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Is there an Information Channel of Monetary Policy?

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Abstract

Exploiting the heteroscedasticity of the changes in short-term and long-term interest rates and exchange rates around the FOMC announcement, we identify three structural monetary policy shocks. We eliminate the predictable part of the shocks and study their effects on financial variables and macro variables. The first shock resembles a conventional monetary policy shock, and the second resembles an unconventional monetary shock. The third shock leads to an increase in interest rates, stock prices, industrial production, consumer prices, and commodity prices. At the same time, the excess bond premium and uncertainty decrease, and the U.S. dollar depreciates. Therefore, this third shock combines all the characteristics of a central bank information shock.

Keywords: central bank information shock, high-frequency identication, identication through heteroskedasticity, monetary policy, proxy SVAR

JEL classification: C36, E52, E58

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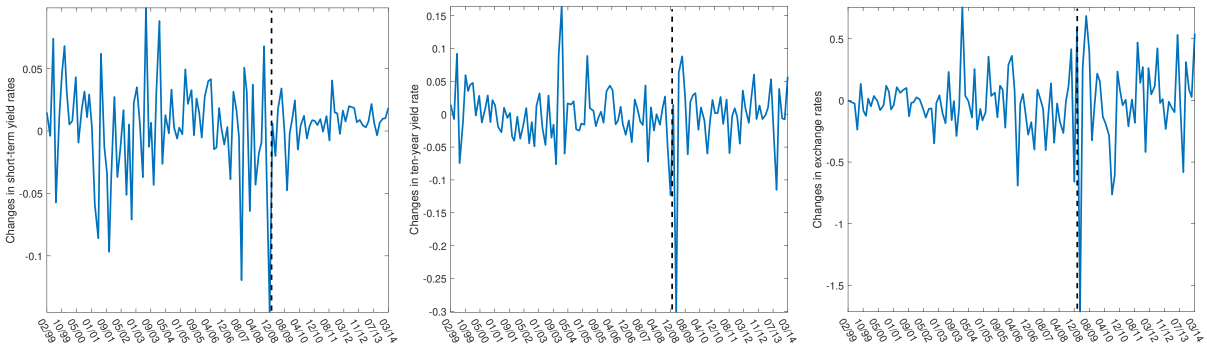
1 Introduction

What are the effects of a monetary policy shock on the economy, and how can we measure it? We investigate the effects of monetary policy shocks on the economy and examine different approaches to measuring those effects. Researchers use movements in interest rate futures in a narrow window around monetary policy announcements as an indicator for monetary policy surprises. The left panel of Figure 1 depicts such a measure derived by Nakamura and Steinsson (2018). Nakamura and Steinsson (2018) and further research by (Jarociński and Karadi, 2020; Miranda-Agrippino and Ricco, 2021) highlight that these measures contain information about not only the current monetary policy stance but also the future state of the economy. The latter component is called the information channel of monetary policy. These papers show that the information channel of monetary policy needs to be considered when analyzing the effects of monetary policy on the economy. Otherwise, the analysis is diluted. However, Bauer and Swanson (2023a) and Hoesch et al. (2020) have raised doubts about the existence of an information channel, attributing the findings in the information channel literature to news that has been made publicly available shortly before a monetary policy announcement.

This paper examines the empirical evidence for the information channel. We start by identifying three different shocks in relation to monetary policy surprises. To do so, we draw on the behavior of the three time series in Figure 1, all measured around announcements by the Federal Open Market Committee (FOMC): changes in short-term interest rates as provided by Nakamura and Steinsson (2018), changes in the 10-year interest rate as provided by Cieslak and Schrimpf (2019), and changes in the effective nominal exchange rate. Each of the three time series experienced a significant change in its respective volatility once the economy hit the effective lower interest rate bound (ELB). Although the volatility of the interest rate futures became smaller, the volatility of the effective exchange rate went up. We identify three structural shocks by exploiting the change in volatilities (Rigobon, 2003).

In the next step, we address the criticism raised by Bauer and Swanson (2023a,b) by controlling for pre-FOMC macroeconomic and financial news. After removing the effects of the news from the shock series, we interpret them economically by examining the change in their volatility, analyzing their impact on financial variables, and evaluating the shock series using narrative accounts. Furthermore, we use them as proxies in a Bayesian Vector Autoregression (VAR) model to obtain the corresponding impulse responses. One shock exhibits the characteristics of a conventional monetary policy shock, while another shock exhibits those of an unconventional monetary policy shock. The third structural shock does not match the characteristics of a standard monetary policy shock. Instead, it has all the characteristics of a central bank information shock. Although it comes with an increase in interest rates, it leads to an increase in stock prices, a decrease in economic uncertainty, an increase in industrial production, and an increase in inflation. Notably, the shock specifically explains the depreciation of the U.S. dollar (USD) following a surprise interest rate hike (Gürkaynak et al., 2021). Therefore, we conclude that the central bank information channel is present, even after controlling for the pre-FOMC macroeconomic and financial news.

Figure 1: Changes in interest rate futures and exchange rates around monetary policy announcements



Notes: The left plot shows changes in short-term interest rate futures around FOMC announcements obtained from Nakamura and Steinsson (2018), the middle plot presents changes in the 10-year interest rate, and the right plot shows changes in the effective exchange rate calculated by the authors. The vertical dashed line for each plot denotes the December 2008 meeting.

To disentangle the three different components of monetary policy, we exploit a change in monetary policy caused by the economy hitting the ELB. We capture this change in an empirical model comprising the monetary policy shock measure of Nakamura and Steinsson (2018) and the change around FOMC announcements in 10-year interest rates and the trade-weighted dollar exchange rate. We choose these variables for the following reasons. The first time series comprises changes in different interest rate maturities, capturing conventional and unconventional monetary policy. In addition, according to Nakamura and Steinsson (2018), it contains a central bank information component. We include the long-term interest rate because it is sensitive to unconventional monetary policy. The changes in exchange rates around the FOMC announcements form part of our model for two reasons. First, recent studies (Gürkaynak et al., 2021; Pinchetti and Szczepaniak, 2021; Stavrakeva and Tang, 2019) highlight the role of central bank information shocks in inducing a negative correlation between interest rates and exchange rates. Second, Rosa (2011) finds that the exchange rate is particularly sensitive to the words of the central bank (compared to the actions embedded in the policy announcements).

