The Missing Surprise: Transmission Protection in Central Bank Announcements[1]

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Abstract

Central bank communications frequently contain information about financial-market backstops that affect monetary policy transmission. We identify these transmission protection surprises in the euro area, alongside policy stance and central bank information surprises, by exploiting heteroskedasticity in minute-by-minute asset price movements. Unlike standard factor models, our approach allows active policy dimensions and their impacts to vary across events. Event-specific decompositions quantify the narrative record and reveal substantial heterogeneity of effects across announcements. We show that transmission protection is a distinct dimension of central bank announcements, with financial-market effects separate from both policy stance and information shocks.

Keywords: Monetary Policy, High-Frequency Identification, Central Bank Communication, Information Effects, Financial Stability, Transmission Protection.

JEL classification : E52, E58, F45, G12.

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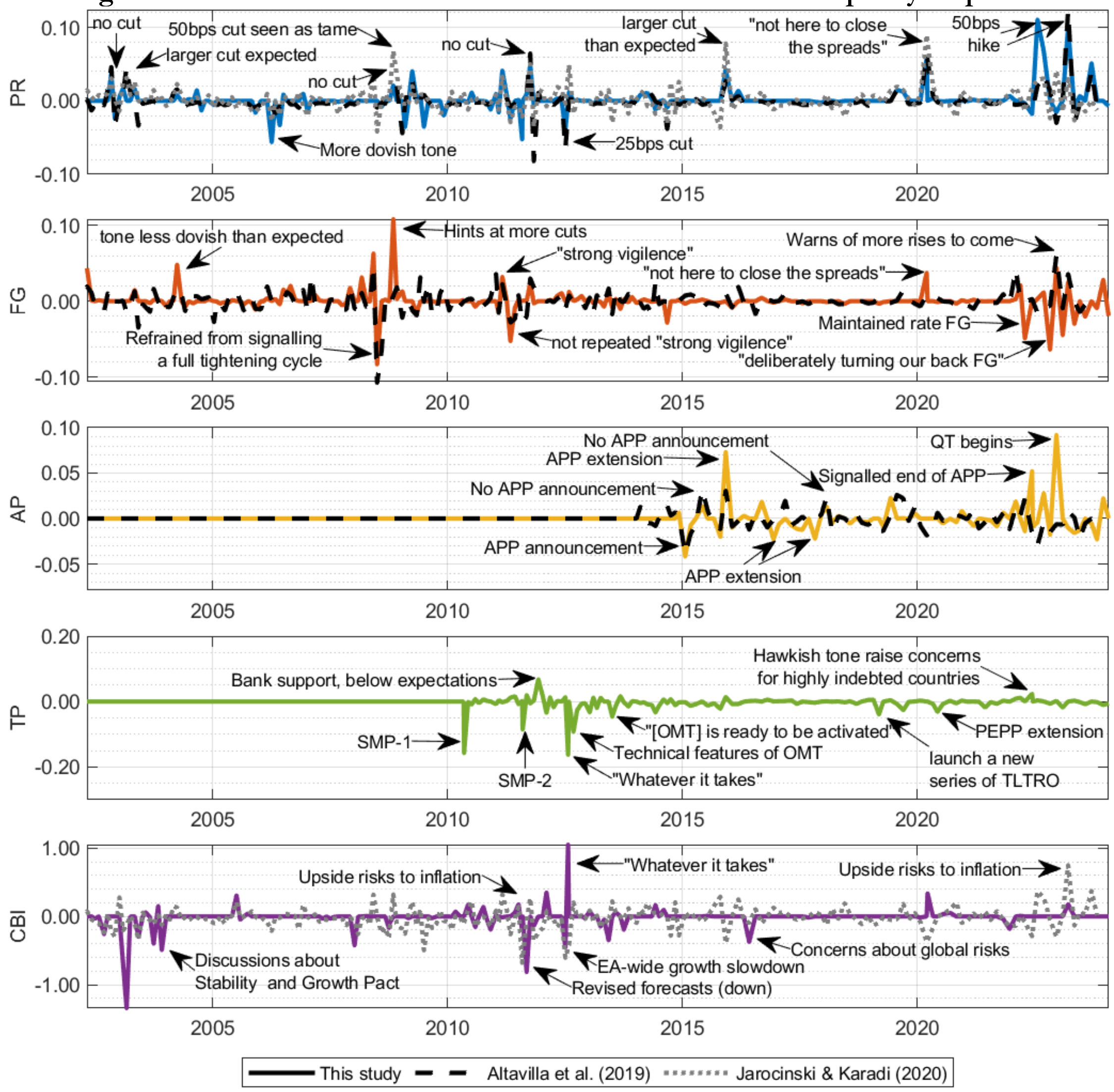
NON-TECHNICAL SUMMARY

Central bank announcements often contain information besides decisions on interest rates. They can also reassure financial markets that the central bank stands ready to prevent financial stress from disrupting the transmission of monetary policy. Such interventions have become an important feature of central banking — not only in the euro area, but also in episodes such as the Bank of England's response to the 2022 LDI crisis and the Federal Reserve's actions following the failure of Silicon Valley Bank 2023. This paper asks whether these messages can be measured separately from conventional monetary policy surprises and central bank information effects regarding the state of the economy, and how doing so matters for our understanding of central bank policies.

Figure 1. Time series of the five identified dimensions of ECB policy surprises



Note: Time series of the monetary policy surprises along five dimensions — policy rate (PR), forward guidance (FG), asset purchases (AP), transmission protection (TP), and central bank information (CBI) — based on end-of-day historical decompositions of reference prices (solid), Altavilla et al. (2019) monetary policy surprises (dashed), and Jarociński and Karadi (2020) surprises (dotted). Units are percentage points of the reference series. Large fluctuations that correspond to notable announcements or statement features are labeled. Source: Authors' calculations.

The paper uses minute-by-minute movements in 16 financial-market prices on ECB announcement days to separate the different messages contained in ECB communication. The key idea is that different policy messages generate distinct patterns of volatility across financial markets as an announcement unfolds. These differences allow the method to statistically disentangle five policy dimensions without imposing in advance how each of them should affect individual asset prices. This flexibility is important because both the content of ECB announcements and their effects on financial markets can change over time. For example, news about asset purchases need not move short- and long-term interest rates by the same relative amounts at every meeting. Similarly, some policy dimensions may be important at one meeting but essentially absent at another. By exploiting the rich information contained in minute-by-minute price movements, the method therefore allows both the mix of policy messages and their financial-market effects to differ across announcements.

This makes it possible to identify a new type of surprise — **transmission protection** — which captures news about the ECB's willingness to safeguard the smooth transmission of monetary policy by preventing fragmentation in sovereign bond markets. Unlike conventional policy-rate or forward-guidance surprises, transmission protection news occurs only from time to time, when such concerns become relevant for ECB communication. Figure 1 presents a novel time series of the five identified dimensions of ECB policy surprises — policy rate, forward guidance, asset purchases, transmission protection, and central bank information — for scheduled Governing Council meetings and selected unscheduled events, including Mario Draghi's *"whatever it takes"* speech in July 2012.

The analysis delivers four main findings. **First**, transmission protection is a distinct and economically important component of ECB communication, separate from interest-rate decisions and the ECB's assessment of the economy. **Second**, these announcements primarily reduce financial stress by lowering sovereign risk and easing concerns about market fragmentation and euro-area dissolution risk. **Third**, ignoring transmission protection can lead to a misleading interpretation of financial-market reactions to monetary policy announcements. **Fourth**, the estimated volatility patterns closely track the timing of key statements and even specific language used during press conferences, helping to identify which messages drive market reactions. Overall, the new approach provides a clearer picture of which ECB announcements and communication strategies have been most effective over time, offering useful lessons for future policy design.

La surprise manquante : la protection de la transmission dans les annonces des banques centrales

RÉSUMÉ

Les communications des banques centrales contiennent souvent des informations sur les dispositifs de soutien aux marchés financiers qui affectent la transmission de la politique monétaire. Nous identifions ces surprises de protection de la transmission dans la zone euro, aux côtés des surprises de politique monétaire et d'information sur l'économie, en exploitant l'hétéroscédasticité des fluctuations des prix d'actifs à la minute. Notre approche permet aux dimensions de politique monétaire et à leurs effets de varier selon les événements. Nous montrons que la protection de la transmission constitue une dimension distincte des annonces des banques centrales, avec des effets sur les marchés financiers différents de ceux des chocs de politique monétaire et d'information.

Mots-clés : politique monétaire, identification à haute fréquence, communication des banques centrales, effets d'information, stabilité financière, protection de la transmission.

1 Introduction

Since the seminal contributions of Kuttner (2001), Cochrane and Piazzesi (2002), and Bernanke and Kuttner (2005), high-frequency asset-price movements around policy announcements have become a standard tool for identifying monetary policy shocks and studying their effects on financial markets and the economy. As central banks have expanded their policy toolkits and communication strategies, however, the mapping from asset-price movements to monetary policy surprises has become increasingly complex. Modern announcements often combine several policy instruments, convey information beyond the policy stance, and differ substantially in both their content and their transmission across events. Consequently, the literature on high-frequency identification has progressively expanded from policy rate surprises to multidimensional decompositions incorporating forward guidance, asset purchases, and information effects (Gürkaynak et al., 2005; Wright, 2012; Hanson and Stein, 2015; Swanson, 2021; Campbell et al., 2012; Nakamura and Steinsson, 2018; Jarociński and Karadi, 2020). However, existing approaches typically maintain a common decomposition across announcements and focus on information about macroeconomic fundamentals.

This paper extends the announcement-specific decomposition of movements in asset prices by Lewis (2025) to obtain monetary policy surprises for the euro area along five dimensions: policy rate (PR), forward guidance (FG), asset purchase (AP), transmission protection (TP) and central bank information (CBI). This approach leverages intraday heteroskedasticity in asset price movements around announcements to identify the active dimensions of monetary policy. We argue that central bank communication contains information about transmission protection as a distinct policy dimension: the central bank's willingness to preserve monetary policy transmission by preventing financial market dysfunction. The framework identifies a unique decomposition of asset price movements for each announcement via heteroskedasticity in minute-by-minute financial data. Different monetary policy shocks exhibit distinct volatility dynamics after announcements, allowing them to be separately identified, as demonstrated by Lewis (2021).

A large theoretical literature has shown that financial markets may be vulnerable to self-fulfilling dynamics and destabilizing feedback loops (Diamond and Dybvig, 1983; Brunnermeier and Pedersen, 2009; Gertler and Kiyotaki, 2015), including in government bond markets (Calvo, 1988; Cole and Kehoe, 2000). Central bank communication reportedly contains financial stability considerations (Born et al., 2014), such that movements in asset prices may incorporate beliefs about the likelihood of future market dysfunction. This dimension is conceptually distinct from central bank information effects, which concern macroeconomic fundamentals.

The euro area provides a natural laboratory to study this mechanism. The combination of a common monetary policy and decentralized fiscal authorities creates the possibility of self-fulfilling equilibria in government bond markets and financial fragmentation (De Grauwe, 2011; Buiter and Rahbari, 2012). Such dynamics impair the transmission of monetary policy and provide a rationale for central-bank backstops (Corsetti and Dedola, 2016; Camous and Cooper, 2019; Fornaro and Grosse-Steffen, 2024). Similar stabilization concerns have recently motivated interventions by the Bank of England during the 2022 LDI crisis and by the Federal Reserve following the failure of Silicon Valley Bank. In the euro area, however, concerns about fragmentation have been a recurring feature of monetary policy. Consequently, the ECB has repeatedly deployed measures to preserve the transmission of monetary policy, including government bond purchases, liquidity facilities, and explicit commitments to counter market fragmentation. Throughout the paper, we refer to policies and communications operating through these channels as transmission protection (TP). Their prominence extends from the Securities Markets Programme (SMP) and Draghi's "whatever it takes" speech leading to Outright Monetary Transactions (OMT), to the Pandemic Emergency Purchase Programme (PEPP) and the Transmission Protection Instrument (TPI). In the early phase of the European debt crisis, these interventions were framed within a so-called "separation principle" that distinguished measures determining the monetary policy stance from those intended to restore the functioning of financial markets and the monetary policy transmission mechanism (Hartmann and Smets, 2018). This distinction gradually faded, most notably with the introduction of the PEPP, underscoring the importance of disentangling transmission protection from the monetary policy stance at the announcement level. Table 1 reports the chronology of major Governing Council decisions since 2010, highlighting the multidimensional nature of ECB announcements.

Our motivation to complement surprises in monetary policy stance with TP surprises is two-fold. First, high-frequency surprises provide a novel opportunity to study the causal effects of transmission protection policies, which remain imperfectly understood despite a growing literature documenting their effects on sovereign spreads, financial markets, and the real economy (Altavilla et al., 2016; Krishnamurthy et al., 2018; Acharya et al., 2019). Second, TP policies may contaminate conventional measures of monetary policy surprises in a manner analogous to central bank information effects. By reducing the probability of adverse financial market outcomes, such policies influence financial conditions and expectations about future policy rates, potentially distorting measured PR, FG, and AP surprises. We find that TP is an active policy dimension in more than 80 percent of all scheduled meetings of the ECB governing council since the beginning of 2010.

We present four sets of empirical results. First, our empirical strategy produces historical decompositions of asset price movements following each announcement. To validate the identification approach, we document how the resulting decompositions for major ECB announcements (detailed in Table 1) closely align with the economic and financial market narrative surrounding each of the announcements. The announcement-specific decomposition is quantitatively important: it changes the classification of several major ECB announcements and reveals time-varying transmission patterns that would be obscured by a common factor structure. For example, effects of extensions of asset purchase programs affected the maturity structure of safe yields differently depending on parallel information about operational details. The December 2016 announcement to enlarge the envelope of asset purchases that alongside a shortening of the maturity of assets eligible for central bank purchases led to a large drop in yields at the 5-year maturity, while leaving the 10-year maturity unaffected. Second, in a novel contribution relative to Lewis (2025) and the broader literature, we consider the intraday shock volatility paths, implied by the identification strategy, as an object of direct economic interest. We compare these

Table 1: Key GC Announcements since 2010

Date	Type	Announcement
10-May-2010*	TP	SMP-1 and liquidity measures.
07-Aug-2011*	TP	Extension of SMP (SMP-2)
08-Dec-2011	PR, LTRO	25 bp rate cut and announcement of two 3-year LTROs
26-Jul-2012*	TP	"Whatever it takes" speech
04-Jul-2013	FG, TP	Introduction of ECB forward guidance; OMT readiness reaffirmed
05-Jun-2014	PR, LTRO	10 bp rate cut and launch of TLTRO-I
22-Jan-2015	AP	Launch of APP (QE)
03-Dec-2015	PR, AP	10 bp rate cut, extension of APP and strengthening purchase guidance
10-Mar-2016	PR, AP, LTRO	10 bp rate cut, APP expansion from (€60 bn → €80 bn), and launch of TLTRO-II
08-Dec-2016	AP	APP extended through December 2017.
26-Oct-2017	AP	APP recalibrated to €30 bn/month through September 2018
14-Jun-2018	AP, FG	APP exit guidance (reducing purchases to €15 bn/month and scheduled to end in December 2018)
07-Mar-2019	LTRO, FG	Launch of TLTRO-III and extension of rate guidance
12-Sep-2019	PR, AP	Deposit rate cut (-10 bp), APP restart (€20 bn/month), and introduction of tiering for central bank reserves.

Note: This table reports the chronology of the ECB's major Governing Council decisions since 2010. "*" indicates unscheduled policy meetings or speeches. PR=policy rates, FG=forward guidance, AP=asset purchases, LTRO=refinancing operations, TP=transmission protection.

paths to the narrative record – statement and press conference timestamps – and show that notable details, in some cases specific language, are immediately reflected in the volatilities. Doing so allows us to pinpoint precise language – for instance, "whatever it takes" that had immediate, detectable impact on financial markets. Third, we construct a novel five-dimensional series of ECB monetary policy surprises for all scheduled Governing Council meetings from May 2002 to January 2024 plus five selected unscheduled meetings related to major TP events.[1] While these measures share important similarities with existing indicators (Altavilla et al., 2019; Jarociński and Karadi, 2020), they differ because they incorporate announcement-specific decompositions and jointly identify CBI

[1]Throughout the paper, we refer to the identified objects arising from the high-frequency SVAR as *shocks*, and the aggregated responses at lower frequencies to those shocks as *surprises*, consistent with the fact that the latter are potentially correlated across dimensions, unlike structural shocks.

Table 1: Key GC Announcements since 2010 (cont'd)

Date	**Type**	**Announcement**
12-Mar-2020	LTRO, AP, TP	COVID-19 liquidity package; easier TLTRO-III terms; temporary €120 bn APP envelope; "not here to close the spreads" remark.
18-Mar-2020*	TP, AP	Launch of PEPP (Pandemic Emergency Purchase Programme), €750 bn envelope
04-Jun-2020	TP, AP	PEPP expanded by €600 bn to €1.35tn and extended to at least June 2021
10-Dec-2020	TP, AP, FG	PEPP expanded by €500bn to €1.85tn and extended to at least March 2022
10-Mar-2022	AP	Faster APP taper: €40 bn in April, €30 bn in May and €20 bn in June
09-Jun-2022	AP, FG	APP net purchases to end on 1 July; first rate hike signalled for July
21-Jul-2022	PR, TP, FG	50 bp rate hike; TPI approved; rate guidane replaced by meeting-by-meeting approach
08-Sep-2022	PR, FG, AP(QT)	75 bp rate hike; further hikes expected; guidance on QT ("it will happen")
15-Dec-2022	PR, AP(QT), FG	50 bp rate hike; further hikes signaled; APP QT announced for March 2023
04-May-2023	AP(QT)	Full stop of reinvestments; framing QT as an ongoing channel of tightening stance

Note: This table reports the chronology of the ECB's major Governing Council decisions since 2010. "*" indicates unscheduled policy meetings or speeches. PR=policy rates, FG=forward guidance, AP=asset purchases (QT=quantitative tightening), LTRO=refinancing operations, TP=transmission protection.

and TP surprises. Fourth, we study the effects of these surprises on financial markets in the days following the event. While PR and AP surprises primarily affect the risk-free yield curve, TP surprises propagate through sovereign risk, liquidity conditions, redenomination risk, equity prices, and exchange rates. These findings support the interpretation of TP as a distinct dimension of monetary policy communication.

These results provide two key sets of empirical findings. First – using announcement-specific historical decompositions – we deepen the understanding of market reaction to specific ECB announcements and which types of announcements prove most effective. Asset purchases exhibit stronger effects than forward guidance, and the introduction, extension/tapering, and removal of policy measures are more impactful than other adjustments. Transmission protection announcements have some of the largest effects, and explain considerable variation in risk-free rates, ruled out by assumption in some existing studies. At the announcement level, our novel analysis of volatility paths probes deeper still, highlighting how precise language moved financial markets for some announcements. Second, we document in detail the nature and effect of transmission protection shocks. We show that they impact short rates, equity prices, inflation expectations and exchange rates through sovereign credit, re-denomination, and liquidity risk channels. These features mean that TP shocks likely contaminate existing studies that do not seek to account for them, especially those featuring central bank information shocks.

Related literature. Our paper contributes to the literature measuring multidimensional monetary policy surprises in the euro area. Altavilla et al. (2019) construct policy rate, forward guidance, and asset purchase surprises for ECB announcements using a factor-based approach with cross-announcement restrictions regarding the transmission of shocks across asset classes following Swanson (2021). Subsequent work emphasizes the role of information effects in euro area monetary policy announcements (Jarociński and Karadi, 2020; Andrade and Ferroni, 2021; Badinger and Schiman, 2023). Relative to this literature, we jointly identify policy rate, forward guidance, asset-purchase, and central bank information surprises within a unified framework and add the dimension of transmission protection.

Our paper also relates to a growing literature identifying sovereign risk, fragmentation, or market-stabilization components in ECB announcements. Examples include sovereign spread factors (Mira-Godinho, 2021), market stabilization asset purchase shocks (Motto and Özen, 2022), spread shocks related to fragmentation risk (Fanelli and Marsi, 2022), asymmetric country risk shocks (Ricco et al., 2024), and country risk premia shocks identified using sign and narrative restrictions (Amorim Cabaço and Grasso, 2025). Also related is Akkaya et al. (2024), who use Varimax with sparsity as an identification assumption, rather than economic or statistical information, to uncover additional risk-related dimensions of monetary policy surprises. While these papers differ in methodology and interpretation, they share the view that euro area monetary policy announcements contain an important dimension related to sovereign risk and monetary transmission. Our contribution is to interpret this dimension as transmission protection, identify it jointly with conventional policy and information shocks, and allow both its composition and transmission to vary across announcements.

