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Monetary News Shocks

We pursue an empirical strategy to identify a monetary news shock in the U.S. economy. We use a monetary policy residual, along with other variables in a vector autoregression (VAR), and identify a monetary news shock as the linear combination of reduced-form innovations that is orthogonal to the current residual and that maximizes the sum of contributions to its forecast error variance over a finite horizon. Real GDP declines in a persistent manner after a positive monetary news shock. This contraction in economic activity is accompanied by a fall in inflation and a rapid increase in the nominal interest rate.

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Over at least the past 30 years there has been a significant effort in macroeconomics to identify the causal effects of monetary policy on economic activity by studying the impact of shocks to central bank rate decisions.[1] These shocks are interpreted as unanticipated or "surprise" deviations of a central bank's policy rate from that implied by a systematic policy rule. Yet, recent evidence suggests that at least some of these policy deviations may have not been surprises

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1. See Ramey (2016) for a detailed overview.

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after all (see, e.g., Gurkaynak, Sack, and Swanson 2005, Campbell et al. 2012, and Nakamura and Steinsson 2015). Rather, a portion of federal open market committee (FOMC) rate decisions appear to be anticipated by private agents in advance of the formal rate-setting meetings. While a handful of recent papers have examined the impact of anticipated components of rate changes on both asset markets and on economic activity, relatively little work has been done to identify anticipated shocks using the structural vector autoregression (SVAR) framework.

The main objective of our paper is to fill this gap. We identify anticipated monetary policy shocks, or monetary news shocks, and determine their effects on the U.S. economy during the Greenspan–Bernanke era of Federal Reserve Chairmanship. These shocks represent pure changes in expectations about the nonsystematic component of future monetary policy, orthogonal to nonsystematic policy in the present. Building on the news shocks view (Beaudry and Portier 2006), our approach is in the spirit of the empirical literature that provided a benchmark for evaluating the effects of surprise monetary policy shocks in theoretical New Keynesian models (e.g. Christiano, Eichenbaum, and Evans 1999).[2] We see our paper as a first step toward developing this empirical benchmark for monetary news shocks.

Our approach involves first constructing a monetary policy residual (MPR) that measures deviations from an estimated interest rate rule that tracks the observed federal funds rate well during 1988-2007.[3] Next, we propose a restriction to identify monetary news shocks using the maximum forecast error variance (MFEV) approach within the SVAR framework similar to Barsky and Sims (2011), Francis et al. (2014), and Ben Zeev and Khan (2015). We identify a monetary news shock as the linear combination of reduced-form innovations orthogonal to current policy residual that maximizes the sum of contributions to the policy residual's forecast error variance over a finite horizon. The information set that we consider includes credit spreads and interest rate futures in the VAR. In our baseline specification, we also impose orthogonality with respect to credit spreads to ensure that monetary news shocks are distinct from credit supply shocks, as measured by the excess bond premium variable from Gilchrist and Zakrajšek (2012).

A potential source of monetary news shocks is the practice of forward-guidance through which a central bank provides information about the future course of monetary policy via formal statements or releases (Rudebusch 2008, den Haan 2013, Svensson 2015). One of its forms—the "Odyssean" forward-guidance— which implies a commitment to a future action, is viewed as a type of a monetary news shock (Campbell et al. 2012). Yet, it need not be limited to that. Informal comments by policymakers to the media outside of regularly scheduled meetings, implicit communication implied by changes in the structure or membership of monetary policy

2. Other examples on identifying unanticipated monetary shocks include Bernanke and Mihov (1998), Romer and Romer (2004), and Barakchian and Crowe (2013).

3. The baseline sample start date is due to the availability of federal funds futures contract data from 1988. We choose 2007 as the sample end date to first establish results without the influence of a variety of considerations in the post-2007 data (such as the financial crisis and the Great Recession [2008–09], Quantitative Easing, and the zero-lower-bound).

operating committees, or public commentary by market observers all have the power to shape private agents' expectations about future monetary policy rate decisions. Our approach allows for all channels through which changes in expectations may arise, focusing on identifiable pure changes in expectations about nonsystematic policy themselves rather than changes in information that emerge through a particular channel.

Our main empirical findings are as follows. There is a persistent decline in output after a positive monetary news shock. This contractionary effect on economic activity builds up gradually, reaching its trough after eight quarters. The federal funds rate responds very little initially but then rises rapidly in subsequent periods, peaking after three quarters. The impact on inflation in the initial periods is muted, although there is a statistically significant fall in inflation that coincides with the trough in output. Interestingly, the responses of output and inflation are in line with conventional views of how monetary policy affects the economy. We find that excess bond premium rises significantly after a positive monetary news shock. This suggests imperfections in the financial markets play an important role in the transmission of monetary news shocks. Recently, Gertler and Karadi (2015) have documented that positive monetary surprise shocks increase excess bond premiums. Our findings highlight a key point that both types of monetary shocks are likely to have a common transmission mechanism operating through the financial markets.

Over a 1-year horizon, monetary news shocks account for about 39% of the forecast variance in the policy residual, indicating that monetary news shocks are strongly present in the data. These shocks account for 46% and 47% of the 1-year horizon forecast variance in federal funds futures and the federal funds rate, respectively. This suggests two things. First, that market participants' expectations about the stance of monetary policy are strongly affected by signals about future monetary policy. Second, that an important component of the Fed's determination of the interest rate is anticipated in advance. Monetary news shocks also account for about 12% of the forecast error variance in the excess bond premium. Over the same horizon, monetary news shocks account for less than 10% of the forecast variance in output and inflation, respectively, indicating that they play a relatively small role in short-run output and inflation fluctuations.

We conduct a variety of robustness checks. These include: (i) exploring alternative estimated policy rules, (ii) considering alternative orthogonalizations in the VAR, (iii) including the Great Recession period, (iv) investigating an alternative identification based on federal funds futures, (v) exploring relationships with other macro-economic shocks, and (v) varying the truncation horizon. In each case, we discuss whether the results remain robust or get modified.

In the remainder of the paper we proceed as follows. In Section 1, we present a literature review. In Section 2, we present our empirical methodology and identification approach. In Section 3, we present the baseline results and provide a discussion. In Section 4, we examine a battery of robustness checks. Section 5 concludes.