Identification by heteroskedasticity has seen increasing implementation in recent research (Sims, 2021; Lütkepohl and Schlaak, 2022; Bruns and Lütkepohl, 2023; Schlaak et al., 2023; Jarociński, 2024). The approach enables the identification of structural shocks based only on the identifying assumption that the volatilities of the time series have changed. In our case, we rely on the assumption that the volatilities have changed due to the nature of the ELB. We show that the volatilities of the structural shocks are indeed different and that the identification requirement defined by Lütkepohl and Netšunajev (2014) holds in our case. However, the disadvantage is that the shocks are purely statistical and have no economic meaning without further reasoning. In our application, we have the advantage of additional information about the shocks: We know that the volatility of conventional monetary policy shocks has decreased, while the volatility of unconventional monetary policy shocks has increased. In addition, to support our economic interpretation of the shocks, we can use the response of financial and economic variables to these shocks.

In our model, identification by heteroskedasticity yields three uncorrelated shocks. One shock leads to an increase in both short-term and long-term interest rates, as well as an appreciation of the USD. Because the response of the short-term rates is stronger than the response of the long-term rates, this is our candidate for a conventional monetary policy shock. A second shock has effects similar to the first shock, differing only in terms of its effects on the different interest-rate measures: It affects long-term rates more strongly than short-term rates. Therefore, it is our candidate for an unconventional monetary policy shock that captures quantitative easing as well as forward guidance. The third shock has an insignificant effect on short-term rates but leads to an increase in long-term rates and a depreciation of the USD. This is our candidate for a central bank information shock.

To address the criticism of Bauer and Swanson (2023a), we account for economic news that has been available before an FOCM meeting. Specifically, we regress the identified structural shocks on news data provided by Bauer and Swanson (2023a). This data includes pre-FOMC-meeting surprises on non-farm payrolls, employment growth, the S& P 500, the yield curve slope, commodity prices, and treasury skewness. Consistent with the findings of Bauer and Swanson (2023a), we find that some of these components have predictive power for the identified shocks. Therefore, we proceed by only applying the parts of the identified shocks that cannot be predicted from the pre-FOMC-meeting news.

We interpret the adjusted structural shocks in three steps. First, we regress financial variables on them. Our candidate for a conventional monetary policy shock leads to a decline in the S&P 500, but increases economic uncertainty and interest rates along the yield curve. Furthermore, short-term interest rates increase more than long-term interest rates. Our candidate for the unconventional monetary policy shock has similar qualitative effects on the stock market, uncertainty, and interest rates. However, long-term interest rates react more strongly than short-term interest rates to unconventional monetary policy. All these effects are consistent with other studies. Our candidate for a central bank information shock raises stock prices and long-term interest rates simultaneously. At the same time, uncertainty is reduced. These effects are consistent with the findings of Miranda-Agrippino and Ricco (2021) and Jarociński and Karadi (2020) and characterize a central bank information shock.

Second, we examine the identified shock series. Our findings show that the shock series of conventional and unconventional monetary policy shocks capture dates that align with narrative evidence, such as the expansionary policies that followed the burst of the dot-com bubble and the terrorist attacks on 9/11, the responses during the global financial crisis (GFC), and quantitative easing (QE 1 and QE 3). Importantly, there is also tapering at the end of our sample. Notably, our candidate shock for a central bank information shock aligns with FOMC statements and the existing literature on central bank information shocks.

Third, we use the shocks in a VAR model. The impulse responses to the conventional monetary policy shock align with the literature: industrial production and price indices decrease, the excess bond premium increases, and the exchange rate appreciates. We observe a similar response to the unconventional monetary policy shock, except for insignificant results for industrial production and a positive response of the CPI in the first three months. The impulse response functions for the central bank information shock lead to an increase in the 10-year bond rate, industrial production, and the price index. At the same time, the real exchange rate depreciates and the excess bond premium falls. These are exactly the impulse response functions one would expect from a central bank information shock. Because the identified shock leads to high-frequency responses of financial variables and impulse response functions of macro variables that align with the expected outcomes after a central bank information shock—and the shock series is consistent with a narrative account—our results strongly suggest the existence of the central bank information shock and channel.

Our paper primarily adds value to the literature on the existence of a central bank information channel by considering a new identification strategy. Nakamura and Steinsson (2018) extract a principal component that includes central bank information from the changes in interest rate futures of several maturities measured around monetary policy announcements. Jarociński and Karadi (2020) combine the response of interest rate futures around a monetary policy announcement with the response of the stock market at the same time and impose a sign restriction to identify a monetary policy and a central bank information shock. They find a positive response of real GDP and a negative response of the excess bond premium to a positive information shock. Miranda-Agrippino and Ricco (2021) derive an informationally robust instrument for monetary policy shocks by accounting for informational rigidities and controlling for information revealed in staff forecasts. Bu et al. (2019) decouple monetary policy and non-monetary policy shocks using Fama-MacBeth cross-sectional two-step regressions. Elsewhere, Melosi (2016) identifies the information component in a monetary policy announcement by estimating a dynamic stochastic general equilibrium (DSGE) model, with Laumer and Santos (2024) also finding a role for central bank information shocks.

Our work also relates to work on the role of the exchange rate in the transmission of monetary policy shocks. For the effect of conventional and unconventional monetary policies on exchange rates, we refer to Faust et al. (2003), Glick and Leduc (2018), Neely (2015), Ferrari et al. (2017), Rogers et al. (2018), Inoue and Rossi (2019), and Dedola et al. (2021). Recently, focusing on the response of exchange rates to new information revealed by the central bank, Gürkaynak et al. (2020) investigate the impact of central bank information on the behavior of exchange rates on policy announcement dates and show that a path shock defined according to Gürkaynak et al. (2005) significantly drives the exchange rate responses to monetary policy announcements and partially resolves the puzzling exchange rate responses based on a target shock. Stavrakeva and Tang (2019) show that U.S. monetary policy easing appreciates the USD during the Great Recession, explaining such abnormal co-movements in terms of forward guidance signaling economic weakness. Jarociński (2019) employs a sign restriction to identify the central bank information shock and finds that there are considerable spillovers of Federal Reserve monetary information shocks on the Euro area. Kerssenfischer (2022) conducts a high-frequency event study around ECB monetary policy announcements and observes the appreciations of the Euro in response to interest rate increases associated with central bank information shocks. Furthermore, several papers have recently analyzed the safe-haven effect, that is, the flight to safety effect, which could account for an appreciation of the USD following bad news (Bruno and Shin, 2015; Pinchetti and Szczepaniak, 2021; Lilley et al., 2022).

The paper is structured as follows. Section 2 introduces the time series model with heteroskedasticity that we use to identify the structural shocks. In Section 3, we provide an economic interpretation of the structural shocks by regressing them on financial variables and by examining the identified shock series. Section 4 employs the shocks as proxy variables in a VAR model and derives the corresponding impulse response functions. The final section concludes.

2 Identification through Heteroskedasticity

In this section, we first describe the data we use to identify structural shocks associated with the conduct of monetary policy. Second, we set up the model with heteroskedasticity and explain the identification scheme. The final part of the section presents and discusses the three identified structural shocks.