More broadly, we contribute to the literature studying non-stance components of monetary policy announcements. Recent work distinguishes monetary policy shocks from central bank information effects, risk premium news, Fed-response-to-news shocks, and other non-yield announcement shocks (Cieslak and Schrimpf, 2019; Bauer and Swanson, 2023; Boehm and Kroner, 2024; Jarociński and Karadi, 2025). We share the view that high-frequency surprises may be contaminated by information unrelated to the policy stance. Our distinction is that transmission protection captures information about the central bank's willingness to stabilize financial markets and rule out adverse equilibria, while other work focuses on information about macroeconomic fundamentals, risk premia, or the monetary policy reaction function.

2 Identifying multidimensional monetary policy

Our methodology is adapted from the announcement-specific approach of Lewis (2025). That paper proposes to identify a separate decomposition of observed asset price movements into underlying monetary policy shocks *for every announcement date*, by working with minute-by-minute data during an approximately two-hour period following FOMC announcements (often including a press conference). Letting η_m be innovations to the common component of asset prices, we aim to recover ϵ_m, where

$$\eta_m = H_t \epsilon_m, \tag{1}$$

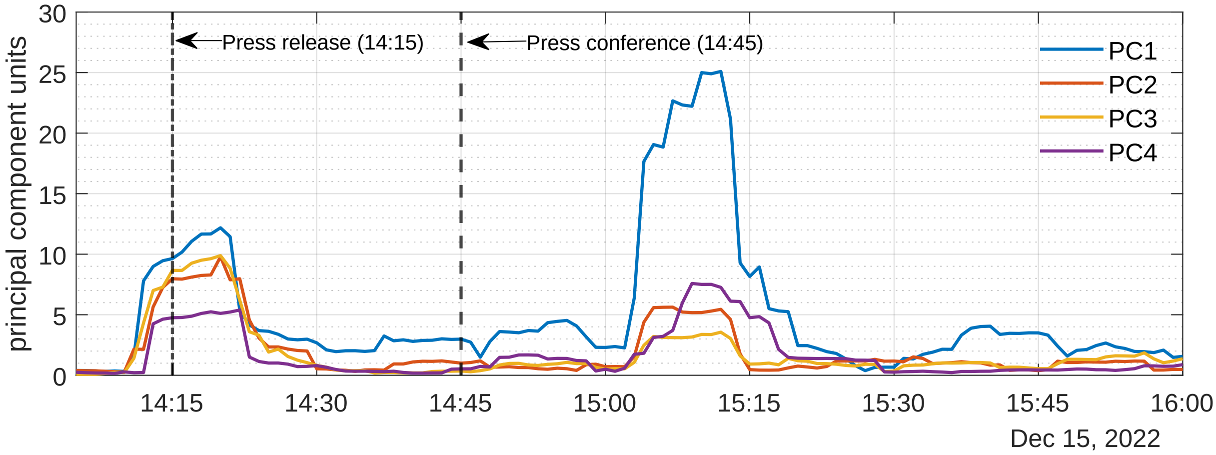
and H_t captures the announcement-specific instantaneous effects of ϵ_m on asset prices. The recovered "high-frequency shocks", ϵ_m, at the minute-by-minute frequency, can then be aggregated to medium-frequency surprises at more typical 30-minute, 1-hour, or 2-hour windows, for instance using historical decompositions. Within each announcement day's high-frequency time series, identification is achieved based on heteroskedasticity. The idea is that, following an announcement, the volatility of each dimension of the monetary policy shock will increase. However, especially when announcements are followed by press conferences, rather than all volatilities rising sharply and falling almost immediately, the volatilities of each active shock will follow different patterns – some remaining persistently elevated as markets continue to process subjective language surrounding forward guidance, for instance, while others will rise and fall repeatedly as a topic from a statement is repriced during a press conference.

Figure 1 plots the squares of the first four principal components of a panel of 16 asset price changes (further details are below) at the minute frequency from 10 minutes prior to the December 15th, 2022 press release to 1 hour 45 minutes after the release. This announcement is notable because the ECB simultaneously adjusted several dimensions of monetary policy. Indeed, the Governing Council decided to raise key interest rates by 50 basis points (bp), signaled further increases ahead, and announced the start of passive quantitative tightening (QT) by stopping reinvesting in full such that its portfolio would decline by an average of €15 billion per month until the end of the second quarter of 2023. The figure clearly shows an increase in variation in all four principal components just prior to the press release, at 14:15. However, the scale of the increases is heterogeneous, and the persistence differs dramatically, with some plateauing while others rise further in the following 15 minutes. The four principal components show increased variation once more after the beginning of the press conference at 14:45. Clearly, heteroskedasticity of multiple dimensions is present in the data, with heterogeneous dynamic properties. These properties are ideally suited to the identification results in Lewis (2021), which establishes identification of SVAR-type models (and thus a decomposition of asset price changes into underlying shocks) based on the autocovariance process of squared innovations, provided that the shock volatilities exhibit different dynamics. Formally, defining $\text{diag}(\sigma_t) = E\left[\epsilon_t \epsilon_t'\right]$, the identification condition is that the matrix

$$\begin{bmatrix} \text{cov}\left(\sigma_t^2, \text{vec}(\epsilon_{t-1}\epsilon_{t-1}')'\right) & E[\sigma_t^2] \end{bmatrix} \tag{2}$$

has rank of at least two and no proportional rows.

Figure 1: Moving Average of Squared Principal Components on December 15, 2022



Note: 10-minute moving averages of squared principal components of a panel of 16 asset price changes on December 15, 2022, from 10 minutes before the press release through 3:30pm.

This methodology is remarkably flexible and well-suited to disentangle multidimensional monetary policy. First, identification is achieved without further assumptions about the effects of monetary policy shocks from one announcement to the next, unlike the existing literature, which assumes that effects are constant over time. That assumption is hard to defend against the narrative record of unconventional announcements. For example, there is little reason to believe that the GC decision in December 2016 to extend asset purchases and simultaneously lower the eligible minimum remaining maturity from two years to one year would have the same effects along the yield curve compared to previous AP announcements targeting on average longer maturities. Moreover, even if the composition of underlying monetary policy shocks is fixed, Faust et al. (2007) argue that their asset price effects need not be stable over time because they depend on both the mapping from shocks to agents' expectations of economic fundamentals and on the mapping from those expectations to asset prices. Further, our approach allows the number of shocks present to vary over time, consistent with the fact that TP and AP were only introduced by the ECB in May 2010 and October 2014, respectively; anomalous spikes in identified AP series prior to the Great Recession have plagued previous identification schemes. Finally, within each announcement-specific dataset, identification is statistical, rather than based on economic assumptions about the shocks' effects, allowing the "data to speak" as to the shocks active for any announcement and their effects, with the researcher using economic theory only to label those statistically-recovered shocks *ex post*. Empirically, not only does the methodology offer surprise series based on these more flexible assumptions, it also provides detailed narrative analysis of the market response to each monetary policy announcement over the following hours.

2.1 Step-by-step guide

The methodology begins from a panel of asset prices for a given announcement at calendar date t, measured at the minute-by-minute frequency. We consider 16 asset prices, consisting of the risk-free yield curve as captured by 1-, 3-, and 6-month, 1-, 2-, 3-, 5-, 7-, and 10-year OIS rates, Euro Stoxx 50 returns, Italian 2-, 5-, and 10-year government bond spreads relative to risk-free rates, and the equivalent Spanish 2-, 5-, and 10-year government bond spreads.[2] For further details on the dataset and data processing, see Appendix A. Denote the first difference of these asset prices at the minute m as ΔY_m, and their standardised values as $\Delta\tilde{Y}_m$. For each announcement prior to 21 July 2022, we consider prices from 13:35 – ten minutes before the 13:45 announcement – until 15:30, yielding a 1 hour and 55 minute window in total. Starting from 21 July 2022, the ECB adopted a new schedule for the publication of its monetary policy decisions and press conferences (ECB, 2022). Accordingly, for these later announcements, we use prices from 14:05 – ten minutes before the 14:15 announcement – until 16:00. There are several steps to identification and estimation, which largely follow Lewis (2025). We sketch them below, making clear any major departures; for further background and theoretical results, the reader should consult Lewis (2025).

Step 1: Recover principal components. Using this minute-frequency intraday time series, we begin by estimating the first $n \in \{3, 4\}$ principal components,

$$\Delta\tilde{Y}_m = \Lambda F_m + u_m, \quad m = 1, \ldots, M. \tag{3}$$

[2] OIS rates are extrapolated using German benchmark bond yields at corresponding maturities.

We estimate three principal components prior to the introduction of TP (prior to which only the PR, FG, and CBI shocks were plausibly active), and four thereafter. Working with principal components allows us to study the co-movement of a sizable panel of asset prices, abstracting from the noise present in individual series at such frequencies.

Step 2: Estimate principal component residuals. We next estimate a VAR in the n principal components to remove any residual predictability in the time series, with lag order selected using the Hannan-Quinn information criterion:

$$F_m = b + \sum_{l=1}^{L} B_l F_{m-l} + \eta_m. \tag{4}$$

The VAR residuals, η_m, are the unpredictable asset price innovations (in principal component space) that we will decompose into monetary policy shocks. The choice to estimate three or four principal components mirrors Lewis (2025). Although we identify five dimensions of monetary policy, we do not consider up to five principal components, and thus do not allow all five dimensions to be active for a single announcement.[3]

Step 3: Test for identification based on time-varying volatility. We next use the test of Lewis (2021) to determine whether there is adequate time-variation in the squared residuals, driven by the volatility process, to statistically identify n shocks. In particular, the test is of the condition

$$\operatorname{rank}\left(E\left[\hat{\zeta}_m \hat{\zeta}'_{m-1}\right]\right) = n, \tag{5}$$

where $\hat{\zeta}_m = \operatorname{vech}\left(\hat{\eta}_m \hat{\eta}'_m\right)$.[4] For more details, see Lewis (2021).

Step 4: Recursion until full identification. If the test fails to reject the null hypothesis, proceed to step 5. Otherwise, replace n with $n-1$, and repeat steps 2-4 until a

[3] This choice is dictated by necessity. Given that we have only 116 observations available for each announcement, it is not possible to reliably estimate the covariance matrices required to conduct rank tests for identification in step 3 below for $n = 5$. However, the constraint only applies for 79 out of 231 announcements, and appears potentially binding for just 16 of those.

[4] In general, we test at the 20% significance level; while this may seem high compared to a 10% test, for example, the null hypothesis is actually stronger than the necessary condition for identification, as discussed in Lewis (2021).

smaller, fully-identified model is obtained.

Step 5: Estimate the identified high-frequency shocks. Set $\hat{s} = n$, the number of *identifiable shocks* on day t. Implement the stochastic volatility (SV) estimator proposed by Lewis (2021) to estimate H_t in the model

$$\eta_m = H_t \epsilon_m, \quad m = 1, \ldots, M, \tag{6}$$

using the estimated VAR innovations $\hat{\eta}_m$. This estimator fits an AR(1) SV process to $\hat{\eta}_m$. Provided the rank condition tested in step 3 holds, H_t is identified without any distributional assumptions from the autocovariance process of the squared residuals. A consequence is that fitting any volatility process to the model whose dynamics maintain that rank will yield a unique solution (up to sign and column order). Extensive simulations in Lewis (2021) and Bertsche and Braun (2022) demonstrate that the AR(1) SV process yields significant efficiency gains over distribution-free approaches and robustness advantages over other parametric models, even when quite badly misspecified.

Step 6: Determining the dimension of monetary policy. We do not assume that the number of *identifiable shocks* is the same as the number of *monetary policy shocks*. Instead, we assume that the number of monetary policy shocks, k, is equal to the dimension of the common component of $\Delta\tilde{Y}_m$, which we estimate using the PC1 information criterion from Bai and Ng (2002). When $s = k$, all shocks driving the principal components are monetary policy shocks. When $s > k$, there may be additional “noise” shocks that are not associated with monetary policy that possess time-varying volatility (and are thus identifiable), but are not pervasive enough amongst the asset prices to be associated with monetary policy. However, estimating and discarding these shocks is a further check on noise (and ignoring them would violate invertibility). Finally, when $k > s$, not all dimensions of monetary policy are identifiable due to inadequate time-varying volatility.

Step 7: Label the shocks. With $\hat{s}$ minute-by-minute statistically-identified shocks in hand for a given announcement, it remains to render them economically meaningful. As in Lewis (2025), we adopt a quantitative labeling criterion to determine which labels are best suited to each shock. It is important to emphasise that this stage has no impact on the recovered shock values themselves, but merely the labels attached to them, for instance, PR or FG. Here, we must develop a novel labeling criterion suited to our more complex setting, which features the additional TP shock, and where the details of policies differ from the U.S. case. We search over all possible mappings between shocks and our five labels to maximise an objective function. First, define $A_{ij} = M^{-1}\sum_{m=1}^{M}\Psi_{ijm}$ as the area under the path traced out by Ψ_{ijm}, the historical decomposition of series i with respect to shock j over our window, and $\bar{A}_i = M^{-1}\sum_{m=1}^{M}Y_{im}$ as the area under the observed path of series i.[5] We measure the share of movement in series i explained by shock j as $\Theta_{ij} = A_{ij}/\bar{A}_i$, which we truncate below at -1 and above at $+1$. Define $S_{ij} = \text{Sign}\left(\Psi_{ij31} + \Psi_{ijM}\right)$, the sign of the average of the decompositions of i with respect to shock j at the 30-minute and 1:55 and windows. Now, define the $5 \times \hat{s}$ matrix-valued labeling function $C(S, \Theta)$ as follows:

$$C_{PR,j}\left(S_{\cdot j}, \Theta_{\cdot j}\right) = \begin{cases} 1 & if\ \forall i \in \{1m, 3m, 6m, 1y, 2y, 3y, 5y, 7y, 10y\}, \Theta_{ij} > 0.6 \\ \Theta_{3m,j} & otherwise. \end{cases} \tag{7}$$

This element quantifies how well shock j aligns with the economic properties of a PR shock. In general, this is measured by the share of variation explained in the 3-month OIS rate, but if the entire yield curve shifts (over 60% of variation explained in all of the listed interest rates) the value is set to the maximum possible, unity, to virtually guarantee labeling as a PR shock.

[5] We compute the decompositions following the method described in Lewis (2025).

$$C_{FG,j}\left(S_{\cdot j},\Theta_{\cdot j}\right)=\begin{cases}1 \quad if \displaystyle\prod_{i\in\{6m,1y,5y,10y\}}\mathbf{1}[\Theta_{ij}>0.6]\mathbf{1}[S_{ij}\neq S_{ESX,j}]=1\\ \left(\displaystyle\prod_{i\in\{6m,1y\}}\mathbf{1}\left[S_{ij}\neq S_{ESXj}\right]\right)\times\frac{1}{3}\displaystyle\sum_{i\in\{6m,1y,ESX\}}\Theta_{ij} \quad otherwise.\end{cases} \tag{8}$$

This entry quantifies how well shock j aligns with the economic properties of a FG shock. Given the nature of the ECB's forward guidance, we focus on OIS rates at 6-month and 1-year horizons. In general, we measure this using the average share of variation explained in these two OIS rates and the Euro Stoxx 50 provided the rates move in the opposite direction as equities, and zero otherwise. However, if the previous two rates and the 5-year and 10-year OIS rates are overwhelmingly explained by the shock (over 60% of variation explained), and all move in the opposite direction to equities, we set the criterion to its maximum of unity, to virtually guarantee labeling as a FG shock.

$$C_{AP,j}\left(S_{\cdot j},\Theta_{\cdot j}\right)=\mathbf{1}\left[S_{y^*j}\neq S_{ESXj}\right]\times\frac{1}{1+\mathbf{1}\left[S_{5yj}=S_{10yj}\right]}\sum_{i\in\{5y,10y\}}\mathbf{1}\left[S_{y^*j}=S_{ij}\right]\Theta_{ij}, \tag{9}$$

$$\text{where} \quad y^*=\underset{i\in\{5y,10y\}}{\operatorname{argmax}}\ \Theta_{ij}.$$

This entry quantifies the extent to which shock j explains movements in risk-free long yields of 5- and 10-year maturities. The criterion is structured to allow the effect of asset purchases to be of different sign at different points on the yield curve (for instance if purchases were announced that disproportionately affect certain maturities), by only considering y^*, the best explained of the two long yields by shock j, if the 5- and 10-year yields move in opposite directions. If the sign of the effect on y^* is opposite to that on the Euro Stoxx 50, then the criterion is equal to the average share of variation explained in both yields, if both move in the same direction, or just the variation explained in y^*, if they move in opposite directions. If y^* responds in the same direction as equities, the entry is equal to zero.

$$C_{TP,j}\left(S_{\cdot j}, \Theta_{\cdot j}\right) = \frac{1}{6} \sum_{i \in \{IT2, IT5, IT10, ES2, ES5, ES10\}} \Theta_{ij}. \tag{10}$$

This entry quantifies the extent to which shock j resembles a TP shock. It computes the average share of variation explained in medium and long spreads for both Italy and Spain. These two periphery countries should see yields rise relative to those of risk-free OIS rates following a transmission protection announcement indicating less commitment to fight financial market dysfunctioning.

$$C_{CBI,j}\left(S_{\cdot j}, \Theta_{\cdot j}\right) = \prod_{i \in \{1y, 2y, 5y, 10y\}} \mathbf{1}[S_{ij} = S_{ESX,j}] \times \frac{1}{5} \sum_{i \in \{1y, 2y, 5y, 10y, ESX\}} \Theta_{ij}. \tag{11}$$

This entry quantifies to what extent shock j behaves like a CBI shock. If the 1-year OIS rate and the 2-year, 5-year, and 10-year safe yields all move in the same direction to the Euro Stoxx 50, then the criterion is equal to the average share of variation explained across those four rates and the Euro Stoxx 50. If they do not all move in the same direction, the criterion is equal to zero.

When there is less than 1 bp variation in the 3-month OIS rate over the window and $\hat{k}$ indicates that there are fewer active monetary policy shocks than the available labels (i.e. $\hat{k} < 3$ prior to the start of transmission protection and $\hat{k} < 4$ prior to the start of asset purchases), we restrict that there is no active PR shock. Likewise, we do not allow labels corresponding to the TP or AP shocks before those policies were introduced for the first time.

With $C(S, \Theta)$ in hand, we search across all combinations of distinct $\hat{k}$ shock-label pairs for the combination for which the sum of the corresponding entries of C is maximsed, under the additional restriction that any selected label-shock pair must correspond to a strictly positive entry in C. In the rare case that this restriction is violated (C does not contain $\hat{k}$ strictly positive entries in unique row-column pairs), we compute an alternative criterion that relaxes the definitions of the shocks. For instance, it reduces the penalty applied when potential FG or AP shocks move certain interest rates and equities in the same direction. For a full description of the alternative criterion employed in such cases, see Appendix B.

Step 8: Measuring the surprises. The minute-by-minute shocks themselves are of modest applied interest. We thus aggregate the cumulative effects of these high-frequency shocks on various asset prices at more conventional horizons using historical decompositions to measure monetary policy surprises. Our baseline surprise series consider the cumulative effects on asset prices from 10 minutes prior to the announcement to 1:45 following the announcement, although the effects at all intermediate times are also reported in our narrative analysis, see Section 3. For a given announcement, each surprise value is measured using the effect of the corresponding shock on a "reference" asset price for consistent units. For the PR surprise, we use the 3-month OIS rate; for FG, the 1-year OIS rate; for AP, the average of the responses of 5-year OIS and 10-year OIS rates; for TP, the average spread of the Italian and Spanish yield over the German Bund for maturities at the 5-year and 10-year horizon; and for CBI, the Euro Stoxx 50 return.

