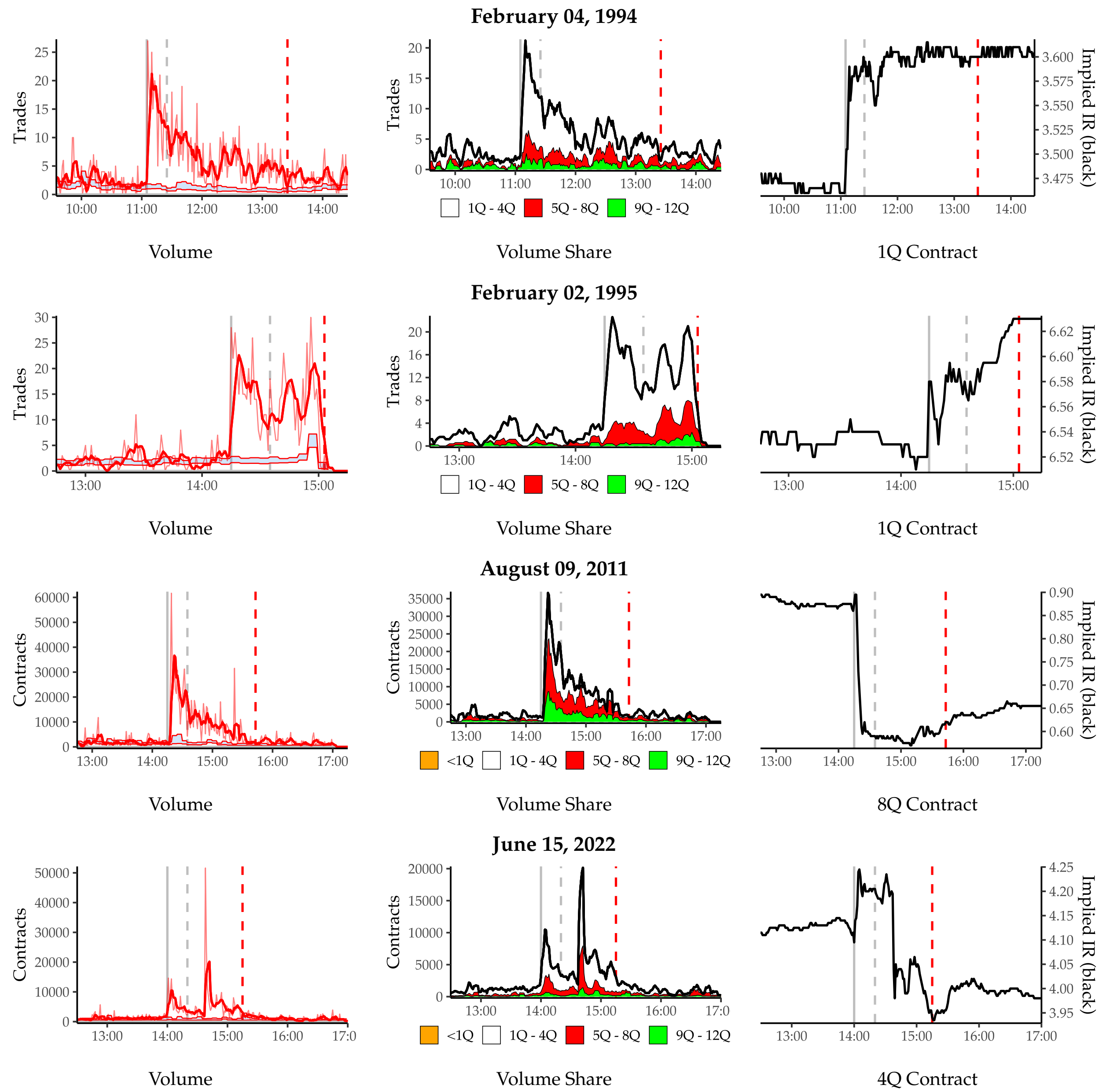
On August 09, 2011, where the Federal Reserve announced that economic conditions are "likely to warrant exceptionally low levels for the federal funds rate at least through mid-2013" (Board of Governors of the Federal Reserve System, 2011). At this explicit forward guidance announcement, trading volume is concentrated at the longer horizons and the price of the eight-quarter Eurodollar future drops substantially. This leads to a large volume-based surprise, which is driven by volume-weighting component while the PNS is close to zero.

On June 15, 2022, where the Federal Reserve raised interest rates by 75 basis points, which was the largest increase since 1994. However, during the press conference, Federal Reserve Chair Jerome Powell indicated that the Federal Reserve raises of this size were not likely "be common" (Powell, 2022), which led to a large repricing in the Eurodollar market. The volume-based surprise, based on a upper window bound of 75 minutes, picks up this new piece of information, which is not captured by the 30-minute PNS.

In summary, the volume-based surprise captures how the Eurodollar market reacts to the FOMC announcements and its press release. For large unexpected announcements, this process can take a long time. On the other hand, for announcements with press conferences, there is new information to which the Eurodollar market reacts. The volume-weighting allows the surprise to flexibly adapt to the contracts in which trading, and therefore most information, is impounded into prices.

A concern is that the flexible windows based on abnormal volume might be adversely affected by the presence of other macroeconomic news releases. To address this concern, I download

Figure 6: Examples: Eurodollar Market Response to FOMC Announcements



The figure shows the smoothed volume (in red) and implied interest rate (in black) for the fourth Eurodollar contract on 2005-03-22. The vertical line indicates the FOMC announcement at 13:15 Chicago/ 14:15 New York time. The dashed vertical grey line indicates the end of the 30-minute window. The blue-shaded area with red boundaries indicates the bootstrapped 99.5% and 0.005% confidence interval of the volume in a given minute over the past 31 trading days. The dashed red vertical line indicates where the trading volume falls into the blue-shaded area and trading volume has returned to normal.

all macroeconomic news releases from Bloomberg Economic Calendar between October 1996 and December 2019 and keep the ones that occur on the FOMC announcement day and have a Bloomberg relevance score bigger than 0. In total, this encompasses the 125 most important news releases for the economy.

Most major macroeconomic news releases only occur prior to the FOMC press release. In particular, Table 1 shows that before 174 FOMC announcements some economic news releases occur, of which on 37 days it is a major news release. A major news release is defined if it is in the top 5 most relevant news releases of the day as classified by Bloomberg and consists of the Non-Farm Payrolls, Jobless Claims, GDP, CPI and ISM Manufacturing Press Releases.

Table 1: Economic News on the FOMC Announcement Day

		Prior (N=174)		After (N=30)	
		Mean	Std. Dev.	Mean	Std. Dev.
News (N.)		2.0	1.0	1.0	0.2
Clostest Release (Minutes)		273.9	98.1	172.9	101.7
		N	Pct.	N	Pct.
NFP | INJ | GDP | CPI | ISM	FALSE	128	73.6	30	100.0
	TRUE	46	26.4	0	0.0

The table describes summary statistics for all economic news releases of the Bloomberg Economic Calendar that occur on the FOMC announcement day between December 1996 and December 2019. It separates those into news release prior and after the FOMC press release. For each category, it calculates the average number of news releases and their distance to the press release. The last row verifies if important macroeconomic news releases occur prior or after the FOMC press release.

In contrast, there are no major news releases after the FOMC press release. However, there are still news releases that occur after 30 FOMC announcements. Table 2 displays these news releases, their ranking among the 125 most important news releases and during which sample they overlap. 16 of these 24 news releases can be attributed to the Langer Consumer Comfort survey, which is released at 5pm New York time. In all of those cases, the volume-based window length ends before the news release occurs.

Table 2: News Releases after the FOMC Press Release

Release	Meetings	Ranking	First Meeting	Last Meeting	Min Distance	News in Window
Consumer Credit	2	77	2002-05-07	2007-08-07	45	1
Langer Consumer Comfort	18	52	2005-03-22	2008-12-16	165	0
Monthly Budget Statement	4	36	2007-08-10	2013-10-30	90	2
U. of Mich. Sentiment	1	6	2007-08-17	2007-08-17	120	0
Pending Home Sales MoM	1	35	2008-10-08	2008-10-08	180	0
Wards Total Vehicle Sales	3	73	2010-11-03	2013-05-01	110	0
Net Long-term TIC Flows	2	40	2016-06-15	2017-03-15	120	0

The table displays news releases which occur after the FOMC press release between December 1996 and December 2019.

There is only three cases where the post-announcement news release overlaps with the volume-based window length. On August 7, 2007, the Consumer Credit report is released at 15:00 New York time. The volume-based window length for the fourth Eurodollar contract ends at 15:00 New York time. However, the Consumer Credit report ranks only at 76 out of 125 news releases.

Therefore, I conclude it is unlikely that the volume-based window lengths are influenced by other news releases.

Secondly, the Treasury budget report is released jointly with the start of the press conference in September and December 2012. In both cases, the volume-based surprises picks up a spike in volume later then booth release dates, suggesting this is due to new information revealed by chairman Bernanke during the press conference. Appendix [TO BE DONE] shows more narrative evidence for these cases.

An important aspect of the communication of the Federal Reserve is its statement. The statement is released jointly with the interest rate decision and provides a rationale for the decision. Media reports often focus on the statement, and provide markets immediately with a summary of the changes[4]. Therefore, changes in the statement are a key piece of information for market participants.

This is in line with theoretical models of information processing after public announcements where the signal precision is a key determinant of the volume and trading dynamics. In particular, in concurrent (Cocoma and Jensen, 2023) show the comovement between signal precision and trading volume can be very helpful in distinguishing between rational and disagreement-based models of information processing. In their framework, a more precise public signal should leads investors who disagree to put more weight on their own signal and therefore increases trading volume. The effect is reversed if investors share common priors.