2.1 Data

We use a VAR model to identify three structural shocks related to monetary policy. We do this by analyzing changes in three variables within 30-minute windows around FOMC press releases, specifically, from 10 minutes before to 20 minutes after the event. The first variable is a measure of short-term interest rates, which we compute by taking the first principal components from five short- to medium-term interest rates. The construction of the measure follows Nakamura and Steinsson (2018); it includes monetary policy shocks and central bank information shocks. The second variable is the change in the 10-year treasury yield around FOMC announcements, which we obtain from Cieslak and Schrimpf (2019). We include this measure to cover changes along the yield curve in the spirit of Swanson (2021) and (thus) to pick up unconventional monetary policy innovations. The third variable is the change in the U.S. effective exchange rate. We construct this measure by using tick-by-tick high-frequency exchange rates for the USD versus the Euro, the Canadian dollar, the British pound, the Swiss franc, the Japanese yen, the Australian dollar, and the Mexican peso covering the period from February 1, 1999, to April 31, 2014. The exchange rates are defined in foreign currency per USD, i.e., a positive change implies an appreciation of the USD. We measure the changes in the exchange rates around FOMC announcements and calculate the change in the effective USD exchange rate within a short window around policy announcements using the currency weights in the BIS narrow nominal effective exchange rate (NEER) index. We include changes in the exchange rate in the model because the exchange rate is especially sensitive to the central bank's words compared to the actions embedded in policy announcements (Rosa, 2011).

We hypothesize that volatilities change around the start of the ELB period, based on the three measures of high-frequency surprises around policy announcements in Figure 1.[1] We test the hypothesis of equality of the covariance matrices of the high-frequency surprises for the pre-ELB and ELB periods using Box's M-test. The null hypothesis is that the covariance matrices are homogeneous, with the null rejected if Box's M statistic exceeds the Chi-square critical value. In our sub-samples, the homogeneity of the covariance matrices is clearly rejected at the 1% significance level: Box's M statistic is 112.58, the Chi-square approximation is 109.08, and the p-value is 0.0001.

The test result shows that the covariance matrices for the subsamples differ significantly, excluding the peak of the GFC from July 2008 to August 2009. The homogeneity of covariance matrices is still rejected because Box's M statistic is 70.28, the Chi-square value is 68.21, and the p-value is 0.0001. Therefore, the changes in the variance-covariance matrices around the GFC period are not due only to additional fluctuations caused by the GFC.[2]

2.2 Empirical model and identification

We assume that the high-frequency measures are a linear combination of three underlying structural shocks:

$$\begin{pmatrix} \text{Short-term futures} \\ \text{Ten-year rate} \\ \text{Exchange rate} \end{pmatrix} = \underbrace{\begin{pmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{pmatrix}}_{A} \begin{pmatrix} \text{Shock 1} \\ \text{Shock 2} \\ \text{Shock 3} \end{pmatrix} \tag{1}$$

The fact that the covariances of three high-frequency responses to FOMC announcements change around the beginning of the ELB period is used to identify structural shocks that are consistent with the statistical properties of the data. For a variance-covariance matrix Σ_1 in the pre-ELB period and Σ_2 during the ELB period, there exists a decomposition of two variance-covariance matrices as follows:

$$\Sigma_1 = A\Gamma_1 A', \quad \Sigma_2 = A\Gamma_2 A'. \tag{2}$$

where $\Gamma_1 = I_3$ is normalized so that the underlying structural shocks feature unit conditional variance in the pre-ELB period and Γ_2=diag$(\lambda_1, \lambda_2, \lambda_3)$ is a diagonal matrix with positive diagonal elements. The λs can be interpreted as variances of structural shocks in the ELB period relative to those in the pre-ELB period. Therefore, distinct λs, the requirement for exact identification, imply that volatility changes are not homogeneous across three high-frequency surprises. As Rigobon (2003) and Lanne and Lütkepohl (2010) demonstrate, if the diagonal elements of Γ are distinct, the contemporaneous matrix A can be identified up to the sign and permutation of the shocks

[1] Given that the Federal Reserve sets interest rates between 0% and 0.25% in December 2008, we take December 2008 as the starting month of the ELB period.

[2] Despite concerns about the abnormal behavior of financial variables during the 2007–2008 GFC, we retain our sample for shock identification. Quantitative easing (QE1) is the main unconventional monetary policy event that overlapped with a peak of the GFC. Therefore, by omitting the GFC period, we may lose information that is significant for capturing the unconventional MP shock component.

Table 1: Estimates of A and Γ

	A						Γ_2	
	Candidate for ... Shock							
	Conventional		Unconventional		Information			
Short-term rate	a_{11}	0.045	a_{12}	0.003	a_{13}	-0.002	γ_1	0.099
		(0.010)		(0.001)		(0.004)		(0.051)
Long-term rate	a_{21}	0.031	a_{22}	0.020	a_{23}	0.018	γ_2	7.664
		(0.008)		(0.008)		(0.008)		(2.808)
Exchange rate	a_{31}	0.094	a_{32}	0.136	a_{33}	-0.091	γ_3	1.104
		(0.032)		(0.049)		(0.051)		(0.408)

Note: Standard errors obtained by bootstrap simulation are in parentheses. Columns 1, 2, and 3 correspond to candidate shocks of conventional, unconventional, and central-bank information shocks. The contemporaneous responses to these shocks appear in the first row for short-term rates, the second row for long-term interest rates, and the third row for the exchange rate.

corresponding to changes in the order of the λs.

We estimate A and Γ_2 using maximum likelihood estimation. To obtain standard errors, we use bootstrap simulation within sub-samples for pre-ELB and ELB periods. In our analysis, the break-point for the heteroskedasticity is known to be December 2008. Our approach of residual bootstrapping within each sub-sample maintains the heteroskedasticity between two sample periods. Furthermore, as Swanson (2021) discusses, we specify our sampling algorithm such that QE1 events happen fewer than two times to remove the chance that simulated heteroskedasticity is mainly driven by QE1 observations.

The focus of the paper is to investigate whether there is a central bank information shock. The period before and during the existence of the ELB is an event perfectly suited to applying our approach. Therefore, we focus on the period up to 2014 to demonstrate how our identification approach works. It is straightforward to extend the approach to a longer time period. As Rigobon (2003) shows, provided there are only two volatility regimes, our approach can be directly applied upon estimating two variance-covariance matrices for the two regimes using, for example, a Markov-regime-switching model.[3] In principle, the approach can also be extended to more than two volatility regimes.