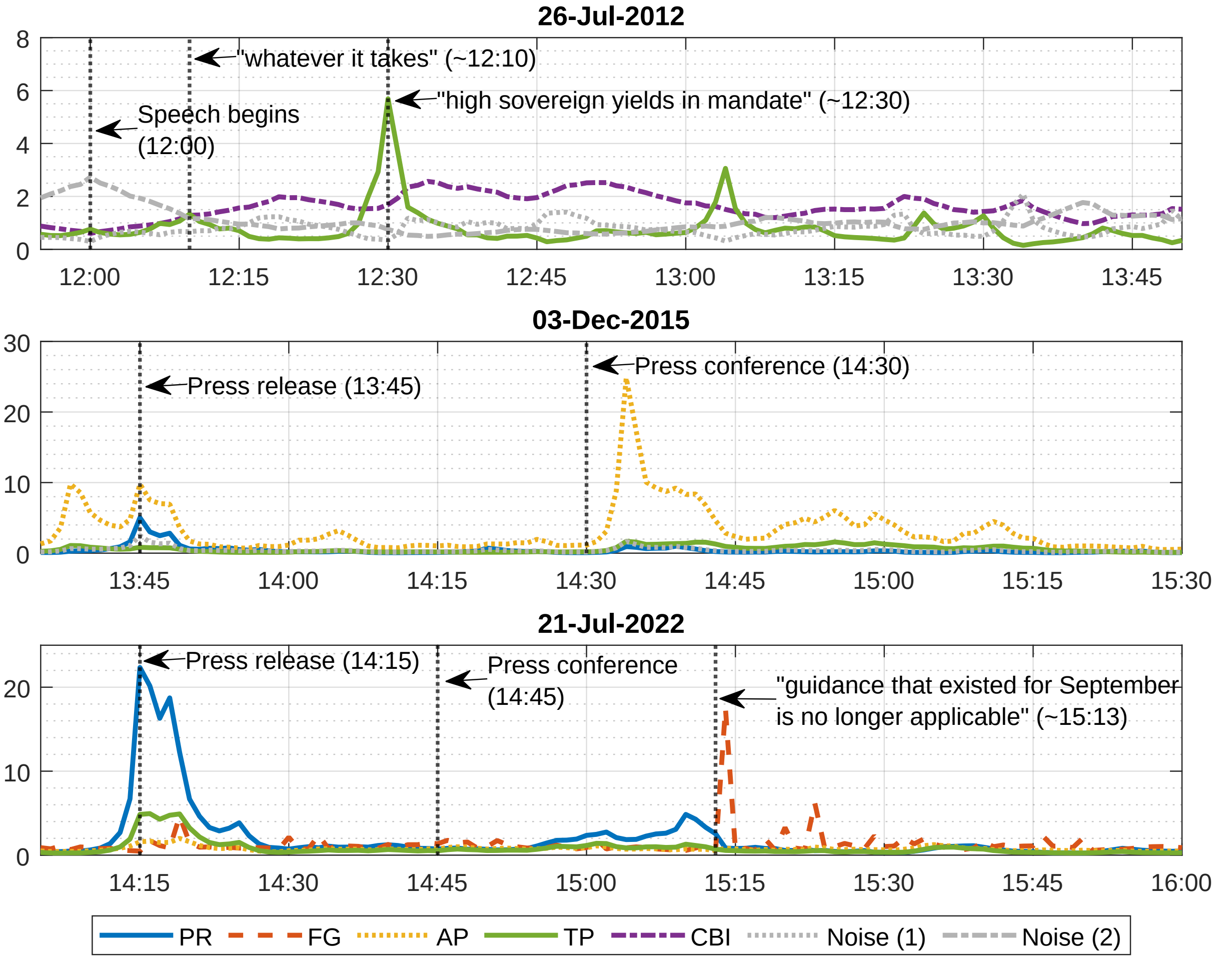
2.2 Economic interpretation of identifying variation

Before we present our results, we provide an illustrative example of how heteroskedasticity over the announcement windows can furnish identification in an economically meaningful manner. In particular, we document the properties of the estimated variances on three dates, beginning with the window around President Draghi's "whatever it takes" speech from July 26, 2012. The top panel of Figure 2 plots the variance paths for the four identified high-frequency shocks for this announcement, which are TP, CBI, and two noise shocks. First, the fact that these two dimensions of monetary policy are identified squares firmly with the narrative record; the speech was so much focused on the sovereign spreads that in commentary available from Bloomberg during and immediately following, there is no mention whatsoever of risk-free rates or yields, while a search returns dozens of mentions of Spanish and Italian yields and spreads. Before interpreting the narrative evidence further, it is clear that the variances follow linearly independent processes over the announcement window. Recall that Rigobon (2003) shows that shocks are identified provided that there are two non-proportional sets of variances in a sample – and more generally, shocks are identified from variance paths provided they are linearly independent, as shown by Sentana and Fiorentini (2001). Therefore, that paths contain ample information for identification via heteroskedasticity to exploit.

Moreover, the movements of these variances are not statistical artifacts, but closely linked to economic events. For instance, the TP shock's variance peaks sharply around 12:30, when Draghi explicitly stated that addressing high yields on sovereign debt in the euro area comes within the central bank's mandate. There is a smaller peak around 12:10, when Draghi famously said the ECB was "ready to do whatever it takes" and a moderate one at 13:04, as Bloomberg pushed summaries and commentary on the speech. The ability of a statistical identification approach to precisely recover this economic narrative is uncanny. The rise in the CBI shock's variance between 12:15 and 13:00 coincides with the Euro appreciating against the dollar, even though exchange rates are not part of our asset price panel. The appearance of a CBI shock on this date, despite little explicit signaling about the state of the economy, is consistent with the theoretical literature on off-equilibrium announcement effects of transmission protection policies, which has emphasized the role of multiple equilibria Camous and Cooper (2019). To the extent that the speech contains information about closing sovereign spreads, this is news seen as avoiding a fragmentation equilibrium, which is a positive CBI shock above and beyond the transmission protection channel itself. Finally, the second noise shock's variance fell dramatically at the start of the speech, before gradually rising as Draghi concluded, consistent with the majority of movement in the chosen panel of asset prices being driven by monetary policy news around major announcements (e.g., Lucca and Moench 2015). This episode provides the narrative restriction used to identify the TP shock in Amorim Cabaço and Grasso (2025); by contrast, our statistical methodology instead *recovers the narrative* present in the economic record, highlighting the difference between our approaches.

In the online Appendix, we show that the autocorrelations of the variances mirror the information contained by the paths. The autocorrelation matrix clearly does not have proportional rows, validating the Lewis (2021) identification condition, on which our analysis is based. This is because the variances of all four shocks are strongly persistent (the CBI and noise shocks extremely so), while generally much more weakly or indeed negatively correlated with those of the other shocks. The variances of the CBI and TP shocks are indeed essentially dynamically uncorrelated. The variance of one of the noise shocks is negatively correlated with the lagged variances of all other shocks, and the other is positively associated only with the lagged variance of the CBI shock. The observed pattern is consistent with the prominent TP shock content of the event being largely independent of other news contained.

Figure 2: Variance Paths for Key Dates



Note: Panels report the expected variance of identified shocks over the window of the Draghi'speech in 26 July 2012 (top panel) and of two Governing Council meetings in December 2015 and July 2022 (middle and bottom panels). The vertical lines mark the time of the press releases, the press conferences and notable quotes.

The narrative interpretation of volatility paths also reveals important insights for scheduled GC meetings. For 3 December 2015 (middle panel), the model identifies three monetary policy shocks. The policy decision for this meeting included a reduction in the deposit facility rate by 10 bp to -0.3 percent and an extension of the APP program. Unsurprisingly, the bulk of volatility occurred around 13:45 and shortly after 14:30, when the monetary policy decisions were published and the press conference with the President began, and hence market-sensitive information was revealed. Market commentary and surveys conducted among economists prior to the announcement reveal that several participants expected a larger rate cut and larger monthly volumes of bond purchases, leading to overall tightening PR and AP surprises. The model also captures a TP shock, which aligns well with the decision to extend the set of eligible assets for central bank purchases under the APP to euro-denominated marketable debt instruments issued by regional and local governments located in the euro area. At the same meeting, it was also decided to lower the ceiling for Greek banks' access to emergency liquidity assistance (ELA), reflecting progress in stabilizing the Greek banking system. This announcement illustrates the fact that within usual high-frequency windows, market participants process information about monetary policy stance alongside information affecting the proper functioning of financial markets.

Another important scheduled meeting was 21 July 2022, which marks the first rate hike of the ECB in more than a decade. The bottom panel documents that the model identifies all four dimensions of monetary policy, which is consistent with the complex set of decisions announced on that date. Specifically, the ECB hiked rates by 50 bp, twice the amount signaled at the previous meeting, and only predicted by four out of 53 economists surveyed by Bloomberg. This is reflected in the substantial spike in the volatility of the PR shock as the statement is released. At 15:13, President Lagarde is quoted as saying that prior guidance on the September rate move no longer applies, inducing a repricing around FG as reflected in its volatility path at precisely this time. The monetary policy decisions entailed the shift to a meeting-by-meeting approach of rate setting, de facto abandoning any predating forward guidance, which is also consistent with the presence of a FG shock. Regarding the identified TP shock, the meeting was particularly insightful. In order to maintain a smooth transmission of the higher policy rates across the euro area member countries, the GC announced the Transmission Protection Instrument (TPI), which could be activated to address disorderly market dynamics via targeted bond purchases in distressed market segments, while reinvestments from the pandemic emergency bond purchase program (PEPP) were considered as a first line of defense. Finally, the model also detects an AP shock; the meeting implied guidance on the reinvestment horizons for APP ("as long as needed") and PEPP ("at least until end 2024").

Overall, analysis of the recovered variances shows the connection between our statistical identification scheme and the economic narrative. Our approach is able to recover evidence strongly consistent with the latter, even though such economic information is never used for identification. It is this very narrative that furnishes starkly different variance paths amongst the identified shocks, which in turn possess the full-rank autocorrelation matrix we require for identification.

3 Announcement-specific decompositions

In this section, we first use historical decompositions to examine the sources of asset-price movements on a set of key announcement dates. We then assess the contribution of the identified shocks to explaining variation in asset prices over the full sample of announcements. Finally, we construct time series of announcement surprises and compare their properties with existing measures used in the literature.

3.1 Historical Decompositions for major announcements

In this section, we describe in detail the lessons provided by the historical decompositions for 12 key announcement dates. These announcements, drawn from Table 1, illustrate how the nature and transmission of ECB policy shocks have evolved over time, from the introduction of the securities market program (SMP) in 2010 to the normalization phase beginning in 2022.[6] For each date, we plot the decomposition of asset price movements into distinct monetary policy shocks, as shown in Figure 3 to Figure 5. We focus on

[6] The historical decompositions for for the remaining dates of Table 1 are available in the Online Appendix.

the responses of six representative asset prices. Specifically, we study the reactions of the 3-month, 1-year, 5-year, and 10-year OIS rates, the Euro Stoxx 50 index, and the Italian–German 5-year sovereign bond yield spread. Blue denotes the PR shock, red the FG shock, gold the AP shock, green the TP shock, and purple the CBI shock. For reference, the observed path of each asset price is shown as a solid black line with a diamond marker.

The 10 May 2010 announcement took place on an unscheduled, non-GC date, urgently convened as fragmentation risks intensified. The first Greek bailout package on 2 May 2010 failed to convince markets with the result that fears spread rapidly to Portugal, Spain and Ireland, with dramatically widening of peripheral spreads. On this occasion, the ECB introduced SMP, initiating targeted purchases of stressed government bonds to restore market functioning (ECB, 2010). The event is characterized by a sizable TP shock, which contributed to the decline in the Italian spread and the rise in the Euro Stoxx 50 observed during the event window. Quantitatively, the TP shock accounts for at least half of the compression in the spread and roughly half of the increase in equity prices, reflecting market expectations that the ECB was now prepared to intervene directly to stabilize sovereign bond markets.

In early August 2011, ECB President Jean-Claude Trichet and incoming President Mario Draghi sent a letter to the Italian government pressing for fiscal consolidation and structural reforms. Italy and Spain subsequently announced new policy measures over the weekend. At the same time, European leaders had agreed in principle to expand the role of the European Financial Stability Facility (EFSF), but those measures were not yet operational, leaving a gap in crisis management. Against this background, the ECB issued its statement on 7 August 2011 (ECB, 2011), announcing it would actively implement SMP again, which had been inactive for several months. This statement later became known as SMP-2, although there was no distinct second programme. Our model detects a TP shock that contributes to the decline in the Italian spread, though its impact is noticeably smaller than that associated with SMP-1 in May 2010. This more moderate reaction suggests that markets viewed this second intervention as less forceful or less surprising than the initial SMP announcement, consistent with diminishing marginal effects of repeated stabilization measures.

The 8 December 2011 announcement combined a 25 bp cut in the key policy rates with the introduction of two 3-year longer-term liquidity operations (LTROs), aimed at alleviating funding pressures in the banking system. During the press conference, President Draghi downplayed expectations that the ECB would engage in a significant government bond purchase programme to support stressed euro area countries, recalling that the European Treaty prohibits the monetary financing of governments. We do not detect a PR shock associated with this announcement; instead, we identify an FG shock, which contributes little to asset price movements. However, we do identify a TP shock, which contributed to the rise in the Italian sovereign spread later in the day. This shock reflects market disappointment with the ECB's communication on its role as *buyer of last resort* in government bond markets. Interestingly, as is the case for the 7 March 2019 meeting, liquidity operations emerge as a transmission protection event via a feedback channel between the banking system and sovereigns. Acharya et al. (2021) show how ECB as *lender of last resort* to the banking system improves liquidity in government bond markets, thereby alleviating the bank-sovereign nexus (Farhi and Tirole, 2018). However, the liquidity effects of this event were dominated by the affirmative reticence regarding central bank bond purchases.

The 26 July 2012 communication is an unscheduled event from President Draghi's public speech in London, which became famous for the "whatever it takes" statement (Draghi, 2012), see also the discussion of Figure 2, panel a). After several insufficient stabilization attempts based on limited interventions in government bond markets and liquidity operations targeting the banking system, the time was ripe for an unlimited statement to save the euro area in the face of markets questioning the reversibility of the euro, associated with rising redenomination risk - the possibility that countries might leave the euro. The speech was setting the stage for the adoption of OMT at the September 2012 GC. A large TP shock is registered, explaining more than half of the compression in the Italian spread and contributing modestly to the rise in 10-year yields and the Euro Stoxx

50. In addition, a sizable CBI shock is identified and accounts for a substantial share of the movements in medium and long-term rates and equity prices. This pattern suggests that, beyond signaling the ECB's readiness to counter fragmentation risk, the speech provided a major informational update about the macroeconomic outlook, effectively ruling out the "bad equilibrium" scenario priced in by market participants.

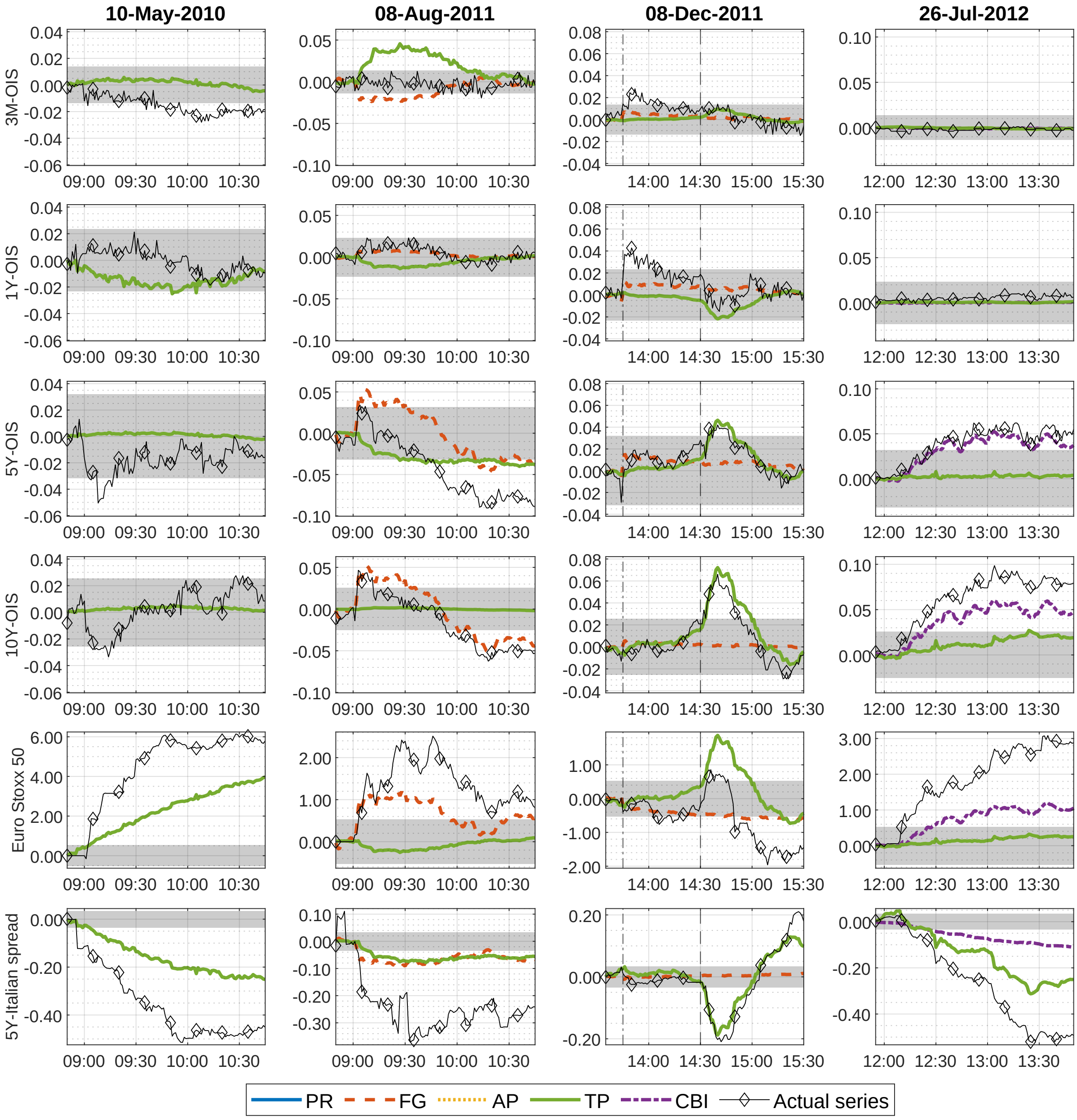
The 4 July 2013 announcement marked the ECB's first explicit use of forward guidance. Markets priced earlier rate hikes than the GC felt appropriate for the euro area, which remained in a weak recovery. The GC stated that it would maintain the key ECB interest rates at their present or lower levels for an extended period of time, signaling a commitment to a prolonged accommodative stance. During the press conference, President Draghi also reiterated that the OMT programme remained ready to be activated if necessary. The announcement was perceived as an expansionary FG shock, which led to a decline in medium- and long-term yields and a rise in stock market. At the same time, the TP shock contributed to a narrowing of the Italian spread during the press conference, reflecting improved confidence in the ECB's backstop against market fragmentation.

The 22 January 2015 announcement marked a historic turning point for the ECB, as the GC introduced a large-scale asset purchase program (APP) for the first time. This came in response to a persistent period of below target inflation and at times when euro area inflation had fallen to negative territory, while inflation expectations had declined noticeably. The AP shock significantly lowered long-term yields, particularly at the 5- and 10-year maturities, and narrowed the Italian spread, while having little discernible effect on equity prices. A FG shock is also identified on this date, even though the GC did not issue any explicit communication related to future policy rates, but consistent with the signaling channel of asset purchases (Eggertsson and Woodford, 2003). This shock is associated with a decline in the one-year OIS yield and a modest increase in the Euro Stoxx 50, suggesting that markets interpreted the overall tone of the asset purchase announcement as signaling a more accommodative policy stance extending beyond the immediate horizon.

The 3 December 2015 announced a 10 bp cut in the deposit facility rate and an extension of the asset purchases until at least March 2017. (Figure 2, panel c). Market participants, however, had expected a more aggressive package of measures. Consequently, this announcement was perceived as restrictive. The PR shock raised yields across all maturities, while the AP shock further contributed to higher long-term yields and the decline in equity prices. These dynamics in minute-by-minute movements in asset prices underlying identified monetary policy shocks aligns well with related analysis that exploits the discrepancy between *ex ante* market expectations as documented in market surveys and *ex post* announcements to gauge the quantitative effectiveness of ECB asset purchase programs on the yield curve and economic activity (Eser et al., 2023; Lhuissier and Nguyen, 2025). Additionally, we find a TP shock driving up government bond spreads. This is consistent with a GC decision to extend the eligible assets for purchases under the APP to euro-denominated marketable debt instruments issued by regional and local governments located in the euro area. Together with the overall surprise on the volume, this explains a rise in spreads and lower equity market prices.

The 8 December 2016 announcement communicated an extension of scheduled monthly net asset purchases. At the time, market participants viewed the APP as increasingly constrained by the scarcity of eligible German Bunds trading below the deposit facility rate (Arrata et al., 2020). Rather than relaxing more fundamental purchase constraints, such as the capital-key allocation or issuer limits, the Governing Council opted to broaden the eligible universe by permitting purchases of securities yielding below the deposit facility rate and reducing the minimum remaining maturity to one year. As a result, the APP surprise has asymmetric effects on the 5-year and 10-year maturities: while APP has no effect on the 10-year rate, the 5-year rate is lowered. This is in strong contrast with the effects of the APP shock during the December 2015 announcement, where maturities from one to ten years are all moved in the same direction. Therefore, this event illustrates the benefits of announcement specific decompositions, since maintaining a common factor structure across events would incur bias when relative effects along the yield curve vary by event. We further detect a TP shock, which is likely related to discussions during the press conference on the smooth functioning of repo markets due to the scarcity of safe assets in the euro area.

