Trading Volume and Monetary Policy Surprises

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Abstract

High-frequency identification of the causal effects of monetary policy relies on measuring monetary policy surprises–changes in interest rate futures prices in narrow windows around FOMC announcements. This paper introduces the Volume-Based Monetary Policy Surprise (VBS), which uses abnormal trading volume to let the market endogenously determine announcement-specific event windows and loadings across interest rate futures contracts. Relaxing the assumptions of a fixed event window length and fixed loadings substantially increases the estimated effects of monetary policy: the VBS doubles the impact on Treasury yields and equity markets and generates sizable impacts on macroeconomic aggregates. The flexible event windows capture when prices continue adjusting beyond the conventional 30-minute window. The flexible loadings naturally shift toward longer-dated contracts when the Federal Reserve relies on forward guidance about future policy.

Keywords: High-Frequency Identification, Monetary Policy Surprises, Volume, Eurodollar Futures, Event Studies, Forward Guidance
JEL Classification: E43, E52, E58, G12, G14

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1 Introduction

Identifying the causal effects of monetary policy is fundamental to understanding how central banks influence financial markets and the economy. The standard approach measures monetary policy surprises from changes in short-term interest rate futures in tight windows, typically 30 minutes, around Federal Open Market Committee (FOMC) announcements. By capturing unexpected shifts in market expectations about current and future policy, these surprises provide plausibly exogenous variation in monetary policy. They have become a central tool for understanding how monetary policy affects financial markets, household consumption and savings decisions, firm investment, and the broader economy.

Two critical assumptions underlie the high-frequency approach to measuring monetary policy surprises. First, existing measures use the same fixed window length—typically 30 minutes—for all announcements (Gürkaynak et al., 2005; Nakamura and Steinsson, 2018). Shorter windows increase the precision of the surprise by minimizing contamination from other macroeconomic news, but risk truncating the market's full processing of the new information. Second, conventional measures extract factors from a fixed set of interest rate securities with time-invariant loadings, commonly restricting the maturity spectrum to contracts maturing within 12 months. However, as FOMC communication has evolved—with the introduction of press conferences, detailed forward guidance, and the publication of policy rate projections (the "dot plot")—these fixed assumptions may no longer adequately capture how markets process monetary policy announcements and where market attention is focused along the path of interest rates.

This paper introduces the Volume-based Monetary Policy Surprise (VBS), which uses abnormal trading volume to let the market endogenously determine the relevant announcement-specific event windows, set of interest rate futures contracts, and their loadings. I leverage the fact that trading volume in the Eurodollar futures market—commonly used to measure interest rate expectations—is available at high frequency. Trading volume reveals when and where market participants are actively processing the implications of new information (He and Wang, 1995; Vives, 1995; Banerjee and Kremer, 2010; Barillas and Nimark, 2017). To operationalize this, I establish a counterfactual baseline of normal trading volume for each FOMC announcement. The window extends until volume returns to this baseline and each contract is weighted by its share of total volume over this window. The VBS is thus the volume-weighted average price change in the Eurodollar futures market, naturally shifting weight to the contracts where market attention is concentrated.

My main empirical finding is that monetary policy has substantially larger effects on financial markets than conventional measures suggest. For Treasury securities, a contractionary Volume-based Monetary Policy Surprise generates responses in nominal yields roughly twice as large, with particularly pronounced effects on real yields and a sizable impact on breakeven inflation across the entire maturity spectrum. These differences have grown substantially over time, consistent with changes in the Federal Reserve's communication strategy—including more elaborate announcements, forward guidance, and press conferences—and the introduction of electronic trading. Prior to 2004, the VBS and conventional measures show broadly similar effects, but they diverge sharply thereafter. Equity markets show the same pattern. The estimated impact is also twice as large and the VBS explains five times more variation in daily stock returns around FOMC announcements compared to the surprise from Nakamura and Steinsson (2018).

These financial market responses—particularly in lowering breakeven inflation today—are consistent with realized inflation dynamics. Using conventional high-frequency surprises as instruments in vector autoregressions and local projections typically produces weak or insignificant inflation responses to contractionary monetary policy shocks (Gertler and Karadi, 2015; Ramey, 2016). In contrast, the VBS generates large negative and significant CPI responses in both empirical approaches. The volume-weighting component that drives the breakeven inflation response also generates these larger inflation effects, capturing longer-dated forward guidance about the future path of monetary policy. These findings complement recent work showing that controlling for the Fed's information set (Miranda-Agrippino and Ricco, 2021) or economic news (Bauer and Swanson, 2022) increases the estimated real effects of monetary policy shocks. Even after adjusting for these predictors, the VBS continues to generate larger and more precisely estimated effects.

Three features of the VBS methodology explain these results. First, announcement-specific windows allow for extended processing of FOMC statements, capturing price adjustments that continue well beyond 30 minutes. Second, the windows endogenously incorporate press conferences when volume remains elevated during the chair's public remarks. Third, announcement-specific loadings capture shifts in market attention toward longer-dated forward guidance, particularly following the publication of FOMC members' policy rate projections (the "dot plots"), as trading volume migrates to longer-maturity contracts. These features allow the VBS to capture aspects of monetary policy communication that conventional measures miss.

The paper proceeds in three parts. In the first part, I document three novel facts about price discovery in Eurodollar futures markets around FOMC announcements. First, volume and volatility remain abnormally elevated for up to 90 minutes, contrasting sharply with the current-month federal funds futures (Kuttner, 2001), where market reactions complete within conventional 30-minute windows. Second, prices adjust gradually, requiring on average 45 minutes to reach their new level following announcements without press conferences. Third, trading volume shifts substantially toward longer-dated contracts in recent years, with significant activity in contracts capturing interest rate expectations up to three years ahead. These findings challenge the appropriateness of fixed window lengths and loadings, motivating a methodology that allows both to vary across announcements.

The second part develops the Volume-based Monetary Policy Surprise (VBS) methodology. For each FOMC announcement, I establish baseline expected volume from the prior 21 trading days across all actively traded Eurodollar futures contracts up to 12 quarters ahead, defining the window as the period when realized volume exceeds this baseline. Contract loadings equal their share of total volume over the event window, naturally weighting where market attention is focused. The resulting windows exhibit substantial variation over time: averaging 41 minutes during pit trading (1988-2003) and extending to 60 minutes for regular announcements and 100 minutes for press conferences in the electronic era (2004 onwards). Contract loadings shift even more dramatically—during the zero lower bound, longer-dated contracts maturing beyond two years capture over 40% of volume while near-term contracts fall below 20%, reflecting the Fed's increasing reliance on forward guidance. This generates a sharp divergence between the VBS and conventional measures: pre-2004, the conventional measure explains 85% of VBS variation; post-2004, this falls to 52%.

The divergence between the VBS and conventional measures can be decomposed into two components: one capturing announcement-specific window lengths and another capturing volume-weighted loadings. Extended window lengths are driven by two factors. First, on days without press conferences, window lengths correlate strongly with statement dissimilarity—a measure of new information in the FOMC press release. Second, press conferences themselves extend windows substantially, particularly during the 2021 tightening cycle when differences between 30-minute surprises and the VBS are most pronounced. Volume-weighting matters most between 2011 and 2015, when the Fed relied heavily on forward guidance following the introduction of the dot plot. The volume-weighting component correlates strongly with the gap between market participants' median forecasts from the Primary Dealer Survey and FOMC members' median dot plot forecast at the same horizon. This reflects the market's shift toward longer-dated contracts when assessing the timing of lift-off from the zero lower bound and the subsequent path of interest rates.

The third part establishes the economic significance of these methodological changes, focusing on the period since 2004 when windows lengthen and forward guidance becomes more prominent. For Treasury markets, a one-standard-deviation contractionary VBS shock generates responses in nominal yields roughly twice as large as conventional measures, with statistically significant effects extending to 14-year maturities compared to only 6 years for conventional measures. The effects operate through both real yields and breakeven inflation: real yields show particularly persistent responses across the entire maturity spectrum, while breakeven inflation displays a significant negative shift. For equity markets, the differences are even more pronounced. The VBS explains 15 percent of daily stock return variation around announcements compared to just 3 percent for conventional measures, with a one-standard-deviation contractionary shock reducing stock prices by 0.43 percent—nearly double the 0.22 percent decline from conventional measures, which is no longer statistically significant.

These differences between the VBS and conventional measures have grown substantially over time, providing important validation for the methodology. Prior to 2004, when institutional features—pit trading with limited post-announcement hours—constrained window lengths and trading volume naturally concentrated in the first four quarterly contracts used by conventional measures, the VBS and conventional measures generate comparable estimates for Treasury yields and equity returns, consistent with the existing literature. The measures diverge sharply beginning in 2004 with the shift to electronic trading and changes in Fed communication. While conventional measures suggest monetary policy's influence weakened dramatically during this period, the VBS shows that monetary policy's influence has remained strong throughout the sample.

The VBS also has substantial effects on macroeconomic outcomes. In local projections, a one-standard-deviation contractionary shock reduces CPI by around 0.2 percentage points after 24 months and industrial production by 0.4 percentage points—statistically significant and economically meaningful responses. The identical specification using the surprise by Nakamura and Steinsson (2018) yields negligible and insignificant inflation responses. A Structural VAR using the internal instrument approach (Plagborg-Møller and Wolf, 2021) produces qualitatively similar results. Adjustments for predictors of monetary policy surprises from financial conditions (Bauer and Swanson, 2022) and the Fed's information set (Miranda-Agrippino and Ricco, 2021) do not affect these conclusions, with the VBS consistently generating larger and more precisely estimated real effects. The volume-weighting component that shifts toward longer-dated contracts drives this difference, capturing forward guidance about the future policy path communicated through the dot plot.

Related Literature and Contribution

This paper contributes to the literature on the measurement of high-frequency monetary policy surprises. The foundational work by Kuttner (2001) isolates the level ("Target") change in the federal funds rate from daily changes in federal funds futures around FOMC announcements. Building on this, Gürkaynak et al. (2005) incorporate Eurodollar futures maturing within 12 months to capture effects on the path ("Path") of interest rates and introduce the use of intraday data with 30-minute windows. The literature subsequently often summarizes these effects into a single surprise measure by extracting the first principal component over 30-minute changes in federal funds and Eurodollar futures (Nakamura and Steinsson, 2018; Acosta et al., 2024; Bauer and Swanson, 2023).

This is the benchmark surprise to which I compare the Volume-based Monetary Policy Surprise. Several recent measures incorporate additional dimensions of monetary policy (Kaminska et al., 2021; Swanson, 2021; Kroencke et al., 2021; Acosta et al., 2025) but maintain the assumptions of fixed window lengths and fixed loadings. The notable exception is Lewis (2023), who uses identification-by-heteroskedasticity to identify announcement-specific loadings. This paper's contribution is to measure announcement-specific window lengths and loadings determined by observable market behavior—trading volume—that can be motivated from economic theory.

The paper also speaks to the literature on monetary policy's effects on financial markets. The literature documents that conventional monetary policy has sizable impacts on long-term yields (Gürkaynak et al., 2005), driven by effects on bond risk premia (Hanson and Stein, 2015; Kekre et al., 2022; Herbert et al., 2025) or trend inflation (Gürkaynak et al., 2005). I show that monetary policy has substantial effects on both long-term real rates and breakeven inflation across the entire maturity spectrum. For equity markets, surveyed recently by Knox and Vissing-Jorgensen (2025), the closest studies are Bernanke and Kuttner (2005), who investigate daily stock price responses to target surprises, and Gürkaynak et al. (2005), who conduct high-frequency event studies of equity returns. I show that through 2004—which closely aligns with the samples in both studies—both conventional measures and the VBS generate large negative impacts of monetary policy on equity prices. Since 2004, however, only the VBS continues to show large, significant effects, consistent with evidence on market behavior around press conferences (Gómez-Cram and Grotteria, 2022; Narain and Sangani, 2023; Acosta et al., 2025). These results have implications for stock return decompositions into discount rate and cash flow effects (Knox and Vissing-Jørgensen, 2022; Nagel and Xu, 2024; Golez and Matthies, 2025), which rely on data that is only reliably available since the early 2000s.

A third contribution is to the literature on monetary policy's macroeconomic effects. A persistent finding is relatively weak inflation responses to conventional high-frequency surprises (Gertler and Karadi, 2015; Ramey, 2016). Recent work addresses this by adjusting surprises to account for the learning problem markets face when deciphering FOMC communication—whether markets learn about shifts in the Fed's reaction function (Bauer and Swanson, 2022, 2023) or the Fed's superior information about fundamentals (Campbell et al., 2012; Cieslak and Schrimpf, 2019; Jarociński and Karadi, 2020; Miranda-Agrippino and Ricco, 2021; Ricco and Savini, 2025; Jarociński and Karadi, 2025). Bianchi et al. (2025) use a structural macro-finance model to decompose high-frequency market reactions into distinct channels, finding that beliefs about future policy regimes and risk premia frequently drive reactions rather than conventional policy shocks or information effects. These papers focus on imperfect information between markets and the central bank but take the measurement of high-frequency surprises—with fixed windows and loadings—as given. This paper shows that relaxing these measurement assumptions using observed trading volume substantially increases the estimated effects of monetary policy on macroeconomic aggregates.

Finally, the use of trading volume as a measurement tool is motivated by the literature on trading around public announcements. While the literature highlighted in the previous paragraph focuses on information asymmetries between markets and the central bank, trading volume reveals heterogeneity and learning among market participants. Abnormal volume around announcements has been documented extensively (Beaver, 1968; Fleming and Remolona, 1999; Green, 2004), leading to theoretical investigations of when and how volume arises in financial markets as departures from the No-Trade Theorem (Milgrom and Stokey, 1982). Using volume to identify window lengths and loadings is motivated by dynamic noisy rational expectations models (He and Wang, 1995; Vives, 1995) and dynamic differences-of-opinion models (Banerjee and Kremer, 2010), which model how dispersed information gets incorporated over time among heterogeneous market participants and generate realistic patterns of volume and volatility. Variants of these models (Allen et al., 2006; Cespa and Vives, 2012, 2015) can generate the slow predictable price patterns documented in this paper. This paper applies these insights to measuring monetary policy surprises and provides empirical evidence on Eurodollar market behavior around FOMC announcements.

2 Interest Rate Futures and High-Frequency Monetary Policy Surprises

This section discusses the construction of monetary policy surprises around FOMC announcements and introduces the high-frequency data used to construct both the Volume-based Monetary Policy Surprise (VBS) and the benchmark 30-minute surprise.

Monetary policy surprises are commonly extracted from high-frequency changes in interest rate futures around FOMC announcements

$$s_{m,x=\overline{x}+\underline{x}} = \Lambda(f_{m,t+\overline{x}} - f_{m,t-\underline{x}})$$

where s_m represents the surprise around meeting m, $f_{t+\overline{x}}$ and $f_{t-\underline{x}}$ denote implied interest rates at the upper and lower window bounds, and Λ maps multi-dimensional implied interest rate changes to the surprise measure. The implied interest rate $f_{t,h}$ is derived from short-term interest rate futures prices and captures the time t expectation of the underlying reference rate at maturity t+h under the assumption of risk-neutrality (Veronesi, 2010). Piazzesi and Swanson (2008) show that while these contracts have risk premia, these matter less in short-windows around FOMC announcements. Therefore, under the assumption of constant risk premia, changes in implied interest rates capture changes in market expectations of future interest rates.

Underlying this approach are two key assumptions: the event window length $x = \overline{x} + \underline{x}$, the set of prices included and how they load onto the surprise measure through Λ. A short and fixed event window implicitly assumes that all information is incorporated into prices within this time frame. A common choice is the 30-minute window introduced by Gürkaynak et al. (2005), who show that 30-minute and 60-minute windows produce relatively similar results in high-frequency event studies for the target surprise, albeit with some differences in estimated effects for the path surprise. Shorter windows minimize contamination from other macroeconomic news but risk truncating the market's full adjustment to new information. In the euro area, Altavilla et al. (2019) set a longer fixed window of 2 hours and 15 minutes to capture the entire period of the ECB press conference. Swanson (2023) set even longer windows around congressional testimonies and speeches by Fed officials. Generally, these are ad-hoc choices that reflect the researcher's institutional knowledge and judgement about how quickly markets incorporate information.

The set of futures prices and their loadings Λ are also commonly fixed over time. The standard approach is to use Principal Component Analysis (PCA) to extract the common movements across a set of short-term interest rate futures contracts. This is intuitive since principal components maximize the explained variance in the data for a given number of factors. However, the loadings are fixed over time, therefore assigning the same weight to each interest rate future across the entire sample. This prevents the inclusion of futures contracts that were historically less liquid or not traded at all into surprise measures that span long time periods and does not adapt to changes in the FOMC communication strategy that may affect which parts of the term structure react more strongly to announcements.

The benchmark I use is the 30-minute Policy News Surprise (30M-PC) developed by Nakamura and Steinsson (2018). It uses a 30-minute window (10 minutes before to 20 minutes after the announcement), following Gürkaynak et al. (2005). The loading matrix Λ is estimated using Principal Component Analysis on these 30-minute price changes across the current-month federal funds futures and Eurodollar futures contracts with maturities up to 12 months. I calculate the 30M-PC using the current-month federal funds futures and the first four quarterly Eurodollar futures. [1] The measure summarizes the overall monetary policy surprise, combining target and path surprises into a single measure over a long sample period.

2.1 Federal Open Market Committee Communication

The FOMC announcement timestamps are from Bauer and Swanson (2023).[2] During the sample period of November 1988 to December 2022, there were 304 FOMC rate decisions of which 274

[1]Historical front-month federal funds futures changes up to 1988 are from Gürkaynak et al. (2005). I use the first quarterly Eurodollar future to capture interest rate expectations between 1-3 months instead of the next-meeting federal funds future used in Nakamura and Steinsson (2018). This change does not matter empirically—the resulting 30M-PC has a correlation of 0.99 with other versions calculated in Bauer and Swanson (2023) and Acosta et al. (2024) over the matching sample.

[2]An updated version is available at https://www.frbsf.org/research-and-insights/data-and-indicators/monetary-policy-surprises/

are scheduled and 32 unscheduled. I consider all events contained in both Gürkaynak et al. (2005) and Bauer and Swanson (2022), as the Gürkaynak et al. (2005) dataset contains front-month federal funds futures changes up to 1988, which are required to construct the benchmark surprise measure over the full sample.

The FOMC's communication strategy evolved substantially over this period. Between 1988-1993, the FOMC released no public information; actions had to be inferred from trading desk operations (Cook and Hahn, 1989), with most actions occurring at 11:30 AM. The Fed began releasing statements with rate changes in February 1994, moving announcements to 2:15 PM. Since May 1999, a statement has been released at every meeting. Press conferences were introduced in April 2011 (initially quarterly, expanding to every meeting since 2019), accompanied by the Summary of Economic Projections. Since January 2012, this includes the dot plot—individual FOMC members' projections for the federal funds rate at various horizons, providing explicit forward guidance about the path of interest rates. Since 2013, the press release occurs at 2:00 PM Eastern Time with press conferences at 2:30 PM. In total, 65 of the scheduled FOMC statements in my sample are accompanied by a press conference, while 44 include a dot plot.

2.2 High-Frequency Data

The primary dataset is the Time and Sales dataset from the Chicago Mercantile Exchange, which comes in two files for each trading day: one covering the Trading Pit ("Restricted Trading Hours") and one covering electronic trading on the CME's Globex platform ("Extended Trading Hours"). I focus particularly on Eurodollar futures contracts, which are the most liquid short-term interest rate futures contracts and the primary instrument used to measure the path of interest rates in the monetary policy surprise literature (Gürkaynak et al., 2005; Nakamura and Steinsson, 2018).

The Eurodollar Futures Trading Pit was historically open from 8:20 AM to 3:00 PM Eastern Time on all business days. For FOMC announcements scheduled at 2:15 PM, post-announcement trading was therefore limited to a maximum of 45 minutes. Electronic trading becomes the dominant mode for Eurodollar futures in December 2003, when the number of transactions in the electronic market exceeds the number in the pit, matching anecdotal evidence from the CME (Melamed, 2009). Eurodollar futures contracts are traded continuously throughout the week on the electronic platform, apart from a 1-hour daily maintenance period at 16:00/17:00 (CT/ET). I focus on the subset between 05:00/06:00 until 16:00/17:00 (CT/ET), which is sufficient to capture all relevant trading activity around FOMC announcements. I use the Trading Pit data until November 2003 and the electronic trading data until December 2022 when most market volume moved to SOFR futures (Acosta et al., 2024).

From both files I obtain transaction timestamps, prices, and transaction volumes (expressed in the number of contracts for electronic trading; approximated by the number of trades for pit trading, as contract volumes are not available). I create a minute-by-minute dataset of prices and trading volume for the two monthly contracts and first twelve quarterly Eurodollar futures contracts, the front-month federal funds futures contract, and the E-mini S&P 500 futures contract. For the front-month federal funds futures contract, I use the current-month contract until the last seven days before expiration, when I switch to the second-month contract (Kuttner, 2001). In cases where no trading occurs in a given minute, I fill the dataset backwards with the last available price and set trading volume to zero. For each FOMC announcement, I keep at most the past 21 trading days and the announcement day itself.[3]

2.3 An Anatomy of Short-Term Interest Rate Futures Market Around FOMC Announcements

Fleming and Remolona (1999) show that government bond markets display substantial abnormal volume and volatility after macroeconomic news releases, arguing that this reflects dealers resolving their private interpretations until the market converges. The behavior of volume and volatility is important because it reveals when prices have fully incorporated new information and are therefore most informative about the underlying monetary policy shock. Appendix A discusses how the behavior of volume and volatility can reveal when prices have fully incorporated new information through the lens of asset pricing under asymmetric information. Understanding these dynamics directly informs the two fundamental assumptions underlying the construction of monetary policy surprises: how long do markets need to process FOMC announcements, and which contracts contain the most policy-relevant information?

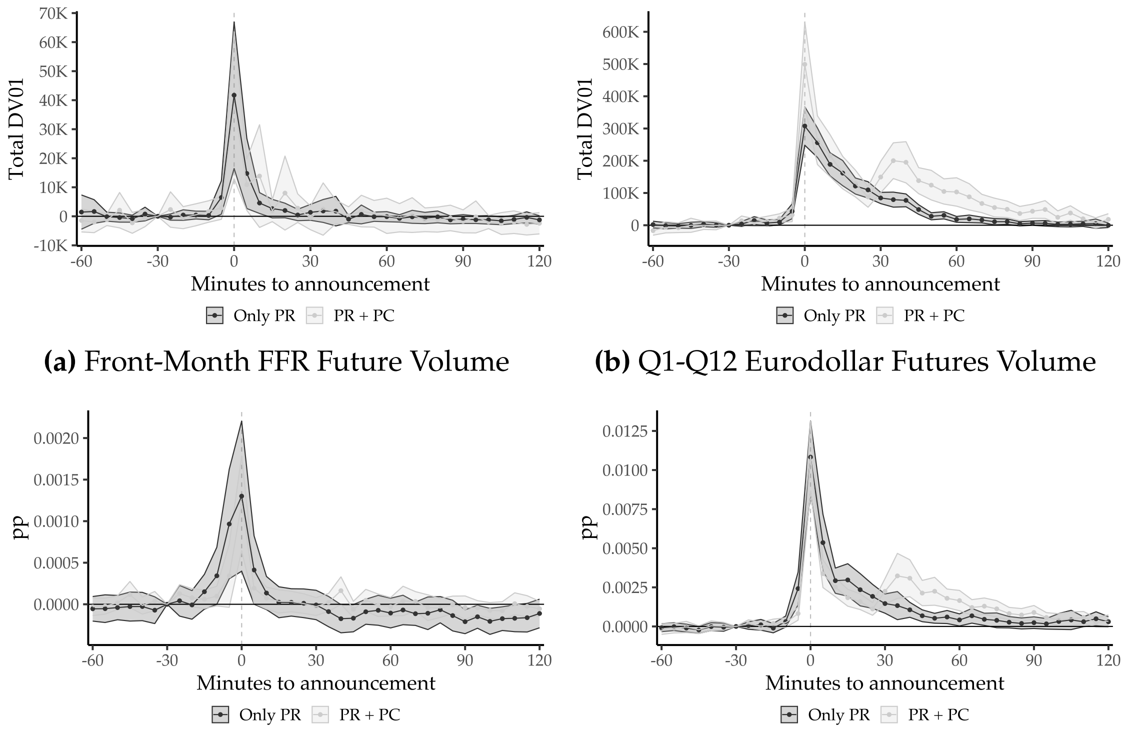
In this section, I document three key facts about short-term interest rate futures markets around FOMC announcements since December 2003, when electronic trading allowed for extended post-announcement activity.