2.3 Three identified structural shocks

The identification using heteroskedasticity yields the estimates for the matrix A and entries of Γ_2 shown in Table 1. We observe that the diagonal elements in Γ_2 differ considerably. We conduct Wald tests for equality of pairs of λs and reject three null hypotheses, H_0: $\lambda_1 = \lambda_2$, $\lambda_1 = \lambda_3$, and $\lambda_2 = \lambda_3$, at the 1% significance level. Each column in the A matrix shows how interest rates and the USD respond to one of three structural shocks. Meanwhile, as the first column shows, the first structural shock increases both interest-rate measures and leads to an appreciation of the USD.

[3]ELB periods in the US span from December 2008 through to December 2015 and again from March 2020 until March 2022, a function of the COVID-19 pandemic.

Table 2: Predictive regressions using macroeconomic and financial data

	Conventional	Unconventional	CB information
Nonfarm payrolls	0.001	-0.001	-0.001
	(0.001)	(0.002)	(0.001)
Empl. growth (12m)	0.083	0.015	0.028
	(0.038)	(0.153)	(0.046)
Δ log S&P 500 (3m)	1.464	3.740	0.484
	(1.104)	(3.373)	(1.450)
Δ Slope (3m)	-0.215	0.267	0.025
	(0.123)	(0.346)	(0.178)
Δ Comm.price (3m)	1.635	-1.384	3.269
	(1.029)	(1.717)	(1.320)
Treasury skewness	0.453	-0.189	-0.351
	(0.309)	(0.699)	(0.565)
adj. R^2	0.189	-0.024	0.055

Note: Standard errors are in the parentheses.

Because the effect on short-term rates is higher than the effect on long-term rates ($a_{11} > a_{21}$), this is our candidate for a conventional monetary policy shock. The impacts of the second shock on interest rates and the exchange rate qualitatively resemble those from the first shock, but the second shock affects long-term interest rates more strongly than short-term interest rates ($a_{22} > a_{12}$). Therefore, this is our candidate for an unconventional monetary policy shock. Finally, there is one structural shock that has no significant immediate effect on short-term rates, but does have a positive effect on the long-term interest rates, while at the same time causing a depreciation of the USD, as shown in the third column of the A matrix. This shock is our candidate for a central bank information shock.

2.4 Are the shocks predictable?

Recent contributions by Bauer and Swanson (2023a,b) demonstrate that many high-frequency monetary policy measures can be predicted on the basis of pre-FOMC-meeting economic news. More precisely, they estimate the regression:

$$mps_t = \alpha + \beta' news_t + \epsilon_t, \tag{3}$$

where mps_t denotes the high-frequency monetary policy shock at t and $news_t$ is a vector of economic news released between the beginning of the month and the day of the FOMC announcement. The news vector includes surprises about non-farm payrolls, employment growth, the S&P 500, the yield curve slope, commodity prices, and treasury skewness. Before we continue with the economic interpretation of the identified structural shocks, we examine whether they are predictable using the regression and the data provided by Bauer and Swanson (2023b). Table 2 presents the results. We find that the shock that resembles a conventional monetary policy shock can be predicted by several news measures. Meanwhile, the unconventional monetary policy candidate can be predicted by the S&P 500 and the central bank information shock candidate by commodity price news. Notably, the signs of estimated regression coefficients are consistent overall with Bauer and Swanson (2023a): An upward slope of the yield curve predicts a monetary policy easing. Strong non-farm payroll employment, stock market movements, and higher commodity prices predict a more hawkish monetary policy.

According to Bauer and Swanson (2023a,b), the predictability of high-frequency surprises can potentially generate significant bias in a VAR analysis. Here, an omitted variable will cause an estimation bias if it both correlates with the high-frequency surprise and independently affects the outcome. Examples include the monthly frequency macro variable and the Blue Chip forecast revision. The authors propose taking this into account by orthogonalization of the residual high-frequency surprise from the predictability regressions. We do this by computing the fitted residuals from the regression Equation (3). The resulting time series is our purged new shock series.

3 Economic interpretation of structural shocks

In Section 2, we identified three structural shocks. From the impact each of those shocks has on changes to short-term interest rates, long-term interest rates, and the exchange rate around the FOMC announcement we consider one shock as a candidate for conventional monetary policy, one shock as a candidate for unconventional monetary policy, and one shock as a candidate for a central bank information shock. In the following subsection, we regress financial variables on the three shocks before examining the narrative time series and relating them to the FOMC statements.

3.1 Financial variables

To understand the nature of each identified shock better, we follow Nakamura and Steinsson (2018) and compute the change in the stock market and along the yield curve over a 30-minute window around the FOMC announcements. Following Nakamura and Steinsson (2018), we employ Eurodollar futures as short-term interest rates (up to one year) and treasury bonds of different maturities as long-term interest rates. Additionally, we consider the VIX as an uncertainty measure. Due to data limitations, we compute the change over the day only.

Specifically, we estimate the following regression:

$$\Delta y_t = \alpha + \beta * Shock_t + \epsilon_t \tag{4}$$

where Δy denotes the change in a high-frequency financial variable measured around the 30-minute window of each FOMC announcement. *Shock* is one of three identified shock components and ϵ is a regression residual. When estimating the regression, we have to be careful because the variable on the right-hand side is a generated regressor. To address this issue, we compute the standard error using 3,000 bootstrap replications to account for the additional sampling variability associated

Table 3: Regression with high frequency surprises

	S&P 500	VIX	ED:2Q	ED:3Q	ED:4Q	2-year	5-year	30-year
Conventional MP	-0.359	1.549	0.063	0.074	0.077	0.055	0.047	0.015
(std.err.)	(0.075)	(0.665)	(0.004)	(0.004)	(0.005)	(0.004)	(0.005)	(0.005)
Unconventional MP	-0.138	0.507	0.004	0.006	0.008	0.009	0.018	0.018
(std.err.)	(0.014)	(0.215)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
CB Information	0.231	-1.174	-0.010	-0.005	0.002	0.008	0.014	0.019
(std.err.)	(0.059)	(0.776)	(0.006)	(0.010)	(0.008)	(0.007)	(0.005)	(0.004)

Notes: Each estimate comes from a separate heteroskedasticity-consistent OLS regression. Standard errors in parentheses are calculated from 3,000 bootstrapped samples, reflecting an extra uncertainty from the generated regressor issue. The dependent variable in each regression is the high-frequency surprises over 30-minute windows around the time of FOMC announcements, as stated in the first row. An exception is the VIX, which is measured as a daily change. ED:2(3,4)Q denotes an expected three-month Eurodollar interest rate at horizons of two (three, four) quarters. The independent variable is one of the decomposed shocks we identified. All regressions include a constant.

with the calculation of the identified shock.[4] Table 3 presents the results. First, we find that the response of financial variables to our candidate conventional and unconventional monetary policy shocks is consistent with the literature: After a contractionary monetary policy shock stock, prices decline (Swanson, 2021) and uncertainty rises (Bekaert et al., 2013; Bruno and Shin, 2015; Passari and Rey, 2015). Regarding the yield curve, we find that the conventional monetary policy shock foremost moves the shorter maturities, with its effects slowly decreasing with longer maturities. The unconventional monetary policy shock primarily affects the longer maturities along the yield curve. Our candidate central bank information shock leads to an increase in stock prices, a decrease in uncertainty, and a simultaneous increase in long-term interest rates. These properties resemble the identifying assumption of Jarociński and Karadi (2020), who assume that a central bank information shock moves stock prices and interest rates in the same direction.