1. RELATED LITERATURE

Our work is related to Campbell et al. (2012) who identify forward guidance shocks at the quarterly data frequency. Like them, we also consider the MPR based on an interest rate rule as the starting point for identifying monetary news shocks. The identification approaches, however, are different. Campbell et al. (2012) use quarterly aggregates of Blue Chip forecasts and interest rate futures prices in an interest rate rule with two lags of the interest rates and measures of the unemployment gap and inflation. The MPR has both an unanticipated contemporaneous component and a forward guidance component that is anticipated by the public up to four quarters before the change in interest rate. The four quarter ahead forward guidance shock is constructed as a gap between two expectations: the four-period ahead expected interest rate minus the four-period ahead expected interest rate implied by the interest rate rule, given values of the parameters in the rule. They use a generalized method of moments (GMM) approach to estimate the parameters and regress various macroeconomic variables on their news shock series. They find that news shocks raise interest rates but also raise economic activity and inflation, which is inconsistent with conventional wisdom. Bruneau (2015) pursues a similar strategy as Campbell et al. (2012) and uses Survey of Professional Forecasters data to infer anticipated monetary shocks, via a Kalman Filtering estimation procedure, and examines their effect on durable consumption. Relatedly, Bundick (2015) and Hamilton, Pruitt, and Borger (2011), who similar to Campbell et al. (2012), estimate expectations about policy directly using the implied expectations from futures leads of a policy rule.

Recent event-studies or high-frequency approaches such as Gurkaynak, Sack, and Swanson (2005) have studied the effects changes in information that emerge specifically from FOMC meetings. Our approach complements this work by potentially capturing information communicated to private decision makers via other channels available to the FOMC as mentioned above.

Campbell et al. (2012) distinguish between Odyssean and Delphic central bank communications. The former implies public commitment to action whereas the latter does not. Calomiris (2010) has stressed the importance of forward guidance on the information provided to the public about the Federal Reserve's objectives and beliefs about the long-run natural rate of unemployment. Our approach allows for a general view of forward guidance without taking an explicit view on the level of commitment.

Finally, our work is also relevant for the recent literature that seeks to quantify the impact of forward guidance using dynamic stochastic general equilibrium (DSGE) structural models, including Laséen and Svensson (2011), Milani and Treadwell (2012), Ilbas and Wouters (2014), Harrison (2015), De Graeve (2014), Gavin et al. (2015), McKay, Nakamura, and Steinsson (2016), Gomes, Iskrev, and Mendicino (2017), Hirose and Kurozumi (2017), among others. As a way of capturing forward guidance in these models, this literature has typically included anticipated components to the exogenous (nonsystematic) portion of the policy rule. These anticipated components are modeled using exogenous news shocks in the spirit of the structural total factor productivity (TFP) news shock literature stemming from Beaudry and Portier (2006). Indeed, this approach has formed the basis for policy analysis of forward guidance within DSGE models.[4] A key contribution of our paper is to provide a benchmark for assessing whether the effects of monetary news shocks in DSGE models are consistent with their empirical counterparts.

2. EMPIRICAL METHODOLOGY

In this section, we present the empirical methodology to identify monetary news shocks. We first describe how we obtain the MPR and then present the identification strategy that uses the MFEV approach.

2.1 MPR

Consider a policy rule

$$i_t = g(\Omega_t) + \varepsilon_t, \tag{1}$$

where i_t is the nominal interest rate, Ω_t is the time t information set of the policymaker, $g(\Omega_t)$ is a function of the variables in the information set and denotes the unobserved systematic component of policy, and ε_t is a collection of both unanticipated and news shocks to the interest rate.

Specifically, ε_t is given as

$$\varepsilon_t = v_t + n_{t-j}, \tag{2}$$

where v_t denotes the unanticipated shock at time t, and n_{t-j} is a news shock received j periods in advance of period t but that impacts the interest rate process in period t. We define the MPR as

$$\widehat{MPR}_t = i_t - \widehat{g}(\Omega_t), \tag{3}$$

where $\widehat{g}(\Omega_t)$ is the estimated systematic part of the policy rule. We consider a linear and historical rule that approximates $g(\Omega_t)$ in (1) over the sample period with $\Omega_t = \{i_{t-1}, \pi_t, u_t\}$ given as

$$i_t = c + \rho_i i_{t-1} + \phi_\pi \pi_t + \phi_u u_t + MPR_t, \tag{4}$$

where π_t is the inflation rate, u_t is the unemployment rate, and $\widehat{MPR_t}$ is the residual, obtained after netting out the estimated historical policy rule (4) from the nominal interest rate, using time-series observations on i_t, π_t, and u_t. The baseline specification

4. See, for example, the "FRBNY DSGE Model" (Del Negro et al. 2013) and the "Chicago FED DSGE model" (Brave et al. 2012).

in (4) is similar to the parameterized monetary policy rule in Clark (2012). Campbell et al. (2012) also consider a policy rule with unemployment.

We use the instrumental variable (IV) approach to estimate (4) via GMM using four lags of the federal funds rate, inflation rate, and the unemployment rate as instruments.[5] The estimated policy rule is

$$i_t = \underset{(0.257)}{0.965^{***}} + \underset{(0.016)}{0.921^{***}} i_{t-1} + \underset{(0.050)}{0.197^{***}} \pi_t - \underset{(0.037)}{0.198^{***}} u_t + \widehat{MPR}_t, \tag{5}$$

with standard errors shown in brackets below the coefficient estimates.[6] From (19), we use $\widehat{MPR}_t$ as the baseline MPR in our analysis below. Panel (a) in Figure 1 shows a plot of i_t and the estimated policy rule (19) from 1989Q3 to 2007Q4. As is clear from the figure, this estimated policy rule tracks the federal funds rate quite closely for much of the sample. Panel (b) in Figure 1 shows $\widehat{MPR}_t$ over this same period, constructed as in (3) using (19). Evidently, the residual moves systematically in and out of recessions, reflecting the unanticipated and news shocks relative to the historical rule.

2.2 *Identifying Monetary News Shocks*

Our objective is to identify the empirical counterpart of the monetary news shocks that have been considered in the recent DSGE literature. We wish to do this within the framework of VARs that has been traditionally used to identify unanticipated monetary shocks. Based on the discussion in the previous section, we can write

$$MPR_t \approx v_t + n_{t-j}. \tag{6}$$

Equation (6) then shows the basis of our identifying assumption that MPR_t is well approximated as a stochastic process-driven unanticipated and news shocks.