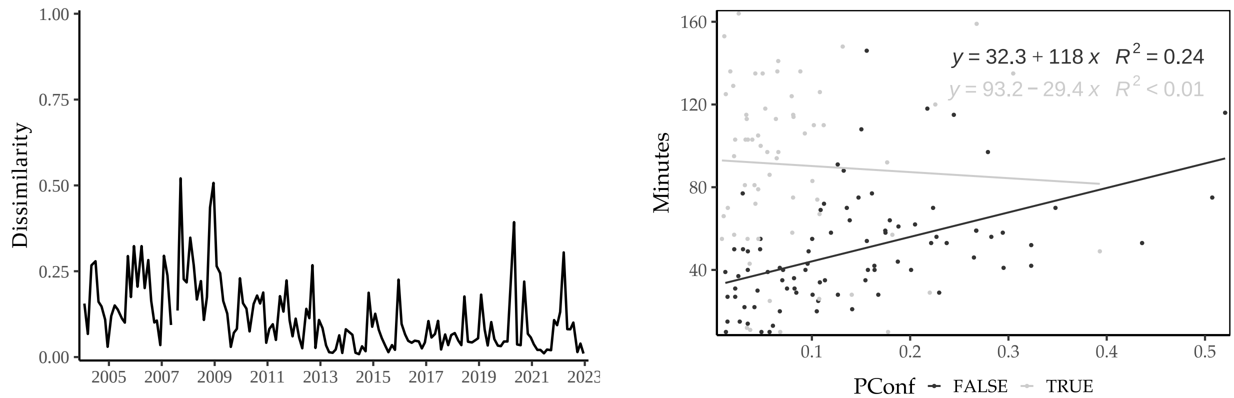
Therefore, studying the changes in the statement can provide a proxy for the signal precision. I develop a text-based measure of statement dissimilarity, which is calculated as the cosine similarity between the FOMC statement and the previous statement. I derive this measure on a per-statement basis on the term-frequency times inverse document-frequency calculated upon the current and all prior statements. The statement dissimilarity is displayed in Figure **??** and shows that the statement dissimilarity is correlated with the window length. This suggests that the statement dissimilarity is a key determinant of the volume-based window length.

I then estimate the impact of the statement dissimilarity on the window length. Table **??** documents these estimations based on the panel of window-lengths and volume per contract over all FOMC announcements. The results suggest that the statement dissimilarity is positively correlated with the window length. In particular, a 0.1 increase in the statement dissimilarity is associated with a 11.8 minute increase in the window length.

The results show that changes in the informational content of the statement, which can proxy

[4] For instance, the Wall Street Journal provides a "Fed Statement Tracker" which highlights changes in the statement. Its current version can be found here

Figure 7: Statement Dissimilarity and Its Correlation with Window Length



(a) Statement Dissimilarity

(b) Statement Dissimilarity is correlated with Window Length

Statement dissimilarity is calculated as the cosine similarity between the FOMC statement and the previous statement. A larger value signifies more changes in the statement. More details are provided in the appendix. The table shows the results of the following linear model

$$y_{c,m} = \alpha_{c,m} + \beta Z(Dissimilarity_m) + \epsilon_{c,m}$$

where c denotes contract and m denotes FOMC meeting m. The outcome variable y and the fixed effects α vary across specifications.

for signal precision, are a key determinant of the window length. This evidence is not necessarily causal since the Federal Reserve does not randomly change the statement. Additionally, it can not be used to distinguish between rational and disagreement-based models of information processing as of now. This would require on taking a stance if providing more information/ changing the statement is making the signal more precise or noisier. However, the results suggest that absolute changes in the statement are a key piece on which market participants focus on.

4 Results

In this section, I analyze the impact of volume-based monetary policy surprises on financial markets and the economy and compare the results to using the 30-minute Policy News Surprise (PNS) (Gürkaynak et al., 2005; Nakamura and Steinsson, 2018).

4.1 Event Studies

To gauge the impact of monetary policy surprises on financial markets, I use the typical event study approach, which traces out the impact of the surprise on short-run asset prices, such as Treasury yields and stock prices as in Gürkaynak et al. (2005) & Bernanke and Kuttner (2005).

I estimate the following regression at announcement-level m

$$y_m = \alpha + \beta \cdot s_m + \epsilon_m \tag{4}$$

where y_m is the change in asset y at announcement m and s_m is the respective monetary policy surprise at announcement m.

The surprises are the volume-based monetary policy surprise (VBS) and the 30-minute window-based Policy News Surprise (PNS). To test if the volume-based surprises contain additional information I use the variation in VBS that can not be explained by PNS. In order to make the estimated $\hat{\beta}$ comparable across surprises, I standardize surprises such that all coefficients can be interpreted as the change in asset y to a 1SD increase in the monetary policy surprise.

The analysis is conducted in two samples. The first sample runs from November 1988 to November 2003, which is similar to the sample in Gürkaynak et al. (2005) and Bernanke and Kuttner (2005), and prior to the availability of electronic trading volume data for Eurodollar futures. During this period, monetary policy is mainly conducted through the federal funds rate and short-run guidance on the future path of monetary policy (Lunsford, 2020). The second sample runs from December 2003 to December 2022, which contains the zero-lower bound period, expanded forward guidance and the introduction of the press conference in 2011. These changes in monetary policy implementation present a challenge for the identification of monetary policy surprises. In both samples, I exclude all unscheduled FOMC announcements after 1994, as these occur mostly during periods of financial distress and can lead to large outliers in the data. Prior to 1994, the FOMC did not disclose its actions to the public and uses unscheduled announcements more frequently.

Table C.1 presents the results of the event study for the Treasury market, where the outcome variables are daily changes in Treasury securities from the Federal Reserve's H.15 report. During the early sample period, the treasury market reacts strongly to both surprises and the estimated coefficients and R-squareds are similar in size. The largest difference in cofficients and explained R-squared is observed for the 3-Month Bill rate, suggesting that the PNS captures larger level shifts in the short-term interest rate. However, the unexplained variation in the VBS is not significantly different from zero suggesting that there is no fundamental difference which is responsible for the difference in the estimated coefficients.

The picture substantially changes in the later sample period. The estimated coefficients for the PNS are no longer significant at the 3-month and 10-year horizon, and the R-squared drop by 18 - 39 percentage points. While this effect may be expected for the 3-month Bill rate as the fed funds rate is at the zero lower bound for approximately nine years, it suggests that the FOMC lost its ability to affect longer-term interest to the same policy paths before 2004. This begs the question of wether monetary policy lost its ability to influence the term structure of interest rates or whether the PNS is not sufficiently capturing monetary policy surprises that do not work through level shifts in the fed funds rate.

Table 3: Treasury Market - Event Study Results

	1988/11 - 2003/11 (n= 141)			2003/12 - 2022/12 (n= 142)		
	PNS	VBS	VBS ⊥ PNS	PNS	VBS	VBS ⊥ PNS
Dep Var: 3M Bill						
Estimate	0.049***	0.038***	-0.014	0.006	0.009**	0.007**
SE	(0.005)	(0.006)	(0.009)	(0.005)	(0.004)	(0.003)
R^2	0.416	0.243	0.027	0.027	0.084	0.051
Dep Var: 1Y Treasury						
Estimate	0.051***	0.049***	0.007	0.016***	0.026***	0.021***
SE	(0.004)	(0.005)	(0.007)	(0.006)	(0.004)	(0.006)
R^2	0.467	0.420	0.001	0.153	0.426	0.270
Dep Var: 5Y Treasury						
Estimate	0.042***	0.044***	0.016**	0.020**	0.052***	0.052***
SE	(0.004)	(0.004)	(0.007)	(0.009)	(0.006)	(0.005)
R^2	0.310	0.349	0.041	0.074	0.524	0.518
Dep Var: 10Y Treasury						
Estimate	0.027***	0.031***	0.015**	0.009	0.034***	0.037***
SE	(0.004)	(0.004)	(0.007)	(0.007)	(0.006)	(0.004)
R^2	0.189	0.243	0.053	0.014	0.291	0.360

This table reports the estimated coefficients of a regression selected Treasury market yields on the respective monetary policy surprise. All dependent variables stem from the Federal Reserve H.15 report and can be found here. Reported standard errors are heteroskedasticity-robust (HC3) and the stars indicate significance at the 10%, 5% and 1% level.

Table 4: Equity Market - Event Study Results

	1988/11 - 2003/11 (n= 141)			2003/12 - 2022/12 (n= 142)		
	PNS	VBS	VBS ⊥ PNS	PNS	VBS	VBS ⊥ PNS
Dep Var: SP Future						
Estimate	-0.217***	-0.172***	0.006	-0.298***	-0.435***	-0.321***
SE	(0.035)	(0.050)	(0.054)	(0.033)	(0.060)	(0.096)
R^2	0.251	0.139	-0.007	0.401	0.317	0.169
Dep Var: VWRETX						
Estimate	-0.198***	-0.179**	-0.006	-0.218	-0.445***	-0.404***
SE	(0.070)	(0.078)	(0.076)	(0.137)	(0.111)	(0.123)
R^2	0.046	0.036	-0.007	0.029	0.146	0.119

This table reports the estimated coefficients of a regression of the stock market return on the respective monetary policy surprise. The S&P Future Return is calculated from the price of the E-Mini (Ticker: ES) contract after 1998 and the broad SP Future (Ticker: SP) in earlier sample periods. It is measured over the same window as the surprise. In the first column, the window is the 30-minute window, while in the second and third column, the window is the flexible window length. The daily CRSP value-weighted stock market return is measured on the day of the announcement. Reported standard errors are heteroskedasticity-robust (HC3) and the stars indicate significance at the 10%, 5% and 1% level.