First, volume and volatility remain abnormally elevated in the Eurodollar market. Figure 1 illustrates the dynamics of trading volume and absolute price changes around FOMC announcements for the front-month federal funds futures and the first twelve Eurodollar futures. Volume is rescaled to DV01 to allow comparison across contracts.

The front-month federal funds futures contract adjusts immediately to the new federal funds target rate. Trading volume spikes briefly for 10-15 minutes before returning to normal levels.

[3] The pre-announcement period can contain fewer than 21 trading days when files are missing in the Time and Sales dataset. I exclude the 2014-01-29 announcement entirely, as the Time and Sales dataset is missing for that day. This should not affect results, as the 30-minute changes in the first four Eurodollar contracts are below 0.0025 bp in the Bauer and Swanson (2022) dataset.

Figure 1: Trading Volume and Absolute Price Changes Around FOMC Announcements



(a) Front-Month FFR Future Volume **(b)** Q1-Q12 Eurodollar Futures Volume

(c) Front-Month FFR Future Volatility **(d)** Q1-Q12 Eurodollar Futures Volatility

Panels (a) and (b) show the estimated $\hat{\beta}_k$ and their 99% confidence intervals from

$$Volume_{m,d,\tau} = \alpha_{m,\tau} + \alpha_d + \sum_{\substack{k=-60 \\ k\neq -30}}^{120} \beta_k \cdot \mathbb{1}\{\tau = k\} \cdot FOMC_d + \epsilon_{m,d,\tau}$$

where m indexes FOMC meetings, d denotes the calendar day, τ denotes event time in minutes relative to the FOMC announcement (in 5-minute intervals), and $FOMC_d$ is an indicator equal to one on FOMC announcement days. Panels (c) and (d) show the estimated $\hat{\beta}_k$ and their 99% confidence intervals from

$$|\Delta P_{c,m,d,\tau}| = \alpha_{c,m,\tau} + \alpha_{c,d} + \sum_{\substack{k=-60 \\ k\neq -30}}^{120} \beta_k \cdot \mathbb{1}\{\tau = k\} \cdot FOMC_d + \epsilon_{c,m,d,\tau}$$

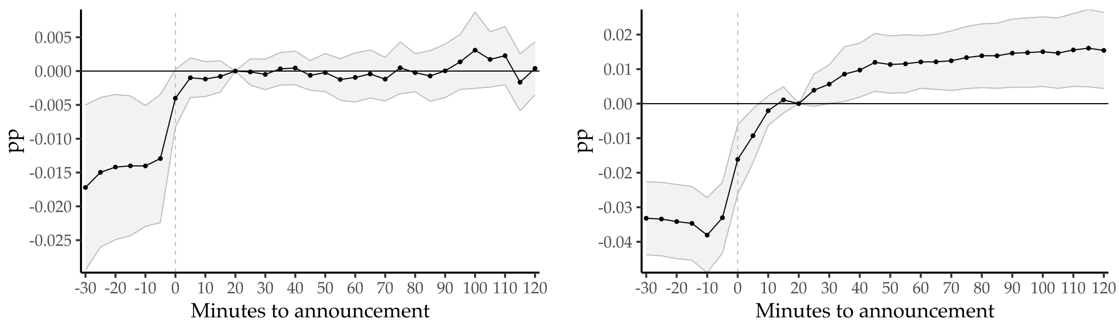
where c denotes the contract and other subscripts are as defined above. In both panels, the baseline period is $\tau = -30$ and the sum is over 5-minute intervals: $k \in \{-60, -55, -50, \ldots, 115, 120\}$. The coefficients are estimated by OLS. The sample runs from 2003-12-01 to 2022-12-31 and contains all scheduled FOMC announcements and the 21 prior trading days. The vertical line indicates the FOMC announcement at $\tau = 0$. Standard errors are clustered at the day level.

In contrast, Eurodollar futures exhibit substantially larger and more persistent volume responses. The initial volume spike is an order of magnitude larger than in federal funds futures and remains significantly elevated for 75 to 100 minutes after the announcement, depending on whether a press conference is held. During press conferences, volume increases again as market participants process the additional information.

Volatility patterns mirror those for volume. Federal funds futures experience a sharp but brief volatility spike that subsides within 10 minutes. Eurodollar futures exhibit elevated volatility that persists for 75-90 minutes after the announcement.

These patterns suggest substantial information processing within the Eurodollar futures market, consistent with Fleming and Remolona (1999). Appendix B.3 shows similar patterns using Poisson regression to model percentage changes in volume: volume remains 500% higher 20 minutes after the announcement compared to 30 minutes before, indicating active information processing well beyond the conventional 30-minute window. Similar patterns also emerge in other asset classes such as E-mini S&P 500 futures, as shown in Appendix B.5.

Figure 2: Cumulative Absolute Price Changes



(a) Front-Month FFR Future **(b)** Q1-Q12 Eurodollar Futures

Figure shows $\hat{\beta}_k$ and their 99% confidence intervals from

$$|P_{c,m,\tau} - P_{c,m,-10}| = \alpha_{c,m} + \sum_{\substack{k=-30 \\ k\neq 20}}^{120} \beta_k \cdot \mathbb{1}\{\tau = k\} + \epsilon_{c,m,\tau}$$

where c denotes the contract, m indexes FOMC meetings, and τ denotes event time in minutes relative to the FOMC announcement. The baseline period is $\tau = 20$. The regression is estimated using only FOMC announcement days. The sample runs from 2003-12-01 to 2018-11-08 and contains all scheduled FOMC announcements where no press conference was held. Event time runs from $\tau = -10$ to $\tau = 120$, where $\tau = 0$ 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 meeting level. The baseline period $\tau = 20$ represents the cumulative absolute price change in the 30-minute window of Gürkaynak et al. (2005).

Second, prices take on average 45 minutes to reach their new level. Figure 2 shows the cumulative absolute price changes in the front-month federal funds futures and the first twelve Eurodollar futures around FOMC announcements without a press conference. The results reveal a striking difference between the two markets. The front-month federal funds futures contract adjusts almost instantaneously, with the 30-minute cumulative price change virtually indistinguishable from the immediate price movement.

In contrast, Eurodollar futures exhibit gradual price discovery. The average cumulative absolute price change reaches 4 basis points over the first 30 minutes but continues increasing until stabilizing at 5 basis points after 45 minutes. A 30-minute window therefore captures on average only

80% of the total price adjustment in Eurodollar futures, missing significant information content that continues to be incorporated over longer horizons. The strength of the initial jump and the speed of adjustment varies substantially across announcements. Appendix B.3 shows that this variation is systematically related to empirical proxies for the amount of new information, signal precision, and residual uncertainty.

Third, trading volume in Eurodollar futures increases substantially after the introduction of electronic trading, with activity shifting toward longer-dated contracts. Figure 3 illustrates this evolution by showing trading volume across contract maturities on FOMC announcement days.

When Eurodollar futures were primarily traded in the Pit (before December 2003), trading volume was heavily concentrated at the front of the curve, with the first four quarterly contracts accounting for the majority of activity. This concentration motivated the literature's focus on these contracts (Gürkaynak et al., 2005) to capture the path of interest rates.

Figure 3: Eurodollar Futures Volume on FOMC Announcement Days

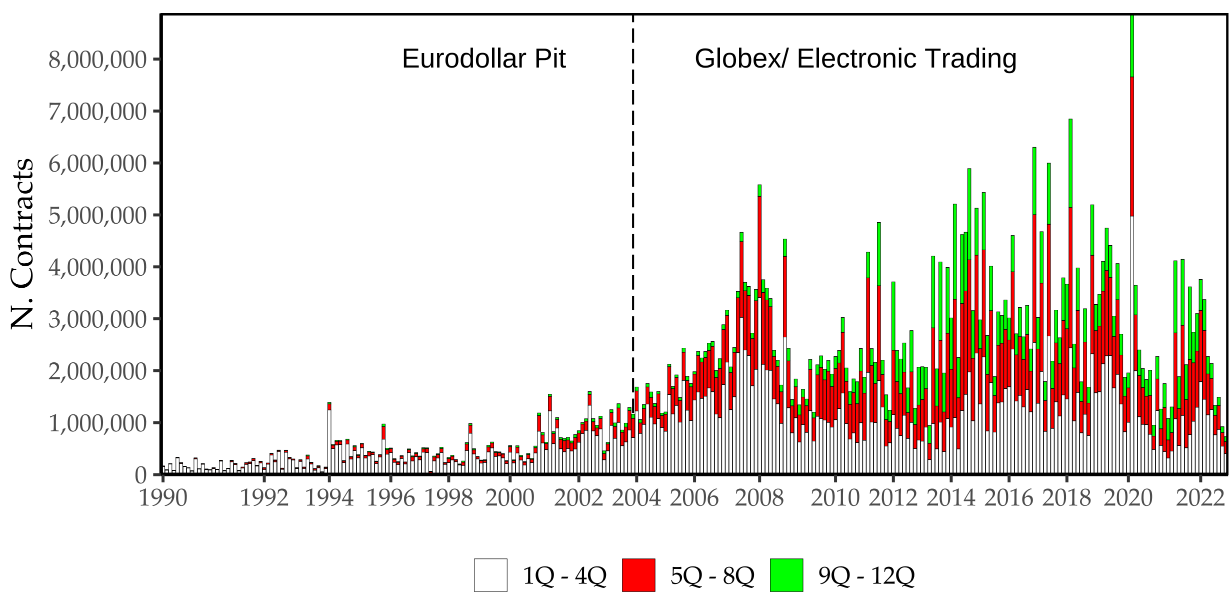


Figure shows the trading volume (contracts) in the first 12 quarterly Eurodollar futures, aggregated by contract maturity, on the FOMC announcement day. The data is from Bloomberg as the Time and Sales dataset does not contain volume for trades in the Eurodollar Pit. The dashed vertical line indicates the meeting in December 2003, when the number of transactions in electronic trading overtakes Pit trading in the Time and Sales dataset.

The transition to electronic trading in December 2003 brought two key changes. First, overall trading volume increased significantly as electronic platforms enabled broader market participation and extended trading hours. Second, volume became more evenly distributed across the term structure, with substantial activity shifting to longer-dated contracts. This redistribution is particularly pronounced during the zero lower bound period, when the first four quarterly contracts account for only a small fraction of total FOMC-day trading volume. Between 2010 and

2022, substantial volume concentrates in contracts with interest rate expectations beyond twelve months, well outside the maturity range typically used in conventional monetary policy surprise measures.

These findings challenge the appropriateness of fixed window lengths and loadings for measuring monetary policy surprises. Markets require substantially longer than 30 minutes to process FOMC announcements: volume remains elevated for 75-100 minutes and prices take 45 minutes on average to fully adjust after the announcement, with a 30-minute window capturing only 80% of the total price movement. Moreover, the relevant contracts have shifted dramatically over time. During the pit trading era, the first four quarterly contracts captured the majority of trading activity, justifying their use in conventional measures. However, since the transition to electronic trading and the Fed's increased reliance on forward guidance, substantial volume concentrates in contracts with maturities beyond twelve months—well outside the range typically used in conventional surprise measures. These patterns motivate a methodology that allows both event windows and contract weightings to vary across announcements based on observable market behavior.

3 Volume-Based Monetary Policy Surprise

The empirical findings from Section 3 revealed three key facts about the Eurodollar market around FOMC announcements. First, trading volume and price volatility spike and remain elevated for extended periods, indicating gradual price discovery. Second, prices take on average 45 minutes to reach their new level, with substantial variation across announcements. Third, volume shifts substantially across the term structure of Eurodollar futures, particularly when forward guidance becomes an important policy tool.

These patterns motivate a methodology that can flexibly adapt to heterogeneity across announcements. Trading volume captures when market participants are actively processing new information, with elevated volume indicating ongoing price discovery. Building on these facts and the theoretical insights surveyed in Appendix A, I develop the Volume-Based Surprise (VBS) methodology, which determines announcement-specific window lengths and asset weightings using observable trading volume dynamics.

The underlying idea is to create a baseline of normal expected trading volume that would prevail in the Eurodollar market absent the FOMC announcement. This baseline is then compared to actual trading volume observed around the announcement. The window length is defined as the point where trading volume returns to the normal range, and contract loadings are determined by each contract's share of total volume during the announcement window.

Let $V_{m,t} = \sum_{c=1}^{14} V_{m,t,c}$ denote aggregate trading volume across Eurodollar contracts in minute t on

FOMC announcement day m. The set of Eurodollar contracts includes two monthly serial contracts and the first twelve quarterly Eurodollar contracts, capturing interest rate expectations over the next three years—consistent with the maximum horizon of the FOMC's dot plot projections.

The Volume-based Surprise (VBS) is defined as

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

where:

- $\overline{x}_m$ is the announcement-specific upper window bound determined by volume normalization
- Λ_m represents announcement-specific loadings based on relative trading volume across contracts
- The lower window bound is fixed at 10 minutes before the announcement following Gürkaynak et al. (2005)

To construct the baseline, I estimate the expected volume distribution from the past 21 trading days for each announcement day m. This estimation window is sufficiently long to provide robust estimates of normal volume patterns while being short enough to capture recent market conditions and seasonality effects. It also avoids contamination from previous scheduled FOMC announcements, which typically occur every six weeks. For each 5-minute interval t^{5M}, I bootstrap the distribution of average one-minute volume from these 21 prior trading days using the cluster bootstrap approach of Rao and Wu (1988), clustering by day to preserve the intraday correlation structure. The non-parametric bootstrap approach avoids downward bias from periods with zero volume that can arise with alternative estimation methods (Davison and Hinkley, 1997). This generates a distribution of normal expected volume $V^{\text{Normal}}_{m,t}$ for each minute t on announcement day m.

To reduce noise, I smooth the one-minute volume by taking a 5-minute moving average. I then compare the smoothed volume to the baseline distribution to identify when abnormal trading subsides. Specifically, I use the 99.5th percentile of the normal volume distribution $V^{\text{Normal},0.995}_{m,t}$ as the threshold.The upper window bound $\overline{x}_m$ is defined as the minute where the

$$V_{m,t} \leq V^{\text{Normal},0.995}_{m,t}.$$

For announcements with press conferences, I check for renewed abnormal volume during the conference period. If there exists $t_0 \in [t_{PC}, t_{PC}+75]$ such that for any 10-minute window $[t_0, t_0+10]$, $V^{5M}_{m,t} > V^{\text{Normal},0.995}_{m,t}$, then I restart the search for $\overline{x}_m$ from t_0. The resulting final window length is

$x_m = \overline{x}_m + 10$.

I determine the loadings Λ_m based on the relative share of total volume each contract contributes during the announcement window $[t-10, t+\overline{x}_m]$:

$$\lambda_{m,c} = \frac{\sum_{h=t-10}^{t+\overline{x}_m} V_{m,h,c}}{\sum_{c=1}^{14} \sum_{h=t-10}^{t+\overline{x}_m} V_{m,h,c}}$$

where c indexes the twelve quarterly and two monthly serial Eurodollar contracts.

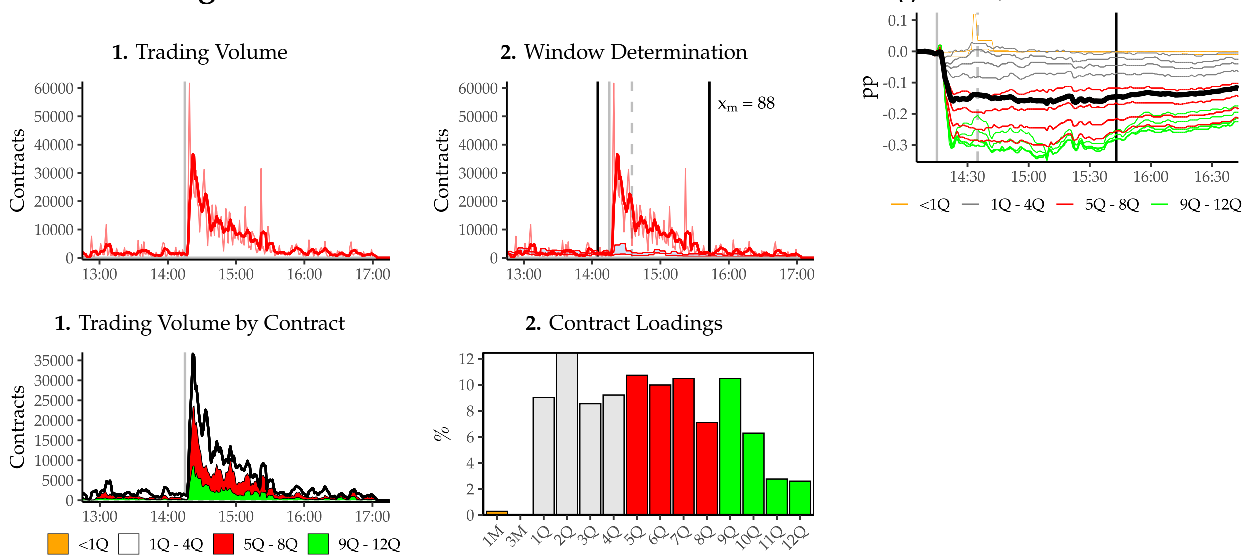
Contracts with higher trading volume during the announcement window receive greater weight in the surprise calculation. This approach allows the surprise measure to adapt to changing market conditions and communication strategies over time, naturally incorporating longer-dated contracts when they become more relevant. Importantly, the volume-weighting ensures that the surprise is constructed only from prices of actively traded contracts. If a contract is not traded during the announcement window, $\lambda_{m,c} = 0$, avoiding the use of stale prices that may not reflect current market conditions.

This volume-based approach has an additional practical advantage: it can be directly evaluated in real-time. Unlike conventional measures where loadings are estimated via PCA and must be re-estimated as the sample grows, the VBS loadings equal each contract's observed volume share. As the announcement unfolds, the window length and loadings are calculated directly from observed volume, allowing the surprise measure to be available immediately once volume returns to normal levels, as illustrated in Figure 4.

Figure 4 illustrates the VBS construction using a prominent forward guidance announcement. On August 9, 2011, 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). The top left panel shows that trading volume spikes and remains elevated for 98 minutes after the announcement. The top middle panel overlays the bootstrapped confidence interval of expected volume, with the black vertical lines marking the announcement-specific event window. The bottom panels show the volume distribution across contracts (left) and the resulting loadings (middle), which weight longer-dated contracts more heavily in response to the extended forward guidance. Panel 3 (right) displays the resulting VBS.

In principle, approaches based on price volatility could be used instead of volume. Figure 1 documents similar patterns in volatility over the FOMC announcement day, as documented in Fleming and Remolona (1999). However, I focus on volume for two main reasons. First, volatility is unobservable and must be estimated or approximated, which introduces additional noise and estimation risk. The Eurodollar options market is not as liquid as the futures or equities mar-

Figure 4: Illustration: FOMC Announcement on August 09, 2011



The figure illustrates how the volume-based surprise measure is constructed using the FOMC announcement on August 9, 2011 as an example. The first row (top left) shows 1-minute volume in light red and the 5-minute moving average in dark red. The figure in the second column adds the expected trading volume from the 21 prior trading days. The window length x_m is determined as the first minute after the announcement where volume returns to normal levels, the solid black lines denote the window lower $\underline{x} = -10$ and upper bound $\overline{x_m}$ respectively The bottom left panel shows the volume by contract during the announcement window. The bottom middle panel shows the loadings Λ_m as the relative share of each contract of total volume over the event window. Panel 3 (right) shows the resulting volume-based monetary policy surprise, which is calculated as a weighted sum of volume-weighted price changes across contracts during the announcement window using the loadings from panel 2.

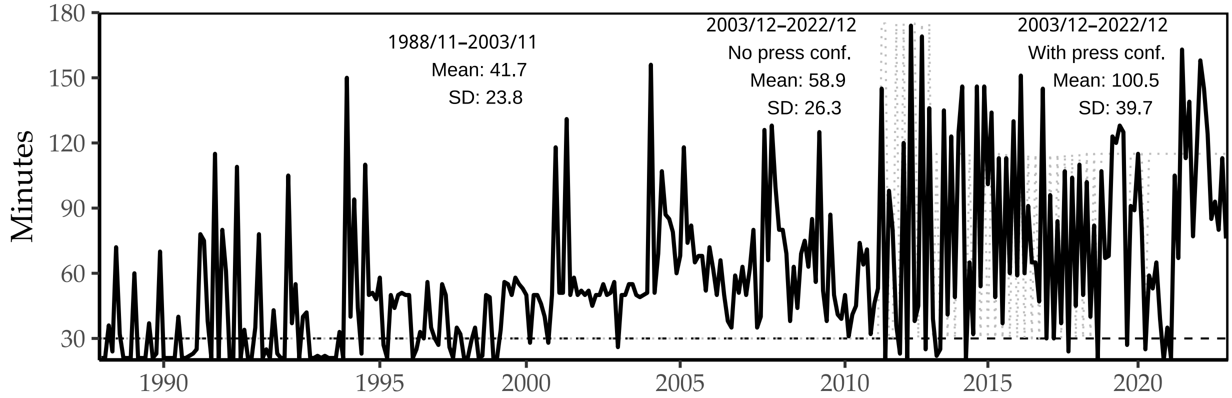
ket, making it difficult to obtain reliable high-frequency estimates of implied volatility. Second, aggregating price volatility across contracts and determining appropriate weights is not straightforward, particularly for longer-dated contracts with low trading volume where realized volatility is difficult to estimate reliably. Therefore, this paper focuses on volume as the primary metric for determining window lengths and loadings.

3.1 Announcement-Specific Window Lengths and Loadings

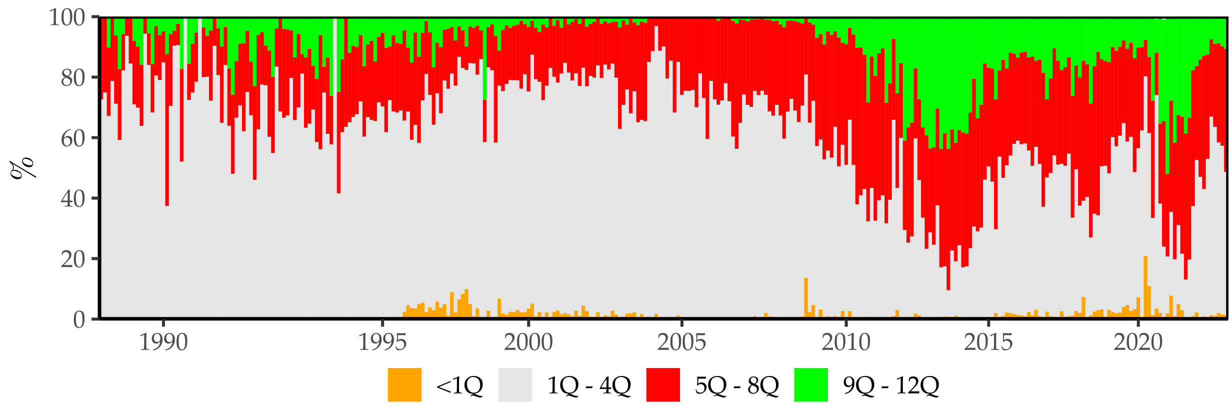
I now turn to documenting the evolution of announcement-specific window lengths x_m and loadings Λ_m over time. Figure 5 displays these two components of the VBS measure across the full sample period from November 1988 to December 2022.