The motivation behind our identifying assumption is twofold. First, the identified shock should be a "news" shock. That is, uncorrelated with contemporaneous "surprise" innovation in the policy residual. Second, the identification should isolate a shock that best explains future policy deviation. The MFEV approach discussed in Section 2.3 is particularly useful for this purpose. It allows us to determine the shock that explains the maximum variation in the policy residual over a typical policy-relevant horizon of a year to 2 years. Our proposed identification meets these two criteria.

We use a VAR-based procedure using quarterly time series on $\widehat{MPR}$, the Federal Funds Rate (*FF*), the 6 months out expected interest rate from the Federal Funds Rate futures index (*FFF*), CPI inflation (*CPI*), the natural log of real GDP per capita (Y),

5. The data were obtained from FRED Database at the Federal Reserve Bank of St. Louis. The effective federal funds (FF) rate is a quarterly average of the monthly series. The inflation rate is measured as annualized percentage of the growth in the GDP deflator (`GDPDEF`). The unemployment rate is the quarterly average of the monthly civilian unemployment rate (`URATE`).

6. The symbols ***, **, * denoting statistically significant at the 1%, 5%, and 10% levels, respectively.

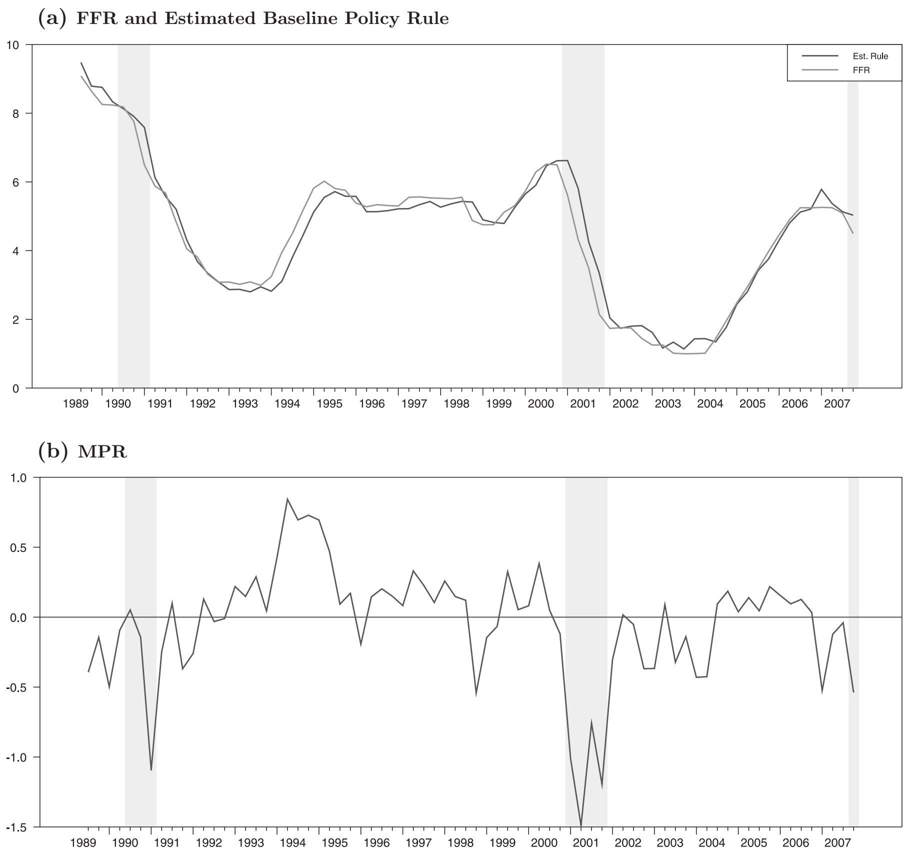


FIG. 1. Federal Funds Rate (FFR), Estimated Baseline Policy Rule and the Monetary Policy Residual (MPR).

and the credit spread measure constructed by Gilchrist and Zakrajšek (2012). The estimation period for this baseline specification is 1988Q4–2007Q4.[7]

We include two forward-looking variables in the VAR, namely, *FFF*, and the credit spread index. First, the *FFF* is a contract for the average daily FF rate during the particular month of the contract (in our case, 6 months in the future). We include these futures data to exploit its forward-looking nature to capture variation due to changes in expectations about future monetary policy, much in the same way that the original news shock literature such as Beaudry and Portier (2006) used stock prices to capture unobserved changes in expectations about future productivity.

7. As noted in the introduction, we exclude the Great Recession period given its uniqueness and a variety of considerations. Campbell et al. (2012) similarly exclude the Great Recession period from their sample. Later in the paper, we investigate robustness to including the Great Recession period.

Second, any empirical analysis that deals with the recent credit-supply–driven period requires the inclusion of an appropriate measure of the credit spread so as to be able to ensure that credit supply shocks are not driving the results. Gilchrist and Zakrajšek (2012) use microlevel data to construct a credit spread index, which they decomposed into a component that captures firm-specific information on expected defaults and a residual component that they termed as the excess bond premium (*EBP*).[8] We use their *EBP* series as the measure of credit spread and interpret VAR innovations in this series as credit supply shocks.