The results confirm the latter intepretation. The VBS, during the same sample period, has a stronger impact on the entire term structure that is statistically significant. The estimated coefficients to the VBS are up to 3.7 times higher and R-squared increase up to 40 percentage points compared to the PNS. However, in contrast to the PNS, these coefficients are similar in size and explained variation for the 5-year and 10-year Treasury yield in the early sample period. This shows that surprise measurement creates a significant difference in the estimated coefficients and the explained variation in the Treasury market. While the influence of monetary policy on the short-end of the yield curve is lost at the zero lower bound, its guidance on the future path of monetary policy is active and similarly effective.

Monetary policy does not only affect rates but also the equity market. The literature documents a sizable and negative effect of a contrectionary monetary policy surprises on stock prices (Gürkaynak et al., 2005; Bernanke and Kuttner, 2005). To quantify the short-term impact of monetary policy on financial markets, I analyze the equity market response, measured over the same window, to the monetary policy surprise. Table C.2 presents the regression coefficients of a regression of the return of stock market indices to monetary policy surprises. The S&P Future Return follows the approach by Gürkaynak et al. (2005) where the equity return is measured over the same window as the monetary policy surprise. The CRSP value-weighted stock market return on the other hand is measured on the day of the announcement (Bernanke and Kuttner, 2005).

Table C.2 reaveals a similar striking pattern for the equity market. Between 1988 to 2004, both

Table 5: Event Study Results Decomposed

	PC + No PC			No PC		
Dep Var:	1Y	10Y	VWRETX	1Y	10Y	VWRETX
Constant	-0.006**	-0.002	0.209**	-0.002	0.004	0.120
	(0.002)	(0.004)	(0.092)	(0.004)	(0.006)	(0.144)
PNS	0.018***	0.007	-0.227*	0.014**	0.004	-0.313
	(0.004)	(0.005)	(0.129)	(0.006)	(0.006)	(0.200)
+ WL	0.025***	0.022***	-0.353***	0.019***	0.019***	-0.062
	(0.006)	(0.004)	(0.131)	(0.003)	(0.006)	(0.281)
+ VW	0.002	0.032***	-0.206	0.004	0.033***	-0.249
	(0.004)	(0.004)	(0.139)	(0.008)	(0.006)	(0.409)
R2 Adj.	0.555	0.406	0.145	0.463	0.331	0.099
Num.Obs.	142	142	142	80	80	80

This table reports the estimated coefficients of a regression selected Treasury market yields on the decomposed monetary policy surprise. The monetary policy surprise ... Reported standard errors are heteroskedasticity-robust (HC3) and the stars indicate significance at the 10%, 5% and 1% level.

monetary policy surprises lead to a large negative effect on equity market. However, between 2004 to 2022 the VBS leads to a substantially larger negative, that doubles in size compared to the PNS and the earlier sample period. This effect is present in the intraday as well as the daily event study. Similarly, the explained variation of the daily return increases from 4% up to 14% and the intraday return from 18% to 32%.

This begs the question what part of the volume-based surprise is responsible for the difference in the estimated coefficients. To that end, I decomposed the unexplained portion of the VBS into window length (WL) and volume-weighting (VW). Table 5 documents the estimated regression coefficients of the decomposed volume-based surprise for the late sample period.

The results show that the window-length component has a significant impact for all dependent variables. This could be either driven by new information revealed during the press conference or more fundamental effects how markets process the information from the press release. To that end, I reestimate the regression in the subsample without press conferences. It shows that while for equity markets the results disappear without the press conferences, they remain present

For the 10-Y Treasury yield, the volume-weighting component is large and positive with the estimated coefficients being larger than the window-length and PNS respectively. This is not surprising, as the volume-weighting allows the surprise to capture the information in the relevant segment of the Eurodollar market, which can be in futures rate with a maturity of up to 3 years. Under standard no-arbitrage arguments, the implied futures rate should be closely related to the 3-year forward rate and therefore substantially affect the 10-Y Treasury yields.

In contrast, the equity market response is entirely enhanced due to the window length and not substantially affected by the volume-weights.

4.2 Macroeconomic Impact

The analysis of high-frequency monetary policy surprises, pioneered by Gertler and Karadi (2015), has been instrumental in understanding the impact of monetary policy on the economy. Under some identifying assumptions, the monetary policy surprises identify the structural monetary policy shock (Stock and Watson, 2018) and the impact of these shocks on the economy can be traced out using impulse response functions (IRFs).

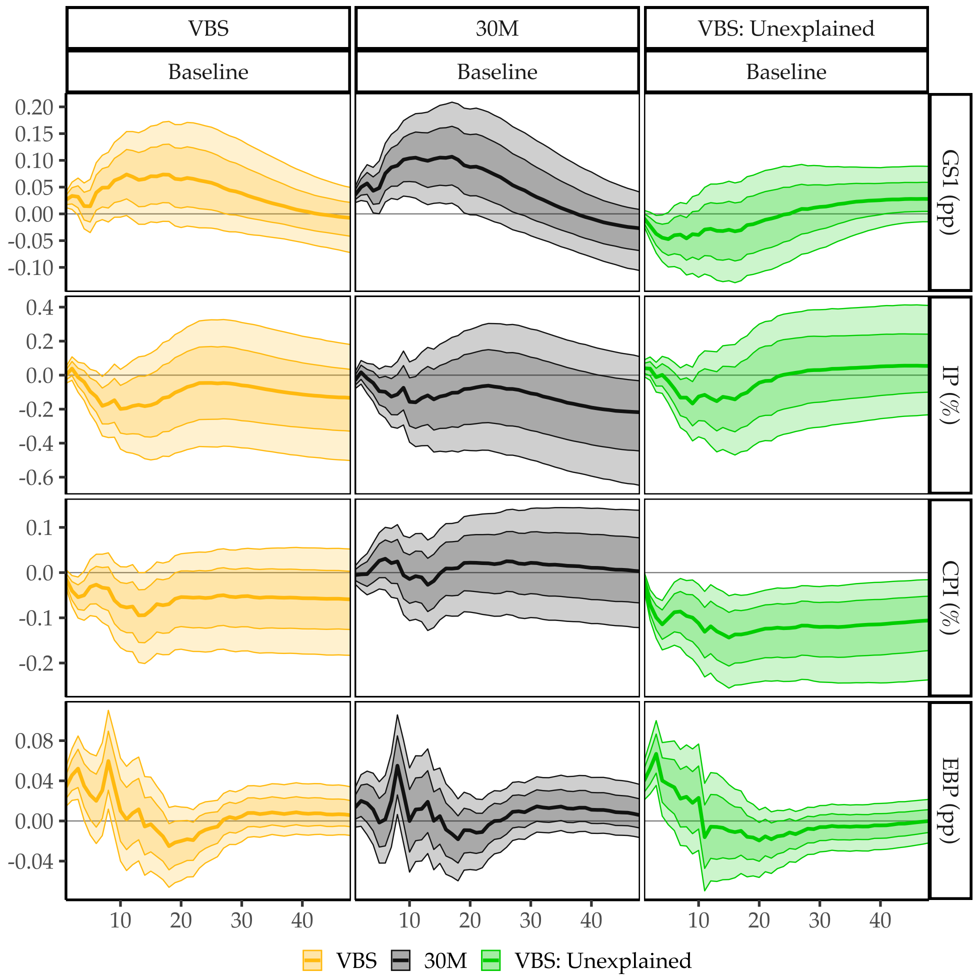
One of the key issues, highlighted by Ramey (2016), is the choice of sample period. The IRFs of the economy to monetary policy shocks are stronger in samples that include the 60s and 70s and do not hold up well in later samples. Ramey argues that this is due to the fact that monetary policy is being conducted more systematically leading to less surprises and making it more difficult to identify a monetary policy shock.

Therefore, I test if the volume-based monetary policy surprises can recover the effects of monetary policy on the economy during the later years, in particular during a sample from 1988/11 to 2020/02. To assess the impact, I use a Bayesian Vectorautoregressive model with flat priors from the Ferroni and Canova (2021) toolbox. Similar to Gertler and Karadi (2015), I choose a lag length of 12 and include the 1-year government bond yield (GS1), the excess bond premium (EBP) and output, measured by Industrial Production (IP), and inflation, measured by the CPI in the VAR.

I estimate this VAR separately for the VBS and PNS, as well as the unexplained portion of the VBS, which is orthogonal to the PNS. The respective monetary policy surprise is ordered first in the VAR and the structural shocks are identified via short-run restrictions. This is akin to the internal instrument approach (Plagborg-Møller and Wolf, 2021), although I do not rescale to a unit effect on the 1-year government bond yield but rather express all impulse response functions in terms of a 1SD increase in the respective monetary policy surprise. The key advantage is that the impulse-response function to the monetary policy surprise are identified under non-invertibility of the VAR. Similar timing assumptions are used in (**??**Jarociński and Karadi, 2020).