Panel (a) of figure 5 displays the time series of announcement-specific window lengths x_m throughout the sample period. Several distinct patterns emerge that reflect the evolution of FOMC communication and market structure. During the pre-electronic trading era (1988-2003), window lengths averaged 42 minutes with substantial variation across announcements. Some windows are as short as 20 minutes, while others extend to 150 minutes, such as the first press release in February 1994 that caught markets by surprise. Since 1999, when the FOMC began providing statements after each meeting, window lengths commonly exceed 30 minutes, often reaching 55

Figure 5: Volume-Based Surprise



(a) Window length x_m



(b) Loadings Λ_m

Panel (a) shows the announcement-specific window lengths $\overline{x}_m$. Panel (b) shows the announcement-specific loadings Λ_m aggregated into four maturity buckets: <1Q (two monthly serials), 1Q-4Q (3-12 months), 5Q-8Q (13-24 months) and 9Q-12Q (25-36 months).

minutes due to the Eurodollar futures pit closing at 3pm ET.

The introduction of electronic trading in December 2003 marked a structural shift toward longer windows, with averages increasing to 59 minutes for announcements without press conferences. This is particularly evident during 2004, when the federal funds rate was at 1% and markets were uncertain about the path of future rate hikes, and during the global financial crisis in 2008-2009. During the zero-lower bound period, window lengths on days without press conferences are generally quite small.

What drives this variation in window lengths across announcements? The period from December 2003 to November 2018, when no press conferences were held, provides a clean setting to investigate this question. During these announcements, window lengths are not bound by the pit trading close at 3pm ET and are not influenced by press conference communications. I find that window lengths are strongly correlated with the information content of FOMC statements. Specifically, a text-based measure of statement dissimilarity—the cosine distance between the current and prior FOMC statement—accounts for 30% of the variation in window lengths. More substantial changes in FOMC communication require longer processing times as market participants work to incorporate the new information. This relationship provides direct evidence that the volume-based windows capture economically meaningful differences in information content across announcements. The full analysis is presented in Appendix C.2.

The most dramatic changes occur with the introduction of regular press conferences in 2011. Average window lengths extend to 100 minutes for announcements with press conferences, providing direct evidence that press conferences contain important information (Gómez-Cram and Grotteria, 2022). Since 2021, window lengths always extend to at least 67 minutes, highlighting the prominent role of press conferences in current FOMC communication.

Panel (b) illustrates the evolution of volume-based loadings over time, revealing fundamental changes in how markets process FOMC information. For illustrative purposes, I aggregate the loadings into four maturity buckets: <1Q (two monthly serials), 1Q-4Q (3-12 months), 5Q-8Q (13-24 months), and 9Q-12Q (25-36 months).

During 1988 to 2003, volume was heavily concentrated in the first four quarterly Eurodollar contracts (1Q-4Q), entirely consistent with conventional 30M-PC construction. These contracts, covering expectations for the next 12 months, captured the primary focus of market attention when monetary policy operated through current rate adjustments with limited forward guidance.

However, starting in 2003 volume gradually shifted toward longer-maturity contracts that accelerated dramatically during the zero lower bound period. At the onset of the zero lower bound in late 2008, the share of contracts in the 25-36 month maturity bucket (9Q-12Q) began increasing substantially. By 2013, during the peak of the Fed's forward guidance communications, these longer-maturity contracts accounted for over 40% of total trading volume, while the traditional 1Q-4Q contracts that form the basis of conventional 30M-PC measures fell below 20% of total volume.

This shift reflects a fundamental change in FOMC communication. As the Fed increasingly relied on forward guidance about the future path of policy rates, market participants focused their trading activity on contracts most sensitive to this information. Contracts with maturities extending 25-36 months became the primary vehicle for expressing views about the timing and pace of policy normalization.

Even after policy normalization began, longer-maturity contracts maintained elevated importance relative to the pre-crisis period. Throughout the remainder of the sample, 25-36 month contracts remained at least 10% of total volume, suggesting a permanent shift toward longer-term policy expectations. This persistent change likely reflects both the Fed's continued use of forward guidance and market participants' heightened attention to the path of policy rates.

The evolution of loadings also reveals important heterogeneity across individual announcements. During periods of significant policy communication, volume concentration shifts dramatically toward specific maturity buckets. For instance, announcements containing explicit date-based forward guidance (such as the August 2011 commitment to keep rates low "at least through mid-2013") show particularly high concentration in contracts maturing around the specified dates. Appendix C.5 illustrates these dynamics through specific historical examples.

3.2 Comparison with Existing Measures

Having documented the substantial evolution in window lengths and loadings over time, I now examine how these changes affect the VBS relative to conventional measures. The Volume-based Monetary Policy Surprise (VBS) is displayed in panel (a) of Figure 3.2. It is rescaled to have a unit effect on the daily change in the 1-year Treasury yield for ease of comparison with existing measures. The VBS shows substantial variation across announcements, with a standard deviation of 4.1 basis points.

To assess the economic significance of the time-varying windows and loadings, I decompose the VBS into three distinct components across two sample periods. Between 1988/11-2003/11, contracts were traded in the pit, window lengths averaged around 40 minutes, and trading concentrated in the first four Eurodollar futures contracts—the same contracts used in conventional measures. Between 2003/12-2022/12, electronic trading became dominant, window lengths extended substantially with the introduction of press conferences, and volume shifted toward longer-dated contracts. The decomposition proceeds as follows.

First, I identify the component of VBS variation explained by the conventional 30M-PC through a simple regression. The R-squared quantifies how much of the VBS is captured by the 30M-PC. Second, I construct a "window length component" by estimating the first principal component of the first four Eurodollar futures using the announcement-specific volume-based windows x_m, then regressing it on the 30M-PC and taking the residuals. This isolates additional information captured purely by extending the event windows. Third, the "volume-weighting component" represents residual VBS variation after accounting for both the 30M-PC and window length components. This decomposition strategy separately identifies: (1) information conventional measures already capture, (2) information that could be captured with longer windows alone, and (3) information that requires both longer windows and adaptive weightings.

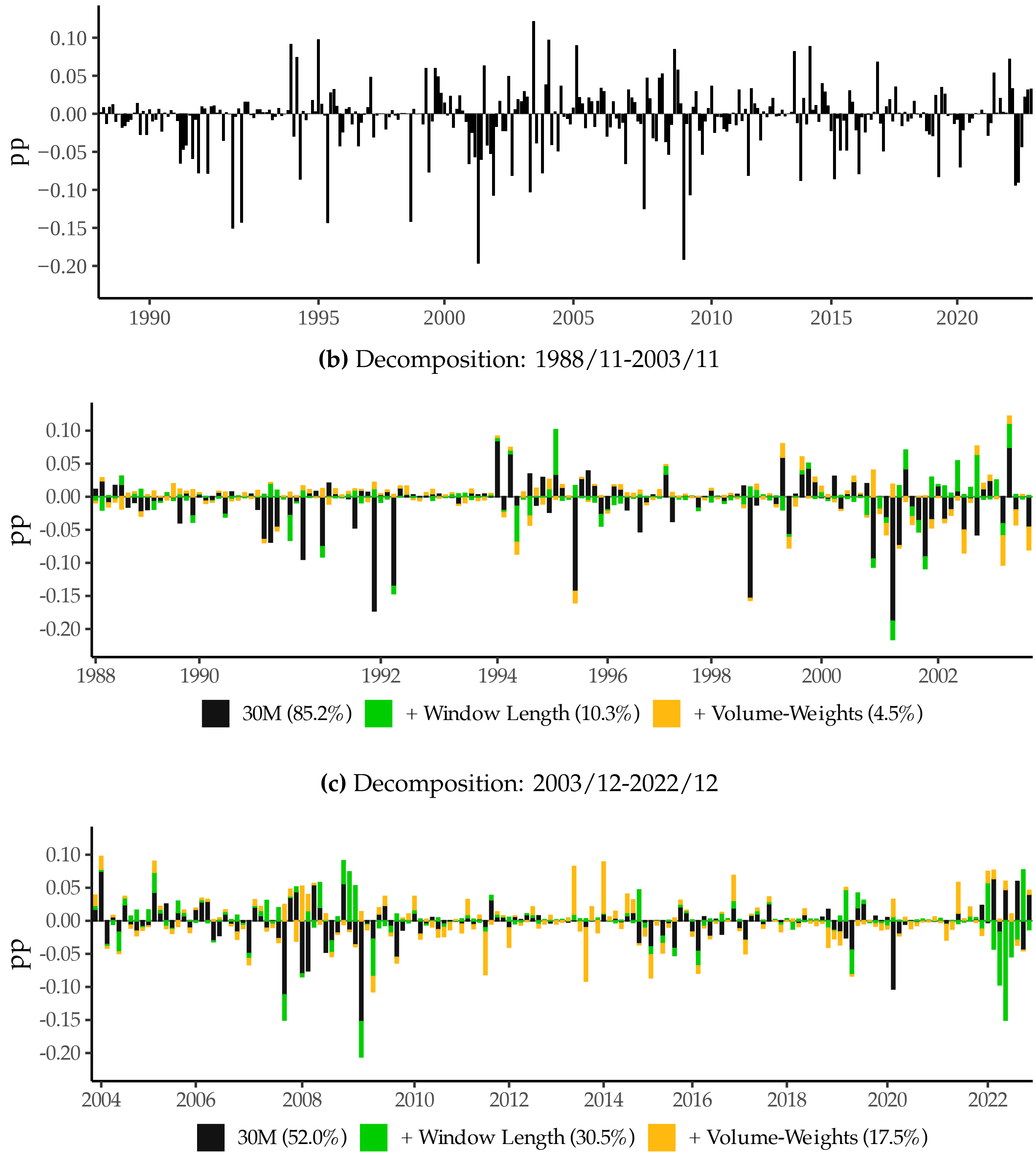
Panel (b) of Figure 6 reveals that during the early sample period, the relationship between the VBS

Figure 6: Volume-Based Surprise

(a) $\Lambda_m(f_{m,t+\overline{x}_m} - f_{m,t-10})$

(b) Decomposition: 1988/11-2003/11

(c) Decomposition: 2003/12-2022/12



The figure shows the decomposition of the volume-based surprise into three components. The first component is the 30-minute 30M-PC 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 30M-PC surprise. The volume-weighting component is the residual variation in the volume-based surprise after regressing it on the 30M-PC and the WL component. The decomposition is implemented separately between 1988/11 - 2003/11 () and 2003/12 - 2022/12.

and conventional measures was remarkably close. The 30M-PC explained 85% of VBS variation, with the window length component contributing only 10% and volume weighting accounting for 5%.

This relationship changes dramatically in the later sample period. Panel (c) shows that only 52% of VBS variation is explained by the 30M-PC, a substantial decline in explanatory power. The window length component now accounts for 30% of VBS variation, while volume weighting contributes 18%.

This transformation reflects the fundamental changes in FOMC communication that occurred during this period. The introduction of regular press conferences and expanded use of forward guidance lead to a substantial information about the path of policy rates being revealed during longer windows and at longer horizons typically considered in conventional monetary policy surprises.

The strong correspondence between the VBS and conventional measures during the early period confirms that when monetary policy operated primarily through current rate adjustments, the fixed assumptions in the literature matched market behavior. The minimal contribution of extended windows explains why Gürkaynak et al. (2005) found little difference between 30-minute and 60-minute windows during their sample period.

The volume-weighting component becomes particularly important during the zero lower bound period. The volume-weighting component is sizable while the 30M-PC barely moves, suggesting genuine policy surprises that conventional measures miss.

What information does the volume-weighting component capture? The largest volume-weighting surprises occur during episodes with significant forward guidance communications. I validate this by comparing changes in long-dated Eurodollar contracts to survey-based measures of policy expectations—specifically the Primary Dealer Survey and the FOMC's Summary of Economic Projections (SEP). When the Fed's dot plot projections deviate substantially from market expectations, the volume-weighting component is significantly correlated with these forecast errors, with an R^2 of 0.3. This indicates that when the Fed's communicated policy path surprises markets—particularly at longer horizons—trading volume shifts toward contracts that directly capture this new information. The volume-weighting thus identifies forward guidance surprises that conventional measures focusing on shorter-maturity contracts miss. The full analysis is presented in Appendix C.3.

Similarly, the window length component gains particular importance during the recent tightening cycle starting in 2022, where press conference communications often provide crucial additional information that unfolds over extended periods. Fed Chair Powell's communications during press conferences frequently clarify or modify the implications of the formal policy statement, information captured only through extended measurement windows.

4 Financial Markets Evidence

Having established the VBS methodology and documented its empirical properties, I now evaluate its performance in capturing monetary policy effects on financial markets. I follow the standard event study methodology, analyzing asset price changes in response to monetary policy surprises. Following Nakamura and Steinsson (2018), I focus on scheduled FOMC announcements and exclude the Global Financial Crisis period (2008/07 to 2009/06) and March to June 2020. I standardize all surprises to unit variance within each sample, allowing for direct comparison of economic magnitudes across surprise measures. Coefficients represent asset price responses to a one-standard-deviation surprise.

4.1 Treasury Market

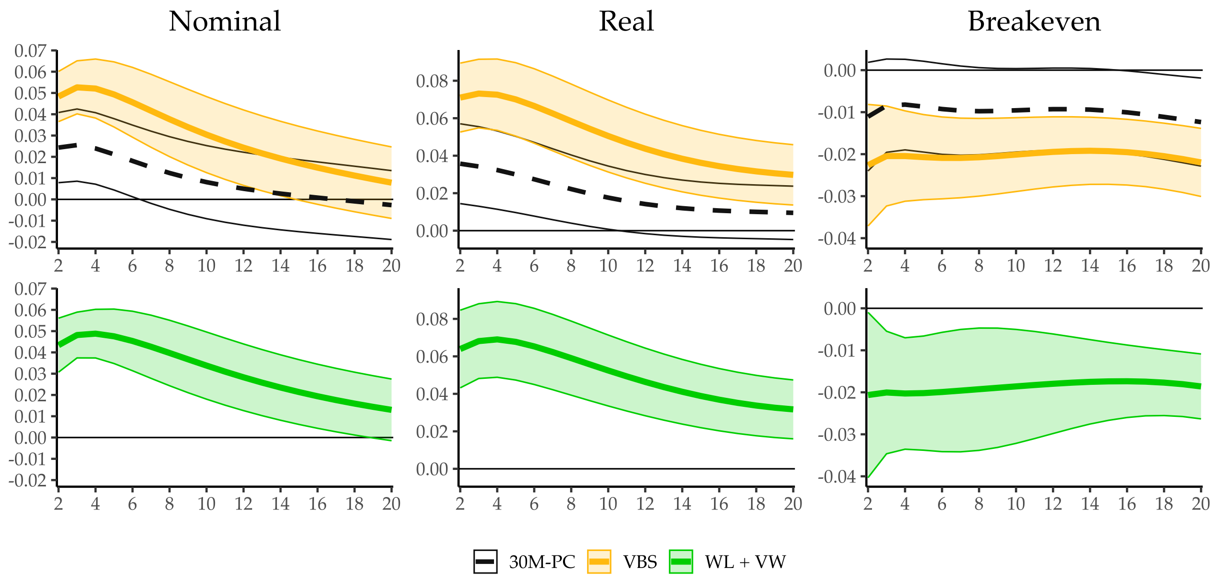
A key channel of monetary transmission operates through Treasury yields, which serve as benchmarks for mortgage rates and corporate borrowing costs. Prior event studies find that monetary policy surprises increase Treasury yields across the yield curve, with effects operating primarily through real yields and little to no impact on breakeven inflation (Hanson and Stein, 2015; Nakamura and Steinsson, 2018). I reexamine these findings using the VBS. The main result is that the VBS generates substantially larger effects on Treasury yields than conventional measures, with a one-standard-deviation surprise increasing yields by approximately 5 basis points at the peak compared to 2.5 basis points for the 30M-PC. Moreover, I find significant effects on breakeven inflation that conventional measures miss entirely. To understand these differences, I decompose Treasury yields into real and breakeven components and analyze how the window length and volume-weighting components of the VBS contribute to these responses.

To examine these effects, I estimate announcement-level regressions of the form:

$$\Delta y_m^h = \alpha^h + \beta^h \cdot s_m + \epsilon_m^h$$

where Δy_m^h is the yield change of a Treasury security with maturity h around announcement m, and s_m is the respective monetary policy surprise. Data for real and breakeven yields come from Gürkaynak et al. (2010), while nominal yield data are from (Gürkaynak et al., 2007). Since the underlying yields in (Gürkaynak et al., 2010) are based on quoted yields at 15:00 ET on each trading day, I follow Hanson and Stein (2015) and measure the yield change over a 2-day window, ensuring that the yield changes extend beyond the VBS's flexible event windows. The regressions

Figure 7: Treasury Market - Yield Curves



The figure shows the 2-day change, from the day prior to the FOMC announcement to the day after, in the yield of a Treasury security with maturity h (in pp) to the respective 1SD surprise measure

$$\Delta y_m^h = \alpha^h + \beta^h \cdot s_m + \epsilon_m^h.$$

The surprises are the first principal component of 30-minute price changes (30M-PC) (Nakamura and Steinsson, 2018) and the Volume-based Monetary Policy Surprise (VBS). The sample includes all scheduled FOMC announcements from December 2003 to December 2022 excluding the Global Financial Crisis (2008/07 to 2009/06) and March to June 2020. The underlying dataset for real and breakeven yields is Gürkaynak et al. (2010) and for nominal yields (Gürkaynak et al., 2007). The shaded areas represent 95% confidence intervals based on heteroskedasticity-robust (HC3) standard errors.

are estimated separately for each maturity h and surprise measure.

Figure 8 displays the estimated effects across the yield curve. A contractionary one-standard-deviation VBS surprise increases nominal yields by around 5 basis points at the peak, with effects remaining statistically significant out to 14-year maturities. In contrast, the 30M-PC shows a peak response of only 2.5 basis points and becomes statistically insignificant for maturities beyond 6 years.

To put these results in perspective, scaling the surprises to generate a 1 percentage point increase in the 2-year Treasury yield, the VBS increases the 10-year yield by 0.6 percentage points compared to 0.3 percentage points for the 30M-PC. This 30M-PC response is consistent with the 0.34 percentage point effect reported by Nakamura and Steinsson (2018) over a slightly different sample. The VBS therefore generates roughly twice the yield curve response of conventional measures.

The decomposition into real and breakeven yields reveals the economic mechanisms driving these differences. A contractionary VBS induces an upward shift across the entire real yield curve, with a peak response of around 7 basis points and statistically significant effects even at the 20-year maturity, suggesting persistent effects on real interest rates. Simultaneously, breakeven inflation responds with a negative level shift of around 2 basis points across the term structure. This negative response—which reflects both inflation expectations and inflation risk premia—explains why nominal yields show weaker responses than real yields.

This breakeven inflation response is a novel finding. Previous event studies find no effect of monetary policy on breakeven inflation (Hanson and Stein, 2015; Nakamura and Steinsson, 2018). The 30M-PC shows similar patterns but with one key difference: significant effects appear only at the very long end of the curve, where risk premia likely dominate, while the VBS shows significant effects at the short end, where inflation expectations are more relevant. Precisely identifying the channels through which monetary policy affects breakeven inflation and real yields requires an explicit term structure model (Abrahams et al., 2016).

To understand what drives the difference between the VBS and 30M-PC, I decompose the VBS into its window length and volume-weighting components. The window length component captures differences due to longer market processing times and press conferences, while the volume-weighting component reflects longer-dated forward guidance.

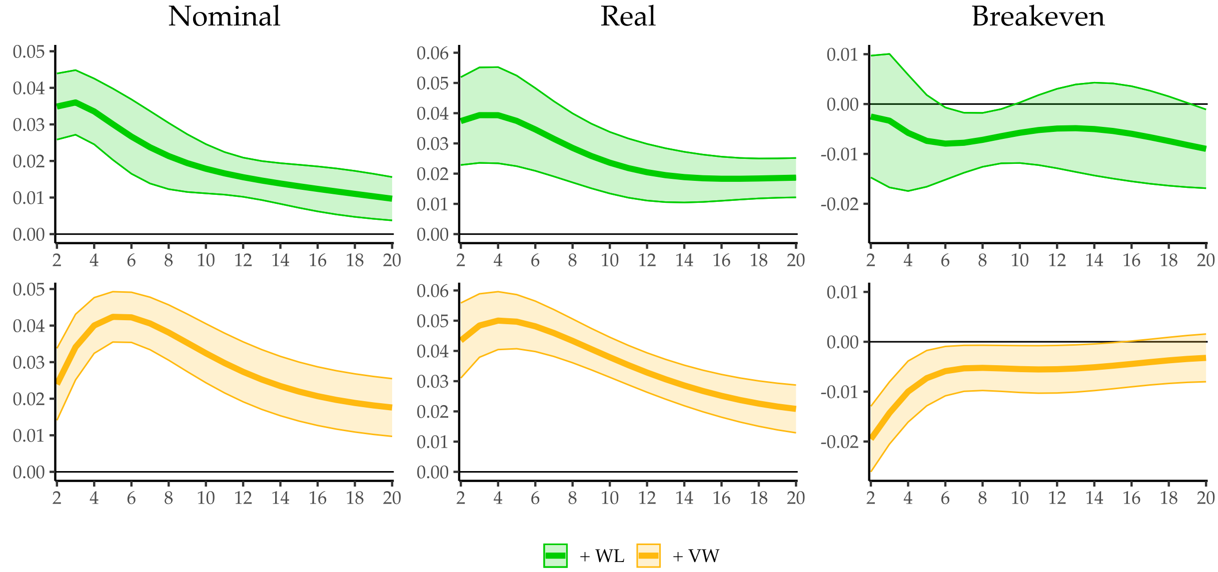
The window length component induces a persistent upward shift in real yields, with a peak effect of 4 basis points and statistically significant effects out to 20-year maturities, implying elevated forward rates even at long horizons. For breakeven inflation, this component has modest effects at the short end but turns negative at intermediate and long maturities, consistent with effects operating through bond and inflation risk premia.

In contrast, the volume-weighting component has more pronounced effects on both real yields and breakeven inflation at the short-to-medium end of the curve. These effects decay substantially at longer maturities. Appendix E confirms that real and breakeven inflation forward rates become insignificant after 10 years. These patterns suggest the volume-weighting component captures longer-dated forward guidance that affects medium-term expectations about real rates and inflation. This interpretation is consistent with the component's link to the Fed's dot plot, as documented in Section 3.2.

I now examine how these patterns vary across sample periods. Table 1 presents results for daily changes in 1-year and 10-year Treasury yields, comparing the early period (1988-2003) with the later period (2004-2022). The underlying dataset for Treasury yields is the Federal Reserve H.15 report.

During the early sample period, both the VBS and 30M-PC perform similarly, with comparable coefficient estimates and explanatory power. This validates the methodology while confirming that

Figure 8: Yield Curves - Surprise Decomposition



The figure shows the 2-day change, from the day prior to the FOMC announcement to the day after, in the yield of a Treasury security with maturity h (in pp) to the respective 1SD surprise measure

$$\Delta y_m^h = \alpha^h + \beta^h \cdot s_m + \epsilon_m^h.$$

Here, s_m denotes the two components of the Volume-based Surprises: the window length component and the volume-weighting component. These components measure the difference in the VBS to the 30-minute principal component surprise (30M-PC) (Nakamura and Steinsson, 2018), due to announcement-specific window lengths and announcement-specific loadings respectively. The sample includes all scheduled FOMC announcements from December 2003 to December 2022 excluding the Global Financial Crisis (2008/07 to 2009/06) and March to June 2020. The underlying dataset for real and breakeven yields is Gürkaynak et al. (2010) and for nominal yields (Gürkaynak et al., 2007). The shaded areas represent 95% confidence intervals based on heteroskedasticity-robust (HC3) standard errors.

conventional approaches were adequate during the era of straightforward rate-based monetary policy. However, the later period reveals substantial differences. For 10-year Treasury yields, a one-standard-deviation contractionary VBS surprise increases yields by 3.4 basis points, compared to only 0.9 basis points for the 30M-PC. The explanatory power also increases substantially, with the R-squared rising from 1.4% using the 30M-PC to 29% using the VBS. Even for the 1-year Treasury yield, the VBS achieves an explanatory power of 42% whereas the 30M-PC drops to 15% from 47% in the earlier period.