2.3 *Methodology*

Let $y_t = [EBP_t \;\; \widehat{MPR}_t \;\; FF_t \;\; 100 - FFF_t \;\; \Delta\log(CPI_t) \;\; \log(Y_t)]'$ be a 6×1 vector of observables.[9] Let the VAR in the observables be given by

$$y_t = F_1 y_{t-1} + F_2 y_{t-2} + \cdots + F_p y_{t-p} + F_c + e_t, \tag{7}$$

where F_i are 6×6 matrices, p denotes the number of lags, F_c is a 6×1 vector of constants, and e_t is the 6×1 vector of reduced-form innovations with variance–covariance matrix Σ. The reduced-form moving average representation in the levels of the observables is

$$y_t = B(L)e_t, \tag{8}$$

where $B(L)$ is a 6×6 matrix polynomial in the lag operator, L, of moving average coefficients and e_t is the 6×1 vector of reduced-form innovations. We assume that there exists a linear mapping between the reduced-form innovations and structural shocks, ε_t, given as

$$e_t = A\varepsilon_t. \tag{9}$$

Equations (8) and (9) imply a structural moving average representation

$$y_t = C(L)\varepsilon_t, \tag{10}$$

where $C(L) = B(L)A$ and $\varepsilon_t = A^{-1}e_t$. The dependence of the MPR_t on n_{t-j} (a lagged shock) as shown in (6) is incorporated via restrictions on $C(L)$ as explained below. The impact matrix A must satisfy $AA' = \Sigma$. There are, however, an infinite number of impact matrices that solve the system. In particular, for some arbitrary orthogonalization, $\widetilde{A}$ (we choose the convenient Choleski decomposition), the entire space of permissible impact matrices can be written as $\widetilde{A}D$, where D is a 6×6 orthonormal matrix ($D' = D^{-1}$ and $DD' = I$, where I is the identity matrix).

8. Gilchrist and Zakrajšek (2012) showed that their spread measure has better predicative power for macro-economic variables than more standard credit spread measures such as the Baa-Aaa Moody's bond spread.

9. Note that subtracting the federal funds rate futures index value from 100 yields the 6 months out level of the expected interest rate.

The h step ahead forecast error is

$$y_{t+h} - E_t y_{t+h} = \sum_{\tau=0}^{h} B_\tau \widetilde{A} D \varepsilon_{t+h-\tau}, \tag{11}$$

where B_τ is the matrix of moving average coefficients at horizon τ. The contribution to the forecast error variance of variable i attributable to structural shock j at horizon h is then given as

$$\Omega_{i,j} = \sum_{\tau=0}^{h} B_{i,\tau} \widetilde{A} \gamma \gamma' \widetilde{A}' B'_{i,\tau}, \tag{12}$$

where γ is the jth column of D, $\widetilde{A}\gamma$ is a 6×1 vector corresponding with the jth column of a possible orthogonalization, and $B_{i,\tau}$ represents the ith row of the matrix of moving average coefficients at horizon τ. We index the unanticipated *EBP* and *MPR* shocks as 1 and 2, and the monetary news shock as 3 in the ε_t vector. Monetary news shocks identification requires finding the γ, which maximizes the sum of contribution to the forecast error variance of *MPR* over a range of horizons, from 0 to H (the truncation horizon), subject to the restriction that these shocks have no contemporaneous effect on $\widehat{MPR}_t$. Formally, this identification strategy requires solving the following optimization problem

$$\gamma^* = \operatorname{argmax} \sum_{h=0}^{H} \Omega_{2,3}(h) = \operatorname{argmax} \sum_{h=0}^{H} \sum_{\tau=0}^{h} B_{2,\tau} \widetilde{A} \gamma \gamma' \widetilde{A}' B'_{2,\tau} \tag{13}$$

$$\text{subject to} \quad \widetilde{A}(1, j) = 0 \quad \forall j > 1 \tag{14}$$

$$\widetilde{A}(2, j) = 0 \quad \forall j > 2 \tag{15}$$

$$\gamma(1, 1) = 0 \tag{16}$$

$$\gamma(2, 1) = 0 \tag{17}$$

$$\gamma' \gamma = 1. \tag{18}$$

The first four constraints impose on the identified news shock to have no contemporaneous effect on *EBP* and $\widehat{MPR}_t$. That is, our news shocks is orthogonal to both unanticipated credit supply shocks as well as unanticipated monetary policy shocks. The fifth restriction that imposes on γ to have unit length ensures that γ is a column vector belonging to an orthonormal matrix. This normalization implies that the identified shocks have unit variance.

We follow the conventional Bayesian approach to estimation and inference by assuming a diffuse normal-inverse Wishart prior distribution for the reduced-form

VAR parameters. Specifically, we take 2,000 draws from the posterior distribution of reduced-form VAR parameters $p(F, \Sigma \mid data)$, where for each draw we solve optimization problem (13); we then use the resulting optimizing γ vector to compute impulse responses to the identified shock.[10] This procedure generates 2,000 sets of impulse responses that comprise the posterior distribution of impulse responses to our identified shock.

Our baseline choice for the truncation horizon is $H = 5$, a horizon that generally corresponds to an operative period of monetary policy of less than 2 years in the future. We examine the sensitivity of our identification to changes in this horizon length in Section 4. The number of lags we use in the VAR is 5, which is a middle value between the optimal lag length of 9 from the Akaike and Hannan–Quinn information criteria and optimal lag length of one from the Schwarz information criterion, and it serves as a sufficiently large lag length for avoiding serial correlation in the VAR residuals.[11]

2.4 Merits of the MFEV Approach

In this section, we highlight two advantages of the MFEV approach described above. First, the MFEV approach is superior to imposing an orthogonalization restriction alone. One may argue, for example, to undertake an approach analogous that of Beaudry and Portier (2006), who identify TFP news shocks as innovations in stock prices orthogonalized with respect to TFP. In our setting, this would entail identifying monetary news shocks as innovations in *FFF* orthogonalized with respect to $\widehat{MPR}_t$. While such a restriction would partition out the impact of the unanticipated monetary shock ε_t^0, nothing assures us that monetary news shocks are the only shock not affecting $\widehat{MPR}_t$ on impact and affecting the *FFF*. For example, consider a persistent demand shock, such as an expansionary preference shock. In this case, output rises in the present and future, and consistent with the monetary policy rule, the FED systematically raises rates in the present. Moreover, agents expect the FED to systematically raise rates in the future, causing *FFF* to rise in the present. Since such a scenario involves an innovation to *FFF* in the present but no change in the policy residual in the present, the Beaudry and Portier (2006) approach would capture such a shock, despite that it involves no policy deviation in the future. Instead, to correctly identify our anticipated monetary deviations and exclude shocks such as the above, we require a method that not only orthogonalizes the news shock with respect to contemporaneous policy deviations, but also isolates shocks that best explain future policy deviations.

Second, the MFEV identification approach is little affected in the presence of measurement errors. If the $\widehat{MPR}_t$, for example, inherits a measurement error from

10. Note that F here represents the stacked $(6 \times (p+1)) \times 6$ reduced-form VAR coefficient matrix, that is, $F = [F_1, \ldots, F_p, F_c]'$.