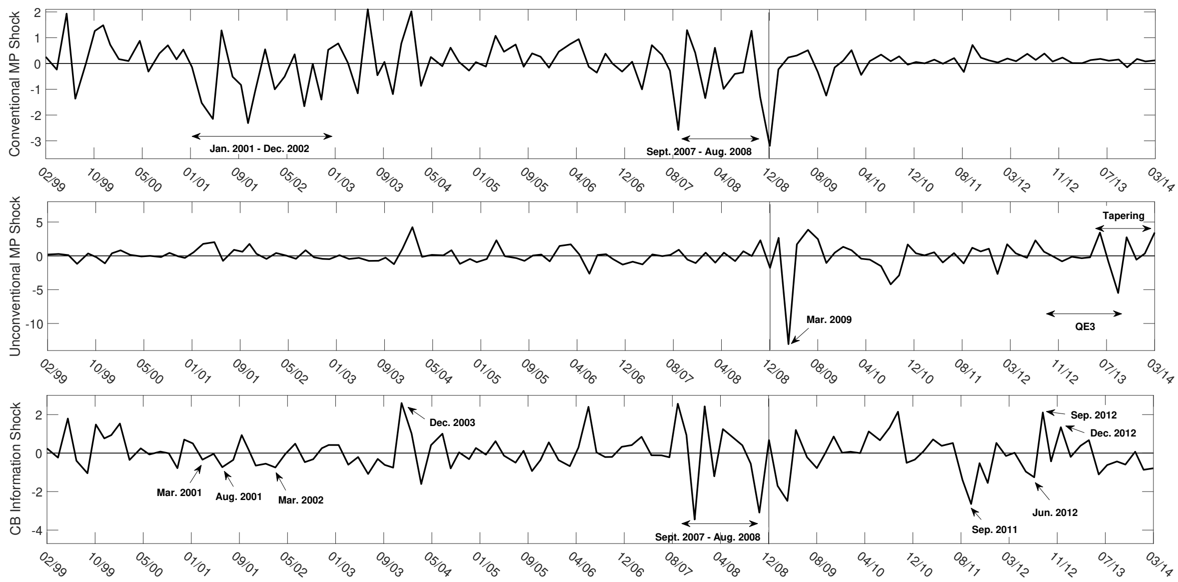
Our analysis reveals that the candidates for monetary policy shocks exhibit effects on financial variables consistent with the existing literature. Additionally, we identify another structural shock that shares similarities with a central bank information shock. Given the state of our analysis, we will no longer refer to these identified shocks as mere candidates.

3.2 Narrative accounts for shock series

Figure 2 plots the time series for the three shocks. The first row represents the identified conventional monetary policy shock, the second row depicts the unconventional monetary policy shock, and the third row illustrates the central bank information shock. Table 4 in the Appendix A provides an overview of the announcement dates discussed in this section and summarizes the corresponding narrative shocks.

[4] We consider the sub-sample for pre-ELB and ELB and a residual bootstrap within each sub-sample to preserve heteroskedasticity between the two sub-samples. Furthermore, as discussed in Swanson (2021), the QE1 event cannot be repeated several times, so we control to ensure that the QE1 event happens fewer than two times to remove the chance that the simulated heteroskedasticity is mainly driven by the QE1 observations.

Figure 2: Decomposed monetary policy shocks



Notes: The upper, middle, and lower panels present decomposed conventional, unconventional, and central bank information shocks from high-frequency surprises. The vertical solid line for each plot denotes the December 2008 meeting.

The period following the dot-com bubble bursting and the September 2001 terrorist attacks (January 2001-December 2002) is characterized by predominantly expansionary conventional monetary policy shocks. Overall, the FOMC lowered the federal funds rate from over 6 percent to close to 1 percent. Interestingly, these expansionary monetary policy shocks were accompanied by several negative central bank information shocks that occurred simultaneously. FOMC statements consistently linked the accommodative stance of monetary policy to weak demand conditions and heightened economic uncertainty, emphasizing downside risks.

For instance, in March 2001, the FOMC surprised the market with a larger-than-expected federal funds rate cut, explicitly highlighting "substantial risks that demand and production could remain soft" in the near future as stated in the FOMC announcement. Notably, following this FOMC announcement, short- and long-term interest rates decreased significantly, while the USD appreciated. Consequently, even in this phase of expansionary conventional monetary policy shocks, we identify some smaller negative central bank information shocks, reflecting a pessimistic outlook regarding the near-term economic status. This observation aligns with the findings of Jarociński and Karadi (2020), who also note clear decreases in three-month fed funds futures and a decline in the S&P 500 stock market index following this announcement.

Another example from this period is the FOMC announcement in August 2001 that it would reduce the target rate by 25 basis points in light of the fact that "[h]ousehold demand has been sustained, but business profits and capital spending continue to weaken and growth abroad is slowing, weighing on the US economy" and that "risks are weighted mainly toward conditions that may generate economic weakness in the foreseeable future.” In March 2002, the FOMC kept its target rate constant (despite stable economic growth), explaining its decision in terms of the continuing uncertainty of “the degree of the strengthening in final demand over coming quarters, an essential element in sustained economic expansion.” For both policy announcements, we observe decreases in short- and long-term interest rates, accompanied by an appreciation of the USD. These events signaled an expansionary conventional monetary policy. Notably, Jarociński and Karadi (2020) also found a positive co-movement between stock prices and short-term interest rates during both events.

In December 2003, we witnessed a positive spike in the information shock. Before the announcement, several U.S. economic data releases exceeded expectations. However, concerns lingered about the US-China trade dispute and the US's current account deficit. The positive information shock on that meeting day indicated that private agents perceived the central bank's decision to maintain the target rate as an optimistic perspective on future economic conditions.

As the financial crisis began to unfold in September 2007 and shortly before reaching its peak in August 2008, we identify two large negative information shocks. The related policy announcements by the FOMC involved rate cuts and the expression of concerns about the financial market and housing market conditions. These statements also highlighted considerations related to a slower pace of economic expansion in the near term and increased uncertainty surrounding the outlook for economic growth. During this critical period, we observed a simultaneous appreciation of the USD and a decline in interest rates.