In sum, the VBS captures economically important aspects of monetary policy that conventional measures miss, operating through both expectations and term premia. Medium-term inflation expectations are substantially affected by the volume-weighting component that captures longer-dated forward guidance.

Table 1: Treasury Market - Event Study Results

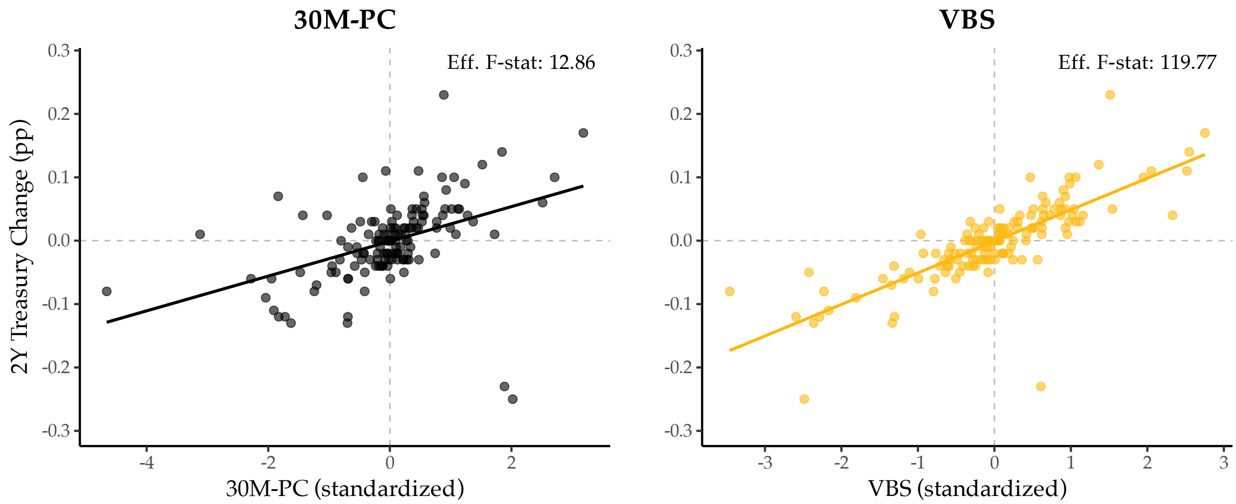
	1988/11 - 2003/11 (n= 141)			2003/12 - 2022/12 (n= 142)		
	30M-PC	VBS	WL + VW	30M-PC	VBS	WL + VW
Dep Var: 1Y Treasury						
Estimate	0.051***	0.049***	0.007	0.016***	0.026***	0.021***
SE	(0.004)	(0.005)	(0.007)	(0.006)	(0.004)	(0.006)
R^2	0.467	0.420	0.001	0.153	0.426	0.270
Dep Var: 2Y Treasury						
Estimate	0.050***	0.052***	0.016**	0.027***	0.050***	0.042***
SE	(0.004)	(0.004)	(0.006)	(0.008)	(0.005)	(0.005)
R^2	0.419	0.444	0.036	0.185	0.627	0.453
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. The sample includes all scheduled FOMC announcements from December 2003 to December 2022 excluding the Global Financial Crisis (2008/07 to 2009/06) and March to June 2020. The surprises are the first principal component of 30-minute price changes (30M-PC) (Nakamura and Steinsson, 2018), the Volume-based Monetary Policy Surprise (VBS) and sum of the window length and volume-weighting of the VBS (WL + VW) Reported standard errors are heteroskedasticity-robust (HC3) and the stars indicate significance at the 10%, 5% and 1% level.

4.2 Economic Magnitudes and Instrument Strength

It is common to scale monetary policy shocks to generate a 1 percentage point increase in a reference yield (Nakamura and Steinsson, 2018), which allows more intuitive interpretation of economic magnitudes. Figure 9 shows the first-stage relationship between the 2-year Treasury yield and each surprise measure. A one-standard-deviation VBS surprise increases the 2-year yield by 5.0 basis points with an effective F-statistic of 119.77, indicating a strong first-stage relationship. In contrast, the 30M-PC increases the 2-year yield by only 2.7 basis points with an effective F-statistic of 12.86, below conventional weak instrument thresholds. When rescaling is based on a weak first-stage relationship, the scaling factor is imprecisely estimated, and standard inference does not account for this additional uncertainty. Therefore, while I report rescaled estimates for the VBS for equity markets that follow, rescaled estimates based on the 30M-PC in this sample period should be interpreted with caution.

Figure 9: Instrument Strength: 2-Year Yield on Monetary Policy Surprises



The figure shows the daily change in the 2-year Treasury yield (in pp) on the y-axis and the respective 1SD surprise measure on the x-axis. The sample includes all scheduled FOMC announcement days between December 2003 and December 2022. I exclude all announcements during the Global Financial Crisis (2007-2009) and March to June 2020. The effective F-statistic (Olea and Pflueger, 2013) is reported for both specifications. The critical values for 10% bias are 23.1 and 37.4 for 5% bias respectively.

4.3 Equity Market

The impact of monetary policy on equity markets is a key channel through which policy affects household wealth and corporate investment decisions. Understanding stock market responses also provides insight into how investors interpret policy communications and incorporate them into expectations about future economic conditions and discount rates.

I estimate announcement-level regressions of the form:

$$y_m = \alpha + \beta \cdot s_m + \epsilon_m$$

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

Table 2 presents the main results. The first panel shows intraday S&P 500 futures returns measured over the same window as the surprise, while the second panel shows daily returns.

During the early sample period, both surprise measures generate similar results: a contractionary policy shock reduces daily stock returns by around 0.23% (30M-PC) and 0.21% (VBS). Rescaling to generate a 1pp increase in the 2-year Treasury yield, both measures imply stock price declines of approximately 4%.

The later period reveals substantial differences. The VBS implies that contractionary policy

Table 2: Equity Market - Event Study Results

	1988/11 - 2003/11 (n= 141)			2003/12 - 2022/12 (n= 142)		
	30M-PC	VBS	WL + VW	30M-PC	VBS	WL + VW
Dep Var: SP500 Future (Intraday)						
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: SP500 Total Return (Daily)						
Estimate	-0.225***	-0.213***	-0.027	-0.218	-0.433***	-0.388***
SE	(0.070)	(0.079)	(0.083)	(0.135)	(0.110)	(0.121)
R^2	0.050	0.044	-0.006	0.030	0.141	0.112

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.

reduces daily stock prices by 0.44%, while the 30M-PC suggests a 0.22% decline that is no longer statistically significant. The explanatory power differences are particularly dramatic: the VBS explains 14% of daily stock return variation around FOMC announcements, compared to just 3% for the 30M-PC.

Rescaling to generate a 1pp increase in the 2-year Treasury yield, the VBS implies an 8.71% decline in daily stock prices. The corresponding 30M-PC estimate of 7.95% should be interpreted with caution given the weak first-stage relationship documented above.

For intraday returns, the explanatory power is higher for both measures, as expected given shorter measurement windows. However, the VBS achieves relatively similar explanatory power despite using substantially longer windows, suggesting that the additional information captured by flexible windows and volume-weighting offsets the noise from longer measurement periods.

These findings reveal that equity markets have become increasingly responsive to Federal Reserve communications over time, with monetary policy surprises now explaining a larger share of stock market variation around announcements. The decomposition analysis that follows examines what drives these improvements.

To understand the sources of improved explanatory power, I decompose the VBS into its window length and volume-weighting components. Table 3 reports regressions that include all three components: the 30M-PC, the window length component, and the volume-weighting component.

Table 3: Event Study Results - Surprise Decomposition

	All			No Press Conf		
Dep Var:	1Y	10Y	SP500	1Y	10Y	SP500
Constant	-0.006**	-0.002	0.195**	-0.002	0.004	0.112
	(0.002)	(0.004)	(0.091)	(0.004)	(0.006)	(0.141)
30M-PC	0.018***	0.007	-0.229*	0.014**	0.004	-0.322
	(0.004)	(0.005)	(0.128)	(0.006)	(0.006)	(0.198)
+ WL	0.025***	0.022***	-0.343**	0.019***	0.019***	-0.042
	(0.006)	(0.004)	(0.133)	(0.003)	(0.006)	(0.292)
+ VW	0.002	0.032***	-0.192	0.004	0.033***	-0.227
	(0.004)	(0.004)	(0.131)	(0.008)	(0.006)	(0.384)
R2 Adj.	0.555	0.406	0.140	0.463	0.331	0.098
Num.Obs.	142	142	142	80	80	80

Table reports the coefficients from the following regression

$$y_m = \alpha + \beta_1 \cdot \text{30M-PC}_m + \beta_2 \cdot \text{WL}_m + \beta_3 \cdot \text{VW}_m + \epsilon_m$$

where WL denotes the window length component and VW denotes the Volume-weighting component. Reported standard errors are heteroskedasticity-robust (HC3) and the stars indicate significance at the 10%, 5% and 1% level.

Both components contribute to improved explanatory power, but their relative importance differs substantially across asset classes. For Treasury markets, both components are statistically significant and economically meaningful. The volume-weighting component is particularly important for longer-maturity securities, capturing information from longer-dated Eurodollar contracts.

For equity markets, the pattern is strikingly different. The improvements are driven primarily by the window length component rather than volume-weighting. To test whether press conferences drive these window length effects, I reestimate the decomposition using only announcements without press conferences. For Treasury markets, both components remain statistically significant, suggesting that extended processing times reflect fundamental aspects of information incorporation. For equity markets, however, the window length effects are substantially reduced in the absence of press conferences, highlighting that stock market responses rely heavily on the additional context press conferences provide. This is consistent with Acosta et al. (2025) and Gómez-Cram and Grotteria (2022) who document substantial stock market responses to press conferences.

In Figure E.4 in the appendix, I document the robustness of the responses of the 2-year Treasury yield and the daily S&P 500 return using a 10-year rolling window. The results confirm that the VBS consistently captures larger responses than the 30M-PC, particularly in recent years. It also shows a strong divergence between the equity response to the 30M-PC and the VBS since the

COVID-19 pandemic, consistent with the important role of press conferences during chairman Powell's tenure (Narain and Sangani, 2023). Across time, the VBS has a larger impact on the 2-year Treasury yield and the S&P 500 return, with a larger explanatory power.

5 Macroeconomic Evidence

Having documented substantially larger effects of monetary policy on financial markets, I now examine macroeconomic implications. The previous section showed that the VBS generates significant responses in breakeven inflation, a novel finding relative to prior work (Hanson and Stein, 2015; Nakamura and Steinsson, 2018). If these movements in inflation compensation—whether through expectations, risk premia, or both—are genuine, they should translate into realized inflation dynamics.

High-frequency identification using monetary policy surprises has been influential in understanding the causal effects of monetary policy on the economy (Gertler and Karadi, 2015; Stock and Watson, 2018). However, estimated effects on inflation are small and insignificant (Gertler and Karadi, 2015; Ramey, 2016; Plagborg-Møller and Wolf, 2022), counter to standard macroeconomic models. Additionally, Ramey (2016) shows that impulse responses are stronger in samples including the 1960s and 1970s but weaken in later samples, potentially due to more systematic monetary policy conduct reducing true surprises. Moreover, she documents substantial differences between VAR and local projection estimates, raising concerns about robustness.

I investigate whether the VBS helps address these challenges and whether these results complement other proposed solutions.

5.1 Methodology and Estimation

I estimate impulse responses using both vector autoregressions and local projections with the same variables as Gertler and Karadi (2015): the 1-year government bond yield (GS1), excess bond premium from Gilchrist and Zakrajšek (2012) (EBP), industrial production (IP), and CPI inflation. The VAR uses 12 lags, while local projections use 12 control lags. The sample runs from November 1988 to February 2020 at monthly frequency.

Identification

Let z_t be the instrument obtained by summing the respective monetary policy surprise in a given month and let y_t be the stacked vector of macroeconomic variables.

There are two key assumptions for identification. First, the variables are driven by a set of structural shocks

$$y_t = \Theta(L)\epsilon_t, \quad \epsilon_t \sim N(0, I_{n_\epsilon}).$$

Without loss of generality, the monetary policy shock is the first structural shock $\epsilon_{1,t}$ and the object of interest is the impulse response function of the macroeconomic variables to the monetary policy shock Θ_1.

Second, the exclusion restrictions requires that the instrument is correlated with the monetary policy shock but uncorrelated with all other structural shocks after adjusting for all past information

$$\text{Cov}\left(z_t, \varepsilon_{j,s} \mid \left\{z_\tau, y_\tau\right\}_{-\infty<\tau<t}\right) \neq 0 \quad \text{if and only if} \quad \text{both } j = 1 \text{ and } t = s.$$

Under these assumptions, Plagborg-Møller and Wolf (2021) show that both VARs and local projections identify the impulse response function Θ_1 up to potential attenuation from measurement error in the instrument. For the VAR, I estimate the following reduced-form system where $w_t = (z_t, y_t')'$:

$$w_t = \mu + A(L)w_{t-1} + u_t$$

where $A(L)$ is a lag polynomial of order 12, and the surprise is ordered first.

For local projections, I estimate at each horizon h:

$$y_{t+h} = \alpha^h + \beta^h z_t + \sum_{j=1}^{12} \gamma_j^h w_{t-j} + \epsilon_t^h$$

where y_{t+h} is the outcome variable at horizon h and w_{t-j} includes 12 lags of both the surprise and macroeconomic variables. The coefficient β^h traces out the impulse response function at horizon h.

This approach differs from the SVAR-IV approach (Mertens and Ravn, 2013; Stock and Watson, 2018) that is commonly used in the literature (Gertler and Karadi, 2015; Bauer and Swanson, 2022). The key difference is that the SVAR-IV approach requires invertibility of the VAR

$$\varepsilon_{1,t} \in \text{span}\left(\{w_\tau\}_{-\infty<\tau\leq t}\right).$$

Plagborg-Møller and Wolf (2022) and Miranda-Agrippino and Ricco (2023) show that non-invertibility can be an issue for these types of VARs. I verify robustness using the VBS as external instrument in the appendix. In addition, the appendix reports the relative impulse response functions rescaled by the impact on the 1-year Treasury yield which alleviates concerns about measurement error in the surprise.

Estimation

I estimate both local projections and VARs using the Ferroni and Canova (2021) toolbox. For local projections, standard errors are computed using the Newey-West estimator to account for serial correlation induced by overlapping forecast horizons. For VARs, I use a flat prior Bayesian VAR, with credible intervals based on 10,000 draws from the posterior distribution.

Following Montiel Olea et al. (2025), my baseline specification uses local projections, which are less sensitive to lag length misspecification than VARs. Montiel Olea et al. (2025) show that an impulse response function from a local projection can be thought of as a an impulse response function from a VAR that controls for a very large number of lags. Therefore, local projections lie on the low-bias high-variance end of the bias-variance tradeoff (Li et al., 2022). In contrast, the flat prior VAR will incur bias if the lag length is misspecified but has lower variance. Appendix F reports results from Minnesota priors (Litterman, 1986) which impose additional shrinkage.

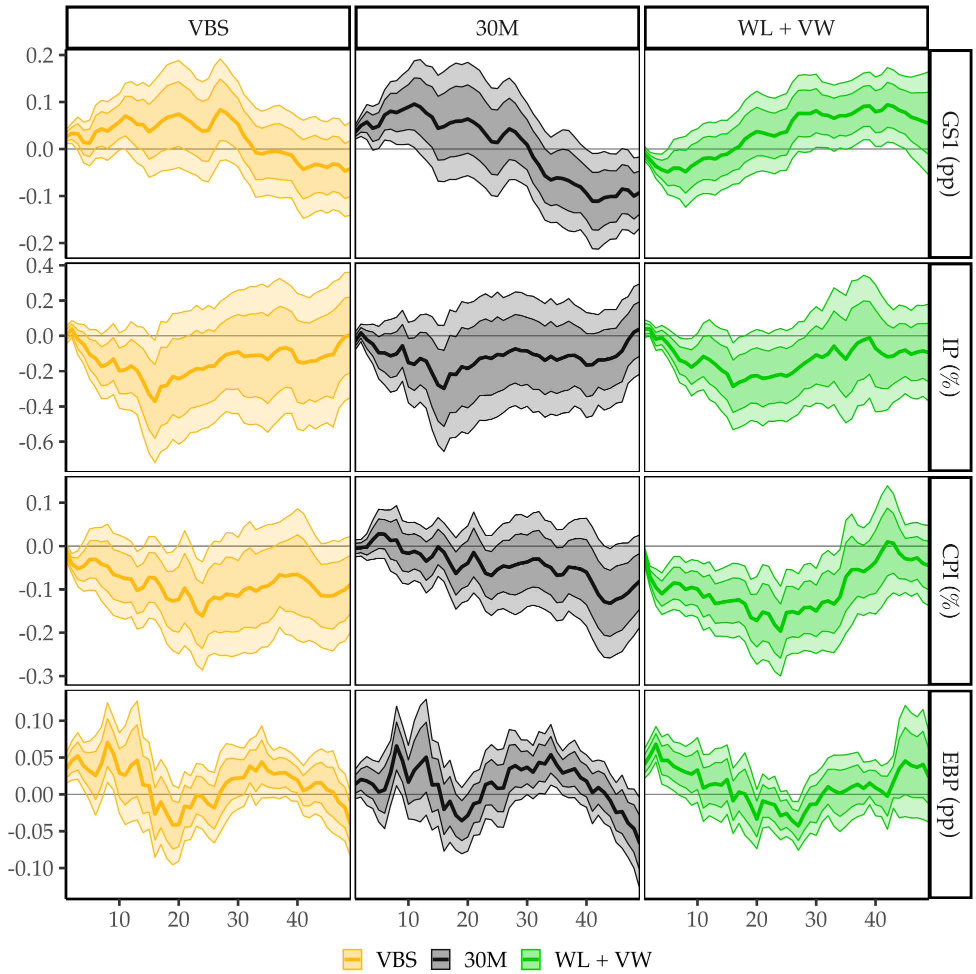
The sample runs from November 1988 to February 2020 at monthly frequency. The starting date is determined by VBS availability, while the end date avoids the Covid-19 pandemic period. I estimate both specifications separately for the VBS, 30M-PC, and the unexplained portion of the VBS (the sum of window length and volume-weighting components). To verify robustness, the appendix reports results using Minnesota priors and external instrument identification.

5.2 Results

Figure 10 reports the impulse responses to the local projection. The VBS generates substantially larger macroeconomic effects than the 30M-PC. Most striking is the inflation response: a contractionary one-standard-deviation VBS surprise decreases CPI by 0.1% after 13 months and 0.16% after 24 months, while the 30M-PC generates a negligible and insignificant response. The peak industrial production response is also larger for the VBS (0.37) than for the 30M-PC (0.3) and much more precisely estimated. There is also a larger and more persistent response in the excess bond premium on impact for the VBS compared to the 30M-PC. The appendix reports the results where the one-year Treasury yield is instrumented with the VBS, showing that an increase in the 1-year government bond yield by 25 basis points leads to a peak 1.7% decline in inflation after 24 months and a peak 3.4% decline in industrial production after 16 months.

To isolate what drives this difference, I use the unexplained portion of the VBS (window length plus volume-weighting components) in the local projection. A one-standard-deviation increase in these components leads to a large and significant decline in inflation of around 0.2% after 24 months, highly significant at the 90% credible interval. Similarly, industrial production and the excess bond premium show responses in the same direction for both the VBS and 30M-PC, but

Figure 10: The Impact of Monetary Policy Surprises on the Economy - Local Projections

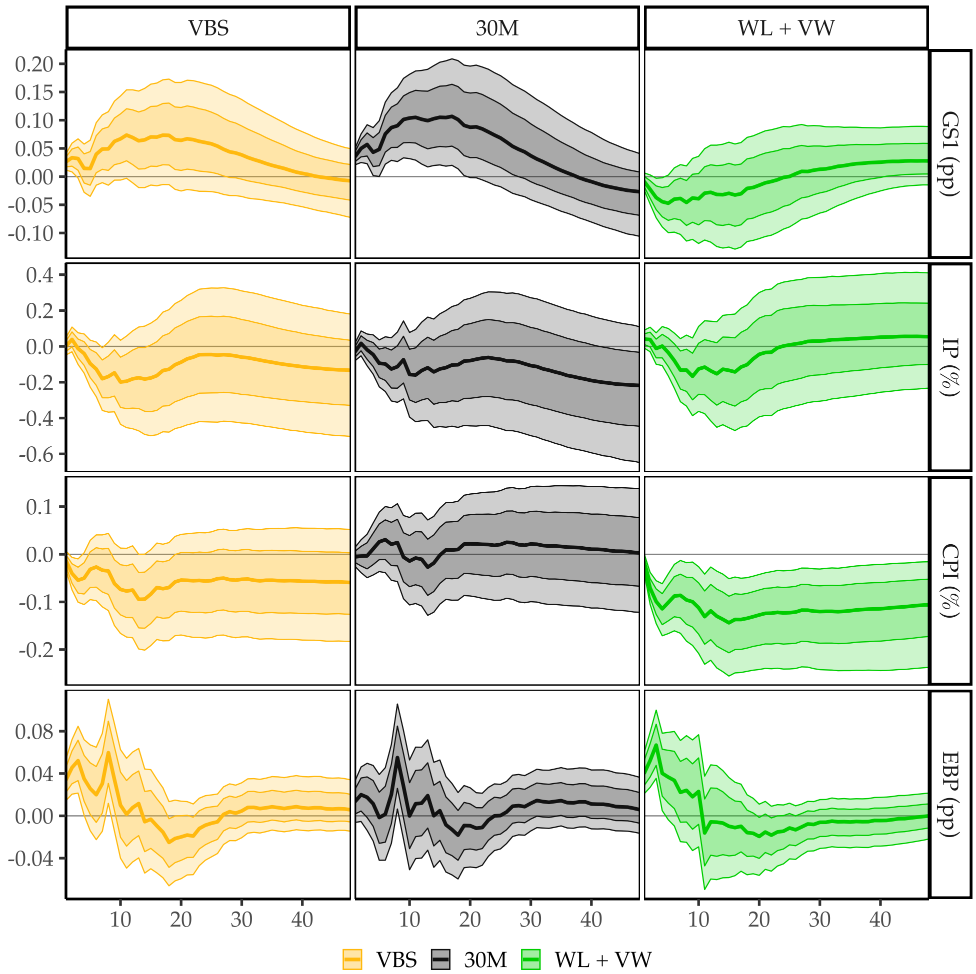


The figure shows impulse response functions of several financial and macroeconomic variables to 1 SD of the respective monetary policy surprise. 'VBS' refers to the volume-based monetary policy surprise, while other column refer to the first principal component of the first four Eurodollar futures '30M' the 30-minute window length. The set of controls includes 12 lags of the monetary policy surprise, 1-year Treasury yield (GS1), Industrial Production (IP), Consumer Price Index (CPI) and Excess Bond Premium (EBP). The impulse response functions are obtained from a Local Projection with a lag length of 12 and is estimated using the BVAR toolbox by Ferroni and Canova (2021). The 68% and 90% confidence intervals are based on Newey-West standard errors. The sample runs from November 1988 to February 2020 and is at monthly frequency.

the VBS generates larger responses, with the unexplained components driving the difference. The 1-year government bond yield response is slightly smaller for the unexplained components on impact, but become larger at longer horizons.