11. We have confirmed the robustness of our results to different VAR lag specifications. These results are available upon request from the authors.

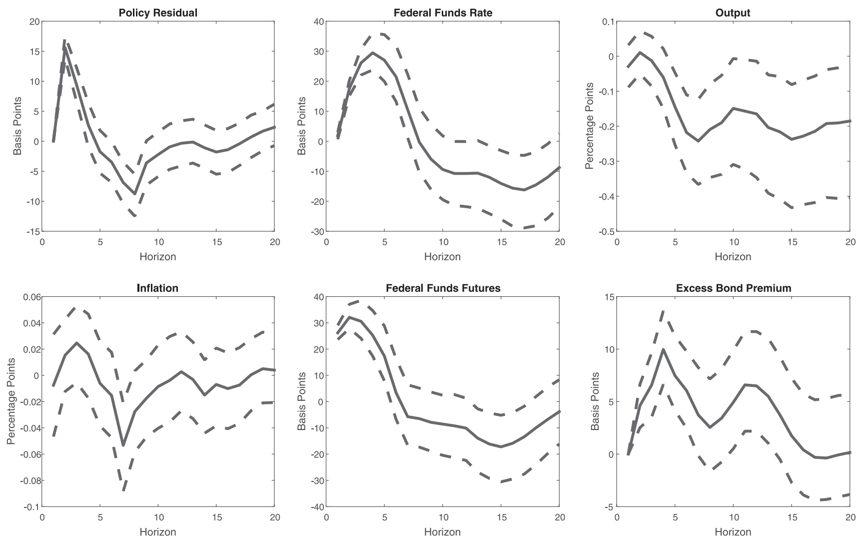


Fig. 2. Impulse Responses to a Monetary News Shock.

Notes: This figure shows the median and 16th and 84th posterior percentiles of the impulse responses to the monetary news shock from the VAR using the monetary policy residuals obtained from the estimated baseline policy rule (19).

unemployment and inflation, this would hurt the identification of the surprise shock (which is not the objective of this paper) but not the news shock. More generally, any other economic shock that affects *FFR* on impact and is not being fully reflected by our specification of the rule, would reduce the precision of the surprise shock identification but not that of the news shock (or at least to a much lesser extent). Taken together, the results from Ben Zeev and Pappa (2015) and Ben Zeev and Pappa (2017) provide formal support for this point. The former paper shows that the presence of measurement errors invalidates the identification of surprise defense shocks while the latter provides evidence consistent with MFEV-based identification of defense news shocks being robust to measurement errors.

3. RESULTS

In this section, we present the main results of the paper using the impulse response functions and the forecast error variance decompositions of the identified monetary news shocks.

3.1 Impulse Response Functions

The solid line in Figure 2 shows the median of the posterior distribution of impulse responses to a positive one standard deviation monetary news shock (i.e., an anticipated tightening of policy). The dotted lines are the 84th and 16th percentiles of the posterior distribution.

Following a positive monetary news shock there is an immediate and persistent decline in output, reaching its trough after six quarters. The impact on inflation begins to be negative after 1 year becoming statistically significant after six and seven quarters, that is, the significant drop in inflation coincides with the trough in the response of output.[12]

The policy residual does not change in the initial period by construction because of the orthogonality restriction. It rises quickly, however, in subsequent periods, peaking after one quarter. The *FFR* that is left unrestricted, changes very little initially, and then peaks after three quarters. The fact that the *FFR* does not move in the initial period when the policy residual also does not move shows that there is no significant systematic effect of monetary policy in the initial period. The *FFF* rises immediately, consistent with the eventual rise in the federal funds rate itself. Finally, the excess bond premium does not move on impact by construction, after which it significantly rises reaching a peak after three quarters. One can interpret this response in terms of a financial accelerator mechanism that takes place in response to the contraction in the economy. Thus, financial market imperfections play an important role in the transmission of monetary news shocks.

One caveat is that the impulse responses of output and inflation are imprecisely estimated over the short horizon. Only after a few quarters, we observe significant effects (between 5 and 10 quarters). We do not think that the imprecision is driven by the fact that the shocks are news shocks *per se* or related to the MFEV approach itself. For example, using a longer sample period of (47 years), Barsky and Sims (2011) find significant effects of news on output on impact (their figure 4). One source that may be the main contributor to this imprecision over the short horizon is the small sample size (19 years).

3.2 Forecast Error Variance Decompositions

Figure 3 shows the median forecast error variance decompositions along with the 68% posterior probability bands. Over a 1 year horizon, monetary news shocks account for 39% of the forecast variance in the policy residual, indicating that monetary news shocks are strongly present in the data. These shocks account for 46% and 47% of the forecast variance in federal funds futures and the federal funds rate over a 1 year horizon. This suggests two things. First, market participants' expectations about the stance of monetary policy are strongly affected by signals about future monetary policy. Second, an important component of the Fed's determination of the

12. Although our focus is not on identifying monetary surprise shocks, we did check to see the impulse responses of these shocks. Inflation decreases immediately upon impact, whereas output initially increases significantly, and then gradually falls albeit insignificantly. While there is clear contrast between the responses to the two shocks, such a discrepancy is not at odds with the literature on news shocks (both technology and defense shocks), which generally found quite dissimilar impulse responses to surprise and news shocks. The impulse responses are available upon request.