During the period of the ELB, approximately 30 percent of FOMC announcements resulted in negative co-movements between the exchange rate and interest rates. Interestingly, during this period, the central bank information shock often occurred in conjunction with an unconventional monetary policy shock. For instance, the announcement and subsequent refinement of QE1 in December 2008 and March 2009 primarily constituted an unconventional monetary policy shock. The FOMC explicitly stated that the Federal Reserve system would purchase agency debt and mortgage-backed securities. Additionally, the policy announcement predicted exceptionally low levels of the federal funds rate for an extended period, reflecting the ongoing economic contraction. Consequently, we estimate a negative central bank information shock alongside an expansionary unconventional monetary policy shock. These findings align with those of Jarociński and Karadi (2020), who also observed negative information shocks associated with QE1-related announcements.

Furthermore, the introduction of the maturity extension program (MEP) in September 2011 and its continuation announcement in June 2012 represent two additional instances of negative central bank information shocks. In September 2011, the FOMC statement expressed concern about the economic outlook that “there are significant downside risks to the economic outlook, including strains in global financial markets.” Previously, this concern had been only ambiguously mentioned (“downside risks to the economic outlook have increased”). The negative central bank information shock in June 2012 captured a similar change in tone. Where an FOMC statement from earlier in 2012 contained phrases such as “labor market conditions have improved in recent months; the unemployment rate has declined [...]," the June 2012 statement adopted a less optimistic tone in detailing its economic outlook: "growth in employment has slowed in recent months [...] household spending appears to be rising at a somewhat slower pace than earlier in the year." The June 2012 statement also revealed that the Fed had decided to extend the exit date of its QE program from September 2012 to "the end of [2012]," adding that "[t]he Committee is prepared to take further action [...] to promote a stronger economic recovery and sustained improvement in labor market conditions."

When the US entered the QE3 phase in August 2012, we estimate several positive central bank information shocks, signaling shifts in market expectations. In September 2012, December 2012, and May 2013, the Fed made positive revisions to its economic outlook (compared to previous meetings). For example, where the August 2012 announcement stated that "economic activity [has] decelerated [...] despite some further signs of improvement, the housing sector remains depressed," the September 2012 announcement stated that "economic activity has continued to expand at a moderate pace in recent months [...] The housing sector has shown some further signs of improvement, albeit from a depressed level." Although the September 2012 statement contained detailed information concerning accommodative forward guidance and QE3, the language describing the economic outlook was (overall less pessimistic than the previous FOMC meeting. Similarly, comparing the October 2012 and December 2012 statements reveals positive revisions to the articulation of economic conditions in the December 2012 statement: "the unemployment rate has declined [...] the housing sector has shown further signs of improvement and household spending has continued to advance."

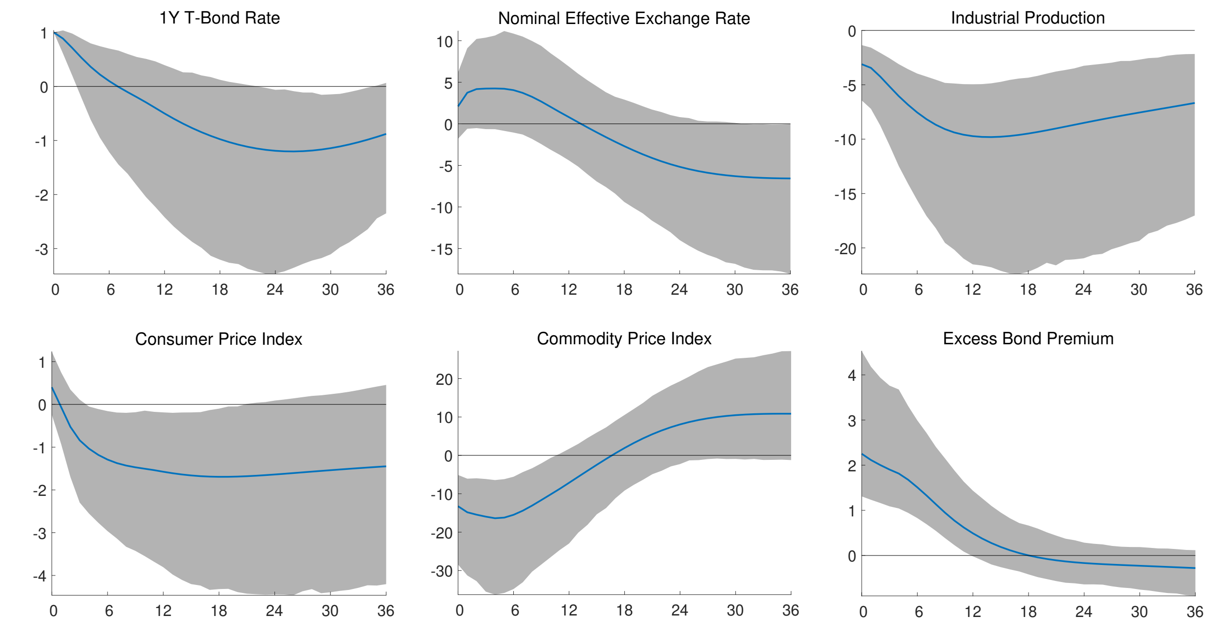
In summary, our shocks effectively capture significant events. This further supports the notion that statistically identified shocks can yield meaningful economic interpretations.

4 Dynamic responses of economic variables

This section examines the dynamic responses of macroeconomic variables to the identified shocks. We do this by estimating a VAR model and using each shock as a proxy variable. The endogenous variables in the VAR model are industrial production, the nominal effective exchange rate, the CPI, the excess bond premium, the commodity price index, and an interest rate measure. For the conventional monetary policy, we use the one-year interest rate as the policy variable, following Gertler and Karadi (2015). For the unconventional monetary policy and the central bank information shock, we use the ten-year interest rate. The choice for the unconventional monetary policy shock is motivated by the fact that it mainly affects long-term interest rates. In the case of the central bank information shock, we did not estimate a significant impact on short-term rates in the previous section. Therefore, we examine the dynamic effects using long-term interest rates as the policy instrument.

The variables in the model are of monthly frequency (except for interest rates in log levels) and span from 1989:01–2014:03. We use the previous data—that is, 1979:01–1989:01—to calibrate

Figure 3: Impulse responses of the variables to a conventional monetary policy shock



Notes: Responses to a contractionary conventional monetary policy shock that is normalized to induce a 100 basis point increase in the one-year rate at impact. The x-axis shows quarters after the shock, and the y-axis represents responses of variables in percentage points. Shaded areas are 68% posterior coverage bands.