Figure 11 shows the corresponding VAR impulse responses. The inflation response remains striking: a contractionary one-standard-deviation VBS surprise decreases CPI by 0.1% after 12 months, while the 30M-PC generates a negligible and insignificant response. The differences in the VAR are less pronounced compared to local projections for the following reasons. First, the

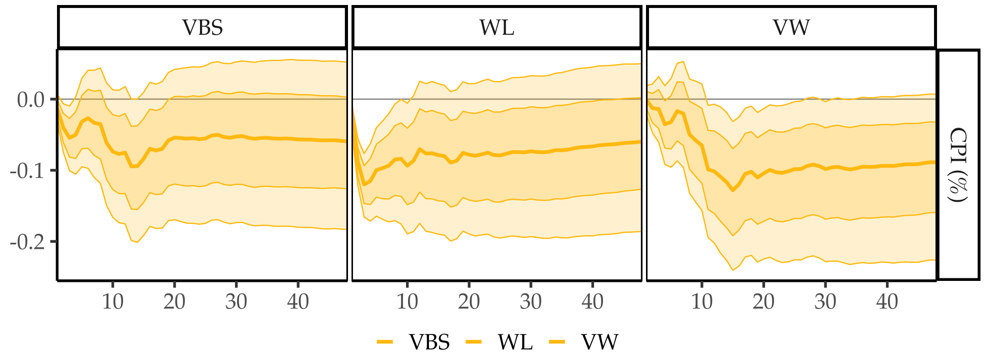
Figure 11: The Impact of Monetary Policy Surprises on the Economy - Baseline VAR



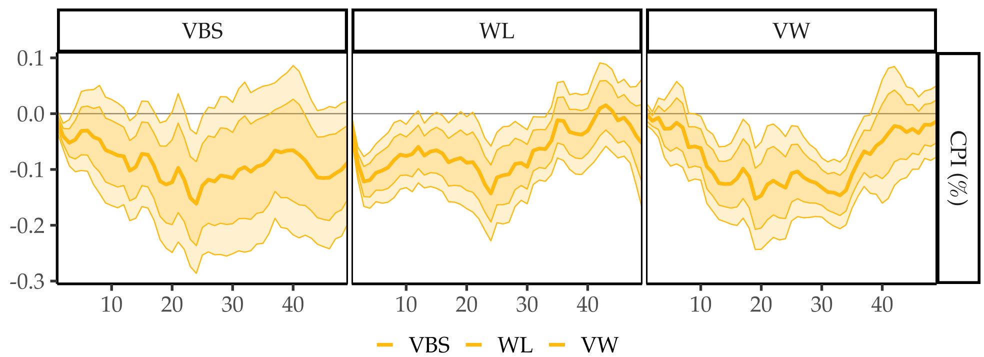
The figure shows impulse response functions of several financial and macroeconomic variables to 1 SD of the respective monetary policy surprise. 'VBS' refers to the volume-based monetary policy surprise, while other columns contain the first principal component of the first four Eurodollar futures '30M' the 30-minute window length. 'WL + VW' refers to the unexplained variation in the volume-based monetary policy surprise. The VAR includes the monetary policy surprise, 1-year Treasury yield (GS1), Industrial Production (IP), Consumer Price Index (CPI) and Excess Bond Premium (EBP). 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.

VAR can be subject to misspecification bias if the lag length is too short. Second, the VAR dynamics return to the mean faster due to its parametric structure. These aspects can lead to attenuation of the differences between the VBS and 30M-PC in the VAR compared to local projections (Li et al., 2022; Montiel Olea et al., 2025). The important takeaway is that both methods show substantially larger responses of macroeconomic aggregates to monetary policy shocks when using the VBS compared to the 30M-PC.

Figure 12: The Impact of Monetary Policy Surprises on Inflation - Window Length and Volume Weighting



(a) VAR(12)



(b) Local Projections

The figure shows impulse response functions of several financial and macroeconomic variables to a 1 SD of the respective monetary policy surprise. The VAR includes the monetary policy surprise, 1-year Treasury yield (GS1), Industrial Production (IP), Consumer Price Index (CPI) and Excess Bond Premium (EBP). 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.

To further understand the contribution of each component, I examine the window length and volume-weighting components separately. Figure 12 shows that both components lead to significant inflation declines but at different horizons. The window length component generates a near-term significant decline in inflation between horizons 0 to 10, becoming insignificant thereafter. The volume-weighting component, in contrast, produces a significant and persistent decline in inflation from horizon 10 to 24. This pattern suggests the window length component captures information affecting near-term inflation dynamics, while the volume-weighting component—linked to longer-dated forward guidance—affects medium-term inflation expectations.

These results contrast sharply with prior high-frequency identification studies. Gertler and Karadi (2015) find small CPI responses that become significant only after around 3 years in a proxy

VAR running from November 1979 to June 2012, instrumenting with the three-month Fed Funds futures from January 1991. Using local projections, Ramey (2016) finds a large discrepancy with VAR results and no response of inflation to monetary policy shocks. The appendix shows that the VBS generates significant negative inflation responses across local projections, Minnesota prior VARs, and external instrument identification, confirming robustness across specifications.

In sum, the VBS addresses the weak inflation response documented in prior work. The larger response is driven by the window length and volume-weighting components, suggesting these components capture important information about monetary policy shocks that the 30M-PC misses.

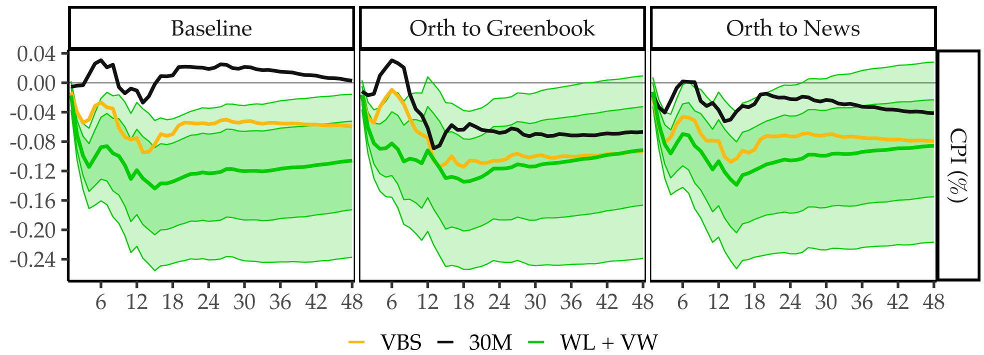
5.3 Central Bank Information vs. Reaction to Economic News Effects

The analysis thus far assumes that monetary policy surprises reflect unexpected changes in interest rate expectations. However, recent evidence shows that surprises are predictable by financial and macroeconomic news and the Fed's information set. This predictability can arise from imperfect information about the central bank's reaction function or from the central bank revealing its private information.

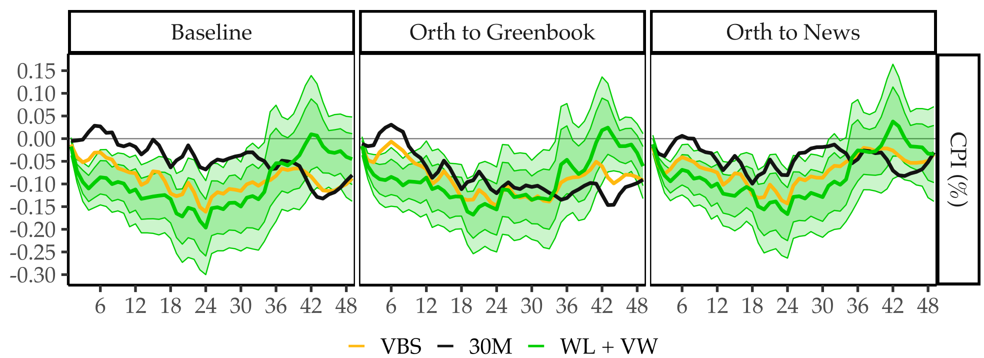
To address these concerns, I orthogonalize the monetary policy surprises to remove predictable components. I orthogonalize the VBS and 30M-PC to the economic news predictors Bauer and Swanson (2022) and to the Fed's information set followingMiranda-Agrippino and Ricco (2021). The Fed information adjustment uses Greenbook and Beige Book forecasts, which are available with a 5-year lag, limiting the sample to November 1988 to June 2019. All orthogonalization regressions are reported in the appendix.

Figure 13 shows impulse responses to the orthogonalized surprises. Each panel displays the unexplained portion of the VBS (window length and volume-weighting components) with 68% and 90% credible intervals, overlaying the full VBS and 30M-PC for comparison. 11 for comparison while the latter columns contain the IRFs of the orthogonalized VBS and 30M-PC. The orthogonalization has indeed an impact on the IRFs, particularly for the 30M-PC. 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.

Figure 13: Reaction to News vs. Fed Information Effect



(a) VAR(12)



(b) Local Projections

Each panel shows the impulse response function of a 1 SD Volume-based Monetary Policy Surprise (VBS), the 30-minute Principal Component (30M-PC) from Nakamura and Steinsson (2018) and the residual variation in the VBS which captures the window length and volume-weighting component (WL + VW). The first column shows the baseline response. The second panel adjusts all surprises to the predictors in the Greenbook (Miranda-Agrippino and Ricco, 2021). The third panel adjusts to economic news that predicts the surprises (Bauer and Swanson, 2023). 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. The 68% and 90% credible intervals are displayed for the window-length and volume-weighting component based on 10000 draws from the posterior distribution. The sample is monthly and runs from November 1988 to February 2020.

6 Conclusion

This paper revisits two key assumptions in monetary policy surprise measurement: fixed event windows and fixed asset loadings. I introduce a volume-based approach that allows both window lengths and loadings to vary across announcements, reflecting how information incorporation and FOMC communication have evolved over time.

Relaxing these fixed assumptions substantially changes estimated monetary policy effects on financial markets and the macroeconomy. The decomposition reveals that both extended window lengths—capturing press conference information and extended processing times—and volume-based loadings—reflecting longer-dated forward guidance—contribute independently to improved explanatory power.

Several directions for future research emerge. First, the volume-based methodology can be applied more broadly to event studies identifying surprises in oil futures (Känzig, 2021), government bond markets (Ray et al., 2024; Phillot, 2025), and other asset classes where fixed windows may be restrictive.

Second, this paper documents a crucial role for dispersed information after monetary policy announcements, as evidenced by the volume responses that underpin the VBS. Understanding the mechanisms through which this dispersion arises requires examining how individual market participants interpret and trade on central bank communications. Camargos Jensen et al. (2025) provide direct evidence on this question using investor-level trading data and survey beliefs from the UK. They show that position changes during the 30-minute window following MPC announcements predict both investors' subsequent positioning and their reported policy rate forecasts, demonstrating that trading patterns reflect genuine belief updates. Moreover, when announcement-window trading widens the dispersion of market participants' positions, it predicts higher disagreement about monetary policy in subsequent surveys. Understanding how this heterogeneity in belief formation across market participants affects aggregate outcomes and the transmission of monetary policy remains an important area for future research.

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Appendix

A Theoretical Framework

This section motivates the choice of announcement-specific window lengths and loadings by connecting the surprise measurement literature to models of price discovery under asymmetric information. Recent work on monetary policy surprises emphasizes imperfect information between the FOMC and market participants (Bauer and Swanson, 2023; Miranda-Agrippino and Ricco, 2021; Jarociński and Karadi, 2025). The framework developed here focuses on a complementary source of imperfect information: heterogeneity across market participants in processing FOMC announcements. Drawing on insights from the asset pricing literature (Brunnermeier, 2001; Vives, 2010), this perspective helps explain the empirical patterns documented in Section 2 and motivates why fixed event windows and loadings may be inadequate.

Consider a fundamental policy indicator determined by:

$$i_m = g(X_m; \theta_m) + \varepsilon_m$$

where θ_m represents policy parameters, X_m denotes economic state variables, and ε_m is the monetary policy shock - the unanticipated change in the policy indicator with variance σ_ε^2. The literature on monetary policy surprises focuses on imperfect information about the policy rule (Bauer and Swanson, 2023) or the information the FOMC provides about the economic state (Miranda-Agrippino and Ricco, 2021; Jarociński and Karadi, 2020), with the prevalence of either being actively debated (Bauer and Swanson, 2023; Ricco and Savini, 2025; Jarociński and Karadi, 2025).

The arguments developed below abstract from these information frictions and focus instead on information processing across market participants at each announcement. The policy indicator i_m is latent and not directly observed by market participants. This nests both the federal funds target rate, which markets observe directly, and the path of future interest rates, which is not directly observed.

Each FOMC announcement represents a single policy action with one underlying monetary policy shock. The FOMC communicates through multiple channels—the press release, the Summary of Economic Projections, the dot plot, and press conferences—but these are all public signals about the same policy indicator i_m. This motivates treating the entire announcement day as a single event. While these information releases could be analyzed separately (Altavilla et al., 2019; Acosta et al., 2025), the approach developed here captures the aggregate information content of the full announcement.

At each FOMC announcement m, market participants receive a public signal c_m about the policy indicator:

$$c_m = i_m + \nu_m$$

where ν_m represents noise with variance σ_ν^2. A Bayesian agent updates beliefs according to:

$$E[i_m|c_m] = \frac{1/\sigma_\varepsilon^2}{1/\sigma_\nu^2 + 1/\sigma_\varepsilon^2} g(X_m; \theta_m) + \frac{1/\sigma_\nu^2}{1/\sigma_\nu^2 + 1/\sigma_\varepsilon^2} c_m$$

When the FOMC provides a perfectly informative signal about i_m ($\sigma_\nu^2 \to 0$), then $E[i_m|c_m] \to i_m$ and the only information that moves prices is the unanticipated policy change ε_m. This is the case for target rate announcements. The Kuttner (2001) surprise exploits the fact that the front-month federal funds futures payoff is determined by the realized target rate at month's end:

$$s_m^{Kuttner} = E[i_m|c_m] - E[i_m] = i_m - g(X_m; \theta_m) = \varepsilon_m$$

Since another FOMC meeting within the same month is unlikely, any post-announcement price captures the full surprise and very short event windows suffice.

Path surprises present a more complex environment. First, when the public signal c_m contains noise ($\sigma_\nu^2 > 0$), the expectation $E[i_m|c_m]$ only partially adjusts to the monetary policy shock ε_m, making heterogeneity among market participants relevant. Market participants may gain informational advantages through re-reading FOMC statements, developing proprietary term structure models, or accessing other information sources. Second, any asset pricing the path of interest rates contains residual uncertainty at the end of the announcement day, as future policy depends on subsequent monetary policy decisions and evolving economic conditions.

These differences raise a key question: how quickly do prices become fully informative about the policy indicator i_m?

Under standard efficient markets assumptions with homogeneous information processing, the no-trade theorem (Milgrom and Stokey, 1982) would imply no trading following public announcements, with prices being fully revealing immediately (Grossman, 1976). However, the empirical patterns documented in Section 2 contradict this prediction: volume remains elevated for 75-100 minutes and prices adjust gradually over 45 minutes.

These patterns can be understood through dynamic noisy rational expectations models. In these models, there is an asset with a fundamental (the policy indicator i_m) and a shock to that fundamental (the monetary policy shock ε_m). Market participants learn about the fundamental through both public signals (the FOMC announcement and observed prices) and private signals (from re-reading statements, proprietary term structure models, and other information sources).

First, these models predict that volume and volatility react to new information. Even with risk-neutral market makers, informed agents trade actively (Vives, 1995). As market participants learn from their private signals and the public price signal, price informativeness increases over time, resolving differences in interpretation and incorporating dispersed information. The speed of convergence depends on the precision of the public signal, the degree of information asymmetry, the uncertainty about the fundamental, and the noise trading process (Vives, 2010). This explains the empirical patterns documented in Section 2 where volume and volatility spike at the announcement and then decay over time.

Second, when market makers are risk-averse rather than risk-neutral, prices can underreact and incorporate information slowly. Allen et al. (2006) show that with short-term risk-averse traders, i.i.d. noise trading, and an informative but imperfectly precise public signal, prices underreact to shocks as agents overweight public information relative to their private signals. While the consensus opinion of market participants converges quickly to the true fundamental, prices only gradually reflect this convergence. Depending on assumptions about the noise-trading process and the precision of the public signal, multiple equilibria with different price informativeness can arise (Cespa and Vives, 2015), generating momentum or reversal patterns. Similar patterns can emerge with long-term traders when assets pricing the path of interest rates contain residual uncertainty about the fundamental at the end of the announcement day (He and Wang, 1995; Cespa and Vives, 2012). These insights are consistent with the gradual price adjustment documented in Section 2 and the exploitable momentum pattern documented in Appendix B.2.

It is important to note that these models are highly stylized. The predictions arise in settings where aggregating dispersed information across all market participants would immediately reveal the true monetary policy shock. In reality, the learning problem is considerably more complex. Market participants must interpret FOMC statements, form beliefs about the policy reaction function and economic state, navigate strategic interactions and face trading frictions—all of which would further complicate the price discovery process. Nevertheless, the empirical patterns documented in Section 2 are consistent with the basic insights from these models: prices take time to incorporate information, and trading volume and volatility reveal when this process is complete.

B High-Frequency Data

B.1 Summary Statistics

Table B.1 shows the summary statistics of the high-frequency data on Eurodollar Futures used in this paper.

Table B.1: Summary Statistics of 1-minute Eurodollar Futures Prices and Volume

	1988/11-2003/11		2003/12-2022/12	
Statistic	Non-FOMC (N=2482)	FOMC (N=121)	Non-FOMC (N=3090)	FOMC (N=151)
Transactions			*Volume*	
Mean	1	2	1393	2363
SD	2	3	2947	4779
P01	0	0	0	0
P50	1	1	518	902
P99	11	16	12193	22851
ΔP			ΔP	
Mean	0.0014	0.0015	0.0009	0.0013
SD	0.0033	0.0039	0.0014	0.0026
P01	0	0	0	0
P50	0	0	0.0004	0.0008
P99	0.01	0.015	0.0058	0.01

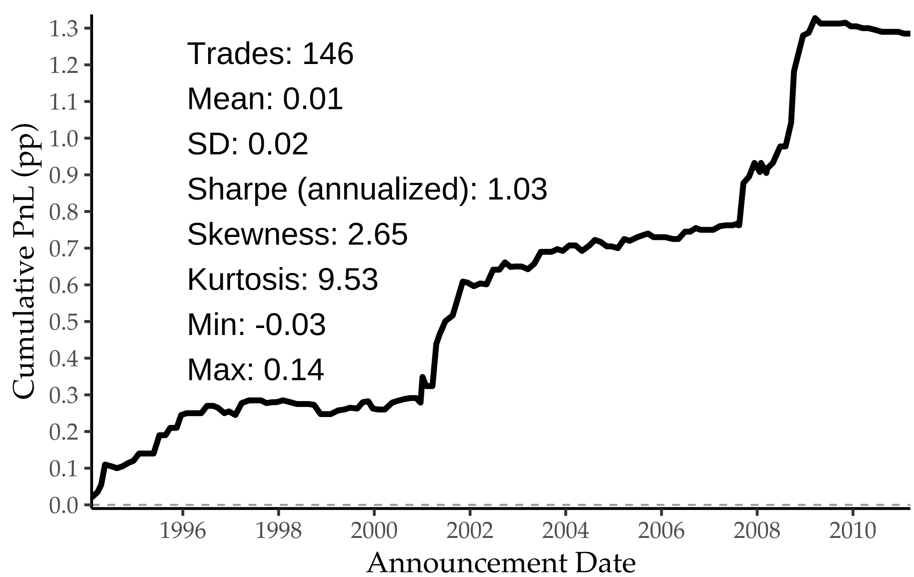
This table shows the summary statistics of the 1-minute Eurodollar futures absolute price changes and volume. From 2003/12 to 2022/12 the sample is restricted between 09:00 to 17:00 ET and Volume is reported in contracts. During 1988/11 to 2003/11 the sample is restricted to 09:00 to 15:00 ET, due to the shorter trading hours in the Eurodollar Pit and the number of transactions is reported.

The data spans November 1988 to December 2022 and contains 1-minute prices and volume for Eurodollar futures contracts traded on the Chicago Mercantile Exchange (CME). The table displays statistics for the first 12 quarterly contracts. The VBS construction also includes two monthly serial contracts, but these account for a negligible share of trading activity. The sample is split into two periods: 1988/11 to 2003/11 and 2003/12 to 2022/12. The first period corresponds to pit trading (Restricted Trading Hours), while the second period corresponds to electronic trading (Extended Trading Hours). Trading hours are shorter in the pit (09:00 to 15:00 ET) than in electronic trading, which occurs around the clock except for a daily maintenance period from 17:00 to 18:00 ET.

The electronic trading dataset is used for the estimations in Section 2, which focuses on scheduled FOMC announcements between December 2003 and December 2022. Some unscheduled FOMC announcements occur earlier than 09:00 ET. To maintain comparability and avoid conflating the summary statistics with periods of low trading activity, the sample is restricted to 09:00 ET onwards for the volume-based surprise creation.

B.2 Trading Strategy

Figure B.1: Cumulative PnL of Long-Short first Eurodollar Contract



The figure shows the cumulative PnL of a long-short strategy in the first Eurodollar contract that enters a long (short) position if there has been a rate increase (decrease) from 10 minutes before to 10 minutes after the FOMC announcement and closes the position once volume is not abnormal anymore. The sample includes all FOMC announcements from February 1994 to March 2011, before the introduction of press conferences.

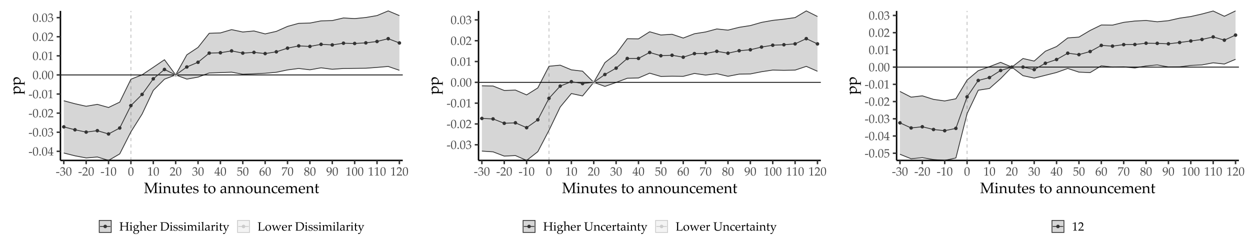
This subsection documents a simple trading strategy that exploited the gradual price adjustment documented in Section 2. The strategy goes long (short) in the first quarterly Eurodollar contract if prices increase (decrease) from 10 minutes before to 10 minutes after the FOMC announcement. The strategy waits for the initial price jump induced by the press release, then bets on subsequent drift in the same direction. It closes the position once volume returns to normal levels.

Between February 1994 and March 2011, before the introduction of press conferences, the strategy generates a cumulative profit of 1.3 percentage points with an annualized Sharpe ratio of 1.03. The returns exhibit positive skewness of 2.65, with a few large positive returns and many small or negative returns. This pattern persists across 126 announcements over 17 years.

A key caveat is that the strategy does not account for transaction costs, bid-ask spreads, or market impact. Fleming and Piazzesi (2005) document a similar pattern in government bond cash markets but show that transaction costs prevent profitability.