The results are presented in Figure 8. It shows that volume-based monetary policy surprises exert

Figure 8: The Impact of Monetary Policy Surprises on the Economy



The figure shows impulse response functions of several financial and macroeconomic variables to 1 SD of the respective monetary policy surprise. 'VBS' refers to the volume-weighted monetary policy surprise, while other columns contain the first principal component of the first four Eurodollar futures '30M' the 30-minute window length. The impulse response functions are obtained from a Vectorautoregressive model with a lag length of 12 and is estimated using the BVAR toolbox by Ferroni and Canova (2021) with a flat prior. The surprise is ordered first and the structural shocks are identified via short-run restrictions. The 68% and 90% credible intervals are based on 10000 draws from the posterior distribution. The sample runs from November 1988 to February 2020 and is at monthly frequency.

a more substantial impact on the macroeconomy than their 30-minute window-based counterparts. Particularly striking is the difference in the inflation response. A contractionary 1SD monetary policy surprise decreases inflation by 0.1% after 12 months, with a response that is significant at the 90% credible interval. In contrast, the PNS leads to a negligible and insignificant response of inflation. To more meaningfully test if there is a difference in the response of inflation, I estimate the unexplained portion of the VBS, which is orthogonal to the PNS.

It is indeed the unexplained variation in the VBS that drives the difference in the response of inflation, that is even larger than the response of the VBS itself. Similarly, the responses of industrial production and excess bond premium move into the same direction between the VBS and PNS, but the VBS leads to a larger response with the unexplained portion of the VBS driving the difference. This comes at a cost of a slightly smaller response of the 1-year government bond yield, with a negative difference that is significant at the 90% credible interval at short horizons.

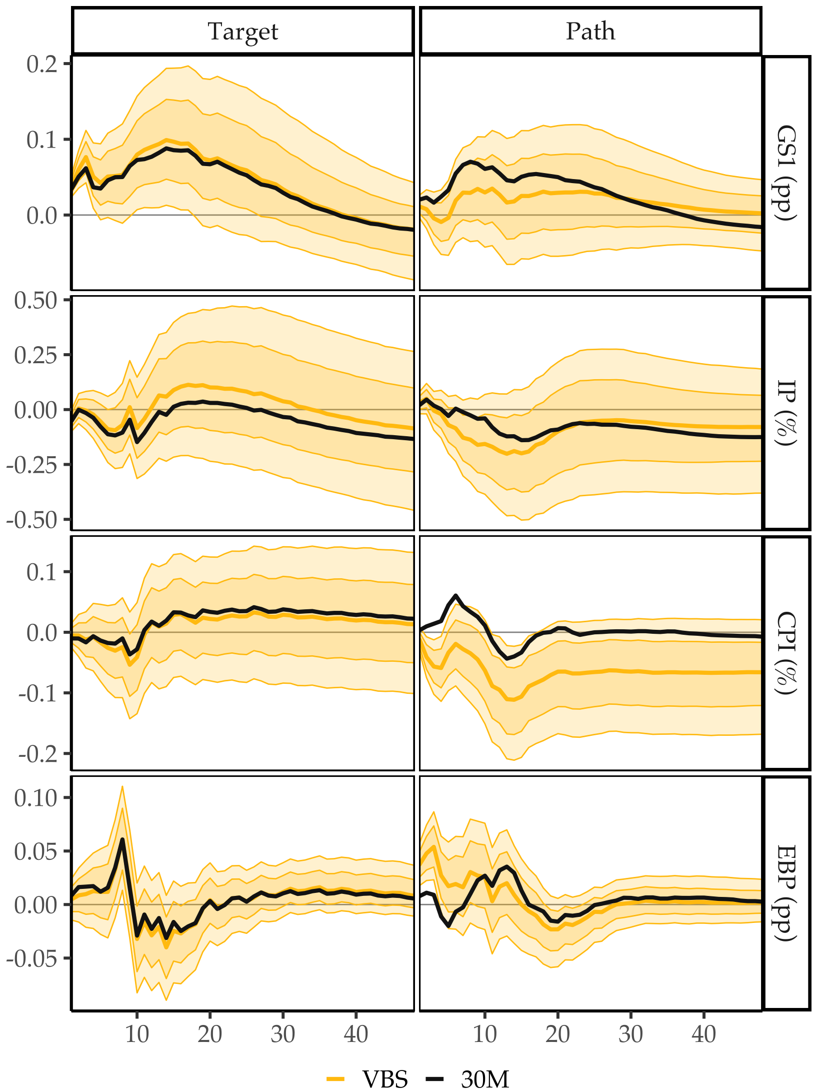
How does this compare to other estimates based on purely high-frequency measures of monetary policy surprises? In Gertler and Karadi (2015), the CPI response to a 1SD monetary policy surprise is small and only significant after around 3 years in a proxy VAR that runs from 1979/11-2012m06 and instrumenting with the three-month Fed Funds future from 1991m01. Using local projections, which automatically reduces the sample to the time frame in which the instrument is available, **?** finds a large discrepancy to the VAR results and no response of inflation to a monetary policy shock.

In the appendix, I verify that the results are robust to different estimation methods, such as local projections (Jordà, 2005), or shrinkage through minnesota priors (Litterman, 1986) which are at the opposite ends of the estimation trade-off between bias and variance (Li et al., 2022). Also different identification schemes such as internal instruments (Plagborg-Møller and Wolf, 2021) and external instruments (**?**), as well as different lag lengths yield similar results.

While the literature has focused a lot on the composite measures of monetary policy surprises, such as the PNS, less attention has been paid if the macroeconomic effects are due the market surprise about the level shift in the fed funds rate (Target) or market's updating their expectations about the future path of monetary policy (Path). Therefore, I decompose the volume-based monetary policy surprise into its Target and Path components, by regressing the VBS on the Kuttner surprise/ MP1 and taking the residuals as the Path component. The PNS is decomposed by following the strategy in Gürkaynak et al. (2005), extracting two principal components from the inputs to the PNS and rotating them such that the second component (Path) does not load on the Kuttner surprise/ MP1.

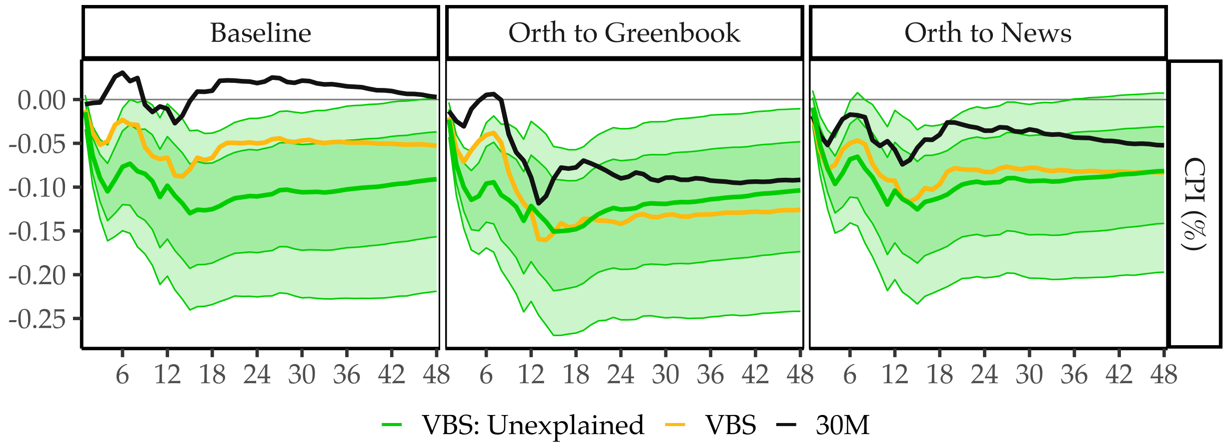
The results are presented in Figure 9 where the first column contains the IRFs to the part of the

Figure 9: The Impact of Monetary Policy Surprises on the Economy - Path vs. Target



The figure shows impulse response functions of several financial and macroeconomic variables to a 1 SD of the respective monetary policy surprise. The impulse response functions are obtained by a Flat Prior BVAR with a lag length of 12, estimated using the BVAR toolbox by Ferroni and Canova (2021). The surprise is ordered first and the structural shocks are identified via short-run restrictions. The 68% and 90% credible intervals are based on 10000 draws from the posterior distribution. The sample is monthly and runs from November 1988 to February 2020.

Figure 10: Reaction to News vs. Fed Information Effect



VBS explained by the Kuttner surprise (Target) jointly with their 90% and 68% credible intervals. In black the IRFS to the 30-minute Target surprise are overlayed. The figure shows that the Target surprise is responsible for the response of the 1-year government bond yield while not having an impact on any of the other variables. The Target component of the VBS and PNS are indistinguishable from each other, which is not surprising giving their construction.

The second columns contains the IRFs to the Path component of the VBS and PNS. The differences between the surprises are entirely driven by the Path component. A contractionary VBS Path component leads to a negative response of inflation and a positive response of the EBP, while PNS Path as well as the VBS Path lead to a decline in output. Another difference is the response of the 1-year government bond yield, which is positive for the PNS Path and of similar size as the Target component, while the VBS Path has no impact on the 2-year government bond yield.

This is surprising as previously documented effects of the Path PNS component on the economy are ambigious. A contractionary PNS Path is shown to increase output forecasts of professional forecasters (Campbell et al., 2012; Nakamura and Steinsson, 2018) and leads to positive responses of output and inflation in VARs (Lakdawala, 2019; Swanson, 2023). This can be partly explained by FOMC forward guidance not giving information about policy inclinations but rather its view about the economic outlook (Lunsford, 2020). Indeed, during the zero lower bound period Path surprises are shown to lead to negative responses of output and inflation similar to the analysis above (Bundick and Smith, 2020).