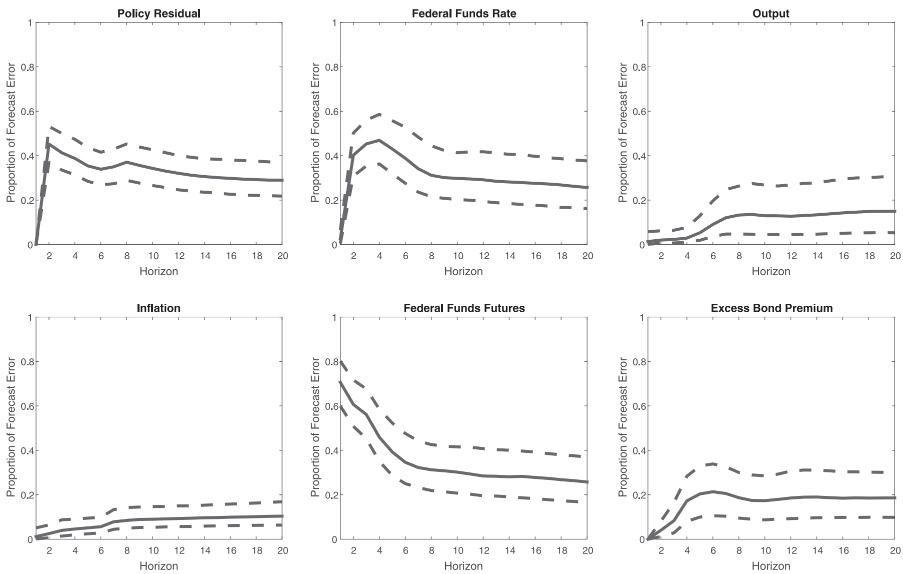


FIG. 3. Forecast Error Variance Decomposition of Monetary News Shocks.

NOTES: This figure shows the median and 16th and 84th posterior percentiles of the contributions of the monetary news shock to the forecast error variance of the variables from the VAR using the monetary policy residuals obtained from the estimated baseline policy rule (19).

interest rate is anticipated.[13] Monetary news shocks account for less than 10% of the forecast variance in output and inflation, respectively, indicating that they play a relatively small role in short-run fluctuations in these variables. Interestingly, our empirical findings on variance decompositions of output and interest rates are similar to those reported in Campbell, Fisher, and Justiniano (2012) and Hirose and Kurozumi (2017) that are based on an estimated DSGE model, and for slightly different time periods. Campbell, Fisher, and Justiniano (2012) find that monetary news shocks account for 9% of the forecast variance of output during 1989–2008. Similarly, Hirose and Kurozumi (2017) also find that anticipated monetary shock contributed 18.2% to the forecast variance of output during 1987–99 period and 14.6% in the 1999–2008 period.

3.3 Relation with Other Monetary Shocks

We assess whether our monetary news shock is related to the monetary shocks identified in the literature. We report the cross-correlations of our recovered shock series with the unanticipated monetary shocks identified in Bernanke and Mihov (1998), Christiano, Eichenbaum, and Evans (1999), Romer and Romer (2004), Sims

13. Our news shocks explain 71% of the contemporaneous variation in the futures index, stressing that market participants react to new information imminently.

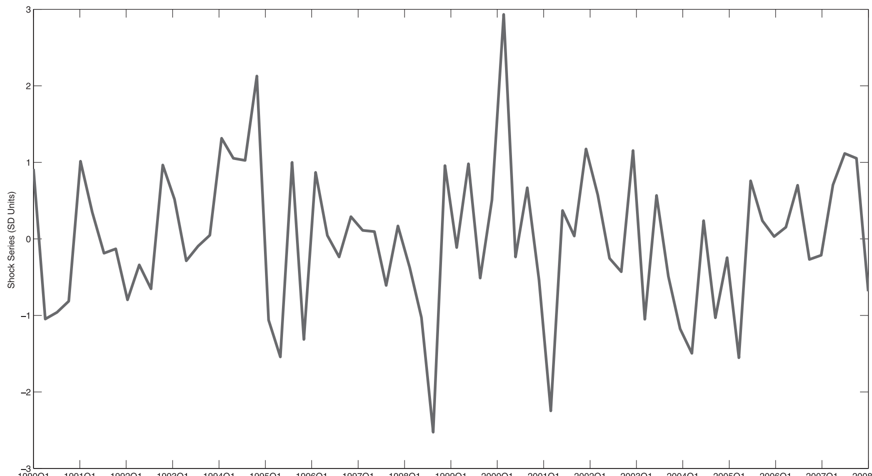


FIG. 4. Monetary News Shock Series from the Baseline VAR.

NOTES: This figure presents the estimated median shock series from the baseline model. The shock series are in terms of standard deviation units.

and Zha (2006), and Barakchian and Crowe (2013), and the monetary news shocks identified in Campbell et al. (2012). All unanticipated monetary shock series were taken from the data appendix file of Barakchian and Crowe (2013), which contains updated versions of these shock series that cover the sample period 1989Q4–2007Q4, apart from the Bernanke and Mihov (1998) series, which starts in 1990Q1. The monetary news shock of Campbell et al. (2012) covers the sample period of 1996Q1–2007Q2.[14] Figure 4 shows the estimated news shocks series.

Figure 5 shows the median and 16th and 84th percentiles of the cross-correlations between monetary news shocks and all the other monetary shocks. The contemporaneous correlation is negligible in nearly all the cases indicating that monetary news shocks are distinct from unanticipated monetary shocks. However, a key property of our monetary news shocks stands out—that it strongly leads all of the considered monetary shocks, including the news shock from Campbell et al. (2012). VARs that produced unanticipated monetary shocks had insufficient information relative to ours, thereby resulting in identified shocks that are effectively a combination of both the true unanticipated monetary shock as well as lags of monetary news shocks. This point is consistent with the work of Milani and Treadwell (2012) based on a DSGE model. Using a Monte Carlo exercise, Milani and Treadwell (2012) show that if the data are generated by a model in which monetary policy news shocks are important, then conventional VAR-based monetary policy shock identification will tend to mistakenly attribute monetary policy news shocks to their identified surprise shock.

14. We thank Christopher Crowe for kindly sharing the data from Barakchian and Crowe (2013) and Jonas Fisher for sharing the news shocks from Campbell et al. (2012).