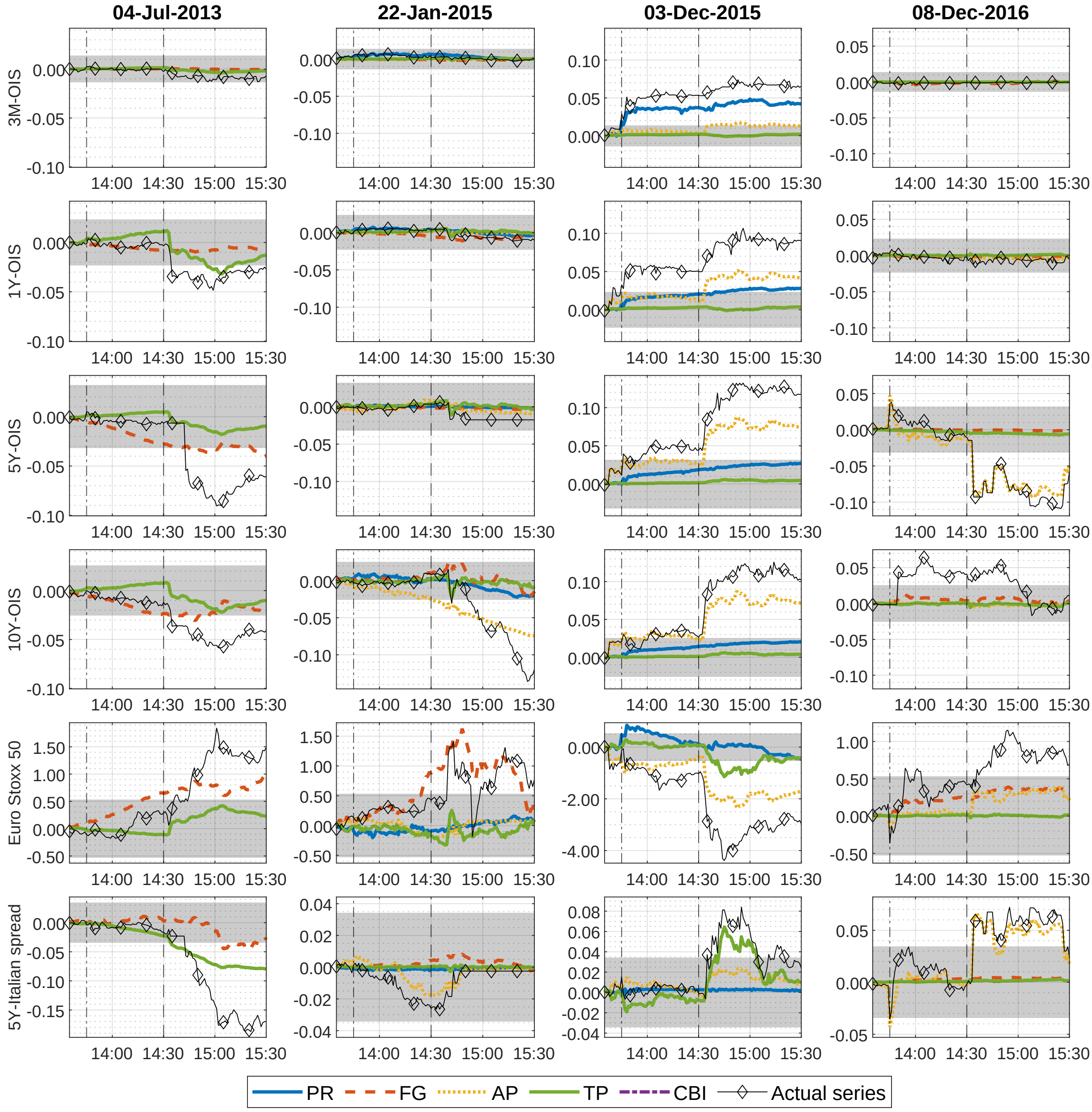
Figure 3: Historical decompositions of key GC announcements.



Note: Historical decompositions for the asset prices indicated in the left margin with respect to each of the five shocks, in percentage points. Blue represents the PR shock, red the FG shock, gold the AP shock, green the TP shock, and purple the CBI shock. The vertical lines mark the time of the press releases and press conferences. The black dashed line is the path of the simple change from ten minutes prior to the announcement. The shaded interval corresponds to 1.96 times the average standard deviation in the asset price following monetary policy announcements.

The 26 October 2017 GC decision was made against the backdrop of a strengthened euro area recovery and deflation risks that had largely disappeared. The ECB wanted to recalibrate and reduce its APP program, but maintain favorable financing conditions.

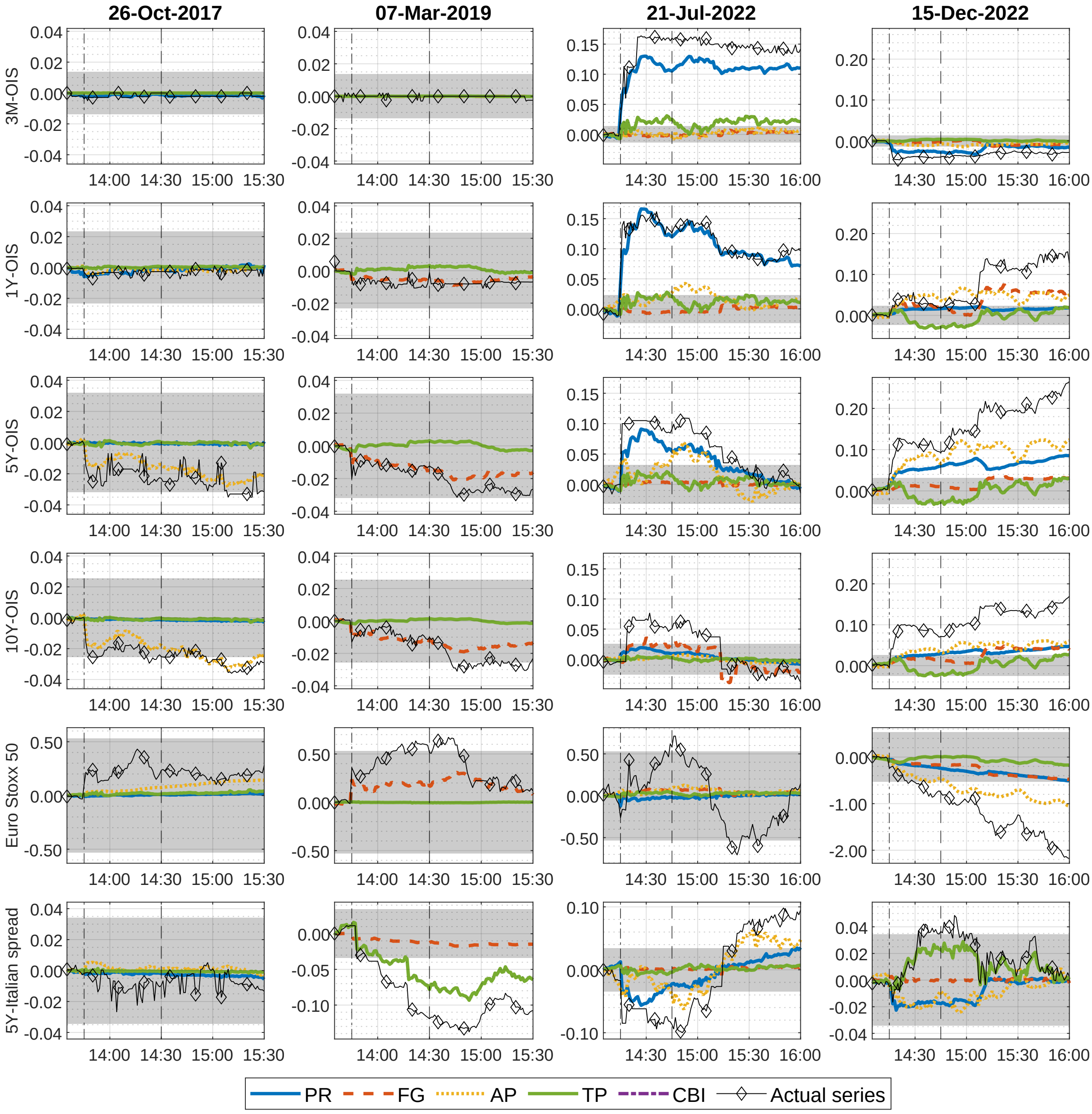
Figure 4: Historical decompositions of key GC announcements (con't).



Note: Historical decompositions for the asset prices indicated in the left margin with respect to each of the five shocks, in percentage points. Blue represents the PR shock, red the FG shock, gold the AP shock, green the TP shock, and purple the CBI shock. The vertical lines mark the time of the press releases and press conferences. The black dashed line is the path of the simple change from ten minutes prior to the announcement. The shaded interval corresponds to 1.96 times the average standard deviation in the asset price following monetary policy announcements.

The announcement implies a pre-scheduled tapering of asset purchases, combined with the first clear guidance on reinvestment policies ("for an extended period of time after the end of its net asset purchases, and in any case for as long as necessary"). Overall, the long reinvestment horizon dominated the tapering decision, which was expected by markets, turning the overall meeting into an accommodative AP surprise.

Figure 5: Historical decompositions of key GC announcements (con't).



Note: Historical decompositions for the asset prices indicated in the left margin with respect to each of the five shocks, in percentage points. Blue represents the PR shock, red the FG shock, gold the AP shock, green the TP shock, and purple the CBI shock. The vertical lines mark the time of the press releases and press conferences. The black dashed line is the path of the simple change from ten minutes prior to the announcement. The shaded interval corresponds to 1.96 times the average standard deviation in the asset price following monetary policy announcements.

The 7 March 2019 announcement introduced a new series of targeted longer-term refinancing operations (TLTRO-III to counter a deteriorating macroeconomic outlook. Further, forward guidance at that time had two legs, one calendar-based and the other state-dependent.[7] This meeting extended the calendar-based leg from "at least through

[7] At this time, state-dependency was still relatively weak. More precise criteria were spelled out at the

the summer of 2019" to "at least through the end of 2019". The resulting FG shock significantly lowered medium- and long-term yields, reflecting consistent market expectations of a more extended period of monetary accommodation. At the same time, the TP shock played an important role by contributing substantially to the decline in the Italian spread, consistent with investors' perception that the new TLTROs would help alleviate fragmentation risks within the euro area through the bank-sovereign nexus.

The 21 July 2022 meeting marked the ECB's first rate increase in over a decade in response to the post-pandemic inflation surge. The statement also introduced the Transmission Protection Instrument TPI to preemptively counter risks that government bond spreads could widen in a disorderly manner in response to a tighter monetary policy stance (Figure 2, panel d). The PR shock significantly raises yields across all maturities and compressed the Italian spread, suggesting that markets interpreted the decision as credible in controlling fragmentation risk. By contrast, the TP-specific shock contributed little to Italian spreads. This result, while seemingly counterintuitive, is consistent with contemporaneous survey evidence: according to Bloomberg, most respondents did not expect the ECB to activate the TPI within the following 12 months. The model also detects a FG shock, which is related to the introduction of a meeting-by-meeting approach to the conduct of policy rate setting that marks the official end of previous rate forward guidance.

The 15 December 2022 announcement is one of the most notable of the sample. It combines four active policy dimensions and the beginning of quantitative tightening (QT) in the euro area, starting in March 2023 with a predicted decline in the ECB's asset purchase portfolio by an average of €15 billion per month through partial reinvestment of redemptions, with the subsequent pace of QT beyond the second quarter of 2023 to be decided later. The AP shock, and hence the effects of QT, had significant negative effects on the Euro Stoxx 50 while substantially raising medium- to long-term risk-free rates. The quantitatively non-negligible effect of a 5 to 10 bp increase in longer-term yields is slightly above estimates the existing literature finds with respect to the effects of QT (Wright,

September 2019 meeting, for instance with explicit reference to backward looking elements encapsulated in underlying inflation dynamics (Lane, 2020).

2022; Du et al., 2024). The GC raised policy rates by 50 bp, which marks an unexpected slowing in the pace of ECB rate hikes from previous two consecutive 75 bp hikes. This is visible in the PR path, which lowered short-term yields, while simultaneously reflecting communications that indicated more hikes to come in the future, which raised yields at longer maturities. A relatively strong TP effect is registered following the press release that included the QT announcement and reiterated on the readiness of TPI as a tool to counter non-fundamental market dysfunction. We interpret this effect on spreads mainly as a market response to the QT announcement. The model also identifies FG effects consistent with the ECB's signal that further rate increases are expected.

These historical decompositions represent our first contribution. They quantify the effects of the different policy dimensions active for these key announcements and, especially when multiple major policy revisions occurred simultaneously, help to understand which of those actually impacted financial markets. Previous methodologies, based on a single mapping from asset prices to shocks for all announcements, cannot offer a detailed narrative understanding of individual announcements. Indeed, the above discussion highlights heterogeneity in the responses of financial markets to monetary policy shocks at different announcements, which are hard to reconcile with the assumption of a time-invariant effect of policies. For instance, AP shocks do not consistently affect equity prices: while the December 2015 announcement generated a strong market reaction, the January 2015 communication had a more muted impact. Similarly, PR shocks can produce asymmetric effects across the yield curve: the July 2022 decision led to a broad-based increase in both short- and long-term yields, whereas in December 2022 short-term yields fell but long-term rates rose through a repricing in the pace of rate tightening. This underscores the advantage of announcement-specific decompositions in capturing these nuances.

On the whole, we find that asset purchases have had more significant effects than forward guidance. For the monetary policy stance, the most impactful announcements tend to be the introduction, extension, or termination of policies (for instance, extension and tapering of APPs, introduction of QT, the introduction of explicit guidance, and lift-off from the ELB), as opposed to more subtle revisions. It is not uncommon for apparently expansionary announcements to have contractionary effects when markets are left disappointed (for instance, PR cut and APP extension in Dec 2015). Finally, many of the largest shocks are TP shocks, for instance the launch of SMP-1 and -2, various LTROS, OMT, and speeches like "whatever it takes". To the extent that such shocks are neglected from msot existing papers, they thus present a credible source of confounding variation.

3.2 Variance Decompositions

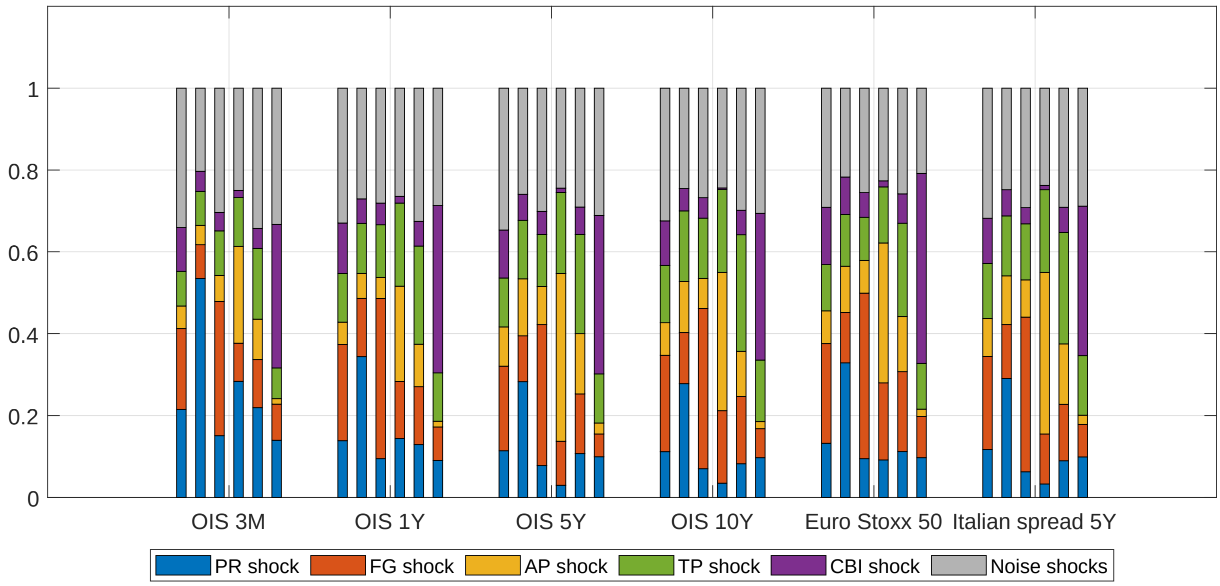
In the preceding section, we examined how asset prices react to monetary policy shocks on a date-by-date basis, exploiting the announcement-specific decompositions. We now discuss the role of the labeled monetary policy shocks in explaining variation in key asset prices throughout the sample. To do so, we compute the forecast error variance decompositions (FEVDs) for the innovations in the $\hat{s}$ dimensional principal component VAR (1-step ahead forecast errors) and report FEVDs scaled to various asset prices, using the loadings on the principal components. Since there is no natural interpretation of one principal component versus another, we report FEVDs scaled to various asset prices, using the loadings on the principal components. In other words, the results reported can be viewed as FEVDs for the 1-step ahead forecast errors of the portion of the asset prices explained by the first $\hat{s}$ principal components. Note, however, that this variation is not generally the same as that explained by the common component of the asset prices, since in most cases $\hat{s}$ is strictly greater than $\hat{k}$, meaning that the $\hat{s}$ principal components contain some idiosyncratic variation. Figure 6 plots the results.

For each asset price, the first set of stacked bars represents the overall FEVD across all announcements. The second set represents the FEVD for the subset of dates when the PR shock was active, the third when the FG shock was active, the fourth when the AP shock was active, the fifth when the TP shock was active, and the sixth when the CBI shock was active. The role of noise shocks is clear: across all asset prices and announcements, they explain about 30% of variation in the forecast errors to the $\hat{s}$ principal components at the minute by minute frequency. This non-negligible number arises because, for most announcements, some of the principal components capture idiosyncratic noise, given that $\hat{s} \geq \hat{k}$. This result suggests that the role of noise shocks is non-trivial, such that ignoring the possibility that not all of the variation in the first $\hat{s}$ principal components is driven by monetary policy shocks could prevent accurate identification of monetary policy shocks (since related asset prices could be impacted by related sources of microstructure noise).

The share of explained variation with economically interpretable shocks is relatively homogeneous at around 70 percent across asset classes and also extends to variation in stock market dynamics. This is considerably higher compared to Lewis (2025), who finds an explained variation of around 45 percent across asset classes considering U.S. data without accounting for transmission protection policies. The result relates to a literature that has difficulties to explain stock market dynamics over announcement days based on shorter window sizes (Bauer et al., 2023; Boehm and Kroner, 2024). While CBI and TP shocks together explain roughly 20-25 percent of the variation in stock prices, we also find a share of close to 50 percent explained through monetary policy, with a strong role for forward guidance policies. Our announcement specific approach provides further insights. CBI and FG shocks explain on average close to 50 percent of the variation in stock prices once they are active, while TP shocks explain about 25 percent in stock prices conditional on being active.

Transmission protection plays a relevant role for the dynamics of risk-free rates over ECB announcements in our sample. Conditional on being active, which is the case for roughly 80 percent of all scheduled meetings after 2010, TP shocks explain about 20 percent of the dynamics in the OIS 3M rate, about 25 percent of the OIS 1Y and 5Y rates, and up to 30 percent of dynamics in the 10Y OIS rate. This highlights the risk of possible mis-measurement of pure monetary policy surprises in the euro area for approaches that do not explicitly account for transmission protection policies. It also casts doubt on identification assumptions made by previous papers seeking to identify similar shocks, which have ruled out effects on risk-free rates, see for instance Ricco et al. (2024).

Figure 6: Forecast error variance decompositions of the principal components



Note: Each stacked bar represents a forecast error variance decomposition (FEVD) for the one-step ahead forecast error of the k_s principal components, scaled by the loadings of the various indicated asset prices. For each asset price, the first set of stacked bars represents the overall FEVD across all announcements. The second set represents the FEVD for the subset of dates when the PR shock was active, the third when the FG shock was active, the fourth when the AP shock was active, the fifth when the TP shock was active, and the sixth when the CBI shock was active.

3.3 Timeseries of monetary policy surprises

We now turn to a timeseries perspective by assembling the announcement-level responses into a sequence of surprises. We document the main features of the resulting surprise series and compare them with existing measures used in the literature.