The above analysis implicitly assumes that any of the monetary policy surprises are surprises about interest rate expectations of market participants. Therefore, the evidence that monetary policy surprises are predictable to financial and macroeconomic news (Bauer and Swanson, 2022) and the Fed Information set (Miranda-Agrippino and Ricco, 2021) is puzzling to say the least and points to either a fed reaction to economic news effect(Bauer and Swanson, 2023) or central bank information effect. To cleanse the surprise, the solution in both papers is to run announcement-frequency regressions, where the monetary policy surprise is the regression residual after adjusting for these predictors. To assess the impact of the economic news, I orthogonalize the VBS and PNS to the predictors in Bauer and Swanson (2022) [5]. Similarly, I orthogonalize the VBS to the Fed Information set as in Miranda-Agrippino and Ricco (2021). Greenbook and Beige Book forecasts are only available with a 5-year lag which limits the sample to 1988/11 to 2019/06. The orthogonalized monetary policy surprises are then used to estimate the IRFs as before.

The results are presented in Figure 10. Each column contains the IRFs of the unexplained portion of the VBS and PNS, with its 90% and 68% credible intervals, and overlays the IRFs of the VBS and PNS for comparison. The first column just repeats the IRFs to the VBS and PNS from Figure 8 for comparison while the latter columns contain the IRFs of the orthogonalized VBS and PNS. The orthogonalization has indeed an impact on the IRFs, particularly for the PNS. In both cases, the response of inflation is now negative and large. However, importantly it shifts the inflation response to the VBS by a similar magnitude and therefore the unexplained portion of the VBS stays highly significant and large. Therefore, the VBS approach is complementary to the orthogonalization approach in identifying the monetary policy shock and its impact on the economy.

5 Conclusion

This paper studies volume on the FOMC announcement day and uses the insights of the asset pricing & microstructure literature to improve upon the surprise identification. For future literature, it would be helpful to have data on trades of individual investors to decompose the volume by investors. Such data could shed light on whether disagreement among investors is the primary driver of volume dynamics around FOMC announcements.

Volume-based surprises offer a valuable tool for event studies aimed at extracting information from prices. Their applicability extends beyond monetary policy settings and could be leveraged in other event study contexts to enhance the precision of surprise identification. Overall, this paper underscores the importance of considering trading volume dynamics in understanding market reactions to policy announcements and highlights the potential of volume-based approaches in event studies.

[5] Data from Bauer and Swanson (2022) is available at https://www.frbsf.org/research-and-insights/data-and-indicators/monetary-policy-surprises/

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Appendix

A Data

The primary dataset for the analysis is the Time and Sales dataset provided by the Chicago Mercantile Exchange. This dataset encompasses all transactions for Eurodollar futures, both in the Trading Pit ("Restricted Trading Hours"/RTH) and electronically on the CME's Globex platform ("Extended Trading Hours"/ETH). It provides transaction timestamps, prices, and, for electronic trading, transaction volumes expressed in the number of contracts.

Historically, Eurodollar futures were traded in the trading pit, with electronic trading initially limited to after-hours sessions. However, since 1999, side-by-side trading has been permitted, allowing simultaneous trading in both the pit and electronically. Notably, electronic trading has become the predominant mode since December 2003(Melamed, 2009).

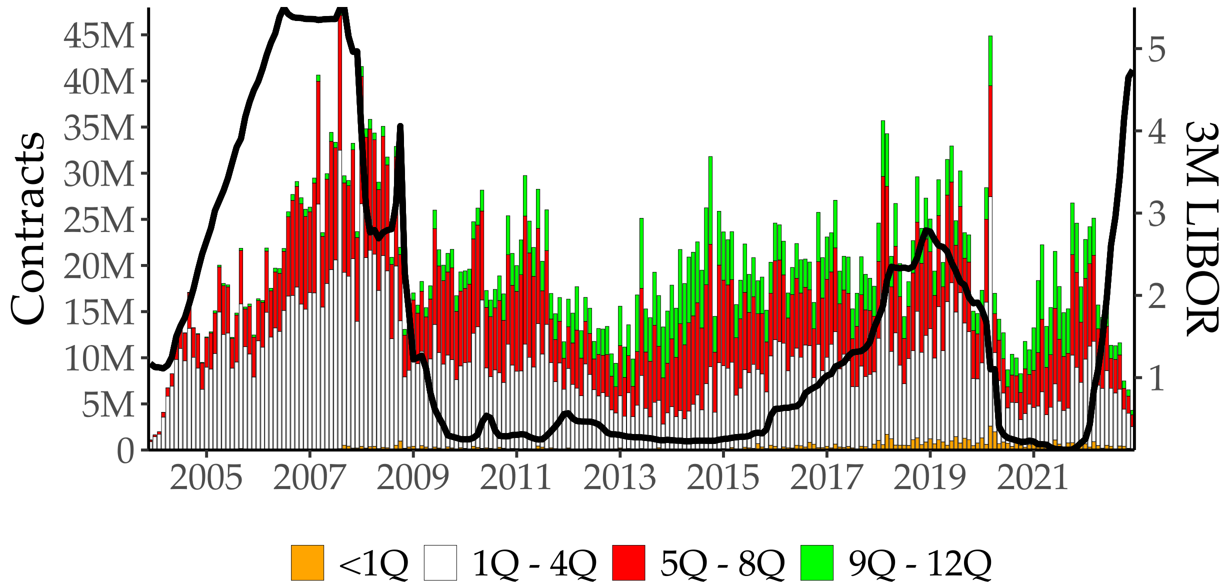
This means that trading volume is only availble from 2003 onwards. I use the number of contracts traded as the measure of volume unless otherwise specified. The contract specification makes transforming volume into dollar volume unnecessary, since the number of contracts traded is directly proportional to the dollar volume by a factor of 2500 to convert it in notional terms or 25 to convert it to DV01. Prior to 2003, trading volume can be approximated by the number of transactions. Under the assumption that the average transaction size is constant, the number of transactions is proportional to the number of contracts traded. This is discussed in more detail in Appendix **??**.

Eurodollar futures prices are quoted as $P_t = 100 - i_{t,s}$, where $i_{t,s}$ is the implied Libor rate (in percentage points) two days prior to the third Wednesday of the delivery month s at time t. Taking differences, $P_{t+1} - P_t = i_{t,s} - i_{t+1,s}$. An investor with a long position in the futures benefits from a decrease in the implied Libor rate, and vice versa. The contracts are standardized such that a 1 basis point change in the futures price corresponds to a \$25 gain or loss per contract. As a heuristic, it is common to interpret the future as having a principal of \$1 million.

Eurodollar contracts are traded continuously throughout the week, apart from a 1-hour maintenance period at 16:00/17:00 (CT/ET). To reduce the dimensionality of the dataset, I focus on the subset between 05:00/06:00 until 16:00/17:00 (CT/ET), the start of the maintenance period. In cases where no trading occurs in a given minute, I use the last available price and set the trading volume to zero.

The focus on trading in the Eurodollar market has shifted from shorter maturities (up to 12 months) to longer-dated contracts (up to 36 months) over the years. Figure A.1 displays the monthly electronic trading volume in the Eurodollar contracts across the market segments up to

Figure A.1: Total Number of Contracts Traded Electronically



The left y-axis displays the number of contracts traded in a given month. The data is summarized by aggregating up the transaction-level data. The figure divides the eight quarterly Eurodollar contracts into 4 groups. The "Orange" contracts contain all monthly serial contracts in the current quarter. The "Whites" denotes the four quarterly serials that expire within 12 months. The "Reds" denotes the four quarterly serials that expire within 13-24 months. The "Greens" denote all four quarterly serials that expire within 25-36 months. The black line indicates the 3-Month USD Libor, the underlying of the Eurodollar future contract.

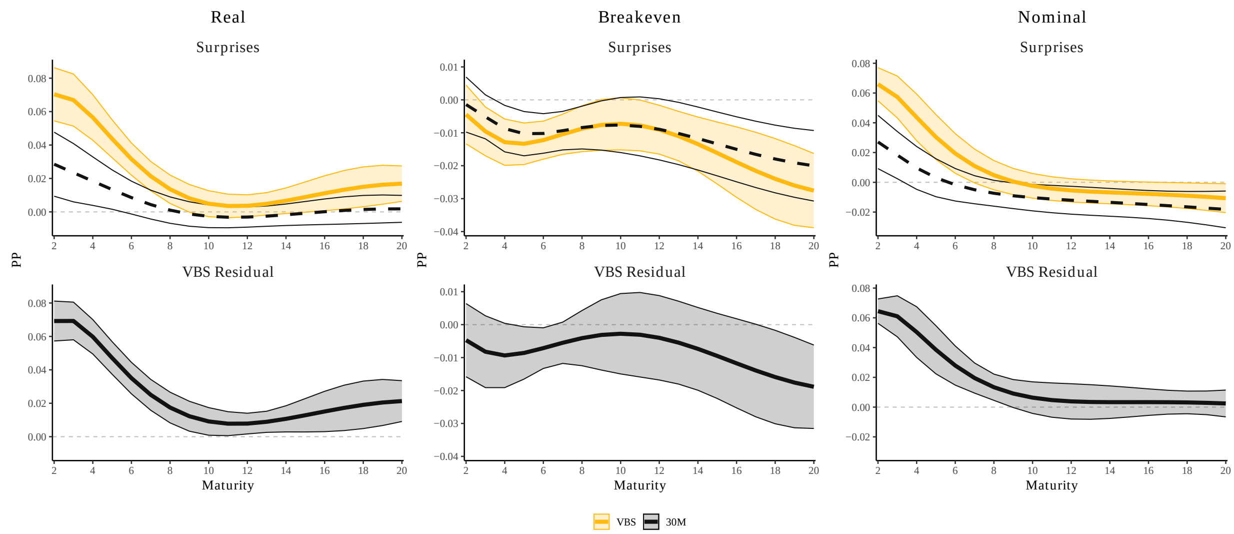
all contracts within three years of expiry. All aggregate statistics are computed based on minute-level data. In early 2004, trading volume rapidly increases as traders transition from pit trading to electronic trading. Trading in the early days of electronic trading is focused on the "Whites", which are the four quarterly serials that expire within 12 months. However, with the continuous rise of trading volume until the end of 2007, the "Reds" and "Greens" contracts, which expire within 13-24 months and 25-36 months respectively, gain in popularity. The trading volume in the "Orange" contracts, which are the monthly serial contracts in the current quarter, remains relatively low throughout the sample period. With the advent of the zero-lower-bound in 2008, the trading volume in the "Whites" contracts drops significantly, while the "Reds" and "Greens" contracts continue to be actively traded. In 2013 and 2014, monthly trading volume in "Green" contracts surpasses that of "Whites" indicating a focus on the market to bets or hedges against the lift-off from the zero-lower-bound.