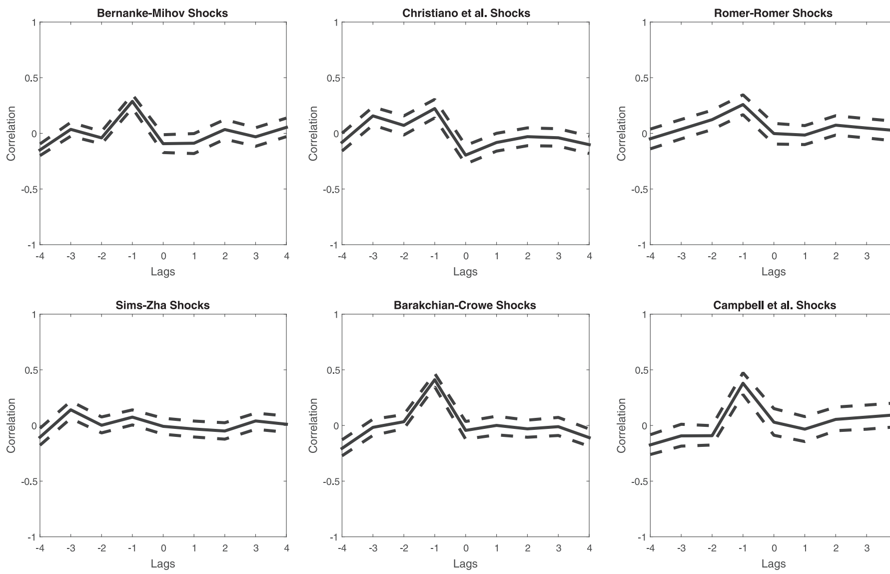


FIG. 5. Cross-Correlations of Monetary News Shock with Other Monetary Shocks.

NOTES: The MPR is based on equation (19). The solid line is the median cross-correlation and the dashed lines are the 84th and 16th percentiles of the posterior distribution of cross-correlations. The other shocks are the unanticipated monetary shocks identified in Bernanke and Mihov (1998), Christiano, Eichenbaum, and Evans (1999), Romer and Romer (2004), Sims and Zha (2006), and Barakchian and Crowe (2013), and the monetary news shocks identified in Campbell et al. (2012). The *x*-axis gives the lags/leads of the MFEV monetary news shock for which the correlation with the other shocks is computed.

Similarly, our monetary news shock significantly leads the Campbell et al. (2012) shock (37% one-lagged correlation) due to the larger information set we use. The information set in Campbell et al. (2012) consists of the observables in their Taylor rule (unemployment, inflation, and the federal funds rate), whereas ours contains additional informationally important variables like credit spreads and the federal funds rate futures index.

3.4 Narrative Interpretations of Monetary News Shocks

It is important to note that some of the large realizations of our shock series shown in Figure 4 are consistent with the large realizations of the news shocks series of Campbell et al. (2012) and hence their narrative interpretation can also be applied here. Specifically, we obtain a very large realization of two standard deviations in 1994:Q4 (the second largest positive realization in our sample); as discussed in Campbell et al. (2012), this could reflect new information transmitted to the public by the congressional testimony by Greenspan on December 7, which was interpreted by *The New York Times* the following day as "..an unusually clear signal that the Federal Reserve will continue raising interest rates . . . "

Moreover, we also obtain two large negative realizations in the first and second quarters of 1995 of −1.5 and −1.6 standard deviations, respectively. The first of these can be explained by Greenspan's testimony before the Senate Banking Committee on February which the *Wall Street Journal* reported the following day as follows: "Mr. Greenspan warned that inflation may still be a threat but added that the Fed might not raise interest rates again even if inflation starts to rise again . . . " The second realization of 1995:Q2 can be potentially attributed to the June 20 Greenspan speech at the Economic Club of New York, in which he stressed that the price stability mandate will be the dominant consideration in the subsequent FOMC meeting and that he felt that inflationary pressures were easing.[15]

4. ROBUSTNESS

We now explore the robustness of our results along a variety of dimensions. Each exercise is motivated by a specific aspect of the assumptions behind the baseline methodology.

4.1 Excluding FFR from the VAR

One concern with our baseline VAR specification may be that since MPR is a component of FFR, including both in the VAR may confound the effects of monetary news shocks. To address this, we could proceed in two ways. First is to put the systematic part of the rule in the VAR instead of FFR, ordering it after the MPR. Second is to simply drop FFR from the VAR. Since our primary focus is to study output and inflation responses, we adopt the second way. Figure 6 presents the results for this case. The impulse responses of output and inflation remain consistent with the baseline case (Figure 2).

4.2 Excluding EBP from the VAR

The baseline monetary news shocks are orthogonalized with respect to EBP to ensure that these shocks are not capturing credit supply shocks (Gilchrist and Zakrajšek 2012). However, the contribution of credit supply shocks to U.S. macro-economic variables during our estimation period remains a matter of debate. Dell'Ariccia, Igan, and Laeven (2012), for example, have emphasized the role of credit demand factors in studying the U.S. subprime mortgage crisis. In light of this debate, we check the

15. Since the *MPR* can be viewed as an unexpected shift in the average preferences of policymakers as measured by the weight they place on the importance of inflation relative to output fluctuations (see Christiano, Eichenbaum, and Evans 1999), this Greenspan speech can be interpreted as providing new information that the FOMC will be putting a larger than average weight on inflation in the near future. This implies an excessively expansionary monetary policy news shock given that inflationary pressures were easing. We emphasize that the two possible qualitative interpretations that we provide here are both examples of informal communications made through channels outside of formal FOMC meetings. That is, they do not constitute the formal notion of forward-guidance statements provided during FOMC meetings.

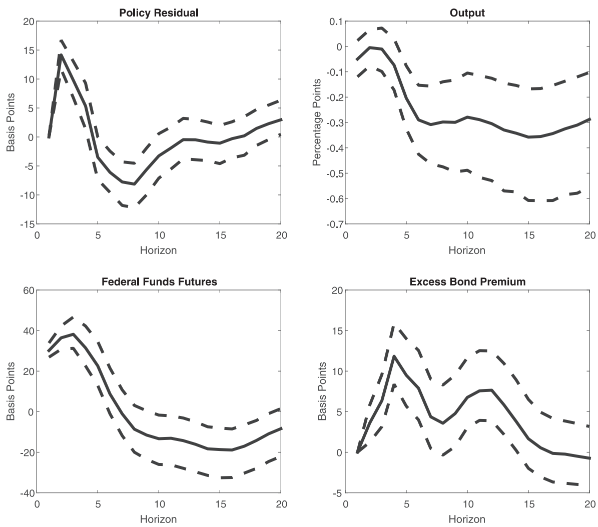


Fig. 6. No FFR in the VAR.

Notes: This figure shows the median and 16th and 84th posterior percentiles of the impulse responses to the monetary news shock obtained as the VAR innovation in the monetary policy residual orthogonalized with respect to EBP. FFR is excluded from the baseline VAR.

results by excluding EBP from the VAR. Figure 7 presents the results, which indicate that output no longer falls in response to the monetary news shock.