Although the event-by-event analysis improves our understanding of several key announcements (and their real-time perception by markets), additional questions can be addressed by constructing a timeseries of surprises across all policy dates. For each announcement, we extract the magnitude of the underlying surprises from the end-of-day (or, more generally, the 1 hour 55 minutes window for announcements occurring earlier) decomposition of a designated reference asset: the 3-month OIS rate for the PR dimension, the 1-year OIS rate for FG, the average of the 5- and 10-year OIS yields for AP surprises, the average of the 5-year and 10-year Italian and Spanish spread for TP surprises, and Euro Stoxx 50 returns for CBI surprises. As discussed earlier, using the end-of-day window ensures that we capture price adjustments that are more likely to be economically meaningful and is broadly comparable to the "statement plus press conference" identification windows employed in some existing studies. Compiling these values yields a timeseries covering all 231 announcement dates. Over this sample, we identify 93 PR surprises, 139 FG surprises, 54 AP surprises, 114 TP surprises, and 70 CBI surprises.[8]

Figure 7 plots the timeseries from 2002 to 2024. For comparison, we plot the Altavilla et al. (2019) and Jarociński and Karadi (2020) surprises, two well-established studies in the field. The behavior of our new surprises accords with the narrative record. PR surprises display substantial variation before the ELB was reached in June 2014, followed by minimal movement until the period of interest rate lift-off in beginning in July 2022. Subsequent adjustments in the policy rate include adjustments in the pace of interest rate changes that lead to sizeable surprises. The most pronounced FG, AP, and TP surprises tend to coincide with the major policy episodes in which these instruments played a central role. Similarly, the largest CBI surprises cluster around moments when the GC issued important assessments regarding macroeconomic conditions. Below, we compare our surprise series with those derived in the existing literature, highlighting both similarities and differences.

Considering the narrative properties on display in Figure 7, for the PR shock, the Altavilla et al. (2019) and Jarociński and Karadi (2020) series register some rate hikes in 2022 and 2023 as larger surprises. For FG, our series and that of Altavilla et al. (2019) register one of their largest restrictive guidance surprises on 15 December 2022. On that day, despite slowing interest rate hikes from 75 bps to 50 bps, the ECB signaled that rates would need to rise "significantly at steady pace". The strong market reaction was further based on projections that contained an upward revision in inflation forecasts, which jointly lead to an upward revision of rate hike expectations consistent with the ECB's reaction function.

Our series identifies the largest FG surprise on 19 November 2008, whereas Altavilla

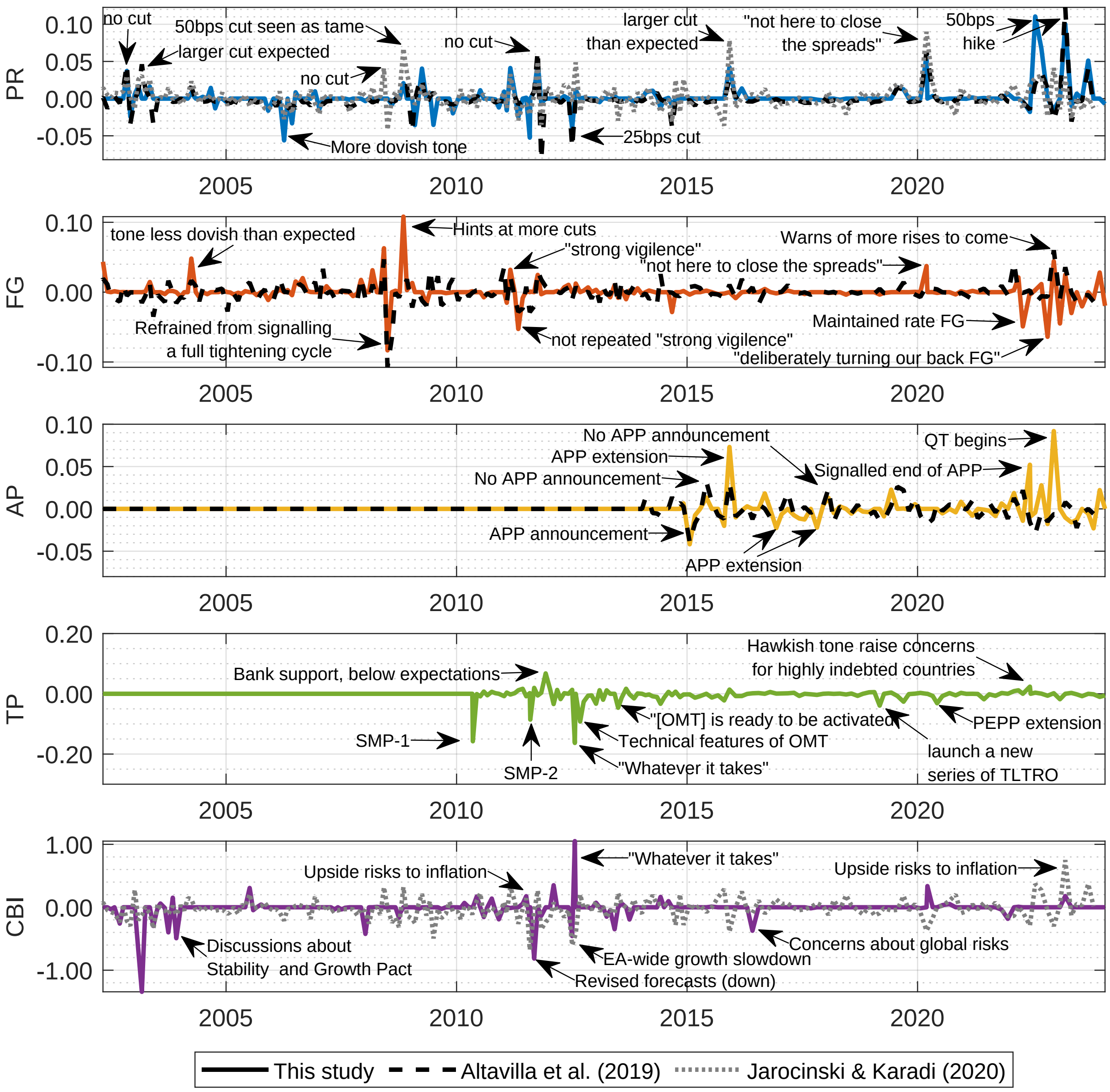
[8] Note that these time series are not, in general, orthogonal, since orthogonality is only imposed on the intraday (minute-by-minute) shocks that are aggregated under the historical decompositions used to measure the end-of-day shocks. The procedure for incorporating the observed change or "drift" between Y_1 and Y_M into the decomposition (see Online Appendix C of Lewis (2025) for details), so that the paths track movements in price levels, not price changes, often implies that the responses of a given asset price to multiple shocks move in the same direction for a given day. Note that without this feature, all decomposition paths would mechanically mean-revert towards zero at the end of the estimation window.

et al. (2019) record no guidance surprise on that date. The communication surrounding that meeting was widely dominated by crisis management in the light of the evolving tensions following the crash of Lehman Brothers. The decided ECB rate cut 50 bps was a deception, as indicated by questions in the the Q&A during the press conference, alluding to larger rate cut decisions of other major central banks. President Trichet then emphasized that the GC never pre-commits to future rate decisions, adding a reference to updated projections at the December 2008 meeting. In the light of ongoing market tensions, this was perceived by markets as a very hawkish communication around the future evolution of interest rate decisions in the euro area.

Our series identifies the second largest FG surprise on 5 June 2008, whereas Altavilla et al. (2019) record no guidance surprise on that date. The communication surrounding that meeting was widely viewed by market participants as signaling the prospect of rate cuts in the near future, yet the tone was perceived as less dovish than expected, generating a notable upward revision in the expected policy path. Financial press commentary supports this interpretation: analysts stressed that the ECB's response appeared insufficient given the speed of the downturn, with calls for a more forceful easing (Financial Times, 2008).

For AP, our surprise series remains by construction zero until October 2014, when the GC first began to signal the possibility of launching a large-scale purchase programme. Both our identification and the series of Altavilla et al. (2019) point to January 2015 as the most substantial accommodative AP shock. Likewise, the June 2015 and December 2015 meetings appear as contractionary in both approaches, though there were no AP announcement in June 2015. Beyond these commonalities, however, important differences arise for several historically significant episodes. Our series detects expansionary AP surprises in December 2016 and October 2017, both periods associated with programme extensions or recalibrations, whereas Altavilla et al. (2019) record more muted corresponding movements. Notably, our series extends over the period of tapering of QE in June 2022, the official beginning of QT in the euro area announced in December 2022 with partial reinvestment of redemptions starting in March 2023, until the announcement

Figure 7: Timeseries of surprise measures



Note: Timeseries of the monetary policy surprises based on end-of-day historical decompositions of reference prices (solid), Altavilla et al. (2019) monetary policy surprises (dashed), and Jarociński and Karadi (2020) surprises (dotted). Units are percentage points of the reference series. Large fluctuations that correspond to notable announcements or statement features are labeled.

in June 2023 that APP reinvestments would fully come to an end in July 2023. Our series captures a sequence of contractionary AP surprises over this period, which we hope can provide a useful basis for future work on the effects of QT in the euro.

For CBI, our surprise series contains a substantially lower number of announcements with non-zero surprises compared to Jarociński and Karadi (2020). This difference arises because their methodology relies on time-invariant decompositions, which imply that the maximum number of surprises active over the entire sample is considered active for all announcements. Consequently, surprise values of zero are measure zero events in their framework. The two series exhibit notable differences, with a correlation of only 0.40. Nevertheless, they both identify one of the most contractionary CBI surprises in our sample: 5 July 2012, when the GC expressed concerns about a euro area-wide growth slowdown. Finally, the "whatever it takes" speech by Mario Draghi on 26 July 2012 emerges as the most significant positive CBI surprise in our series. This event is not captured by Jarociński and Karadi (2020), as their analysis focuses exclusively on scheduled GC announcement dates. We document that TP surprises are a driver of the stock market on ECB announcement days. This raises the broader point that the underlying source of movements in stock markets may be distinct in nature: while a CBI shock affects beliefs about economic fundamentals, TP addresses a coordination problem in financial markets that can turn into a "good" or "bad" equilibrium, with direct implications for economic activity. Hence, asset price movements registered as a CBI surprise by Jarociński and Karadi (2020) may at times be associated with information effects and at others with TP surprises. Indeed, the correlation between our TP series and their CBI shock is -0.31 and, hence, nearly as strong as the correlation with our CBI shock (0.40). Conflating CBI and TP runs the risk of mis-identifying both dimensions themselves as well as surprises related to the monetary policy stance.

4 Effects of surprises on asset prices

In this section, we present results from local projections that document the dynamic effects of surprises on various asset prices.

4.1 Effects on the yield curve

To gauge the effect of surprises over time, we estimate local projections at business day frequency as

$$y_{t+h} - y_{t-1} = c_h + \sum_{j=1}^{N} \beta_{h,j} \times s_j + \sum_{p=1}^{P} \gamma_{h,p} \times (y_{t-p} - y_{t-p-1}) + \varepsilon_{t,h}. \tag{12}$$

Note that the specification considers all $N = 5$ surprises s_j simultaneously, since our measures are not restricted to be orthogonal, see footnote 8. We account for $P = 5$ lags of the dependent variable due to persistence in the data. This is a common way to improve robustness of the model and to take potential autocorrelation of the residuals into account (Montiel Olea and Plagborg-Møller, 2021).

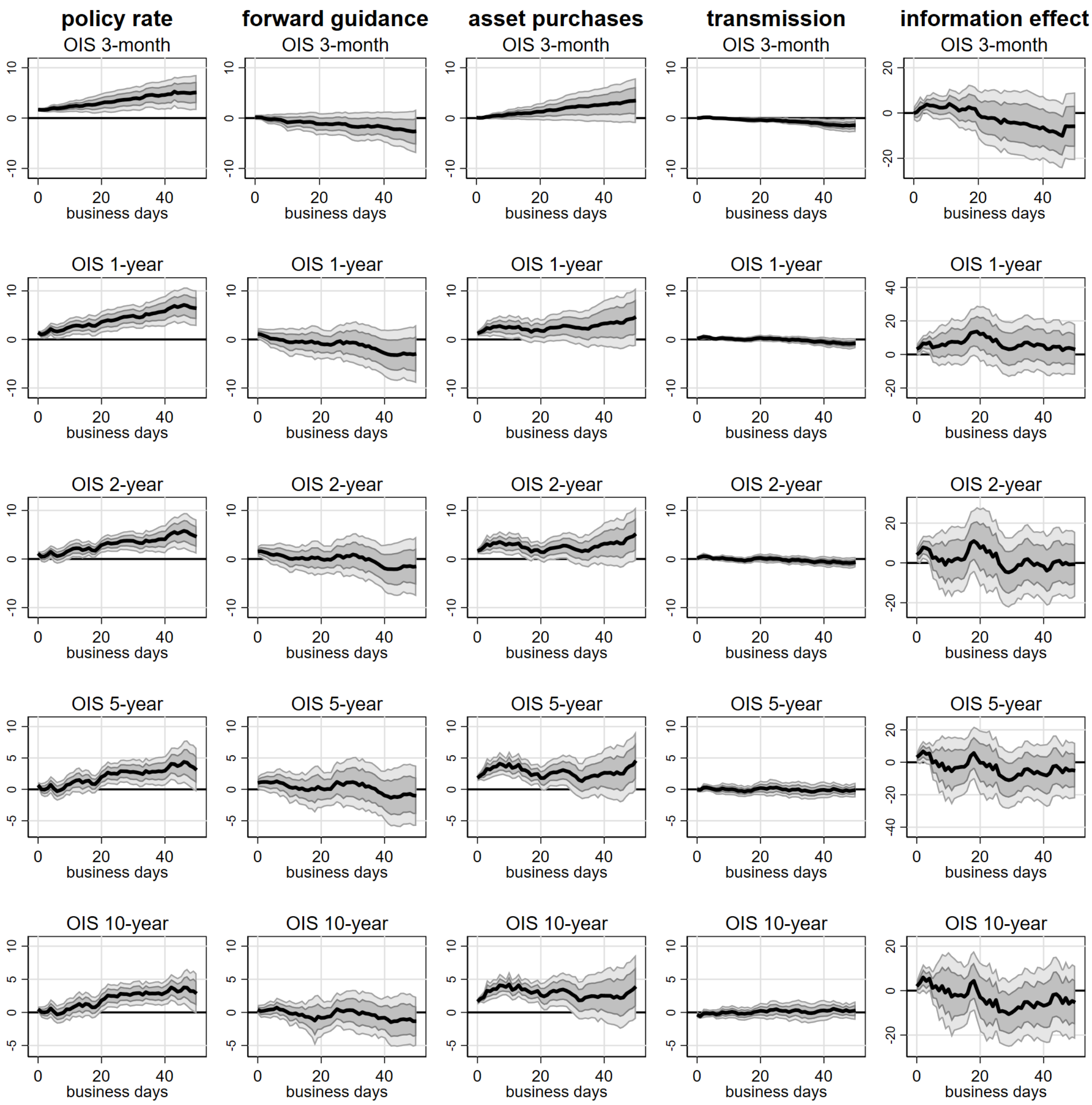
Figure 8 shows the results for the yield curve on OIS rates, the proxy for risk-free rates in the euro area. We consider maturities from 3 months to 10 years over horizons up to 50 business days following a monetary policy event. Hence, impulse responses cover 10 weeks, or slightly above two calendar months. The first column summarizes the effects of PR surprises. A PR surprise forcefully and persistently transmits to all maturities. Even the medium- to longer-term maturities are affected, which can be rationalized by the expectations hypothesis. However, the effect becomes significant only after a few days, and is less forceful with an extension of the maturity under consideration.

The FG surprise significantly raises the yield curve on impact for maturities between 1-year and 5-years. The effect is transitory, remaining significant only for a few business days. Several empirical studies using ECB high-frequency identification find that forward guidance shocks tend to have weaker and less robust effects than PR or AP shocks, while conventional PR and AP surprises often exhibit stronger transmission to financial markets.

The AP surprise moves the yield curve from the 1-year to the 10-year maturity. Consistent with the objective of flattening the yield curve, the effect is strongest in magnitude and most persistent at the long end of the yield curve, where AP tightening surprises leading to a 2 bp rise in the 10 year rate on impact increasing yields by almost 5 bp after 8 days for a 1 bp increase in the reference rate.

The TP surprise is captured in column 4 of Figure 8. The results suggest that there is no strong dynamic propagation of TP surprises on risk-free interest rates. The CBI surprises, shown in the final column, lead to the expected dynamic response of increasing nominal rates, albeit very short lived. Interest rates from 1-year to 10-year maturity increase on impact, but turn insignificant already after a few business days.

Figure 8: Effects of surprises on the yield curve



Notes: Local projections of outcome variables on monetary policy surprises following $y_{t+h} - y_{t-1} = c_h + \Sigma_{j=1}^{N} \beta_{j,h} \times s_j + \Sigma_{p=1}^{30} \gamma_{h,p} \times (y_{t-p} - y_{t-p-1}) + \varepsilon_{t,h}$. The black solid line shows the point estimate for β_j for surprise s_j, which are the policy rate (PR), forward guidance (FG), asset purchase (AP), transmission protection (TP) and central bank information (CBI) surprises. All results are in bp. Shaded areas represent the heteroskedasticity robust 68% and 90% confidence bands. The sample covers 231 announcements from 02-May-2002 to 25-Jan-2024.

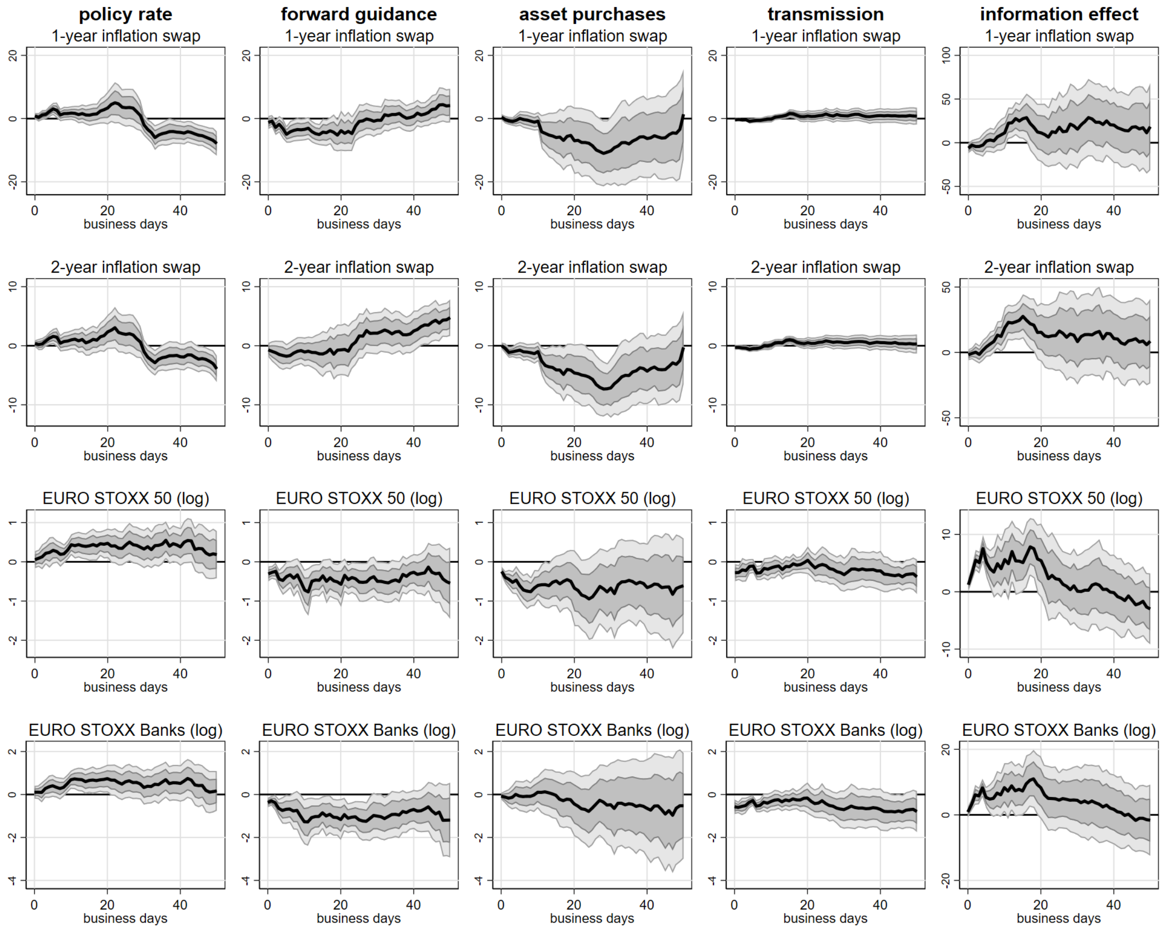
Next, we turn to the effects of surprises on expected economic activity and inflation in Figure 9. We summarize expectations by financial market pricing of firm stocks and inflation linked swaps, which capture market-based inflation expectations. A PR surprise is associated with no significant change on impact in financial markets' outlook for the economy, as stock market indices do not respond.