B Extensions

B.1 Term Structure of Interest Rates

Next, I reassess the impact of monetary policy surprises on the term structure of interest rates. There has been ongoing discussion, initiated by Hanson and Stein (2015) and Nakamura and

Figure B.1: Real Forward Curve Response



The figure shows the real forward curve response (in pp) to a PNS surprise adjusted for the change in Target and Path in the run-up (180-10m) prior to the FOMC press release, which raises the 2-year real yield by 1pp. The 90% confidence bands displayed are calculated from heteroskedasticity-robust standard errors.

Steinsson (2018), regarding how the measurement of the monetary policy surprise influences empirical evidence on the impact of monetary policy on term premia. Hanson and Stein (2015), employing a 2-day change in the 2-year yield, conclude that monetary policy exerts a substantial impact across the entire real forward curve, attributing this effect to term premia. Conversely, using monetary policy surprises based on 30-minute windows, Nakamura and Steinsson (2018) find no significant impact beyond the 10-year maturity.

I follow (Kekre et al., 2022) and estimate the following linear model

$$\Delta f_{\tau-1,\tau} = \alpha + \beta \Delta y_t^{(2)} + \epsilon_t,$$

where $y_t^{(2)}$ is instrumented by the surprise measured over volume-based window length and the 30 minute.

Figure B.1 illustrates the real forward curve response (in pp) to using the volume-based and 30-minute PNS surprises as instruments. While the 30-minute window-based response aligns with the findings of Nakamura and Steinsson (2018)—insignificant beyond the 10-year horizon—the volume-based PNS surprise exhibits a significant impact across the entire real forward curve, consistent with the results of Hanson and Stein (2015). This underscores the critical role of window length selection in shaping empirical evidence regarding the impact of monetary policy on term premia.

Table B.1: Real Forward Curve - Robustness

	Dep. Var: 10Y Forward Rate						
	30M			VBS			
	Full	Exc Crisis	Orthogonal	Full	Exc. Crisis	Orthogonal	PConf Limit
Intercept	-0.006	-0.007	-0.006	-0.004	-0.006	-0.005	-0.004
	(0.006)	(0.005)	(0.006)	(0.006)	(0.005)	(0.006)	(0.006)
2Y Yield	0.196**	0.005	0.151	0.327***	0.090	0.305**	0.358***
	(0.089)	(0.106)	(0.099)	(0.104)	(0.075)	(0.122)	(0.111)
R2 Adj.	0.181	-0.004	0.152	0.217	0.066	0.216	0.215
Num.Obs.	127	119	127	127	119	127	127
	Dep. Var: 20Y Forward Rate						
	30M			VBS			
	Full	Exc Crisis	Orthogonal	Full	Exc. Crisis	Orthogonal	PConf Limit
Intercept	-0.002	-0.004	-0.002	-0.001	-0.003	-0.001	-0.001
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
2Y Yield	0.190*	0.065	0.123	0.248***	0.179**	0.210**	0.258**
	(0.107)	(0.096)	(0.086)	(0.093)	(0.082)	(0.086)	(0.104)
R2 Adj.	0.084	0.049	0.080	0.064	0.099	0.080	0.058
Num.Obs.	127	119	127	127	119	127	127

... * p < 0.1, ** p < 0.05, *** p < 0.01

These findings are robust to various different specifications, reported in Table B.1. The second column reports the results to excluding all announcements during the Global Financial Crisis from July 2008 to July 2009. The third column of the volume-based surprises shows that these results are robust to limiting the window to the start of press conferences on days with scheduled press conferences. Across all specifications using the volume-based surprises as the instrument leads to large and significant increases in the 20-year forward rate.

C Robustness

Table C.1: Treasury Market - Event Study Results

	1988/11 - 2003/11 (n= 145)			2003/12 - 2022/12 (n= 159)		
	PNS	VBS	VBS ⊥ PNS	PNS	VBS	VBS ⊥ PNS
Dep Var: 3M Bill						
Estimate	0.046***	0.038***	-0.013	0.016	0.008	-0.005
SE	(0.010)	(0.008)	(0.009)	(0.010)	(0.006)	(0.007)
R^2	0.347	0.227	0.022	0.075	0.015	0.001
Dep Var: 1Y Treasury						
Estimate	0.049***	0.049***	0.008	0.028***	0.030***	0.014*
SE	(0.008)	(0.007)	(0.007)	(0.009)	(0.005)	(0.008)
R^2	0.402	0.390	0.004	0.257	0.287	0.055
Dep Var: 5Y Treasury						
Estimate	0.037***	0.042***	0.019***	0.032***	0.061***	0.055***
SE	(0.007)	(0.006)	(0.007)	(0.008)	(0.009)	(0.008)
R^2	0.228	0.288	0.055	0.126	0.489	0.400
Dep Var: 10Y Treasury						
Estimate	0.023***	0.028***	0.018**	0.020***	0.045***	0.045***
SE	(0.006)	(0.006)	(0.007)	(0.007)	(0.009)	(0.009)
R^2	0.119	0.182	0.071	0.056	0.323	0.315

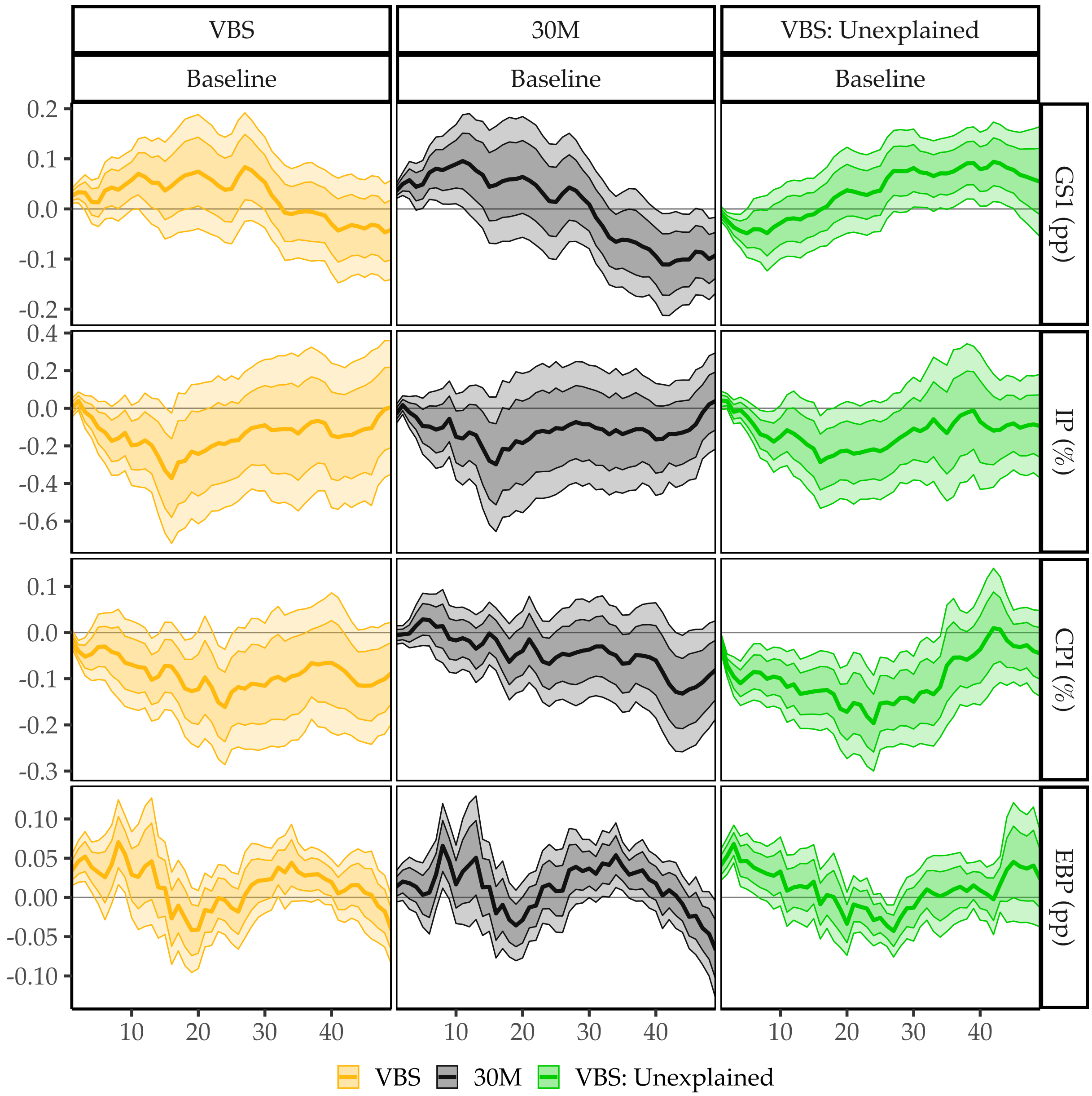
This table reports the estimated coefficients of a regression selected Treasury market yields on the respective monetary policy surprise. All dependent variables stem from the Federal Reserve H.15 report and can be found here. Reported standard errors are heteroskedasticity-robust (HC3) and the stars indicate significance at the 10%, 5% and 1% level.