B.3 Heterogeneity in Cumulative Price Response

Figure B.2: Cumulative Absolute Price Changes - Heterogeneity



(a) Statement Dissimilarity **(b)** Monetary Policy Uncertainty **(c)** Dot Plot

Panels (a) and (b) show $\hat{\beta}_k$ and their 99% confidence intervals from

$$|P_{c,m,\tau} - P_{c,m,-10}| = \alpha_{c,m} + \alpha_{c,\tau} + \sum_{\substack{k=-30 \\ k\neq 20}}^{120} \beta_k \cdot \mathbb{1}\{\tau = k\} \cdot \mathbb{1}\{X_m > \text{median}(X)\} + \epsilon_{c,m,\tau}$$

where c denotes the contract, m indexes FOMC meetings, and τ denotes event time in minutes relative to the FOMC announcement. X_m is a characteristic of FOMC announcement m that captures heterogeneity in the information content of the announcement. The baseline period is $\tau = 20$. The interaction with event-time dummies provides within-group variation for identification despite the presence of contract × meeting and contract × time fixed effects. I consider two different characteristics: (a) text-based statement dissimilarity, which proxies for the amount of new information, and (b) Policy Rate Uncertainty (Bundick et al., 2024), which is a proxy for residual uncertainty as it measures option-implied volatility of Eurodollar futures on the day before the announcement. Panel (c) reports the difference in the cumulative absolute price change between the 12th and 1st Eurodollar contract when the Summary of Economic Projections (SEP) is released. The coefficients are estimated by OLS. The regression is estimated using only FOMC announcement days. Standard errors are clustered at the meeting level.

This subsection examines how price reactions vary with empirical proxies for public signal precision and uncertainty about the fundamental payoff of the futures contract. These correspond to exogenous parameters in noisy rational expectations models. Figure B.2 shows the difference in cumulative absolute price changes between FOMC announcements with high and low values of these proxies, where high and low are defined relative to the median.

Panel (a) shows the difference in cumulative absolute price changes between FOMC announcements with high and low text-based statement dissimilarity (see Appendix D for details). Statement dissimilarity captures the amount of new information in the FOMC statement relative to the previous statement. Announcements with high statement dissimilarity exhibit both a larger immediate price jump and more pronounced subsequent drift, consistent with greater information content requiring more time to process while also generating larger initial reactions.

Panel (b) shows the difference in cumulative absolute price changes between FOMC announcements with high and low levels of Monetary Policy Uncertainty (MPU) (Bundick et al., 2024) measured on the day before the announcement. MPU captures policy uncertainty and serves as a proxy for residual uncertainty about the futures contract payoff. Announcements with high MPU exhibit sustained and large post-announcement drift, consistent with market participants placing less weight on price signals and private information when these are less informative about the contract's ultimate payoff.

Panel (c) shows the difference in cumulative absolute price changes between the 12Q and 1Q Eurodollar contracts on days when the Summary of Economic Projections is released jointly with the FOMC statement. The SEP contains FOMC projections for GDP growth, unemployment, inflation, and the federal funds rate over the next few years. Relative to the 1Q contract, the 12Q contract shows a sizable immediate jump in prices and slight subsequent drift, consistent with the SEP providing a relatively precise signal about the longer-term path of interest rates.

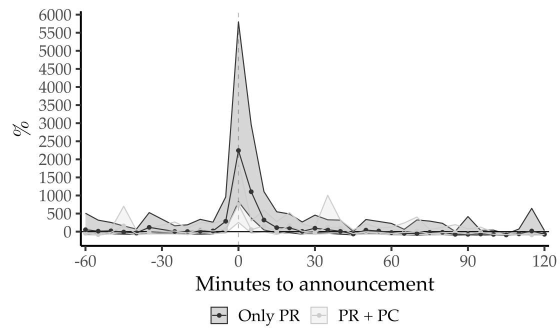
B.4 Poisson Regressions

The main text uses OLS regressions to estimate patterns of trading volume and absolute price changes around FOMC announcements. However, both dependent variables are non-negative and right-skewed. This subsection reports results from Poisson regressions, which account for the count nature of the data and provide consistent estimates (Cohn et al., 2022).

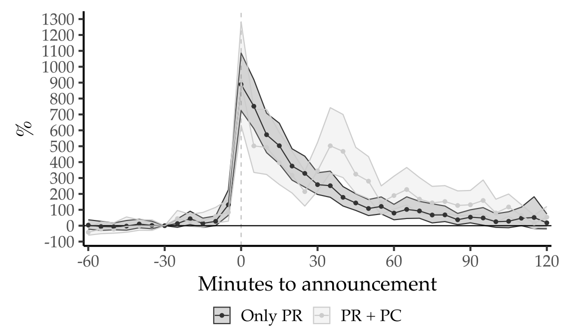
The Poisson specification differs from the OLS results in interpretation. The main text reports economically relevant magnitudes (DV01 for contracts and percentage points for price changes), while the Poisson regression reports percentage changes in the dependent variable by construction. This allows direct comparison of relative changes in volume and absolute price changes. Since the independent variables are indicator variables, I transform the coefficients to percentage changes using $(\exp(\hat{\beta}) - 1) \times 100$.

They reveal similar patterns to the OLS results in Figure 1. Volume and absolute price changes spike at the announcement and then decay gradually over 75-100 minutes. The magnitude of the percentage changes is sizablely larger in the Eurodollar futures market than in the front-month federal funds futures market, consistent with the OLS results. Twenty minutes after the announcement—the upper bound of the conventional 30-minute window—volume is 400% higher than 30 minutes before the announcement in the Eurodollar market, and volatility remains 100% higher. In contrast, volume and volatility in the front-month federal funds futures have returned to their pre-announcement level after twenty minutes.

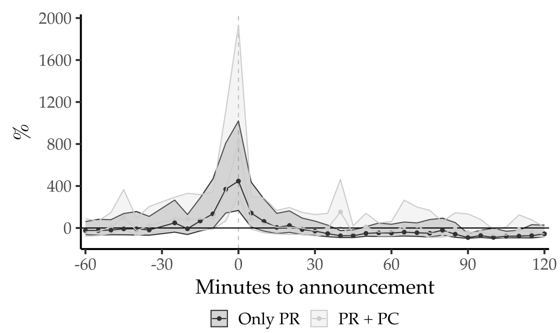
Figure B.3: Trading Volume and Absolute Price Changes Around FOMC Announcements - Poisson



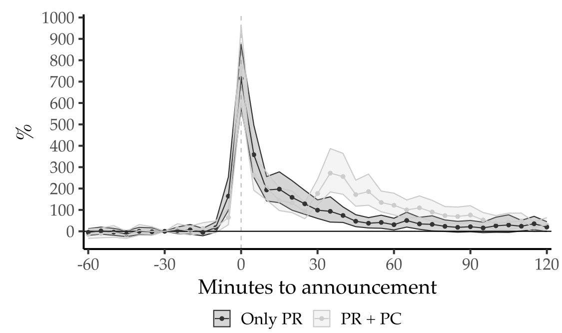
(a) Front-Month FFR Future Volume



(b) Eurodollar Futures Volume



(c) Front-Month FFR Future Price Volatility



(d) Q1-Q12 Eurodollar FuturesPrice Volatility

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

$$log(E[Volume_{m,d,t}|.]) = \alpha_{m,t^{5M}} + \alpha_d + \sum_{j=-60}^{j=120,j+=5} \boldsymbol{\beta}_{j,m=1} \mathbb{1}_{t^{5M}=j} \mathbb{1}_{m=d}$$

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

$$log(E[|\Delta P_{c,m,d,t}|.]) = \alpha_{c,m,t^{5M}} + \alpha_{c,d} + \sum_{j=-60}^{j=120,j+=5} \boldsymbol{\beta}_{j,m=1} \mathbb{1}_{t^{5M}=j} \mathbb{1}_{m=d}$$

where subscripts are similar to above and c denotes the contract. . denotes conditioning on the fixed effects and group indicators. The coefficients are estimated using Poisson regression. The sample runs from 2003-12-01 to 2022-12-31 and contains all scheduled FOMC announcements and the 21 prior trading days. The vertical line indicates the FOMC announcement at t=0. Standard errors are clustered at the day level.

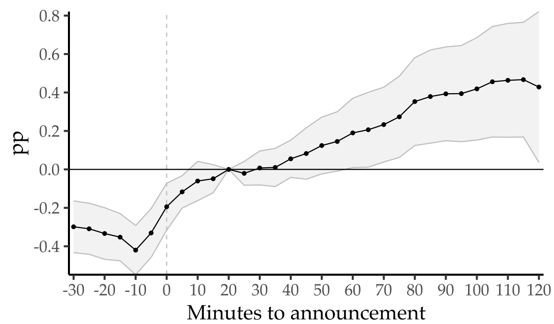
B.5 Equity Markets

The arguments about information processing around central bank announcements apply to equity markets as well. In this context, market participants must process not only information about the path of interest rates, but also its implications for discount rates and future cash flows. Zhu (2023) documents that volume in the SPY ETF and the cross-section of equity markets spikes around FOMC announcements and then decays.

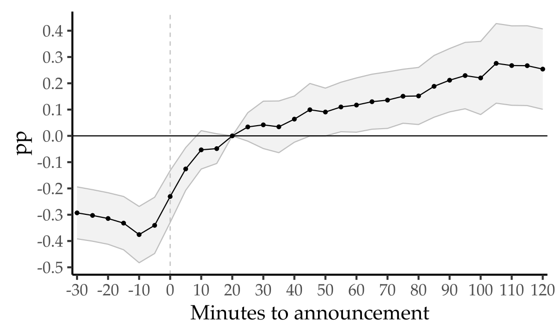
This subsection examines post-announcement volume and return dynamics in the E-Mini S&P 500 futures contract (ES) traded on the CME. The results confirm the patterns documented in the Eurodollar market and show that they are even more pronounced in E-Mini futures.

Since E-Mini futures have been traded electronically since their inception in 1997, they provide evidence on whether longer windows would have been appropriate even in the pre-2004 period. The cumulative return patterns show no qualitative differences across periods. However, the absolute magnitude of cumulative returns is substantially larger in the pre-2004 period.

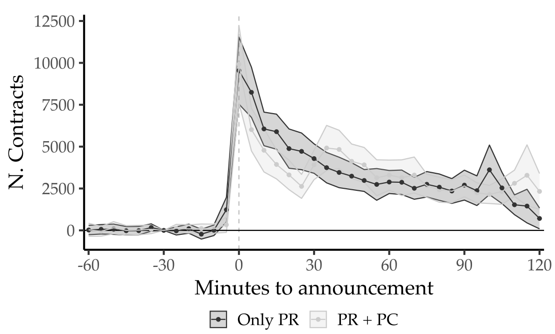
Figure B.4: Behavior of E-Mini Futures Around FOMC Announcements



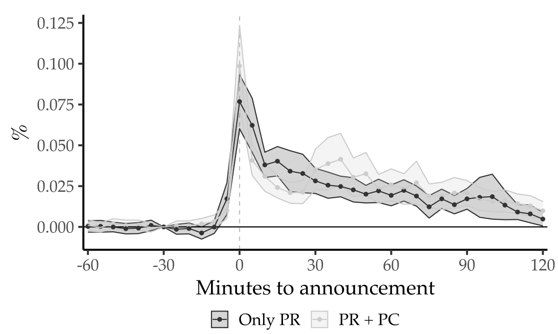
(a) Cumulative Return Pre-2004



(b) Cumulative Return



(c) Volume



(d) Volatility

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

$$Volume_{m,d,t} = \exp(\alpha_{m,t^{5M}} + \alpha_d + \sum_{j=-60}^{j=120, j+=5} \beta_{j,m=1} \mathbb{1}_{t^{5M}=j} \mathbb{1}_{m=d} + \epsilon_{c,m,d,t})$$

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

$$|\Delta P_{c,m,d,t}| = \exp(\alpha_{c,m,t^{5M}} + \alpha_{c,d} + \sum_{j=-60}^{j=120, j+=5} \beta_{j,m=1} \mathbb{1}_{t^{5M}=j} \mathbb{1}_{m=d} + \epsilon_{c,m,d,t})$$

where subscripts are similar to above and c denotes the contract. The coefficients are estimated using Poisson regression. The sample (unless otherwise noted) runs from 2003-12-01 to 2018-12-31 and contains all scheduled FOMC announcement days without press conferences and the 21 prior trading days. The vertical line indicates the FOMC announcement at t=0. Standard errors are clustered at the day level.

C VBS: Additional Details

C.1 Step-by-Step Implementation

Let $V_{m,d,t} = \sum_{c=1}^{14} V_{m,d,t,c}$ denote aggregate trading volume across fourteen Eurodollar contracts in minute t on day d, where m denotes the FOMC meeting. These contracts comprise the first twelve quarterly contracts and two monthly serial contracts that expire in the current quarter.

For each meeting m, the dataset includes the announcement day and 21 prior trading days.

Step 1: Bootstrap Normal Volume Distribution

For each 5-minute time bucket t^{5M}, I collect one-minute volumes:

$$\{V_{m,d-i,t}\}_{i=1}^{21,\ t\in t^{5M}}$$

Rather than resampling individual minutes independently, I perform a day-level cluster bootstrap (Rao and Wu, 1988) to preserve intraday correlation structure:

- Draw randomly 21 trading days d with replacement from the available 21 Pre-FOMC days
- For each drawn day d, include all 5 one-minute observations
- Compute the overall mean of pooled observations
- Repeat $B = 5{,}000$ times to form the bootstrap distribution
- Extract empirical 0.5% and 99.5% percentiles: $\widetilde{V}_{m,t^{5M}}^{\text{Normal},0.005}$ and $\widetilde{V}_{m,t^{5M}}^{\text{Normal},0.995}$

Step 2: Volume Smoothing

Calculate smoothed 1-minute average volume over the past 5 minutes:

$$V5M_{m,d,t} = \frac{1}{5}\sum_{i=0}^{4} V_{m,d,t-i}$$

This smoothing reduces noise while preserving the essential dynamics of volume evolution.

Step 3: Window Length Determination

Define the upper window bound as:

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

where x represents minutes elapsed after the FOMC press release.

Step 4: Press Conference Adjustment

For announcements with press conferences, I check for renewed abnormal volume during the conference period:

If there exists $t_0 \in [t_{PC}, t_{PC} + 75]$ such that for any 10-minute window $[t_0, t_0 + 10]$:

$$V5M_{m,d,t+x} > \widetilde{V}_{m,d,t}^{\text{Normal},0.995}$$

then restart the search for $\overline{x_m}$ from t_0.

Step 5: Volume-Based Loadings

The loading for each contract c is determined by its relative share of total volume:

$$\lambda_{m,c} = \frac{\sum_{h=t-10}^{t+\overline{x}_m} V_{m,d,h,c}}{\sum_{h=t-10}^{t+\overline{x}_m} \sum_{c=1}^{14} V_{m,d,h,c}}$$

The final Volume-Based Surprise (VBS) is:

$$s_m^{VBS} = \sum_{c=1}^{14} \lambda_{m,c} \left(f_{m,d,t+\overline{x}_m,c} - f_{m,d,t-10,c} \right)$$

where $f_{m,d,t,c}$ denotes the implied futures rate for contract c at time t on day d of meeting m.

C.2 Higher Statement Dissimilarity Predicts Longer Windows

An important aspect of Federal Reserve communication is the formal FOMC statement released jointly with the interest rate decision. This statement provides the rationale for policy decisions and has evolved substantially over time in both length and content. Media reports often focus intensively on changes in statement language, providing markets with immediate analysis of modifications that might signal shifts in policy stance or economic assessment [4]. Changes in statement content represent a key source of information for market participants.

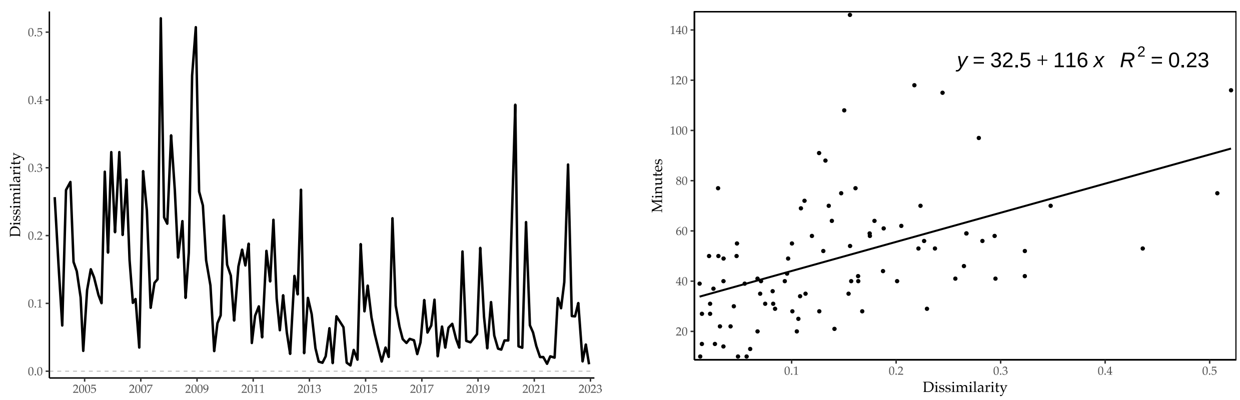
To test whether the volume-based window lengths respond systematically to information content, I develop a text-based measure of statement dissimilarity. This measure is calculated as the cosine similarity $Similarity_m$ between the current FOMC statement and the previous statement, using term-frequency inverse document-frequency (TF-IDF) weights calculated on the current

[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 https://graphics.wsj.com/fed-statement-tracker-embed/

and all prior statements. A higher dissimilarity score, which is $1 - Similarity_m$, indicates a more substantial changes in statement content.

Figure C.1 displays both the time series of statement dissimilarity and its correlation with volume-based window lengths. The dissimilarity measure shows considerable variation over time, with particularly large values during periods of major policy shifts or economic stress. The figure also shows a clear positive correlation between statement dissimilarity and volume-based window lengths, suggesting that larger changes in statement content are associated with longer periods of information processing by market participants. A 0.1 increase in statement dissimilarity is associated with an 11.8 minute increase in the window length, indicating that more substantial changes in the statement lead to longer periods of elevated trading volume as markets digest the new information.

Figure C.1: Statement Dissimilarity Predicts Window Length



(a) Statement Dissimilarity **(b)** Window Length vs. Statement Dissimilarity

Statement dissimilarity is $1 - Similarity_m$, where $Similarity_m$ is 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 right panel shows a scatter plot of the volume-based window length $\overline{x}_m$ against statement dissimilarity. The sample period is 2003/11 to 2018/12, and excludes announcements with press conferences.

This relationship provides important validation of the volume-based approach. The results show that changes in the informational content of the statement, which can proxy for the amount of new information being conveyed, systematically predict that markets require more time to process this information.

C.3 Large Volume-Weight Component Aligns with Survey Forecast Errors

An important validation of the volume-weighting approach comes from examining how the weightings relate to direct measures of policy expectations. Three of the largest surprises in the volume-weighting component occur in June 2013, September 2013, and March 2019 — all episodes involving significant forward guidance communications that shifted longer-term policy expectations.

One potential concern is that these changes might reflect spillovers from the Federal Reserve's asset purchase programs rather than genuine policy surprises about interest rate paths. To address this concern, I examine how changes in long-dated Eurodollar contracts align with survey-based measures of policy expectations, specifically comparing the Primary Dealer Survey conducted by the Federal Reserve Bank of New York with the Summary of Economic Projections (SEP) released by the FOMC.

The Primary Dealer Survey asks primary dealers about their expectations for the federal funds rate at various horizons, while the SEP contains the median projections of FOMC members for the federal funds rate at specified future dates. Importantly, these surveys reflect expectations from different perspectives: market participants versus policymakers themselves.

Panel (a) of Figure C.2 shows the median projection for the year-end federal funds rate two and three years ahead from both surveys, alongside the change in the 12th Eurodollar contract, which incorporates similar horizons. In all three cases where large volume-weighting surprises occur, there is a substantial difference between the Primary Dealer Survey and the SEP of at least 25 basis points. Crucially, the 12th Eurodollar contract adjusts over the volume-based window to reflect this new information, moving at least 25 basis points in the same direction as the survey expectation error.

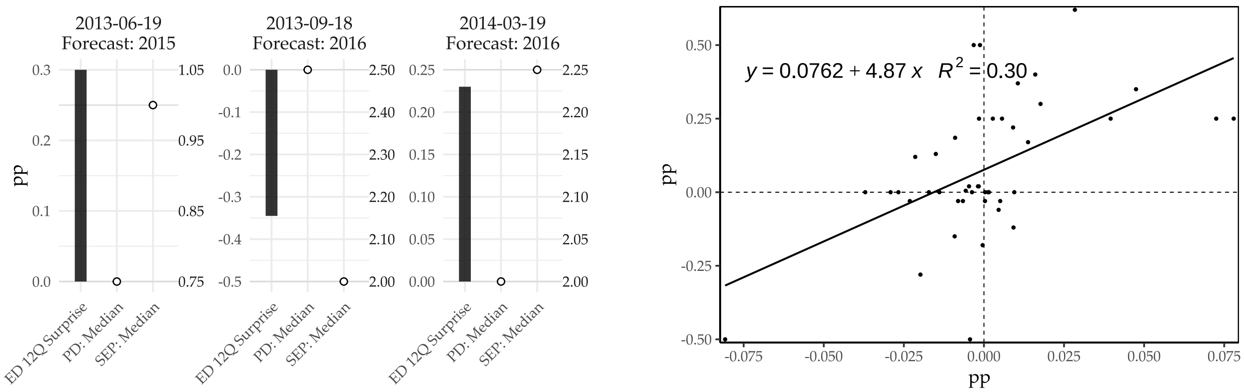
Panel (b) of Figure C.2 provides a scatter plot of the volume-weighting component against the farthest year out forecast error. The figure shows that this is a pattern that holds more generally: the volume-weighting component picks up surprises that originate from the Federal Reserve's dot plot. There is a highly statistically significant and positive relationship between the volume-weighting component and the survey forecast errors, with an R^2 of 0.3 .

These findings point to a previously unrecognized channel through which the Federal Reserve's communication affects markets: the alignment of market expectations with policymaker intentions. Market's immediately price in the new information conveyed in the dot plots at the horizon where the market's and the FOMC's expectation diverge. The volume-based approach naturally captures this information by weighting contracts according to where the most active information processing occurs.

C.4 No confounding with Economic News

A potential 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 examine all macroeconomic news releases from the Bloomberg Economic Calendar between October 1996

Figure C.2: Beliefs About Interest Rates: Primary Dealer Survey vs. Dot Plot



(a) Survey Forecast Differences

(b) Window Length Component vs. Survey Forecast Error

and December 2019 that occur on FOMC announcement days and have a Bloomberg relevance score greater than zero. This encompasses the 125 most important news releases for the economy.

Most major macroeconomic news releases occur prior to the FOMC press release. Table C.1 shows that economic news releases occur before 174 FOMC announcements, including major releases on 37 days. A major news release is defined as one in the top 5 most relevant releases of the day as classified by Bloomberg, consisting of Non-Farm Payrolls, Jobless Claims, GDP, CPI, and ISM Manufacturing.

Table C.1: Economic News on the FOMC Announcement Day

		Prior (N=196)		After (N=33)	
		Mean	Std. Dev.	Mean	Std. Dev.
News (N.)		2.1	1.1	1.0	0.2
Clostest Release (Minutes)		271.3	94.9	168.1	98.1
		N	Pct.	N	Pct.
NFP | INJ | GDP | CPI | ISM	FALSE	147	75.0	33	100.0
	TRUE	49	25.0	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 2022. 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, news releases occur after 30 FOMC announcements. Table C.2 displays these news releases, their ranking among the 125 most important releases, and their sample overlap. Sixteen of these releases are attributable to the Langer Consumer Comfort survey, which is released at 5pm New York time. In all cases, the event window ends before this news release occurs.

There are only three cases where post-announcement news releases overlap with the volume-

Table C.2: News Releases after the FOMC Press Release

Release	Meetings	Ranking	First Meeting	Last Meeting	Min Distance	News in Window
Consumer Credit	2	85	2002-05-07	2007-08-07	45	1
Langer Consumer Comfort	18	56	2005-03-22	2008-12-16	165	0
Monthly Budget Statement	4	37	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	83	2010-11-03	2013-05-01	110	0
Net Long-term TIC Flows	5	41	2016-06-15	2022-06-15	120	0

The table displays news releases which occur after the FOMC press release between December 1996 and December 2022.

based window. On August 7, 2007, the Consumer Credit report is released at 15:00 New York time, coinciding with the end of the volume-based event window for the fourth Eurodollar contract. However, the Consumer Credit report ranks only 76th out of 125 news releases. Therefore, it is unlikely that the volume-based window lengths are influenced by other news releases.