Tightening of the FG surprise is associated with cooling of the economy: stock indices turn persistently negative in the days following such a surprise. Inflation expectations captured over the one year window drop on impact and remain subdued for up to 20 days. The effect is more muted for inflation expectations over the 2-year horizon. FG tightening also leads to a drop in the equity indices Euro Stoxx 50 and Stoxx Banks, which captures 600 European bank stocks. AP tightening is associated with a clear and persistent drop in inflation expectations over the 2-year horizon. AP lowers the broader Euro Stoxx 50 index, while remains insignificant for the Stoxx Banks.

A tightening surprise of TP leads to lower inflation expectations at the 1-year and 2-year horizons, which remains persistent for 10 days. Importantly, an unexpected increase in sovereign bond spreads transmits forcefully to equity markets, taking Euro Stoxx 50 and Stoxx Banks indices into negative territory for 20 business days. CBI surprises, in contrast, show a clear pattern of surges in equity prices, which are also associated with higher market-based inflation expectations. The dynamics are slightly different, though, as the response in stock prices is faster, while inflation expectations pick up more gradually between 5 to 20 days after an announcement.

In the Online Appendix, we also report the effects of surprises on the bilateral exchange rate of the Euro with the U.S. Dollar, Swiss Franc, British Pound, Japanese Yen, and a trade-weighted net effective exchange rate of the euro area with 41 trading partners (Figure G.1). The results are consistent with theoretical predictions. A tightening of monetary policy stance is associated, in general, with a bilateral appreciation of the Euro. However, the effects are not symmetric across currencies and policy instruments. While FG surprises lead to a strong appreciation against the U.S. Dollar and the Swiss Franc, AP surprises have the largest impact on the bilateral exchange rate with the British Pound, and even lower the exchange rate with the Swiss Franc. TP surprises (leading to

Figure 9: Effects of surprises on expected activity and inflation



Notes: Local projections of outcome variables on monetary policy surprises following $y_{t+h} - y_{t-1} = c_h + \Sigma_{j=1}^{N} \beta_{j,h} \times s_j + \Sigma_{p=1}^{30} \gamma_{h,p} \times (y_{t-p} - y_{t-p-1}) + \varepsilon_{t,h}$. The black solid line shows the point estimate for β_j for surprise s_j, which are the policy rate (PR), forward guidance (FG), asset purchase (AP), transmission protection (TP) and central bank information (CBI) surprises. All results are in bp. Shaded areas represent the heteroskedasticity robust 68% and 90% confidence bands. The sample covers 230 announcements from 02-May-2002 to 25-Jan-2024.

wider spreads) lead to a depreciation of the Euro, with the strongest effects for the Swiss Franc as haven currency. CBI surprises generally increase the external value of the Euro, as visible in the net effective exchange rate. Some heterogeneous transmission is also reported, as the Swiss Franc appreciates against the Euro in response to a CBI surprise, which might be related to similar flight safety concerns.

4.2 Dynamic propagation of transmission protection policies

A main motivation for the inclusion of transmission protection surprises mentioned above is to study their causal effects on financial markets related to the uniform transmission of monetary policy. To this end, we use the same dynamic model specification as before, and consider indicators for financial market functioning in the euro area as dependent variables. These variables extend beyond financial variables contained in the high-frequency panel. We consider GDP-weighted variables across a sample of 4 member countries with sovereign stress in the past, namely Italy, Spain, Portugal, and Belgium (see G.1 for details). Figure 10 shows the results for TP surprises, while results for the remaining identified monetary policy surprises are available in the Online Appendix (Figure G.3). The first row shows a composite indicator of systemic sovereign stress (sovCISS) (Garcia-de Andoain and Kremer, 2017). In response to a TP tightening, there is a strong and persistent increase in this multi-dimensional measure. To further deepen the understanding of the propagation of TP surprises to financial markets, we consider three channels of transmission separately (Krishnamurthy et al., 2018): credit risk, re-denomination risk, and liquidity risk.

Regarding the first channel, sovereign credit risk, the GDP-weighted credit default swap (CDS) premium of a given country with respect to Germany depicts a clear and persistent increase over the full horizon of 50 business days. The GDP-weighted spread of government bond yields over the overnight interest rate swap rate (OIS) is a proxy regularly used to measure the smooth transmission across jurisdictions, while elevated levels are considered as hampering transmission (Schnabel, 2020). Considering maturities from two to 10 years, we obtain similar results as for the CDS spread. While risk premia increase at all maturities, the effects are slightly more persistent for maturities of 5 and 10 years compared to the 2 year maturity.

The second channel, re-denomination risk, is defined as the possible risk that a euro area member exits the monetary union and re-denominates its sovereign debt into a newly introduced national currency. We employ two market-based measures to proxy for this risk. First, we define the ISDA documentation premium, denoted by ΔCDS, as the spread differential between otherwise comparable sovereign CDS contracts traded under the 2014 and 2003 ISDA Credit Derivatives Definitions:

$$\Delta CDS = CDS_{2014} - CDS_{2003}.$$

The two contract types differ in their treatment of currency redenomination. Under the 2003 ISDA definitions, repayment in a G7 currency does not constitute a credit event, leaving open the possibility that a country such as Italy could redenominate its public debt into a newly issued national currency without necessarily triggering CDS protection. The 2014 ISDA definitions largely eliminate this loophole by broadening the circumstances under which a restructuring or redenomination event triggers payment. As a result, 2014 contracts typically trade at a premium relative to otherwise identical 2003 contracts. Because both vintages continue to trade in parallel, their spread differential provides a market-based measure of perceived redenomination risk. We find that this ISDA documentation premium responds strongly and persistently to TP tightening surprises.

As an alternative proxy, we consider the quanto spread, defined as the difference between the U.S. Dollar- and euro-denominated CDS spreads for country (i) at maturity (j), adjusted for the corresponding difference in German CDS spreads:

$$CDS_{i,j}^{USD} - CDS_{i,j}^{EUR} - \left(CDS_{DE,j}^{USD} - CDS_{DE,j}^{EUR}\right).$$

If protection denominated in U.S. dollars is relatively more expensive than protection denominated in euros, this indicates that investors assign a higher probability to the sovereign debt being redenominated into a new domestic currency rather than repaid in euros (De Santis, 2018). In contrast to the ISDA documentation premium, however, the quanto spread does not respond significantly to TP surprises, suggesting that the two indicators capture different dimensions of redenomination risk.

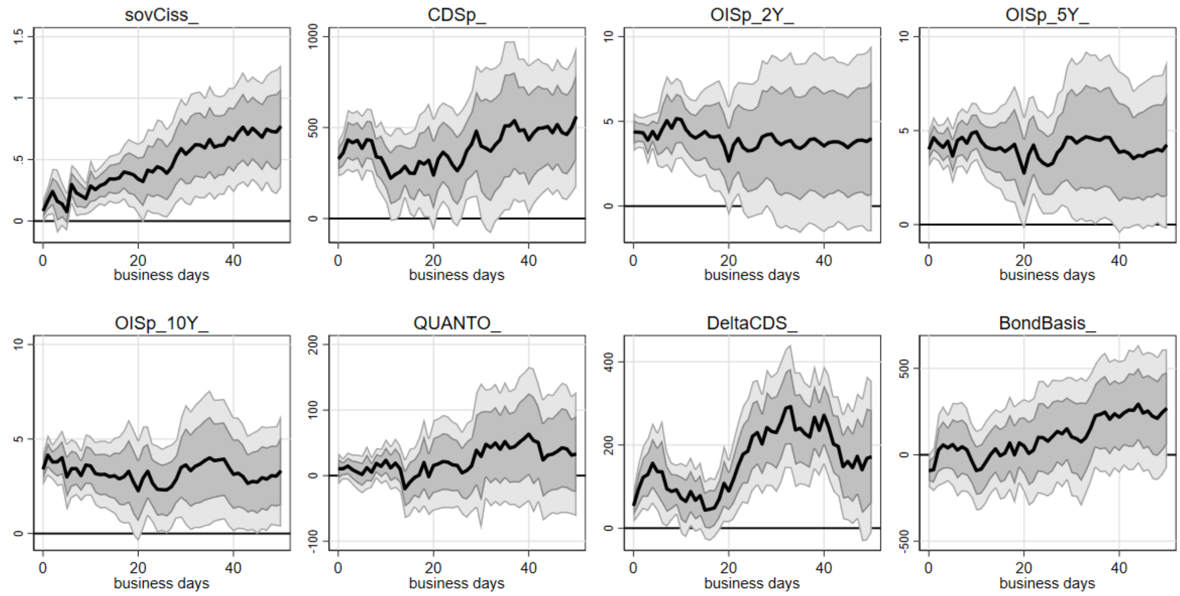
The third channel is liquidity risk. Impediments in the transmission of monetary policy and higher expectations of potential market dysfunctions could translate into higher liquidity needs. We use the response of the CDS bond basis to gauge if this channel is at play. It is defined as the difference between the CDS spread of country i over Germany minus the government bond spread over Germany, also referred to as the convenience yield. We again compute the GDP-weighted average across the four euro area countries. The result, a widening of the CDS spread relative to the government spread over OIS, points to a modest rise in liquidity needs. This finding supports the idea that government bond yield differentials in the euro area partly consist of differential collateral services and liquidity premia associated to government debt in a heterogeneous monetary union (Jiang et al., 2026). However, TP surprises have a transitory effect, remaining significant on the CDS bond basis for a few days only.

Figure G.3 in the Online Appendix documents the effects of other surprises on market functioning in the euro area. While broadly speaking stance policies do not impact market functioning, the results do not support a perfect separation between market functioning and monetary policy stance policies. For example, a tightening via forward guidance appears to increase sovereign CDS spreads. Asset purchases also operate via sovereign credit risk and the demand for liquidity. Finally, fundamental economic news, as contained in CBI surprises, generally improves market functioning in the euro area.

Finally, we briefly discuss the response of risk premia to our series of surprises. Previous work has emphasized the role of risk premia in amplifying the effect of changes in risk-free rates via financial frictions (Gertler and Karadi, 2015). Figure G.2 in the online Appendix shows that this is also the case in the euro area. FG and AP tightening surprises raise the VSTOXX, a measure of equity market volatility, and also contribute to higher corporate bond spreads at the below investment-grade category as captured by the Bank of America High Yield Bond spreads. FG and AP tightening also leads to a steepening of the yield curve, as captured by the term premium, computed as the difference between the 10-year OIS minus the 3-month OIS rate. Transmission protection also propagates via broader risk premia, as seen by the response of the VSTOXX and corporate bond spreads, while CBI surprises lower risk premia.

As argued above, the presence of TP surprises, which can have related – but different – impacts to “information effects” (whatever their source) poses a challenge for previous methodologies that conflate them. Indeed, not accounting for this distinct dimension

Figure 10: Effects of surprises on equal transmission across jurisdictions



Notes: Local projections of outcome variables on monetary policy surprises following $y_{t+h} - y_{t-1} = c_h + \Sigma_{j=1}^{N} \beta_{j,h} \times s_j + \Sigma_{p=1}^{30} \gamma_{h,p} \times (y_{t-p} - y_{t-p-1}) + \varepsilon_{t,h}$. The black solid line shows the point estimate for β_j for surprise s_j, which are the policy rate (PR), forward guidance (FG), asset purchase (AP), transmission protection (TP) and central bank information (CBI) surprises. Shaded areas represent the heteroskedasticity robust 68% and 90% confidence bands. The sample covers 231 announcements from 02-May-2002 to 25-Jan-2024. Estimates for GDP-weighted variables for Italy, Spain, Portugal and Belgium. "Delta CDS" series for Italy only.

of policy means that such approaches may be confounded by non-invertibility. We are ultimately agnostic to the ongoing debate on the origins of so-called CBI surprises, but our results still contribute to that literature by confirming the presence of surprises orthogonal to the yield curve, highlighting this challenge to identifying information effects.

In summary, PR, FG, and AP surpises – the monetary policy stance – are forcefully transmitted to financial markets. The OIS rates at corresponding maturities respond persistently, while forward guidance surprises have less persistent dynamic effects. The effects on equity prices and market-based inflation expectations are in line with theoretical predictions for forward guidance, asset purchases and central bank information surprises. However, our key innovation – identification of transmission protection shocks while remaining largely agnostic to their effects – unmasks a new dimension of policy that operates through sovereign credit, re-denomination, and liquidity risk channels. The effect of TP on variables measuring these channels often dwarfs that of the stance shocks. More importantly, these effects manifest in short rates, equity prices, inflation expectations, EUR/USD exchange rates.

5 Conclusion

This paper provides a novel framework to identify monetary policy surprises in the euro area. We argue that central bank communication contains information about transmission protection as a distinct policy dimension: the central bank's willingness to preserve monetary transmission by preventing financial market dysfunction. Statistical identification is achieved via time-varying volatility of asset price movements during ECB announcements and five selected. We endow the statistically-identified surprises with an economic interpretation by labeling them using a formal rule based on economic theory.

The measured surprises allow us to estimate the propagation of policy. The effects of our monetary policy stance surprises align with the existing literature. However, our contribution lies in the understanding of effects of transmission protection. These surprises are mainly transmitted via sovereign credit risk, re-denomination risk, and, to a limited extent, liquidity needs. They lower government bond spreads over risk-free rates persistently at all maturities. Moreover, they lower CDS basis spreads, reflecting re-denomination risk. Stance shocks also impact these variables, meaning it is challenging to separate these shocks. We do so while avoiding making strong assumptions on the effects of transmission protection, which can be found in contemporary papers. Transmission protection frequently appears alongside information effects, since it can be indicative for "multiple equilibria" risks, providing a further challenge to identification.

Our methodology permits examination of the effects of shocks on an announcement-specific basis via historical decompositions, deepening understanding of the market reaction to specific ECB announcements and modifications to policy language. The introduction, extension, and removal of policy measures tend to have the most substantial impacts, with asset purchases more effective than forward guidance. The decompositions exhibit considerable heterogeneity in the effects of certain surprises over time. These insights can be informative for crafting future policy. Moreover, the extent to which they accord with the narrative record supports the validity of our identification strategy. For key announcements, by considering shock volatility paths as an object of interest in their own right, we show how precise language, like "whatever it takes" can be detected immediately from financial market responses.

Applying our surprises to estimate the macroeconomic effects of various dimensions of ECB policy presents a fruitful, yet challenging avenue for future work. Our novel empirical results on the effects of transmission protection policies should prove useful for both informing the assumptions underlying future identification strategies and providing empirical facts for theoretical models to match. The estimated surprise series will be made publicly available to facilitate future empirical research. In particular, the transmission-protection surprise provides a novel source of plausibly exogenous variation in fragmentation risk that may prove useful in studying its macroeconomic and financial consequences.

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ONLINE APPENDIX

The Missing Surprise: Transmission Protection in Central Bank Announcements

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Note to Readers: This online appendix is intended to complement the main paper and is not self-contained. Readers are encouraged to consult the main text for full context, methodological framework, and empirical results.

Contents

A Data

A.1 Data description

This appendix provides details on the financial instruments used in our analysis, including their Reuters Identification Codes (RICs). All data are sourced from the LSEG Tick History database and cover the period 2 May 2002 to 25 January 2024. Table A.1 summarizes our dataset, showing the RIC for each instrument.

Table A.1: Summary of Assets and Reuters Identification Codes (RICs)

Risk-free rates	**EONIA**	**€STR**	**Germany Yields**
1-month	EUREON1M=	EUREST1M=	
3-month	EUREON3M=	EUREST3M=	
6-month	EUREON6M=	EUREST6M=	
1-year	EUREON1Y=	EUREST1Y=	
2-year	EUREON2Y=	EUREST2Y=	DE2YT=RR
3-year	EUREON3Y=	EUREST3Y=	DE3YT=RR
5-year	EUREON5Y=	EUREST5Y=	DE5YT=RR
7-year	EUREON7Y=	EUREST7Y=	DE7YT=RR
10-year	EUREON10Y=	EUREST10Y=	DE10YT=RR
Sovereign Yields	**Italy**	**Spain**	
2-year	IT2YT=RR	ES2YT=RR	
5-year	IT5YT=RR	ES5YT=RR	
10-year	IT10YT=RR	ES10YT=RR	
Equity Index			
Euro Stoxx 50	.STOXX50E		

Note: The table contains the RICs for each of the 16 asset prices used to construct our intraday panel.

From the raw intraday data obtained from the LSEG Tick History database, we construct a set of 16 asset price series used in our high-frequency analysis. These include risk-free rates with maturities of 1, 3, 6, and 12 months, as well as 1, 2, 3, 5, 7, and 10 years, derived from OIS rates (and German Bund yields when OIS are not available). In addition, we include Italian and Spanish sovereign bond yields relative to risk-free rates with maturities of 2, 5, and 10 years, together with the Euro Stoxx 50 index.

Time Standardization. All raw price and yield observations are timestamped in UTC/GMT. To ensure that the data align with the timing of European financial markets, all timestamps are converted into Central European Time or Central European Summer Time (CET/CEST), depending on the applicable daylight-saving regime on each date.

Missing Values. Missing values are interpolated by projecting latest observations forward at their given level.

A.2 Instrument Transformations

Several pre-processing steps are required before the variables enter the empirical procedure. This section describes these transformations.

A.2.1 OIS Rates

Our OIS dataset comprises both EONIA-based and €STR-based instruments, reflecting the transition of the euro area overnight benchmark rate. The ECB began publishing the €STR on 2 October 2019. From that date onwards, EONIA's methodology was changed so that it was recalibrated to equal €STR plus a fixed spread of 8.5 bp. EONIA publication was discontinued after 3 January 2022. To ensure a consistent timeseries across the entire sample, we harmonise the OIS rates as follows:

1. **Benchmark Harmonisation**. For dates after 2 October 2019, we convert the raw €STR-based OIS rates into an EONIA-equivalent basis by subtracting 8.5 bp. This adjustment aligns the newer benchmark with the historical EONIA series, enabling comparability across the full sample period.

2. **Quote Processing**. For each OIS instrument (each maturity and each date), we construct the representative rate by:

    - Taking the opening ask quote and the closing bid quote to compute a "mid-buy" value;

    - Taking the opening bid quote and the closing ask quote to compute a "mid-sell" value;

- Averaging the mid-buy and mid-sell values to obtain the final OIS rate used in our analysis.

This procedure smooths bid–ask noise and ensures each intraday rate is comparably derived across maturities and time.

High-frequency OIS quotes at maturities longer than two years are only available after August 2011. To maintain consistency in the set of risk-free rates, for dates prior to August 2011 we replace missing longer-maturity OIS observations with the corresponding German sovereign yields, which are used as a proxy for the risk-free curve along the lines of Altavilla et al. (2019).

A.2.2 Sovereign Spreads

For Italian, and Spanish sovereign yield spreads, we first construct yields by taking the midpoint of the closing bid and closing ask yield quotes for each maturity. This mid-yield serves as the intraday yield observation. Formally, each instrument's yield is obtained as the simple average of its closing bid yield and closing ask yield. Then, we construct sovereign yield spreads as the difference between the domestic sovereign yield and the risk-free rates.

A.2.3 Equity Prices

For the Euro Stoxx 50 equity index, we transform the raw price quotes into logarithmic levels.