Table C.2: Equity Market - Event Study Results

	1988/11 - 2003/11 (n= 145)			2003/12 - 2022/12 (n= 159)		
	PNS	VBS	VBS ⊥ PNS	PNS	VBS	VBS ⊥ PNS
Dep Var: SP Future						
Estimate	-0.395***	-0.332***	0.055	-0.283***	-0.423***	-0.276**
SE	(0.082)	(0.080)	(0.078)	(0.067)	(0.083)	(0.117)
R^2	0.359	0.250	0.000	0.131	0.200	0.082
Dep Var: VWRETX						
Estimate	-0.462***	-0.406***	0.055	-0.203	-0.478***	-0.479***
SE	(0.124)	(0.118)	(0.098)	(0.215)	(0.144)	(0.117)
R^2	0.188	0.143	-0.004	0.017	0.125	0.125

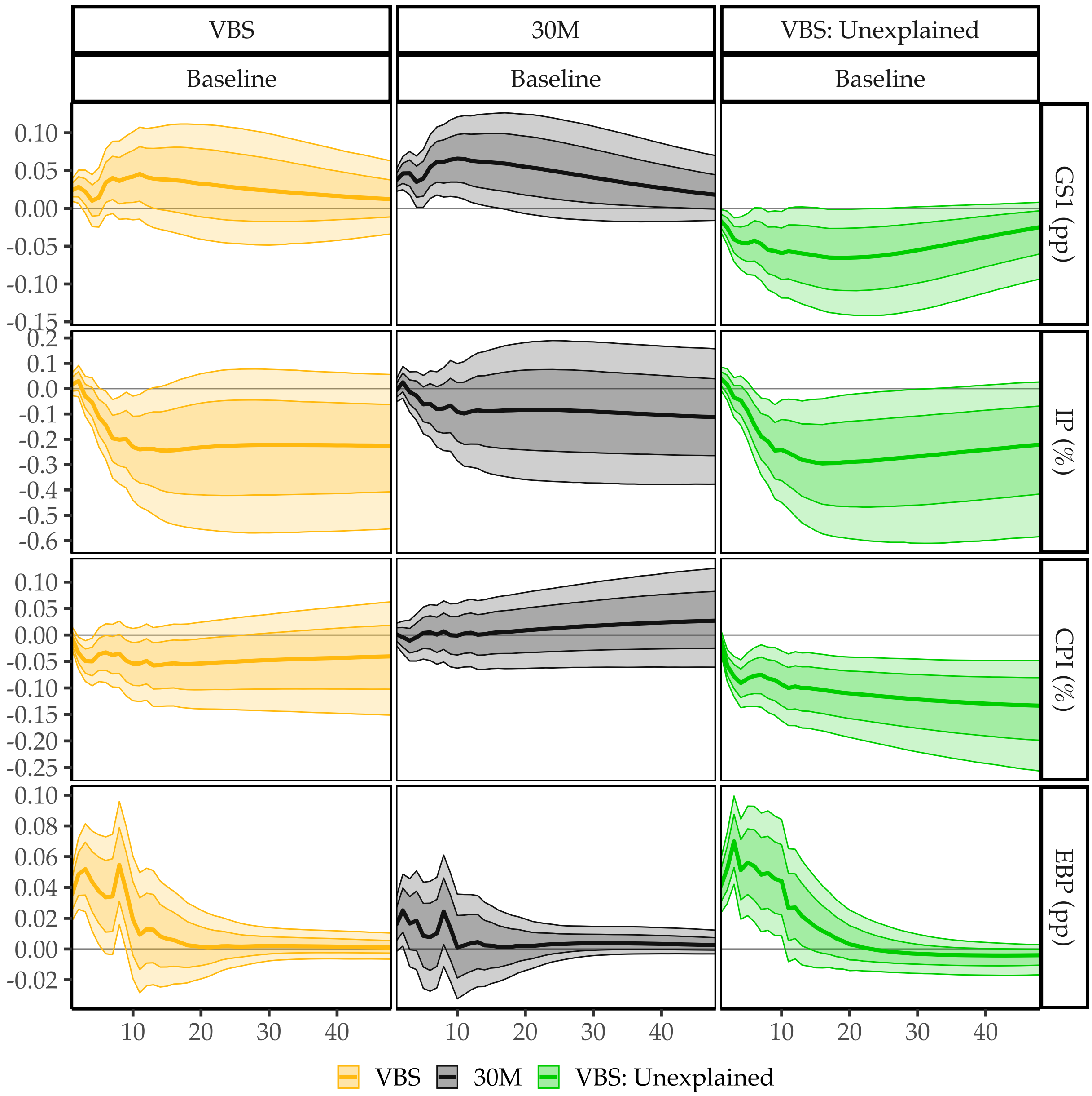
This table reports the estimated coefficients of a regression of the stock market return on the respective monetary policy surprise. The S&P Future Return is calculated from the price of the E-Mini (Ticker: ES) contract after 1998 and the broad SP Future (Ticker: SP) in earlier sample periods. It is measured over the same window as the surprise. In the first column, the window is the 30-minute window, while in the second and third column, the window is the flexible window length. The daily CRSP value-weighted stock market return is measured on the day of the announcement. Reported standard errors are heteroskedasticity-robust (HC3) and the stars indicate significance at the 10%, 5% and 1% level.

Figure C.1: Revisiting Figure 8 - Local Projections



The figure shows impulse response functions of several financial and macroeconomic variables to 1 SD of the respective monetary policy surprise. 'VBS' refers to the volume-weighted monetary policy surprise, while other columns contain the first principal component of the first four Eurodollar futures '30M' the 30-minute window length. The impulse response functions are obtained from a Local Projection with a lag length of 12 and is estimated using the BVAR toolbox by **?**. The surprise is ordered first and the structural shocks are identified via short-run restrictions. The 68% and 90% credible intervals are based on 10000 draws from the posterior distribution. The sample runs from November 1988 to February 2020 and is at monthly frequency.

Figure C.2: Revisiting Figure **??** - Minnesota Prior



The figure shows impulse response functions of several financial and macroeconomic variables to 1 SD of the respective monetary policy surprise. 'VBS' refers to the volume-weighted monetary policy surprise, while other columns contain the first principal component of the first four Eurodollar futures '30M' the 30-minute window length. The impulse response functions are obtained from a Bayesian VAR with a lag length of 12 and is estimated using the BVAR toolbox by **?** with a Minnesota prior. The surprise is ordered first and the structural shocks are identified via short-run restrictions. The 68% and 90% credible intervals are based on 10000 draws from the posterior distribution. The sample runs from November 1988 to February 2020 and is at monthly frequency.