Second, 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 surprise picks up a spike in volume later than both release dates, suggesting this reflects new information revealed by Chairman Bernanke during the press conference.

C.5 Narrative Evidence

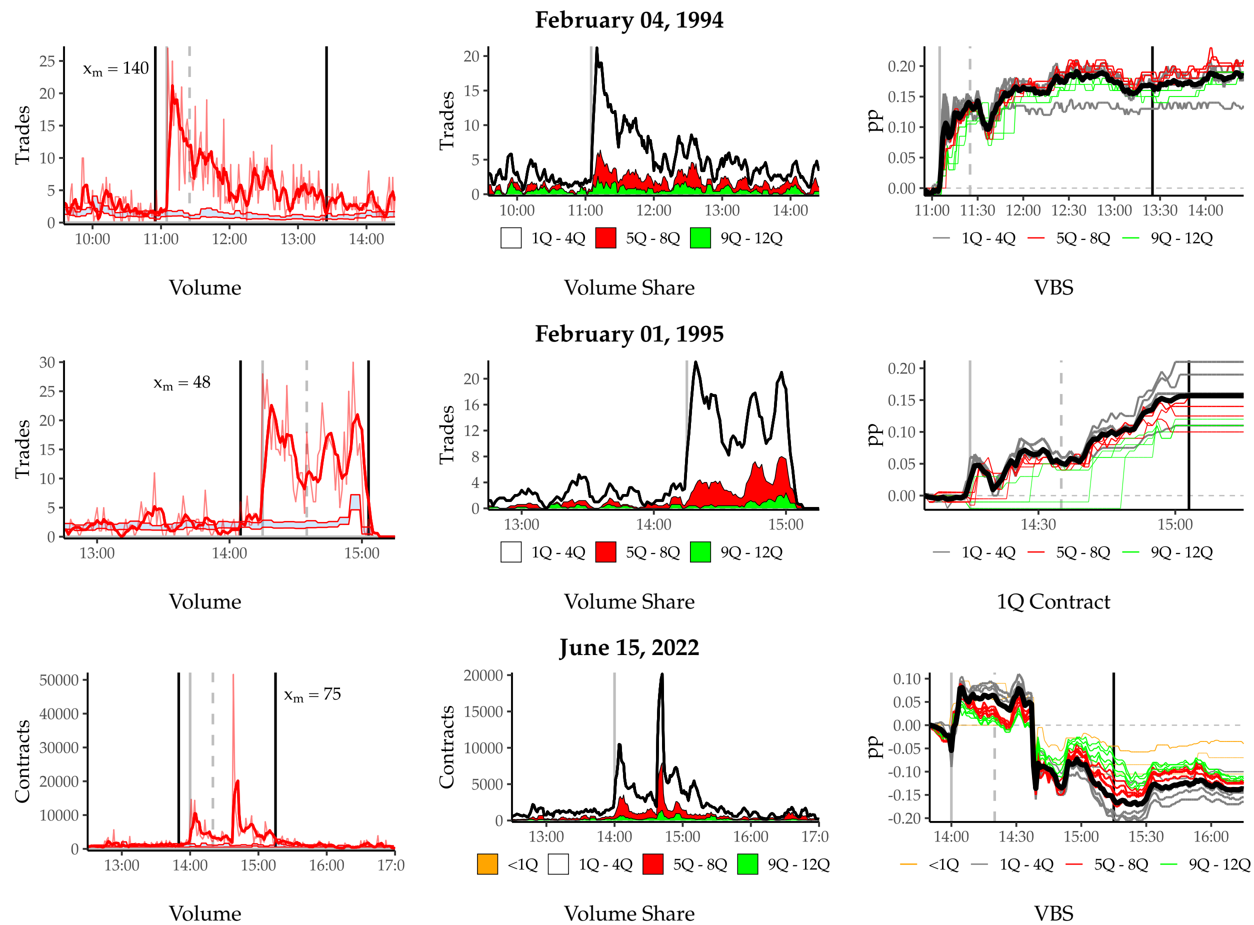
Figure C.3 discusses announcements where the decomposition shows large differences between the VBS and PNS or where window lengths are particularly pronounced.

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 the volume-based surprise gradually increasing over the entire trading day. However, the difference between a 30-minute window and the longer window is small and volume is concentrated in the near-term contracts. Therefore, both the VBS and PNS are similar in size.

On February 1, 1995, the Federal Reserve raised interest rates by 25 basis points, leaving market participants wondering when the peak of the tightening cycle would be reached (The New York Times, 1994). The volume-based surprise gradually drifts upwards. The FOMC press release triggers a spike in transactions that is sustained until the close of the Eurodollar pit at 15:00 ET.

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,

Figure C.3: 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.

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.

C.6 Loadings for Benchmark Surprises

This subsection reports the loadings of the input surprises on the first principal component for both the 30-minute and flexible window principal components in Table C.3.

The first principal component of the 30-minute implied futures rate changes is the benchmark surprise measure used in the main text. It is created according to Nakamura and Steinsson (2018). The first principal component of the flexible window implied futures rate changes is used in the construction of the window length component. It incorporates the flexible window lengths described in the main text but estimates the weights by PCA rather than volume-weighting. The loadings of the principal components are similar in size.

Table C.3: Regression of Input Surprises on PCA Surprises

Sample	MP1	ED1	ED2	ED3	ED4
30M-PC	0.747	0.948	0.985	0.966	0.923
FlexWL-PC	0.687	0.947	0.984	0.966	0.912

This table reports the estimated loadings of input surprise measures (MP1 and Eurodollar futures, ED1–ED4) on the first principal component. Each entry shows the regression coefficient of the corresponding input on the PCA factor, with rows indicating the construction of the PCA surprise (30-minute window or flexible window).

D FOMC Statement Dissimilarity Calculation

This appendix provides a detailed description of the text-based dissimilarity measure used to quantify changes in FOMC statement content between consecutive meetings. The measure captures the degree of linguistic change and serves as a proxy for the informational content of Federal Reserve communications.

D.1 Text Preprocessing

Before calculating dissimilarity measures, each FOMC statement undergoes standardized preprocessing to remove non-substantive content and focus on policy-relevant language. The preprocessing consists of four main steps:

Step 1: Boilerplate Removal. I remove standard formatting elements and administrative text that appear consistently across statements but carry no policy information. This includes:

- Release headers and timestamps ("For immediate release", "For release at...")
- Contact information and administrative details
- Standard disclaimers and technical implementation notes
- Voting member listings with standard phrasing

Specifically, I apply the following regular expression patterns:

- `For immediate release`
- `For release at \d+:\d+ [APMapm]˙+`
- `Voting for the FOMC monetary policy action were:.*?˙`
- `Voting for this action:.*?˙`

Step 2: Text Normalization. I apply standard text cleaning procedures:

- Collapse multiple whitespace characters and line breaks into single spaces
- Remove special characters and formatting artifacts
- Convert text to lowercase for consistency

Step 3: Stopword Removal. I remove both standard English stopwords and FOMC-specific administrative terms that appear frequently but carry little substantive information:

- Standard stopwords: articles, prepositions, conjunctions
- FOMC-specific terms: "federal", "reserve", "fomc", "committee", "board", "governors", "chair", "chairman", "meeting", "statement", "press", "release", "action", "implementation", "note", "open", "market"

Step 4: Word Filtering. The final preprocessed text consists of content words that capture the substantive policy message of each statement.

D.2 TF-IDF Vectorization

Following text preprocessing, I transform each statement into a numerical representation using Term Frequency-Inverse Document Frequency (TF-IDF) weighting. This approach weights terms based on their importance within individual documents relative to their frequency across the entire corpus.

For a term t in statement s, the TF-IDF weight is calculated as:

$$\text{TF-IDF}(t, s) = \text{TF}(t, s) \times \text{IDF}(t)$$

where:

- $\text{TF}(t, s)$ is the term frequency of term t in statement s
- $\text{IDF}(t) = \log\left(\frac{N}{|\{s \in S : t \in s\}|}\right)$ is the inverse document frequency
- N is the total number of statements in the corpus
- $|\{s \in S : t \in s\}|$ is the number of statements containing term t

Vectorization Parameters:

- **Maximum features:** 1,000 terms (focuses on most informative vocabulary)
- **N-gram range:** (1,2) (captures both individual words and two-word phrases)
- **Sublinear TF scaling:** Applied to prevent bias toward longer documents

Time-Consistent Approach: To ensure temporal consistency and avoid look-ahead bias, I employ a recursive fitting procedure. For each statement s_t at time t, the TF-IDF vectorizer is fitted using only statements available up to time t: $\{s_1, s_2, ..., s_t\}$. This ensures that the vocabulary and IDF weights reflect only information available at the time of each statement's release.

D.3 Cosine Similarity Calculation

Once statements are transformed into TF-IDF vectors, I calculate pairwise similarity using cosine similarity, which measures the angular distance between two vectors regardless of their magnitude.

For statements s_t and s_{t-1} with TF-IDF vectors $\mathbf{v}_t$ and $\mathbf{v}_{t-1}$, cosine similarity is:

$$\text{Similarity}(s_t, s_{t-1}) = \frac{\mathbf{v}_t \cdot \mathbf{v}_{t-1}}{|\mathbf{v}_t||\mathbf{v}_{t-1}|} = \frac{\sum_{i=1}^{n} v_{t,i} \times v_{t-1,i}}{\sqrt{\sum_{i=1}^{n} v_{t,i}^2} \times \sqrt{\sum_{i=1}^{n} v_{t-1,i}^2}}$$

where n is the dimension of the TF-IDF vectors and $v_{t,i}$ represents the i-th component of vector $\mathbf{v}_t$.

Since the TF-IDF vectors are non-negative, cosine similarity ranges from 0 (completely dissimilar) to 1 (identical).

D.4 Dissimilarity Measure

The primary measure of statement change is dissimilarity, defined as:

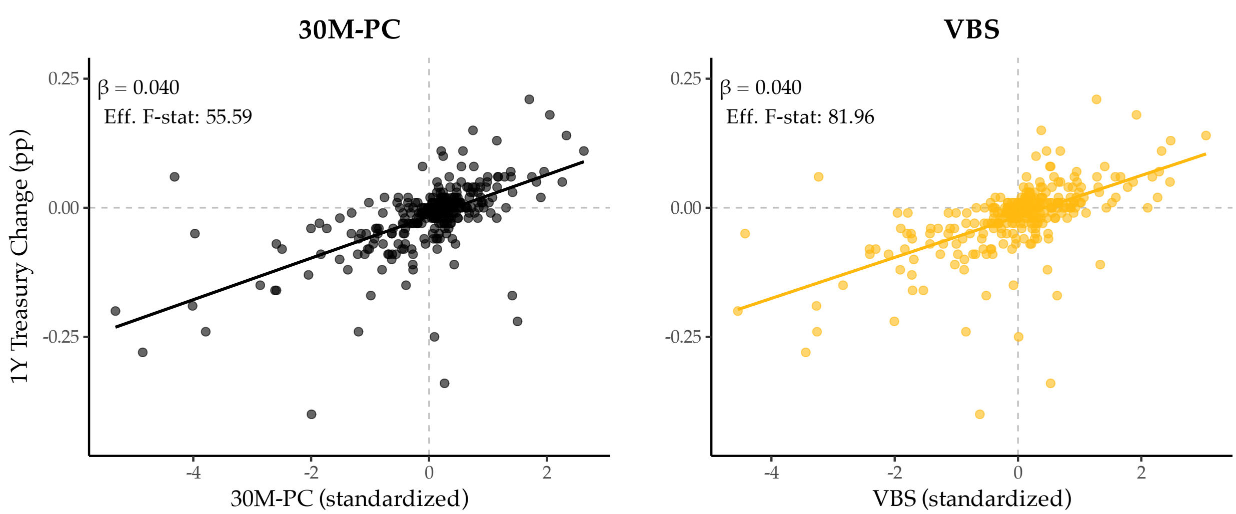
$$\text{Dissimilarity}(s_t, s_{t-1}) = 1 - \text{Similarity}(s_t, s_{t-1})$$

This transformation ensures that:

- Dissimilarity = 0 when statements are identical
- Dissimilarity increases as statements become more linguistically distinct
- The measure is bounded between 0 and 2 (with values near 2 being extremely rare in practice)

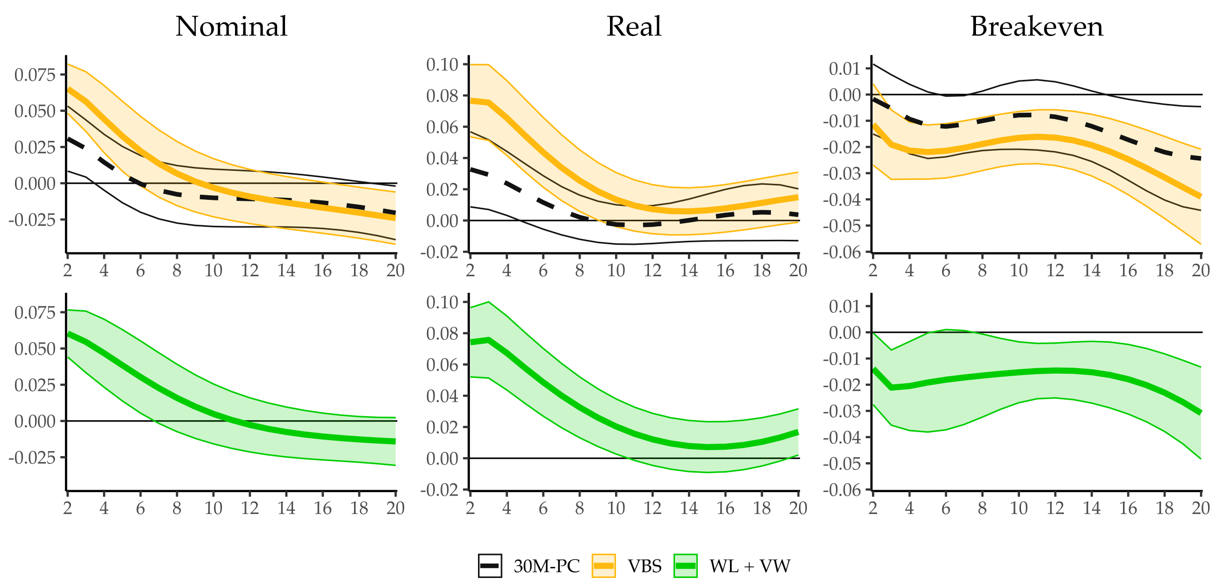
E Robustness & Extensions: Financial Markets

Figure E.1: Instrument Strength (Full Sample): 1-Year Yield on Monetary Policy Surprises



The figure shows the daily change in the 1-year Treasury yield (in pp) on the y-axis and the respective 1SD surprise measure on the x-axis. The sample includes all FOMC announcement from November 1988 to December 2022. The surprises are the first principal component of 30-minute price changes (30M-PC) (Nakamura and Steinsson, 2018) and the Volume-based Monetary Policy Surprise (VBS). The effective F-statistic (Olea and Pflueger, 2013) is reported for both specifications. The critical values for 10% bias are 23.1 and 37.4 for 5% bias respectively.

Figure E.2: Treasury Market - Forward Curves

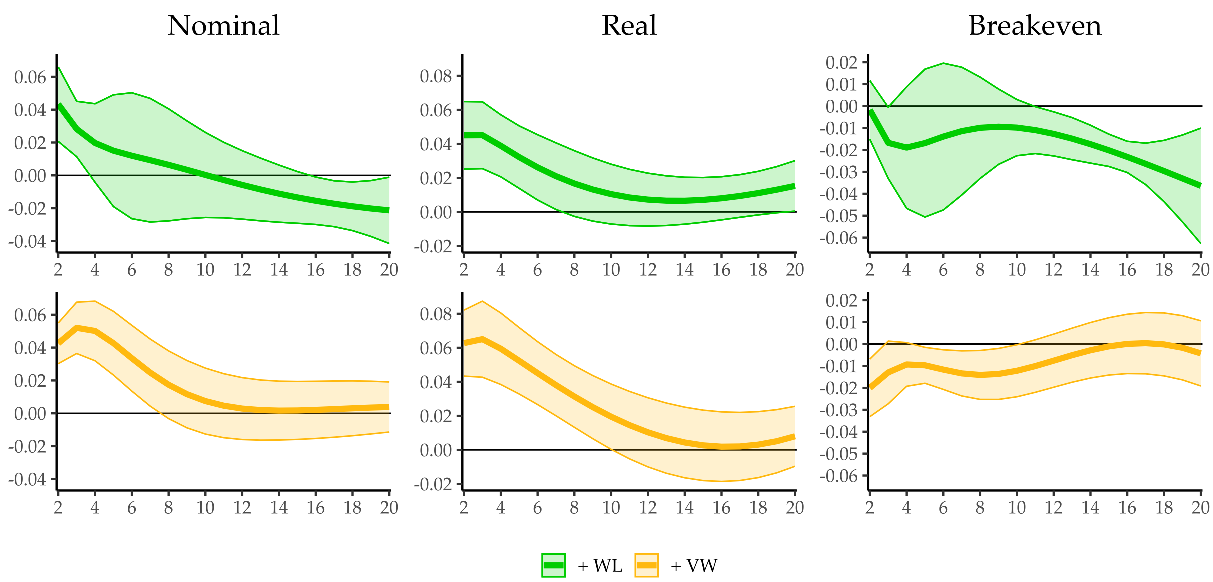


The figure shows the 2-day change, from the day prior to the FOMC announcement to the day after, in the instantaneous forward rate of a Treasury security with maturity h (in pp) to the respective 1SD surprise measure

$$\Delta f_m^h = \alpha^h + \beta^h \cdot s_m + \epsilon_m^h.$$

The surprises are the first principal component of 30-minute price changes (30M-PC) (Nakamura and Steinsson, 2018) and the Volume-based Monetary Policy Surprise (VBS). The sample includes all scheduled FOMC announcements from December 2003 to December 2022 excluding the Global Financial Crisis period (2008/07 to 2009/06) and March to June 2020. The underlying dataset for real and breakeven yields is Gürkaynak et al. (2010) and for nominal yields (Gürkaynak et al., 2007). The shaded areas represent 95% confidence intervals based on heteroskedasticity-robust (HC3) standard errors.

Figure E.3: Real and Breakeven Inflation Forward - Surprise Decomposition



The figure shows the 2-day change, from the day prior to the FOMC announcement to the day after, in the instantaneous forward rate of a Treasury security with maturity h (in pp) to the respective 1SD surprise measure

$$\Delta f_m^h = \alpha^h + \beta^h \cdot s_m + \epsilon_m^h.$$

Here, s_m denotes the two components of the Volume-based Surprises: the window length component and the volume-weighting component. These components measure the difference in the VBS to the 30-minute principal component surprise (30M-PC) (Nakamura and Steinsson, 2018), due to announcement-specific window lengths and announcement-specific loadings respectively. The sample includes all scheduled FOMC announcements from December 2003 to December 2022 excluding the Global Financial Crisis period (2008/07 to 2009/06) and March to June 2020. The underlying dataset for real and breakeven yields is Gürkaynak et al. (2010) and for nominal yields (Gürkaynak et al., 2007). The shaded areas represent 95% confidence intervals based on heteroskedasticity-robust (HC3) standard errors.

Table E.1: Treasury Market - Event Study Results (Including Crisis + Unscheduled)

	1988/11 - 2003/11 (n= 145)			2003/12 - 2022/12 (n= 159)		
	30M-PC	VBS	WL + VW	30M-PC	VBS	WL + VW
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: 2Y Treasury						
Estimate	0.046***	0.049***	0.018***	0.037***	0.055***	0.041***
SE	(0.009)	(0.007)	(0.006)	(0.008)	(0.007)	(0.007)
R^2	0.329	0.380	0.044	0.251	0.550	0.295
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

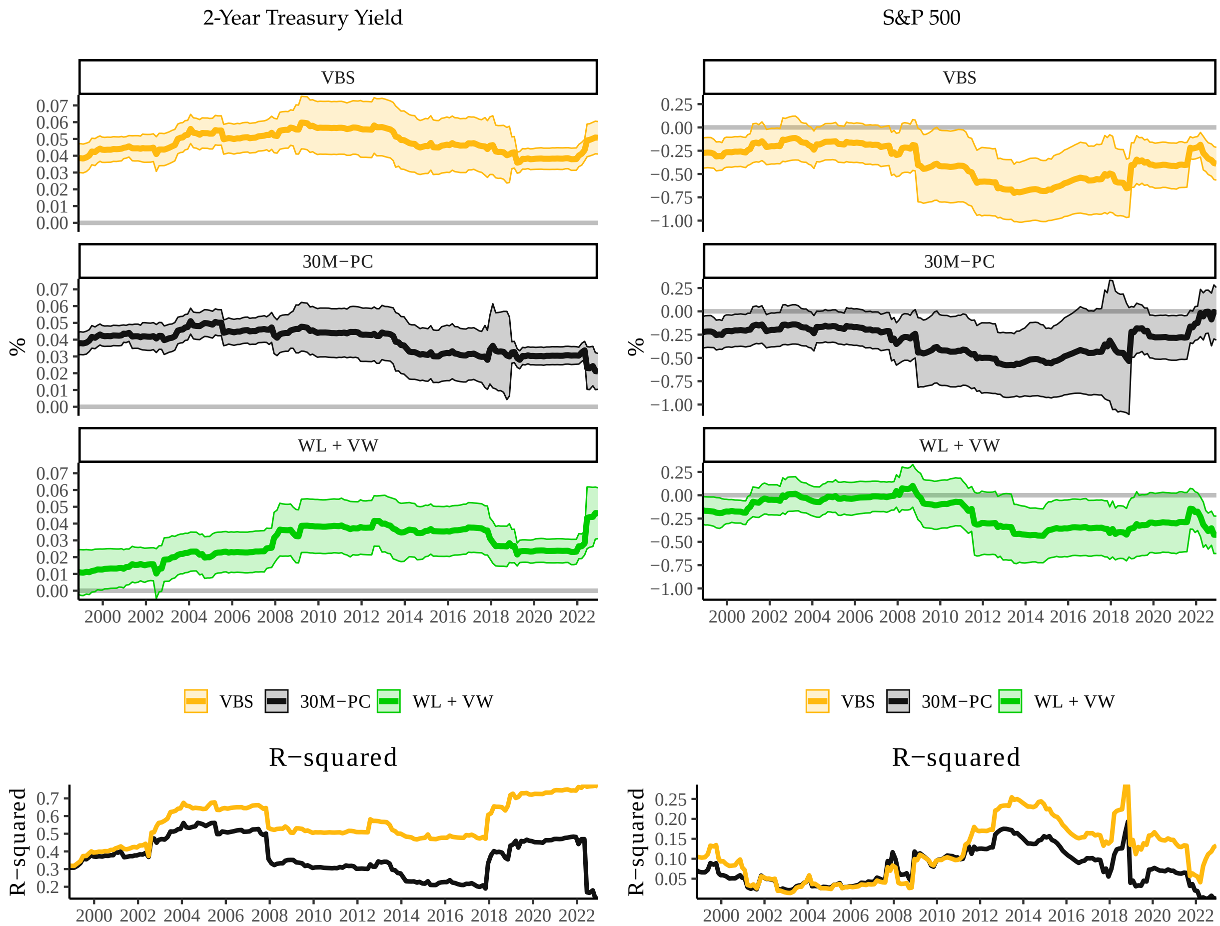
This table reports the estimated coefficients of a regression selected Treasury market yields on the respective monetary policy surprise. All dependent variables stem from the Federal Reserve H.15 report and can be found here. Reported standard errors are heteroskedasticity-robust (HC3) and the stars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

Table E.2: Equity Market - Event Study Results (Including Crisis + Unscheduled)

	1988/11 - 2003/11 (n= 145)			2003/12 - 2022/12 (n= 159)		
	30M-PC	VBS	WL + VW	30M-PC	VBS	WL + VW
Dep Var: SP500 Future (Intraday)						
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: SP500 Total Return (Daily)						
Estimate	-0.481***	-0.432***	0.031	-0.176	-0.457***	-0.476***
SE	(0.117)	(0.113)	(0.102)	(0.218)	(0.145)	(0.116)
R^2	0.183	0.146	-0.006	0.011	0.113	0.123

This table reports the estimated coefficients of a regression of the stock market return on the respective monetary policy surprise on FOMC announcement days.
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 E.4: Rolling Regression (10 Years) - Scheduled FOMC Announcements



This figure reports the estimated coefficients of a 10-year rolling regression of the daily return in the S&P 500 on a one standard deviation increase in the respective monetary policy surprise on scheduled FOMC announcement days. The first row shows the results of a regression using the Volume-based Monetary Policy Surprise (VBS) while the second row shows the results of a regression using the first principal component of 30-minute price changes (30M-PC) (Nakamura and Steinsson, 2018). The third row shows the residual of a regression of the VBS on the 30M-PC during the same rolling window and therefore captures the additional information in the VBS due to the flexible window length and volume-weighting 'WL+ VW'. The x-axis shows the end date of the rolling window. The S&P 500 return is downloaded from CRSP. Reported standard errors are heteroskedasticity-robust (HC3) and the shaded areas show the 90% confidence interval.