B Alternative Labeling Criterion

This appendix describes the alternative labeling criterion that relaxes the quantitative requirements of monetary policy shocks and is applied in cases where the criterion described in the main text fails to assign a positive value to $\hat{k}$ distinct shocks for $\hat{k}$ distinct labels.

$$C_{PR,j}\left(S_{\cdot j}, \Theta_{\cdot j}\right) = \begin{cases} 1 \; if & \Theta_{3m,j} > 0.6 \\ \Theta_{3m,j} & otherwise. \end{cases} \tag{13}$$

This criterion now favours labeling any shock that explains considerable variation in the 3-month OIS rate (as opposed to all of a large basket of interest rates) as a PR shock, in that case setting the criterion to its maximum value of unity.

$$C_{FG,j}\left(S_{\cdot j}, \Theta_{\cdot j}\right) = \frac{1}{3}\left(\frac{\mathbf{1}\left[S_{6m,j} \neq S_{ESXj}\right] + \mathbf{1}\left[S_{1y,j} \neq S_{ESXj}\right]}{2}\Theta_{ESX,j} + \sum_{i\in\{6m,1y\}}\Theta_{ij}\right). \tag{14}$$

This element no longer requires that 6-month and 1-year OIS rates move in opposite directions to the Euro Stoxx 50 in response to shock j in order to take a positive value, but rather discounts the contribution of the Euro Stoxx 50 if one or both of the interest rates react in the same direction as equities.

$$C_{AP,j}\left(S_{\cdot j}, \Theta_{\cdot j}\right) = \frac{1}{1 + \mathbf{1}\left[S_{5y,j} = S_{10y,j}\right]} \sum_{i\in\{5y,10y\}} \mathbf{1}\left[S_{y^*,j} = S_{ij}\right]\Theta_{ij}, \tag{15}$$

This element no longer imposes any restrictions on the signs of the effect of shock j on long yields and equities. $C_{TP,j}\left(S_{\cdot j}, \Theta_{\cdot j}\right)$ is unchanged from the baseline labeling criterion.

$$C_{CBI,j}\left(S_{\cdot j}, \Theta_{\cdot j}\right) = \frac{1}{5}\left(\Theta_{ESX,j} + \sum_{i\in\{1y,2y,5y,10y\}} \mathbf{1}[S_{ij} = S_{ESX,j}]\Theta_{ij}\right). \tag{16}$$

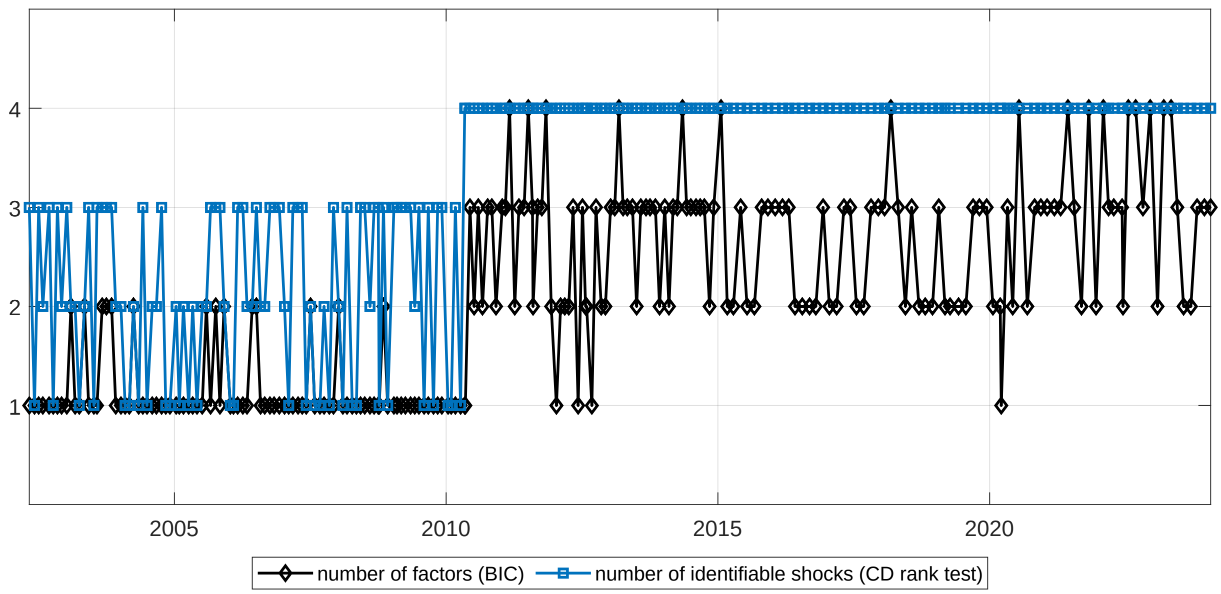
This element averages the variation explained in the Euro Stoxx 50 and medium- and long-term rates by shock j, setting the value to zero for those rates moving in the opposite direction to equities, rather than setting the entire criterion to zero if any single rate moves in the opposite direction to equities.

As a final adjustment, if an entry is on the interval (-0.05,0) for any shock-label combination, we replace the value with a positive epsilon at machine precision so that label can be assigned if absolutely necessary.

C Specification of the Reduced-Form Factor Models

This appendix reports statistics on the specifications selected for the reduced-form factor models. Figure C.1 plots the dimension of the estimated VAR in principal components and the dimension of monetary policy across announcements. The former is $\hat{s}$, the number of identifiable shocks (up to four), based on a Cragg Donald test for the information contained in the time-varying volatility. The latter is determined by the dimension of the common component of the asset prices, $\hat{k}$, estimated using the PC1 criterion of Bai and Ng (2002). For all announcements, $\hat{s} \geq \hat{k}$, meaning all monetary policy shocks are identifiable. The reason for then estimating models of size $\hat{s}$, and not just $\hat{k}$, is to allow for the possibility that additional non-monetary policy shocks, for example microstructure noise, may be driving the innovations to the principal components, η_m. If that is the case, but a model of dimension $\hat{k}$ was assumed, the model would be non-invertible. In essence, this allows one final check on the role of (microstructure) noise, by allowing some of the variation in η_m to be discarded as not relevant to monetary policy.

Figure C.1: The dimension of estimated models and dimension of monetary policy

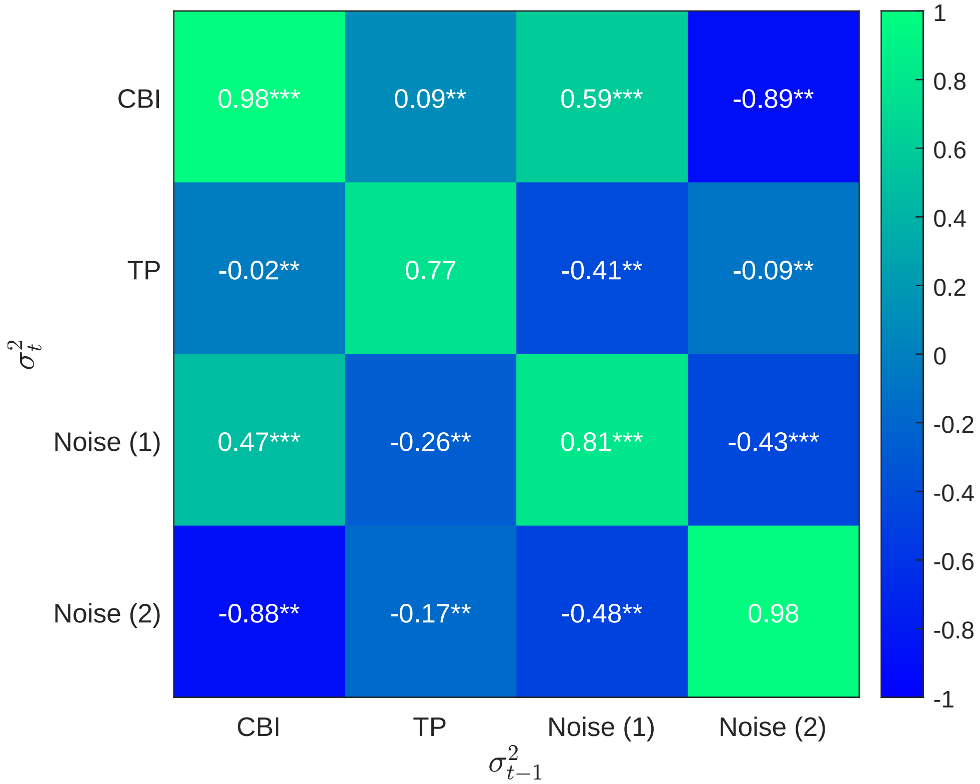


Note: The blue line plots the dimension of the model (number of principal components entering the VAR) for each announcement, which is determined by the number of identifiable shocks (with an upper bound of four), k_s. The red line plots the dimension of monetary policy, equal to the dimension of the common component, k_{mp}.

Before 2010, the total number of identifiable shocks in the model remains relatively stable, most often equal to three, the maximum permitted during this period. From 2010 onward, the number increases to four, corresponding to the higher dimensionality allowed in the later part of the sample. As a consequence, the number of noise shocks is highest earlier in the sample, when the dimension of monetary policy is lower. Note that the finding of only a single shock early in the sample does not rule out FG or CBI shocks at this time, since the PR shock is not always active, as illustrated by Figure 7.

D Autocorrelation of Variances — 26 July 2012

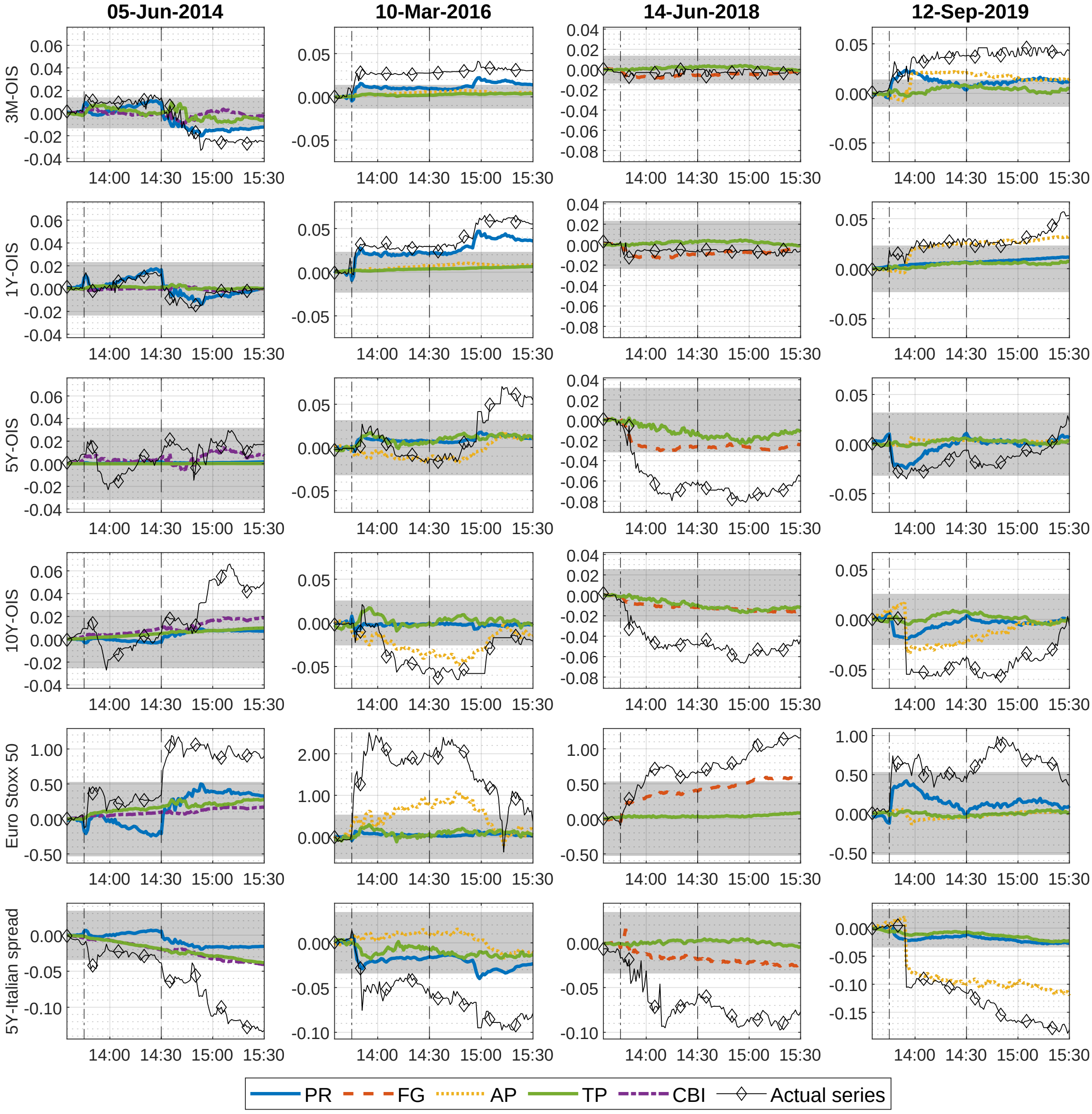
Figure D.1: Autocorrelation of Variances — 26 July 2012



Note: Matrix of first autocorrelations of the shock variances over the same window.

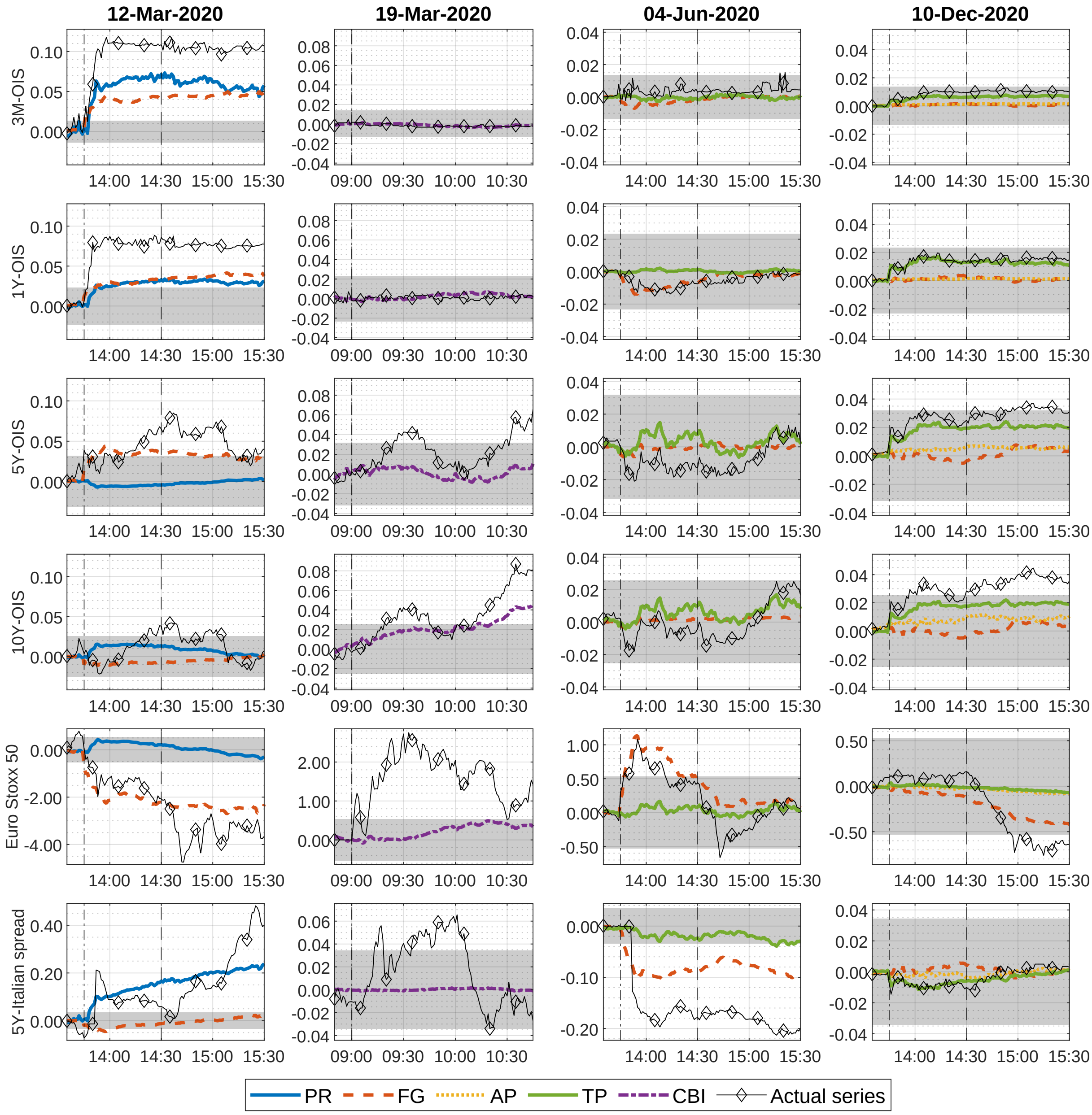
E Historical Decompositions: Additional Results

Figure E.1: Historical decompositions of key GC announcements.



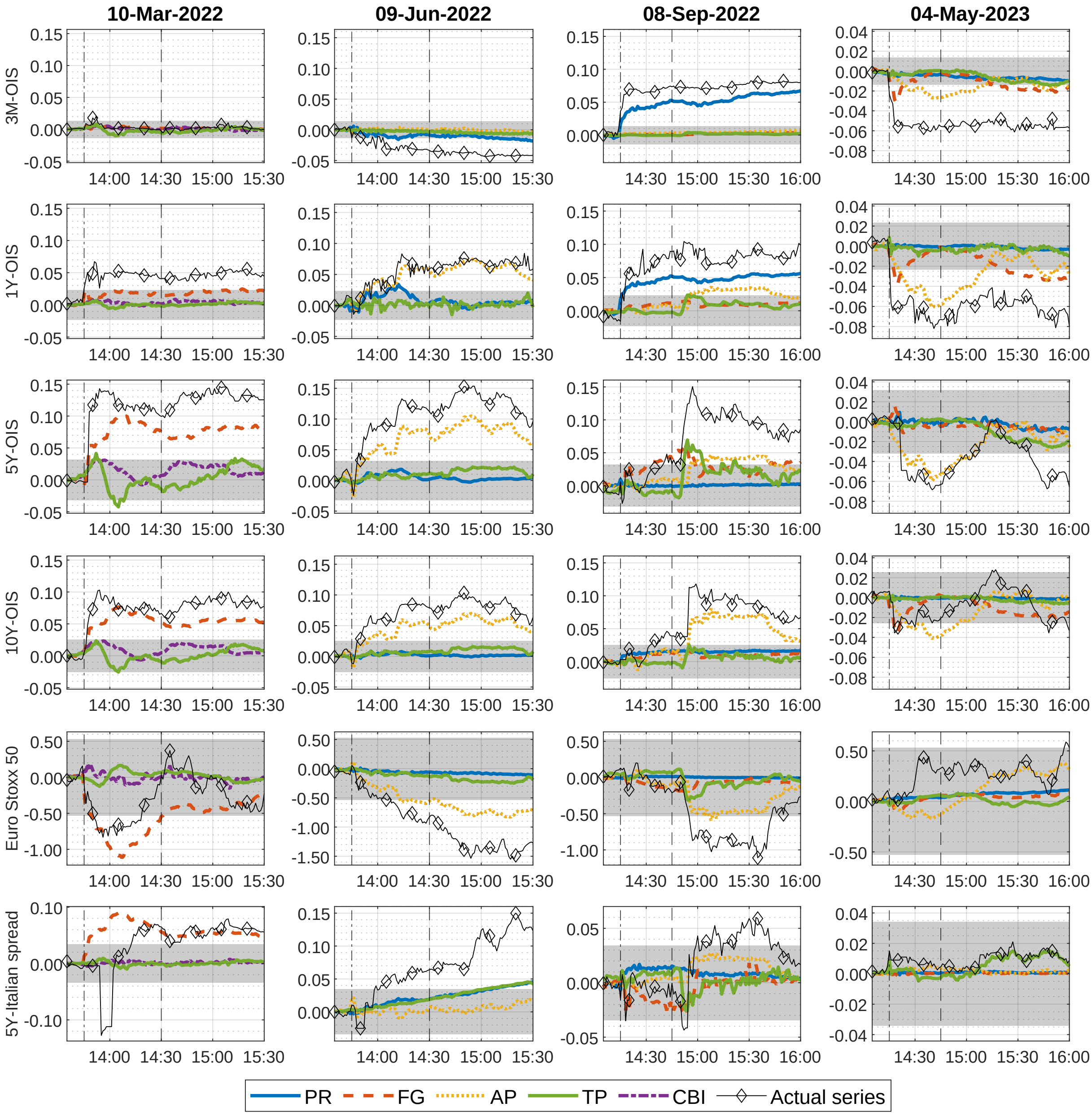
Note: Historical decompositions for the rate series indicated in the left margin with respect to each of the five shocks, in percentage points. Blue represents the PR shock, red the FG shock, gold the AP shock, green the TP shock, and purple the CBI shock. The vertical lines mark the time of the press releases and press conferences. The black dashed line is the path of the simple change from ten minutes prior to the announcement. The shaded interval corresponds to 1.96 times the average standard deviation in the asset price following monetary policy announcements.

Figure E.2: Historical decompositions of key GC announcements.



Note: Historical decompositions for the rate series indicated in the left margin with respect to each of the five shocks, in percentage points. Blue represents the PR shock, red the FG shock, gold the AP shock, green the TP shock, and purple the CBI shock. The vertical lines mark the time of the press releases and press conferences. The black dashed line is the path of the simple change from ten minutes prior to the announcement. The shaded interval corresponds to 1.96 times the average standard deviation in the asset price following monetary policy announcements.

Figure E.3: Historical decompositions of key GC announcements.