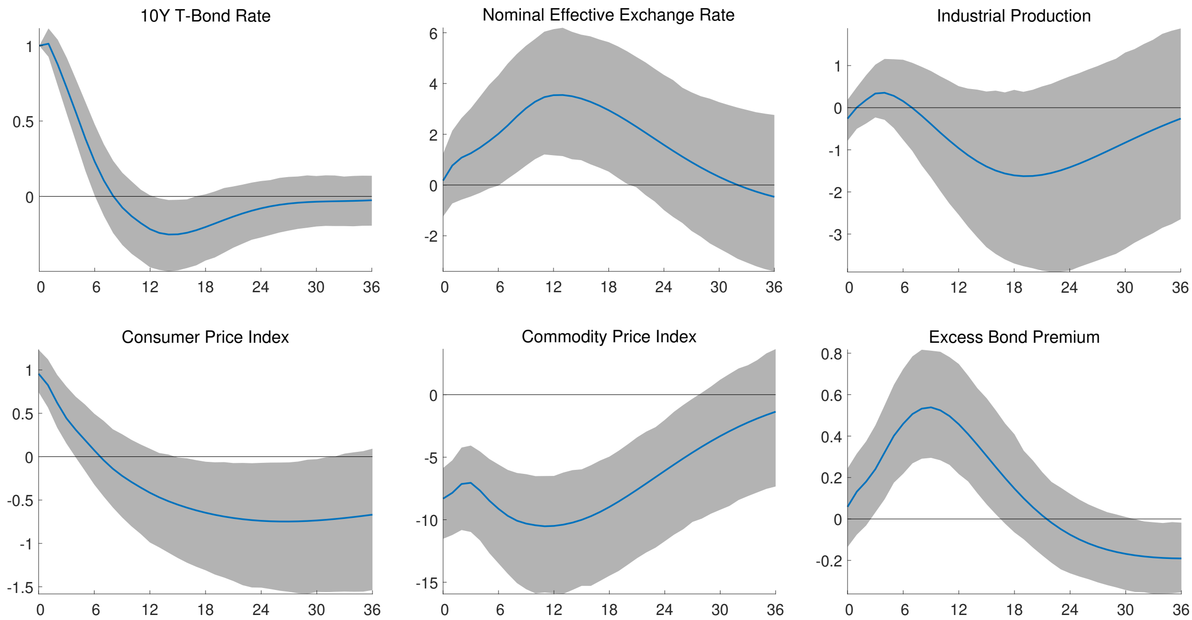
the prior distribution. The prior distribution is a Normal-Inverse Wishart prior, and, following Miranda-Agrippino and Ricco (2021), is specified as a Minnesota prior (Doan et al., 1984). As it is standard in the literature (Miranda-Agrippino and Ricco, 2021; Gertler and Karadi, 2015), the model includes 12 lags.[5]

In Figure 3, we consider a shock that raises the short-term interest rate by one percent, that is, a conventional monetary policy shock. The shock leads to a fall in industrial production, the CPI, and the commodity index and an increase in the excess bond premium. The exchange rate appreciates. This aligns with monetary theory and recent empirical evidence (Jarociński and Karadi, 2020; Miranda-Agrippino and Ricco, 2021; Gertler and Karadi, 2015). The response of the economy to unconventional monetary policy in Figure 4 also aligns with previous studies (Faust et al., 2003; Rogers et al., 2018; Dedola et al., 2021). After a one-percent increase in the long-term interest rate, the USD appreciates, the CPI turns negative after one year, the commodity price index falls sharply, and the excess bond premium increases. We do not obtain significant results for the response of industrial production, but most of the probability mass is concentrated in the negative part of the response.

Critically, Figure 5 shows that the dynamic responses of the economy to the central bank information shock are exactly as they should be (Jarociński and Karadi, 2020; Miranda-Agrippino and Ricco, 2021; Pinchetti and Szczepaniak, 2021). Industrial production, the CPI, and commodity prices all rise in spite of increased interest rates. The excess bond premium falls, and the currency

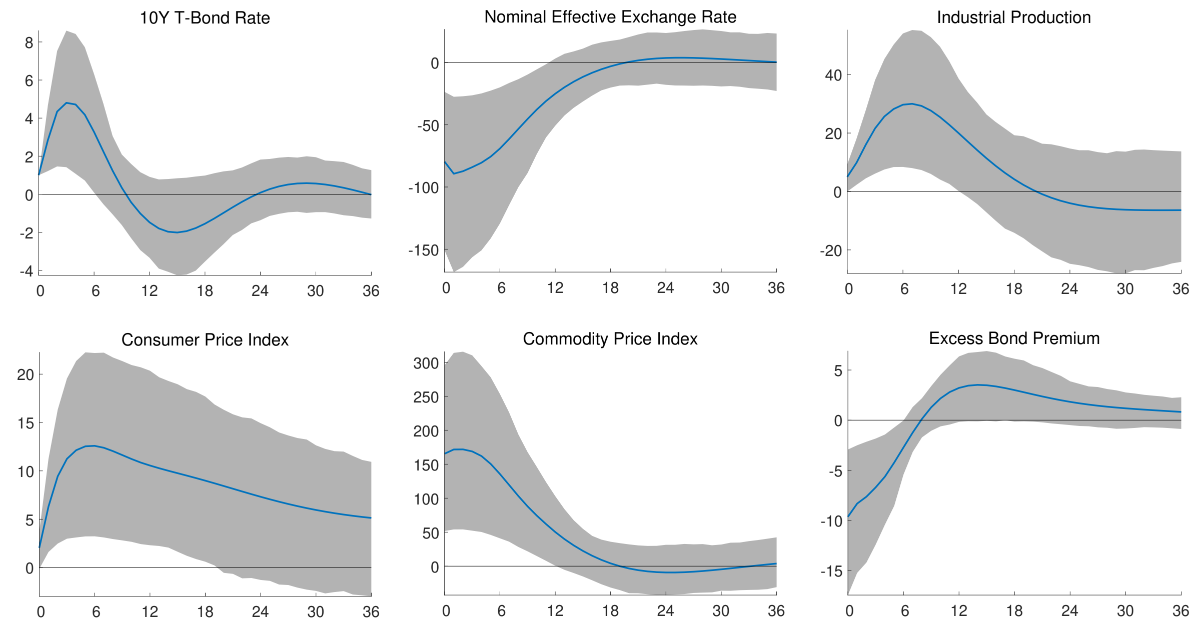
[5]Robustness analysis with six lags is provided in Appendix A.

Figure 4: Impulse responses of the variables to an unconventional monetary policy shock



Notes: Responses to a contractionary unconventional monetary policy shock that is normalized to induce a 100 basis point increase in the ten-year interest rate at impact. The x-axis shows quarters after the shock, and the y-axis represents responses of variables in percentage points. Shaded areas are 68% posterior coverage bands.