Table E.3: Uncertainty Measures - Event Study Results

	1990/01 - 2003/11 (n= 123)			2003/12 - 2022/12 (n= 142)		
	30M-PC	VBS	WL + VW	30M-PC	VBS	WL + VW
Dep Var: VIX						
Estimate	0.182	0.213*	0.125*	0.318	0.618**	0.547**
SE	(0.122)	(0.109)	(0.063)	(0.223)	(0.239)	(0.251)
R^2	0.023	0.036	0.007	0.014	0.074	0.057
Dep Var: KC Fed - Policy Rate Uncertainty						
Estimate	0.013***	0.014***	0.007**	0.005	0.012***	0.011**
SE	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)
R^2	0.148	0.185	0.035	0.021	0.173	0.169

This table reports the estimated coefficients of a regression selected Treasury market yields on the respective monetary policy surprise on scheduled FOMC announcement days. I exclude all announcements during the Global Financial Crisis period (2008/07 to 2009/06) and March to June 2020. The VIX index is downloaded from FRED and can be found here. The Policy Rate Uncertainty (PRU) is calculated by the Kansas City Fed (Bundick et al., 2024). Reported standard errors are heteroskedasticity-robust (HC3) and the stars indicate significance at the 10%, 5% and 1% level.

F Robustness: Macroeconomic Effects

Table F.1: 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 respective surprise to the predictors in Bauer and Swanson (2022). The right table reports the regression results of the respective surprise to the predictors in Miranda-Agrippino and Ricco (2021)

Table F.2: 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	0.134*	0.195**	0.150	0.109	0.061	0.150	-0.045	-0.043	0.118
	(0.079)	(0.091)	(0.117)	(0.109)	(0.091)	(0.113)	(0.097)	(0.097)	(0.108)
Lag 2	0.014	-0.013	0.074	-0.022	-0.074	0.076	-0.103	-0.157*	0.055
	(0.085)	(0.093)	(0.102)	(0.083)	(0.093)	(0.099)	(0.089)	(0.092)	(0.106)
Lag 3	-0.077	0.040	-0.232**	-0.153**	-0.003	-0.215**	-0.139*	-0.031	-0.166*
	(0.071)	(0.081)	(0.110)	(0.076)	(0.078)	(0.108)	(0.077)	(0.086)	(0.090)
Lag 4	0.145**	0.199***	-0.067	0.095	0.171**	-0.065	0.126*	0.111	0.004
	(0.061)	(0.073)	(0.089)	(0.067)	(0.070)	(0.086)	(0.072)	(0.080)	(0.087)
Lag 5	0.095	0.010	0.132*	0.098	0.045	0.130*	0.095	0.011	0.185**
	(0.074)	(0.077)	(0.079)	(0.081)	(0.081)	(0.079)	(0.084)	(0.082)	(0.083)
Lag 6	0.028	0.013	0.013	0.060	0.018	0.023	0.074	-0.016	0.037
	(0.070)	(0.071)	(0.081)	(0.092)	(0.080)	(0.079)	(0.095)	(0.077)	(0.078)
Lag 7	-0.022	-0.071	-0.049	0.014	-0.080	-0.059	0.076	-0.049	0.017
	(0.063)	(0.061)	(0.092)	(0.078)	(0.069)	(0.089)	(0.089)	(0.060)	(0.085)
Lag 8	-0.017	0.058	0.106	0.037	0.028	0.089	0.052	0.063	0.145
	(0.065)	(0.064)	(0.104)	(0.066)	(0.066)	(0.102)	(0.082)	(0.059)	(0.093)
Lag 9	0.024	0.013	0.057	0.028	-0.027	0.051	0.100	0.051	0.033
	(0.062)	(0.073)	(0.088)	(0.061)	(0.058)	(0.089)	(0.064)	(0.062)	(0.080)
Lag 10	-0.020	0.017	-0.083	-0.041	0.014	-0.084	-0.008	0.037	-0.090
	(0.062)	(0.071)	(0.075)	(0.065)	(0.070)	(0.073)	(0.061)	(0.070)	(0.071)
Lag 11	0.060	0.081	0.030	0.067	0.126**	0.033	0.042	0.073	-0.019
	(0.060)	(0.059)	(0.075)	(0.076)	(0.062)	(0.073)	(0.072)	(0.059)	(0.078)
Lag 12	-0.064	-0.086	-0.023	-0.051	-0.021	-0.029	-0.043	-0.067	0.003
	(0.055)	(0.055)	(0.057)	(0.076)	(0.070)	(0.057)	(0.067)	(0.058)	(0.068)
R2 Adj.	0.028	0.066	0.061	0.028	0.022	0.052	0.032	0.021	0.051
Num.Obs.	292	292	292	292	292	292	262	262	262

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

This table reports the estimated AR(12) coefficients of the respective 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).

Figure F.1: Revisiting Figure 11 - LP-IV

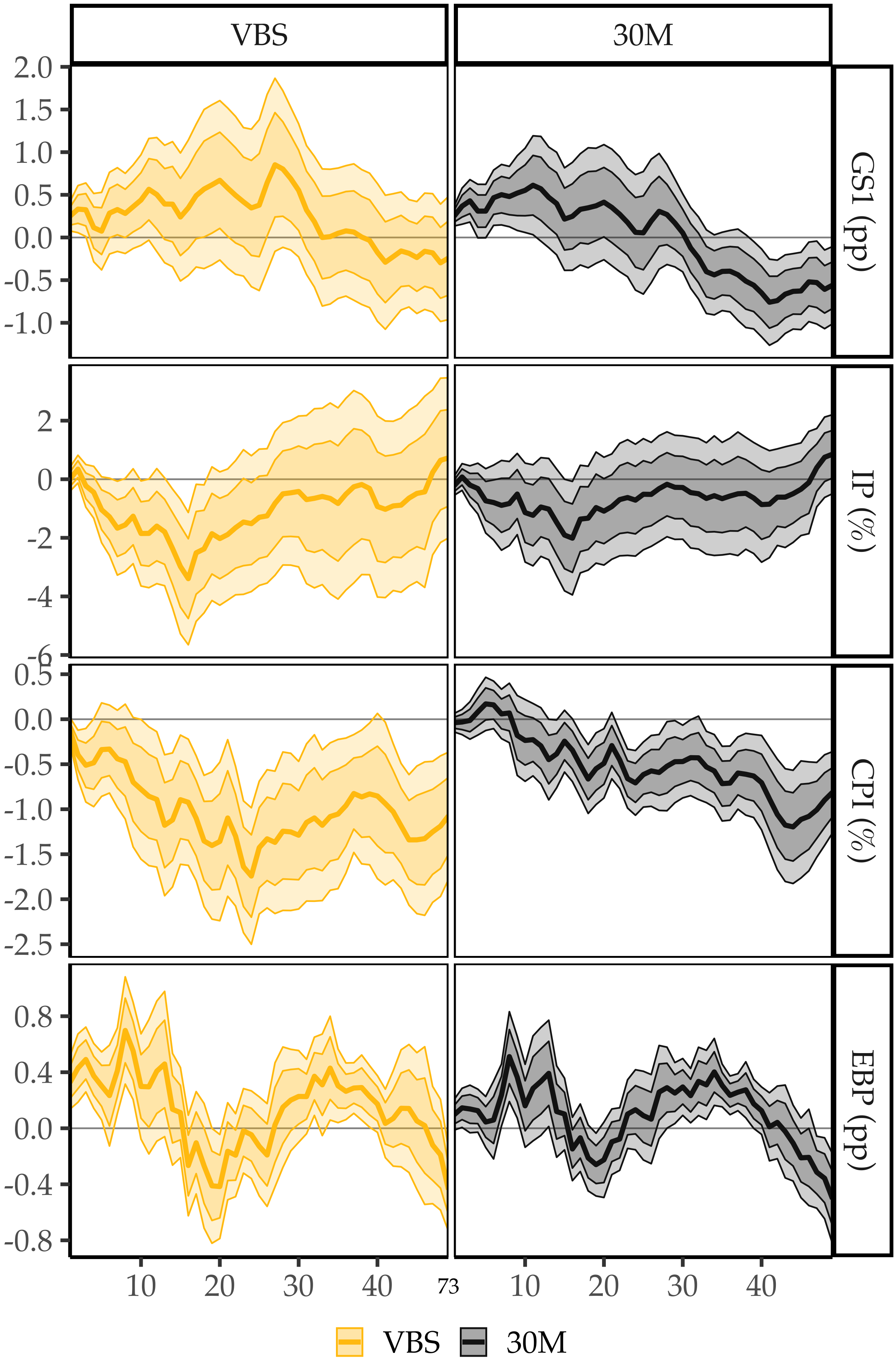
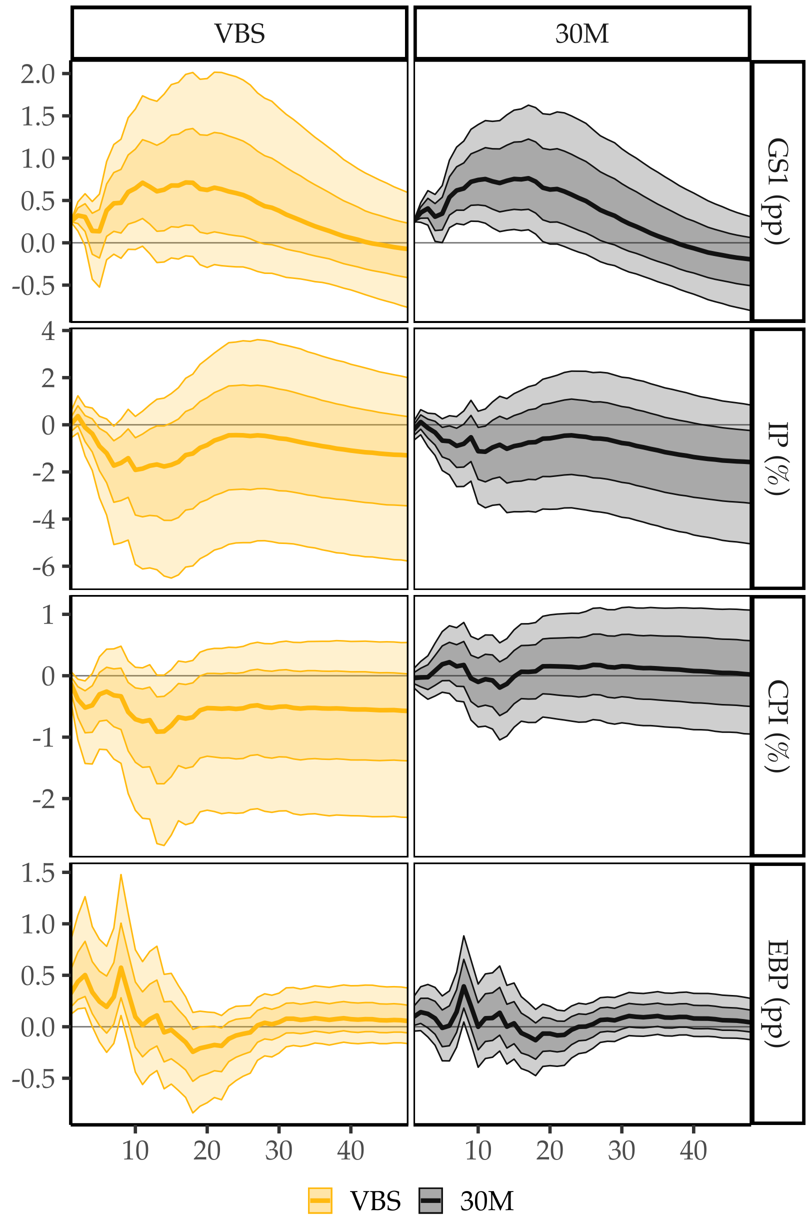
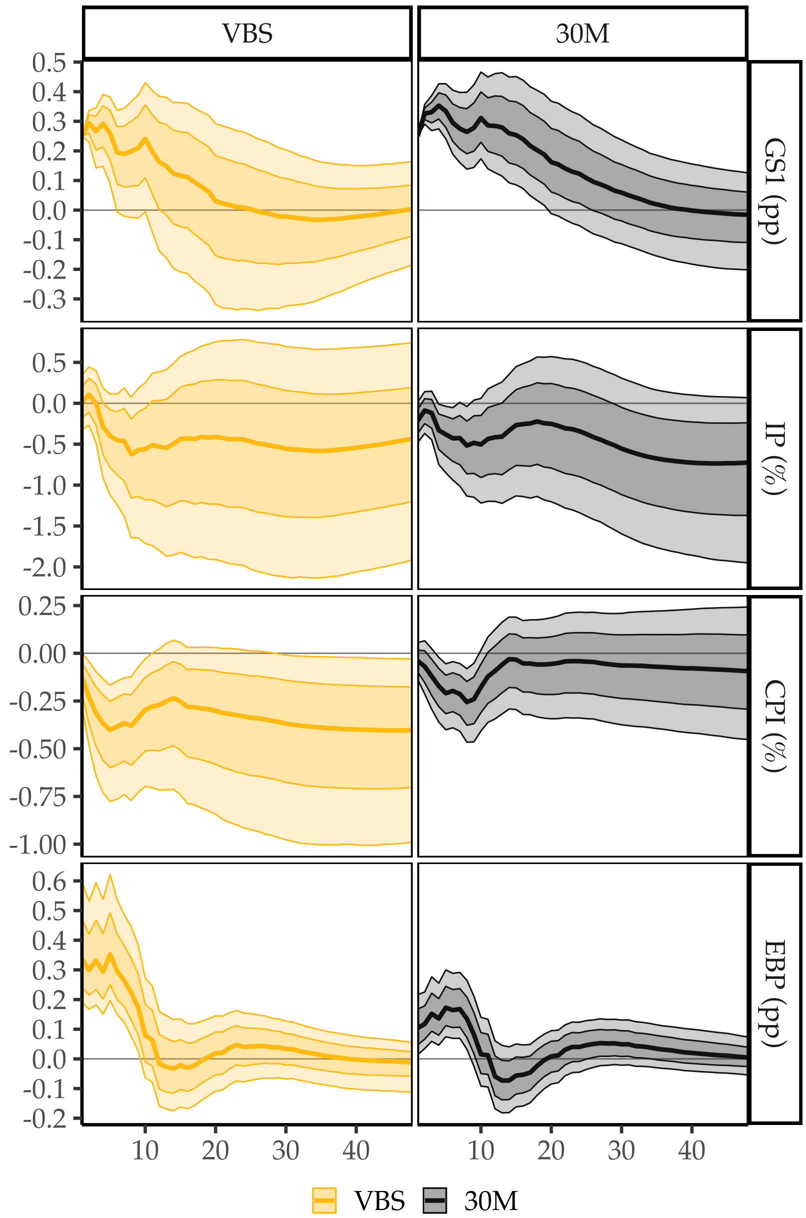


Figure F.2: Revisiting Figure 11 - Internal Instrument Rescaled



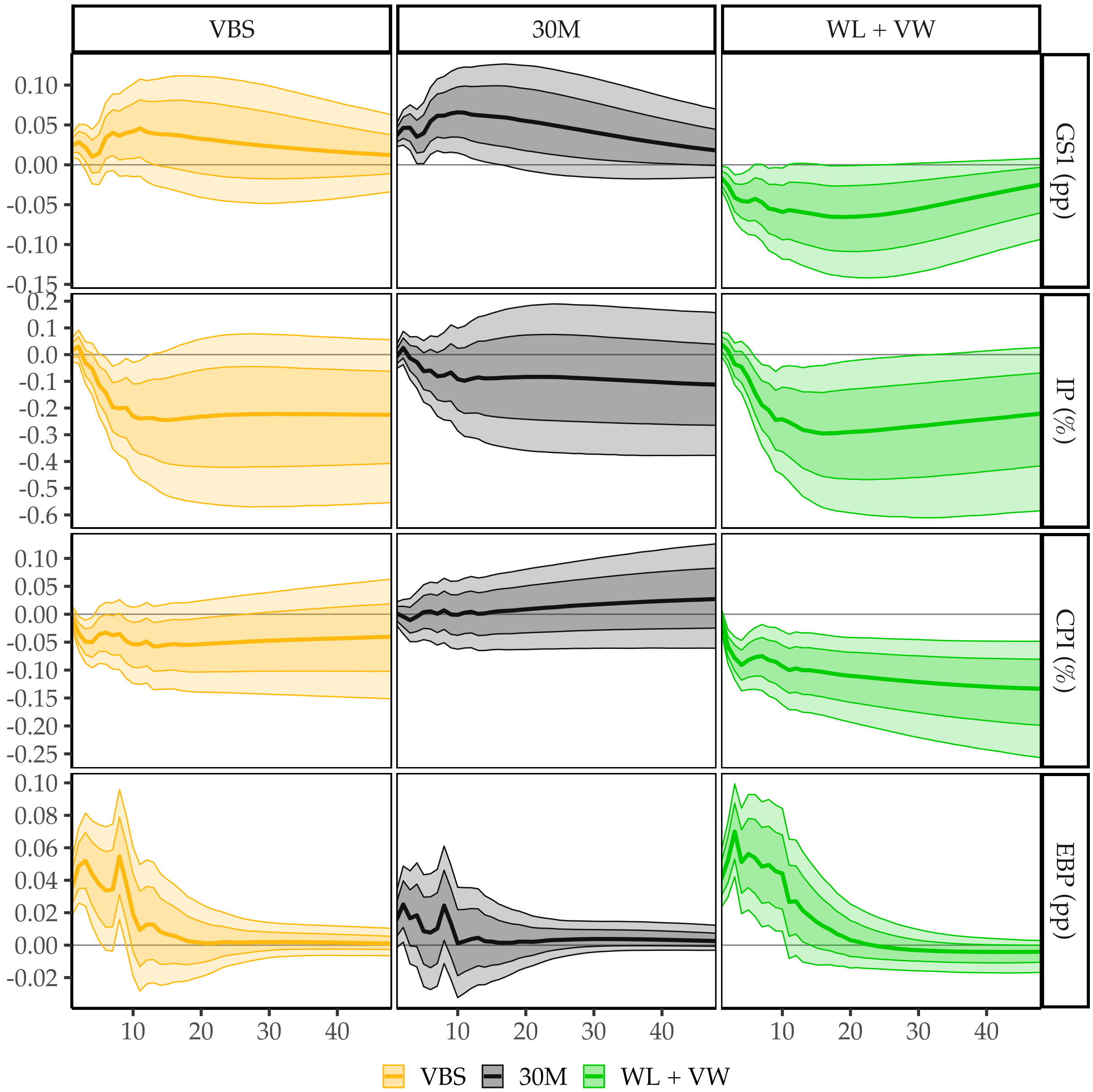
The figure shows impulse response functions of several financial and macroeconomic variables to 1 SD of the respective monetary policy surprise. 'VBS' refers to the volume-based monetary policy surprise, while other columns contain the first principal component of the first four Eurodollar futures '30M' the 30-minute window length. 'WL + VW' refers to the unexplained variation in the volume-based monetary policy surprise. The VAR includes the 1-year Treasury yield (GS1), Industrial Production (IP), Consumer Price Index (CPI) and Excess Bond Premium (EBP). The impulse response functions are obtained from a flat prior Bayesian VAR with a lag length of 12 and is 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 runs from November 1988 to February 2020 and is at monthly frequency.

Figure F.3: Revisiting Figure 11 - Proxy SVAR



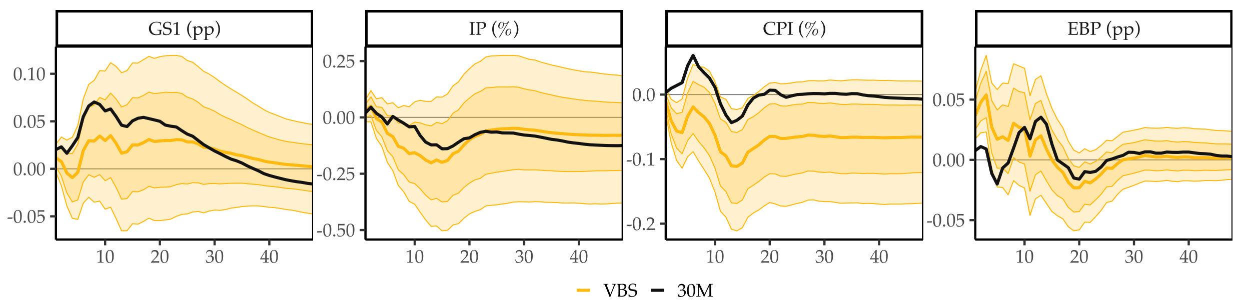
The figure shows impulse response functions of several financial and macroeconomic variables to 1 SD of the respective monetary policy surprise. 'VBS' refers to the volume-based monetary policy surprise, while other columns contain the first principal component of the first four Eurodollar futures '30M' the 30-minute window length. 'WL + VW' refers to the unexplained variation in the volume-based monetary policy surprise. The VAR includes the 1-year Treasury yield (GS1), Industrial Production (IP), Consumer Price Index (CPI) and Excess Bond Premium (EBP). The impulse response functions are obtained from a Local Projection with a lag length of 12 and is estimated using the BVAR toolbox by Ferroni and Canova (2021). The surprise is used as an external instrument in a proxy SVAR for the 1-year Treasury yield (GS1). The robust F-statistics are 9.7 (30M) and 5.1 (VBS), which indicates that both instruments are weak for the residuals of the 1-year Treasury yield. 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 F.4: Revisiting Figure 11 - 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-based monetary policy surprise, while other columns contain the first principal component of the first four Eurodollar futures '30M' the 30-minute window length. 'WL + VW' refers to the unexplained variation in the volume-based monetary policy surprise. The VAR includes the 1-year Treasury yield (GS1), Industrial Production (IP), Consumer Price Index (CPI) and Excess Bond Premium (EBP). The impulse response functions are obtained from a Bayesian VAR with a lag length of 12 and is estimated using the BVAR toolbox by Ferroni and Canova (2021) 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 F.5: The Impact of Monetary Policy Surprises on the Economy - Path



The figure shows impulse response functions of several financial and macroeconomic variables to a 1 SD of the respective monetary policy surprise. The VAR includes the monetary policy surprise, 1-year Treasury yield (GS1), Industrial Production (IP), Consumer Price Index (CPI) and Excess Bond Premium (EBP). 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 displayed for the Volume-based Monetary Policy Surprise and are based on 10000 draws from the posterior distribution. The sample is monthly and runs from November 1988 to February 2020.