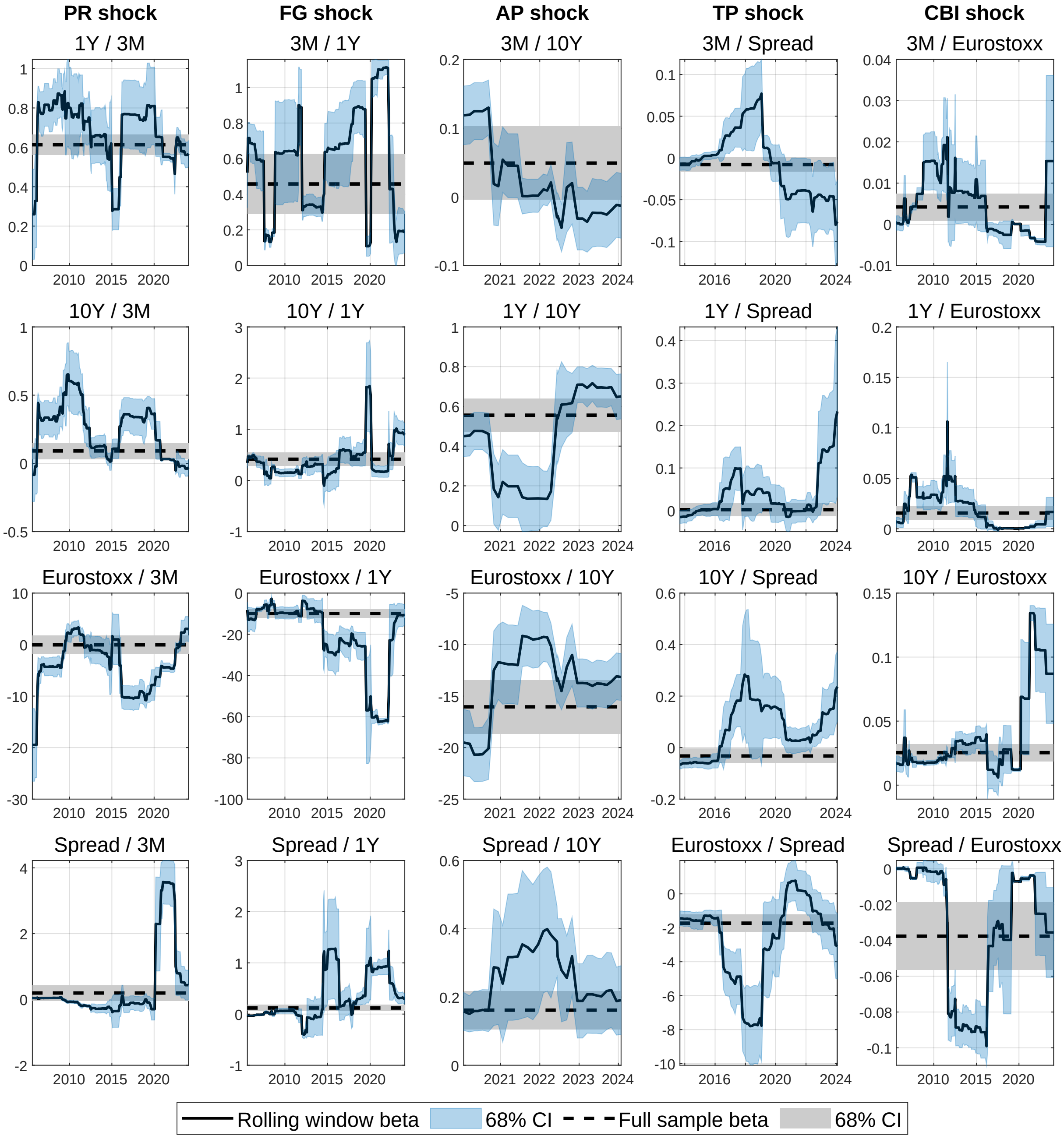


Note: Historical decompositions for the rate series indicated in the left margin with respect to each of the five shocks, in percentage points. Blue represents the PR shock, red the FG shock, gold the AP shock, green the TP shock, and purple the CBI shock. The vertical lines mark the time of the press releases and press conferences. The black dashed line is the path of the simple change from ten minutes prior to the announcement. The shaded interval corresponds to 1.96 times the average standard deviation in the asset price following monetary policy announcements.

F Time variation in relative effects of shocks

We assess the stability of the relative responses of key asset prices to monetary policy more formally. If the decomposition of asset price movements into monetary policy shocks is constant, the underpinning assumption and object of interest in a typical pooled-data event study methodology, then the relative responses of asset prices to the same shock are constant. We conduct rolling-window regressions of the responses of pairs of asset prices to a given shock, and compare the coefficients to those from homogeneous full-sample regressions, computing confidence intervals for each. If the relative impacts are constant over time, the rolling window regression coefficients should be fixed and identical to the homogeneous (full sample) regression coefficients. Figure F.1 plots the results.

Figure F.1: Time variation in relative effects of shocks



Note: Each panel plots the evolution of the relative effects of the stated shock on two asset prices over time. The solid line plots the 40-announcement (approximately 5-year) rolling-window regression ending at the given date of the end-of-day response of the first asset price to the end-of-day response of the second asset price. The dotted lines indicate the 68% confidence interval based on HAR standard errors. For reference, the dashed line plots the full sample homogeneous coefficient and the shaded area its 68% HAR interval.

G Dynamic Regressions

This section provides data definitions for dependent variables used in the estimation of dynamic effects in Section 4 as well as additional dynamic estimates described in the text.

G.1 Data

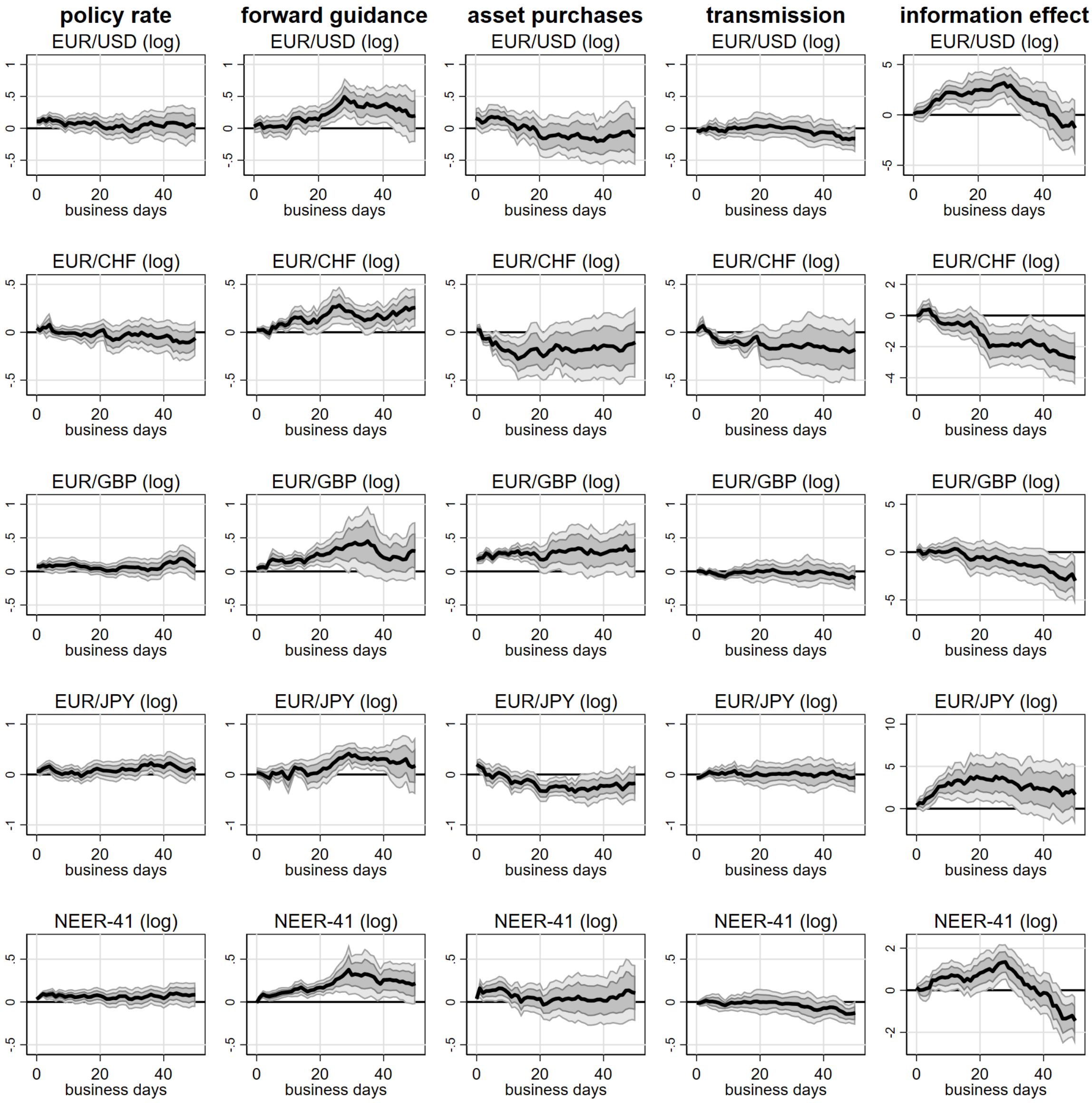
- **TED spread.** The TED spread is computed as the 3-month Euribor minus the 3-month Bund yield.
- **Euro high yield spread.** The series corresponds to the ICE Bank of America high yield index option-adjusted spread, obtained via FRED ($BAMLHE00EHYIOAS$). It tracks the performance of Euro denominated below investment grade corporate debt publicly issued in the euro domestic or eurobond markets.
- **Term premium.** It is computed as the OIS 10-year rate minus the OIS 3-year rate.
- **New CISS.** The series corresponds to the composite indicator of systemic stress, available at the ECB's Statistical Data Warehouse. (series key $CISS.D.U2.Z0Z.4F.EC.SS\_CIN.IDX$)
- **NEER-41.** The daily nominal effective exchange rate of the Euro, as a weighted average of nominal bilateral rates between the Euro and a basket of 41 foreign currencies (series key $EXR.D.E03.EUR.EN00.A$).
- **EURUSD.** Nominal bilateral exchange spot rate between the Euro and the U.S. Dollar, source: Bloomberg.
- **EURCHF.** Nominal bilateral exchange spot rate between the Euro and the Swiss Franc, source: Bloomberg.
- **EURGBP.** Nominal bilateral exchange spot rate between the Euro and the British Pound Sterling, source: Bloomberg.
- **EURJPY.** Nominal bilateral exchange spot rate between the Euro and the Japanese Yen, source: Bloomberg.
- **OISsprd.** The spread of government yields over the overnight index swap rate (ESTR/Eonia) at a given maturity. For the euro area, we compute a GDP-weighted average government bond spreads from generic government bond yields obtained via Bloomberg, and using 9 countries (DEU, FRA, ITA, SPA, NLD, BEL, POR, FIN, AUT) and nominal GDP at quarterly frequency as time-varying weights.
- **CDSp.** The credit default swap (CDS) premium corresponds to the 3-year maturity, ISDA2014 documentation, in denominated in Euros. Source: Bloomberg.
- **Quanto spread.** The measure of redenomination risk follows De Santis (2018). We compute for country i the spread of the U.S. dollar denominated CDS over the

Euro denominated CDS at the 3-year maturity, and subtract the same spread for Germany. We use contracts with the ISDA2014 documentation.

- **Delta CDS.** We define ΔCDS by subtracting the euro-denominated 3-year CDS contract with the ISDA 2003 *Credit Derivatives Definition* (ISDA-2003) from the ISDA 2014 *Credit Derivatives Definition* (ISDA-2014). Series referring to Italy only.
- **CDS-bond basis.** The CDS-bond basis is computed as the CDS spread minus the bond credit spread. We use the CDS spread over Germany at the 3-year maturity for the former, and the government bond yield spread over OIS at the 3-year maturity for the latter.

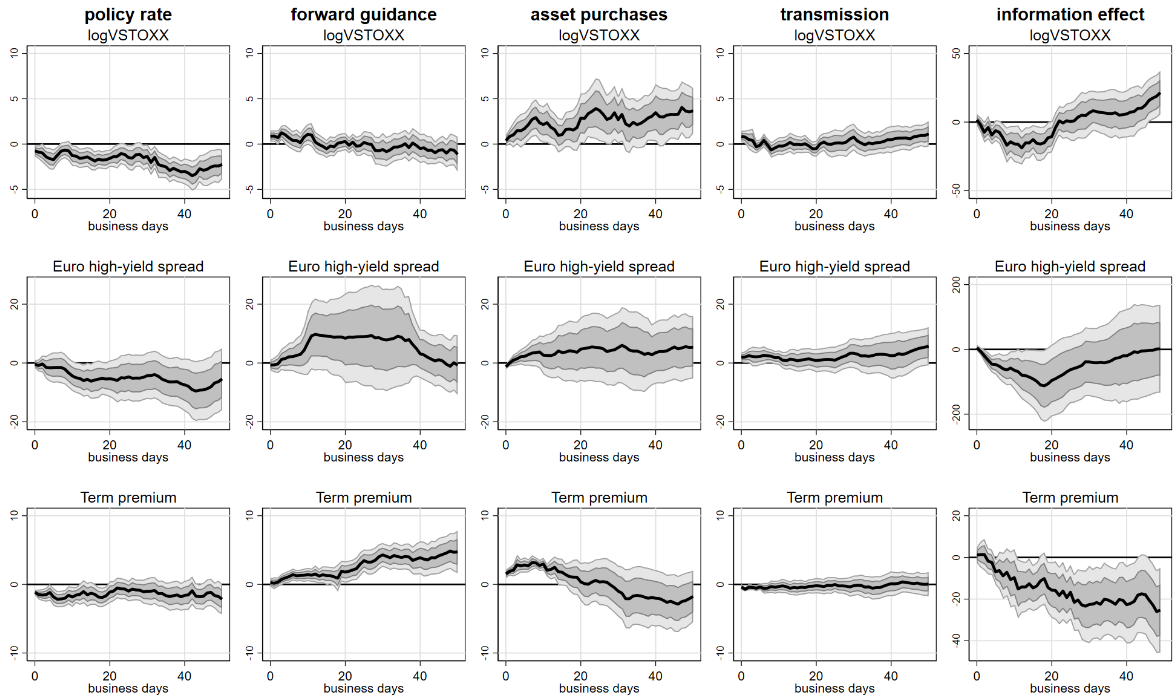
G.2 Additional Results

Figure G.1: Effects of surprises on exchange rates



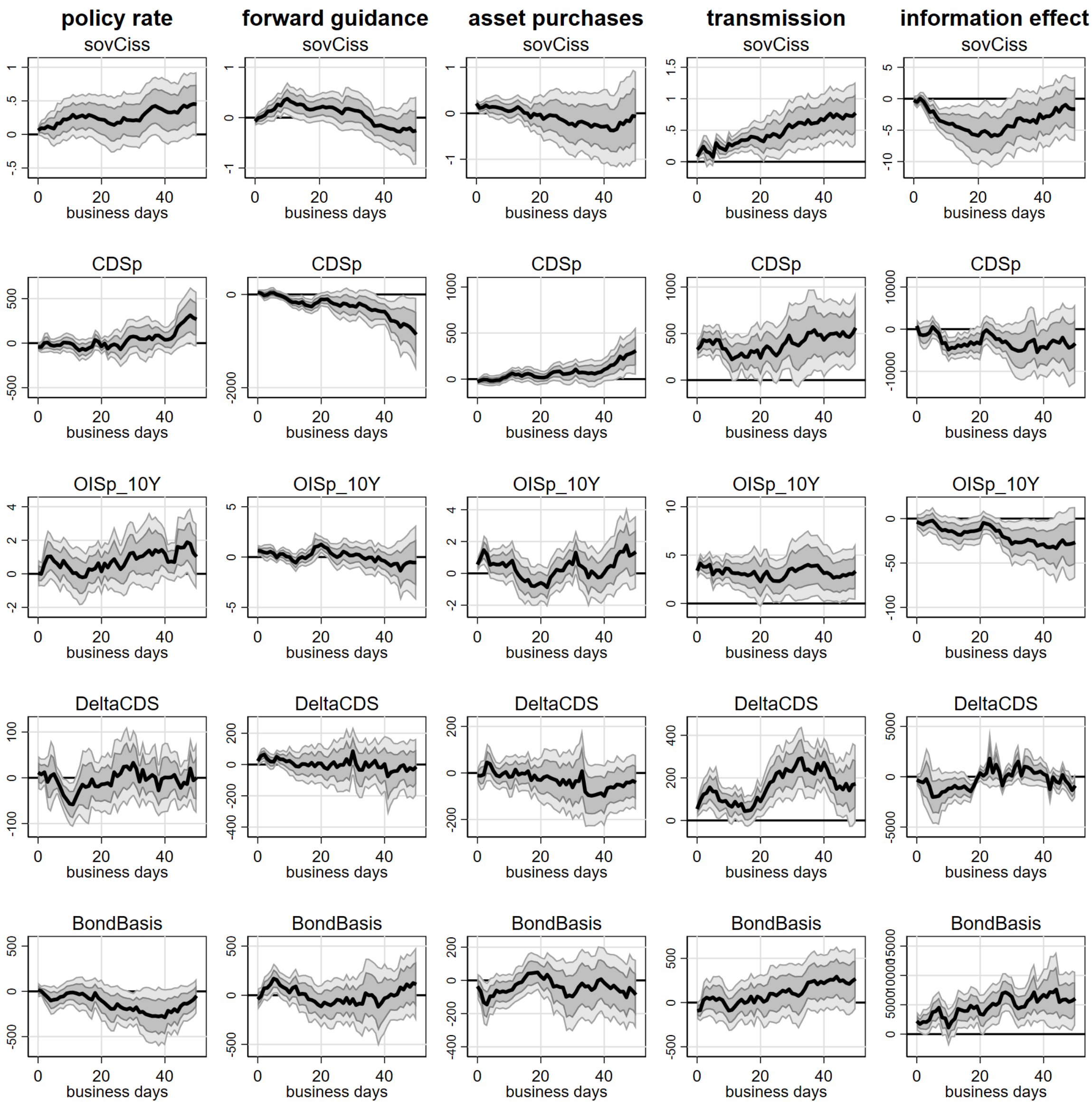
Notes: Local projections of outcome variables on monetary policy surprises following $y_{t+h} - y_{t-1} = c_h + \Sigma_{j=1}^{N} \beta_{j,h} \times s_j + \Sigma_{p=1}^{30} \gamma_{h,p} \times (y_{t-p} - y_{t-p-1}) + \varepsilon_{t,h}$. The black solid line shows the point estimate for β_j for surprise s_j, which are the policy rate (PR), forward guidance (FG), asset purchase (AP), transmission protection (TP) and central bank information (CBI) surprises. Shaded areas represent the heteroskedasticity robust 68% and 90% confidence bands. All results are in bp. The sample covers 231 announcements from 02-May-2002 to 25-Jan-2024.

Figure G.2: Effects of surprises on risk premia



Notes: Local projections of outcome variables on monetary policy surprises following $y_{t+h} - y_{t-1} = c_h + \Sigma_{j=1}^{N} \beta_{j,h} \times s_j + \Sigma_{p=1}^{30} \gamma_{h,p} \times (y_{t-p} - y_{t-p-1}) + \varepsilon_{t,h}$. The black solid line shows the point estimate for β_j for surprise s_j, which are the policy rate (PR), forward guidance (FG), asset purchase (AP), transmission protection (TP) and central bank information (CBI) surprises. All results are in bp. Shaded areas represent the heteroskedasticity robust 68% and 90% confidence bands. The sample covers 231 announcements from 02-May-2002 to 25-Jan-2024.

Figure G.3: Effects of all surprises on market functioning



Notes: Local projections of outcome variables on monetary policy surprises following $y_{t+h} - y_{t-1} = c_h + \Sigma_{j=1}^{N} \beta_{j,h} \times s_j + \Sigma_{p=1}^{30} \gamma_{h,p} \times (y_{t-p} - y_{t-p-1}) + \varepsilon_{t,h}$. The black solid line shows the point estimate for β_j for surprise s_j, which are the policy rate (PR), forward guidance (FG), asset purchase (AP), transmission protection (TP) and central bank information (CBI) surprises. All results are in bp. Shaded areas represent the heteroskedasticity robust 68% and 90% confidence bands. The sample covers 231 announcements from 02-May-2002 to 25-Jan-2024. The series show the GDP-weighted average of four euro area member countries: Italy, Spain, Portugal and Belgium. 'sovCiss' is the composite indicator of sovereign stress, 'CDSp' corresponds to the CDS premium over Germany at the 3-year maturity denominated in euro, 'OISp' is the government bond premium over the OIS swap rate, 'DeltaCDS' is given by $\Delta CDS = CDS_{2014} - CDS_{2003}$ (for Italy only), and 'BondBasis' denotes the difference between the CDS spread minus the OIS spread, or $CDSp - OISp$.

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