Figure 5: Impulse responses of the variables to a central bank information shock



Notes: Responses to a contractionary central bank information shock that is normalized to induce a 100 basis point increase in the ten-year interest rate at impact. The x-axis shows quarters after the shock, and the y-axis represents responses of variables in percentage points. Shaded areas are 68% posterior coverage bands.

depreciates. These impulse response functions provide considerable reassurance that the identified structural shock indeed represents a central bank information shock.

5 Conclusion

In this paper, we employ a statistical approach to identify structural shocks related to monetary policy. Our approach yields two shocks that resemble the characteristics of conventional and unconventional monetary policy shocks. Interestingly, we also identify a third shock that exhibits the properties of a central bank information shock. This shock leads to an increase in long-term rates, industrial production, prices, and the stock market but results in a depreciation of the USD due to higher than previously expected inflation. Notably, the central bank information shock we identify is not predictable from pre-FOMC news.

The results importantly contribute to the debate concerning the existence of a central bank information shock, deepening our understanding of the conduct of monetary policy. Furthermore, supporting the findings of previous studies, once the central bank information component is purged from high-frequency or narrative measures, the impulse response functions do not display counter-intuitive results as the price puzzle.

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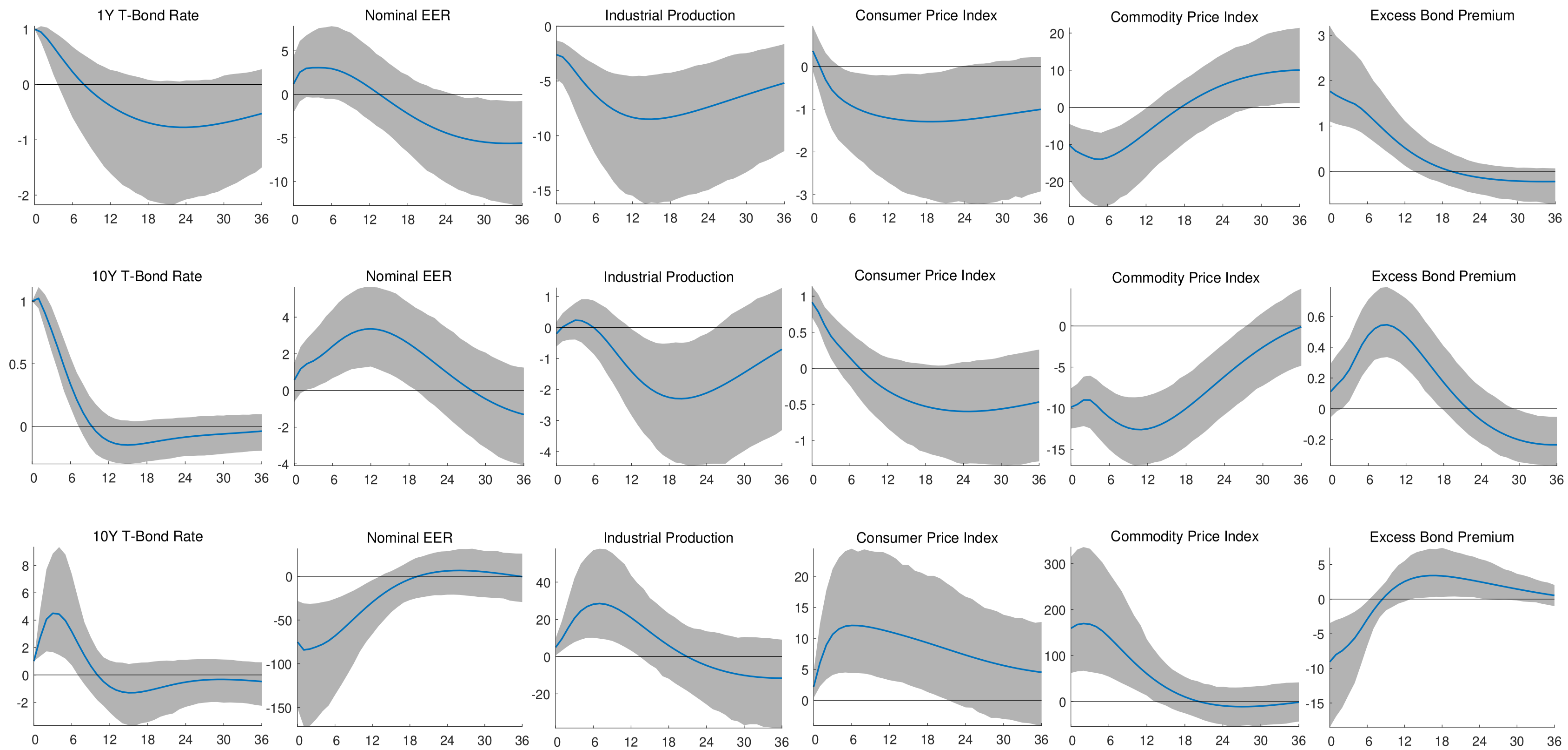
A Extra Figure and Table

Table 4: Decomposed shocks and high-frequency surprises on selected announcement Dates

Date	Conv. shock	Unconv. shock	CBI shock	Shock-term rates	Long-term rate	Exchange rate	S&P 500
Mar 19 2001	-1.527	1.768	-0.341	-0.063	-0.017	0.128	-0.680
Aug 20 2001	-0.513	0.892	-0.552	-0.020	-0.004	0.105	-0.712
Mar 18 2002	-1.002	0.416	-0.747	-0.043	-0.036	0.030	-0.383
Dec 08 2003	0.777	1.030	2.601	0.034	0.091	-0.023	-0.058
Dec 10 2007	0.413	-1.071	-3.449	0.022	-0.071	0.207	-1.597
Oct 28 2008	-1.293	2.300	-3.091	-0.046	-0.049	0.472	-1.880
Dec 15 2008	-3.196	-1.778	0.677	-0.152	-0.122	-0.605	1.710
Mar 17 2009	0.233	-13.051	-2.484	-0.027	-0.300	-1.528	1.528
Sep 20 2011	0.716	1.197	-2.645	0.041	-0.001	0.471	-0.269
Jun 19 2012	0.374	-0.288	-0.961	0.018	-0.012	0.084	-0.052
Sep 12 2012	0.384	0.608	2.112	0.016	0.062	-0.073	0.598
Dec 11 2012	0.229	-0.816	1.346	0.005	0.015	-0.212	0.384

Notes: Each row presents the announcement date discussed in Section 3.2 and the corresponding decomposed conventional, unconventional, and central bank information shock series, as well as high-frequency surprises measured around the specific announcement.

Figure 6: Impulse responses of variables with six lags



Notes: Responses to decomposed shocks that are normalized to induce a 100 basis point increase in the one- or ten-year rate at impact. The x-axis shows quarters after the shock, and the y-axis represents responses of variables in percentage points. Shaded areas are 68% posterior coverage bands. The number of lags is six.

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