Figure C.3: Revisiting Figure ?? - Proxy SVAR

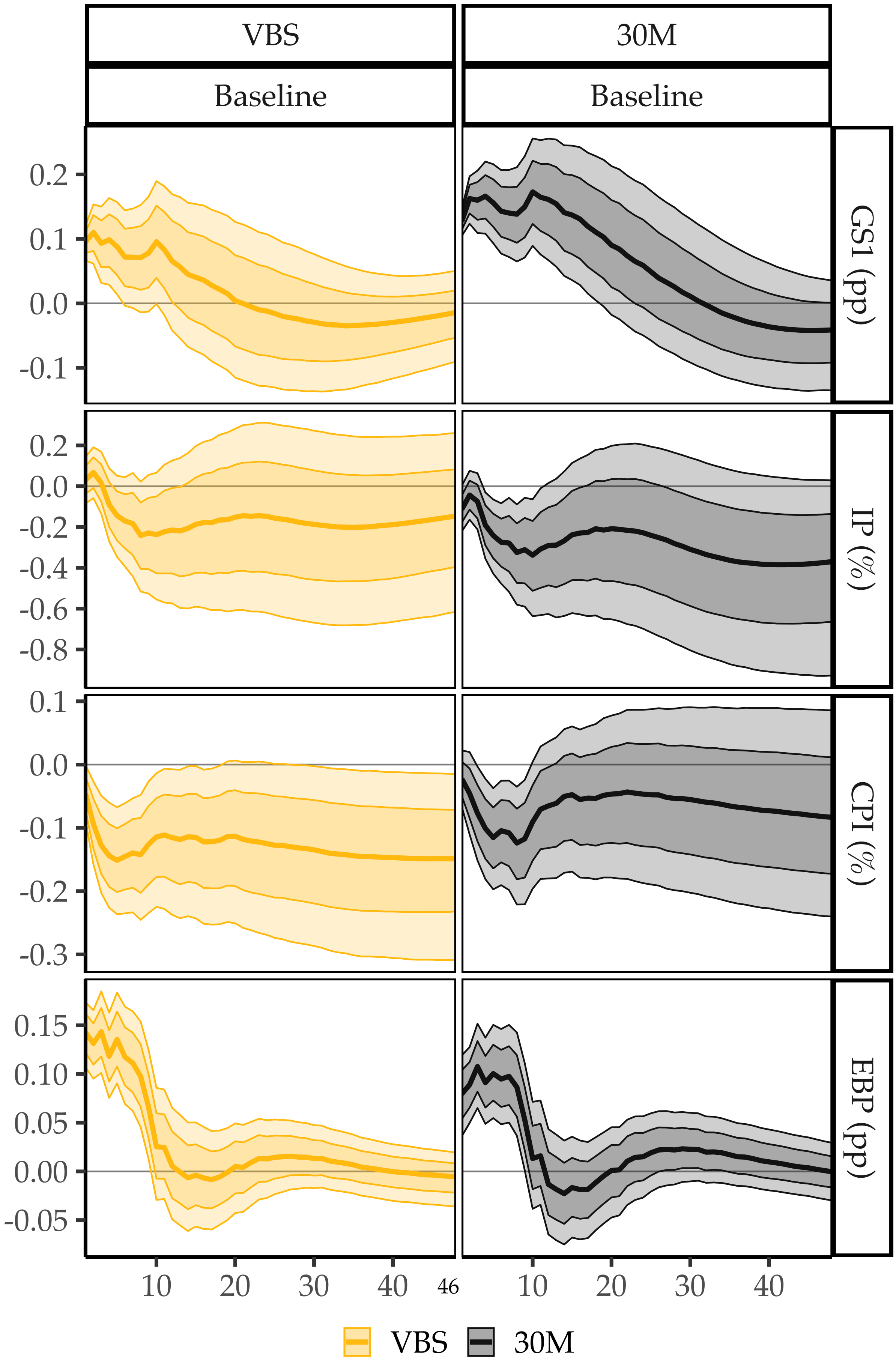


Table C.3: Ortho News and Ortho Info Regression Results

Ortho News

	VBS	30M	VBS Residuals
NFP Surprise	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
NFP 12M	0.005**	0.004***	0.000
	(0.002)	(0.001)	(0.001)
BCom 3M	0.099	0.122**	-0.016
	(0.083)	(0.053)	(0.024)
TR Skew	0.033**	0.028**	0.002
	(0.016)	(0.012)	(0.006)
SP500 3M	0.124	0.081	0.022
	(0.083)	(0.057)	(0.029)
Slope 3M	-0.011	-0.016*	0.003
	(0.011)	(0.008)	(0.004)
R2 Adj.	0.072	0.116	-0.007
Num.Obs.	304	304	304

* p < 0.1, ** p < 0.05, *** p < 0.01

Ortho Info

	VBS	30M	VBS Residuals
(Intercept)	-0.044	-0.025	-0.003
	(0.039)	(0.031)	(0.012)
grgdpb1	0.003	0.001	0.001
	(0.004)	(0.003)	(0.001)
grgdpf0	0.017**	0.013**	0.001
	(0.007)	(0.006)	(0.002)
grgdpf1	-0.002	0.003	-0.003
	(0.011)	(0.010)	(0.003)
grgdpf2	-0.021	-0.016	-0.002
	(0.013)	(0.011)	(0.003)
grgdpf3	0.012	0.003	0.005
	(0.014)	(0.012)	(0.003)
grgdpb1rev	-0.001	-0.001	0.000
	(0.004)	(0.003)	(0.001)
grgdpf0rev	-0.002	0.001	-0.001
	(0.006)	(0.005)	(0.002)
grgdpf1rev	0.018**	0.010	0.004
	(0.008)	(0.007)	(0.003)
grgdpf2rev	0.030***	0.020**	0.005
	(0.009)	(0.008)	(0.003)
gpgdpb1	0.015*	0.010	0.003
	(0.009)	(0.007)	(0.002)
gpgdpf0	0.001	0.003	-0.001
	(0.010)	(0.007)	(0.003)
gpgdpf1	0.000	-0.002	0.002
	(0.013)	(0.011)	(0.003)
gpgdpf2	0.010	0.000	0.005
	(0.017)	(0.012)	(0.006)
gpgdpf3	-0.016	-0.007	-0.005
	(0.019)	(0.012)	(0.007)
gpgdpb1rev	-0.003	-0.007	0.002
	(0.007)	(0.005)	(0.002)
gpgdpf0rev	0.014	0.007	0.004
	(0.010)	(0.008)	(0.003)
gpgdpf1rev	0.002	0.002	0.000
	(0.013)	(0.009)	(0.004)
gpgdpf2rev	-0.002	0.006	-0.004
	(0.016)	(0.012)	(0.005)
unempb1	-0.042	-0.013	-0.016
	(0.055)	(0.039)	(0.017)
unempf0	0.143	0.052	0.050
	(0.105)	(0.076)	(0.039)
unempf1	-0.052	0.024	-0.043
	(0.129)	(0.106)	(0.039)
unempf2	-0.017	-0.048	0.019
	(0.135)	(0.104)	(0.042)
unempf3	-0.033	-0.012	-0.011
	(0.085)	(0.067)	(0.025)
unempb1rev	0.037	0.005	0.018
	(0.030)	(0.020)	(0.012)
unempf0rev	-0.120*	-0.021	-0.056***
	(0.068)	(0.054)	(0.021)
unempf1rev	-0.065	-0.099	0.022
	(0.096)	(0.073)	(0.031)
unempf2rev	0.177**	0.144***	0.014
	(0.076)	(0.054)	(0.028)
R2 Adj.	0.138	0.121	0.052
Num.Obs.	274	274	274

* p < 0.1, ** p < 0.05, *** p < 0.01

The left table reports the regression results of the surprises to the predictors in Bauer and Swanson (2022). The right table reports the regression results of the surprises to the predictors in Miranda-Agrippino and Ricco (2021)

Table C.4: Ortho News and Ortho Info Autocorrelation Adjustment

	VBS	30M	VBS Residuals	VBS Orth	30M Orth	VBS Residuals Orth	VBS Non-Info	30M Non-Info	VBS Residuals Non-Info
Lag 1	-0.033	-0.040	0.025	-0.111	-0.184**	0.010	-0.249***	-0.259**	-0.082
	(0.075)	(0.085)	(0.106)	(0.092)	(0.093)	(0.101)	(0.089)	(0.104)	(0.063)
Lag 2	-0.011	0.047	0.066	-0.079	-0.060	0.054	-0.150*	-0.116	0.032
	(0.090)	(0.099)	(0.102)	(0.079)	(0.090)	(0.099)	(0.081)	(0.088)	(0.099)
Lag 3	-0.097	0.015	-0.262**	-0.202***	-0.069	-0.250**	-0.152*	-0.093	-0.160*
	(0.064)	(0.071)	(0.115)	(0.074)	(0.067)	(0.112)	(0.078)	(0.083)	(0.087)
Lag 4	0.073	0.114*	-0.042	0.005	0.039	-0.045	0.033	-0.031	0.051
	(0.065)	(0.065)	(0.082)	(0.073)	(0.070)	(0.083)	(0.075)	(0.070)	(0.092)
Lag 5	0.089	0.033	0.089	0.096	0.035	0.077	0.133	-0.033	0.161*
	(0.067)	(0.078)	(0.084)	(0.093)	(0.082)	(0.086)	(0.090)	(0.083)	(0.086)
Lag 6	0.046	0.067	-0.017	-0.008	-0.020	-0.020	0.012	-0.057	0.039
	(0.072)	(0.067)	(0.107)	(0.068)	(0.069)	(0.108)	(0.075)	(0.075)	(0.096)
Lag 7	0.078	0.134	-0.178**	0.048	0.068	-0.183**	0.103	0.036	-0.099
	(0.066)	(0.088)	(0.077)	(0.071)	(0.069)	(0.075)	(0.069)	(0.064)	(0.081)
Lag 8	-0.044	-0.017	-0.037	-0.006	0.022	-0.069	-0.014	-0.027	-0.025
	(0.065)	(0.058)	(0.068)	(0.080)	(0.063)	(0.066)	(0.069)	(0.060)	(0.072)
Lag 9	0.037	0.036	-0.007	0.027	0.050	-0.019	0.020	-0.010	-0.061
	(0.070)	(0.060)	(0.071)	(0.076)	(0.068)	(0.074)	(0.066)	(0.059)	(0.068)
Lag 10	0.032	0.038	-0.007	0.056	0.094	-0.007	0.034	0.015	-0.006
	(0.078)	(0.079)	(0.060)	(0.074)	(0.078)	(0.061)	(0.075)	(0.072)	(0.081)
Lag 11	-0.027	-0.001	0.013	0.013	0.083	-0.006	-0.024	0.000	-0.044
	(0.063)	(0.057)	(0.064)	(0.060)	(0.052)	(0.064)	(0.072)	(0.064)	(0.074)
Lag 12	-0.064	-0.058	0.006	-0.026	0.009	-0.003	-0.048	-0.063	0.024
	(0.065)	(0.066)	(0.053)	(0.062)	(0.076)	(0.055)	(0.058)	(0.069)	(0.050)
R2 Adj.	-0.007	0.005	0.056	0.028	0.010	0.054	0.064	0.030	0.032
Num.Obs.	269	269	269	269	269	269	241	241	241

* p < 0.1, ** p < 0.05, *** p < 0.01

This table reports the estimated AR(12) coefficients of the surprise aggregated at the monthly level in months that contain at least one FOMC announcement. This is equivalent to equation (8) in (Miranda-Agrippino and Ricco, 2021).