The correlation between the monetary news shock from this VAR and the credit supply shock from the baseline VAR is −0.27. This significantly negative correlation indicates that excluding EBP from the VAR, and thus not orthogonalizing our news shock with respect to credit supply shocks, results in our partly picking up the latter shocks. And since positive (i.e., contractionary) monetary news shocks are correlated with negative (i.e., expansionary) credit supply shocks, the negative output response that occurs in the baseline case gets effectively eliminated when EBP is excluded from the VAR.

4.3 Not Orthogonalizing MPR with Respect to Current EBP

Figure 8 shows results from the case where EBP is ordered second in the VAR and hence also leading to an identification that does not orthogonalize the news shock with respect to credit supply shocks. We observe here too an insignificant response of output. In this case the correlation between the monetary news shock and the credit supply shock is −0.63, again stressing the importance of eliminating this correlation for properly identifying the monetary news shock. Notably, also consistent with this point is the strong decline of EBP on impact, which, taken together with the aforementioned negative correlation, suggests that not orthogonalizing with respect to current EBP is likely to undermine the identification.

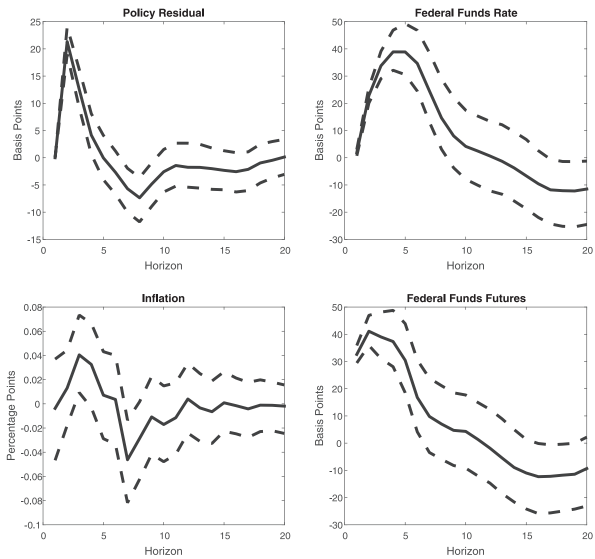


FIG. 7. No EBP in the VAR.

NOTES: This figure shows the median and 16th and 84th posterior percentiles of the impulse responses to the monetary news shock obtained after excluding EBP from the VAR.

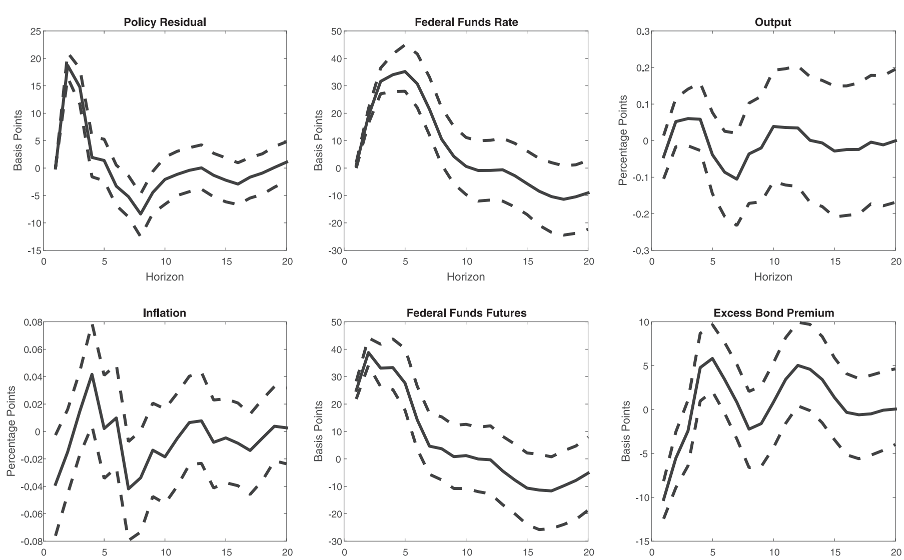


FIG. 8. Without Orthogonalizing MPR with EBP in the VAR.

NOTES: This figure shows the median and 16th and 84th posterior percentiles of the impulse responses to the monetary news shock obtained from estimating the VAR with EBP ordered after MPR.

In sum, the results from Figures 7 and 8 emphasize the significant added value from including EBP in the VAR in the way that we have opted to in the baseline case. Specifically, it ensures that our identification is not confounded by favorable credit supply shocks, thus strengthening the case for structurally interpreting our identified shocks as monetary news shocks.[16]

4.4 *Instrument Set Validity*

Although we use the standard IV approach to estimate (19) with four lags of the instrument variables, it is possible, for example, current unemployment u_t contains a response to the monetary news shock n_{t-j} if news shocks have an effect on the economy, so u_t and n_{t-j} will be correlated.[17] Thus, in the context of news shocks, the instrument validity issue will remain even if we use the standard approach of estimating the policy rule with four lags of the rule determinants as instruments. To address it, we consider a robustness check with instruments lagged $j \geq 4$, given our truncation assumption. Specifically, we use the 4th and the 5th lagged instruments and reestimate (19) as:

$$i_t = \underset{(0.338)}{0.903^{***}} + \underset{(0.024)}{0.893^{***}} i_{t-1} + \underset{(0.076)}{0.081} \pi_t - \underset{(0.055)}{0.116^{**}} u_t + \widehat{MPR}_t, \tag{19}$$

Figure 9 presents the results. There are no noticeable differences relative to the baseline in Figure 2, with both output and inflation significantly falling in similar fashion to the baseline case.

4.5 *Alternative Policy Rule Specifications*

In this exercise, we explore how alternative specifications of the monetary policy rule may affect the measurement of $\widehat{MPR}_t$, and hence the identified monetary news shocks. We adopt the the policy rule specification from Coibion and Gorodnichenko (2011), which includes two lags of the interest rate, output growth (ΔY), and the output gap. Using the Congressional Budget Office's (CBO) output gap measure denoted as Y^{cbo}, along with other variables, we estimate the contemporaneous and forecast-based policy rules via ordinary least squares (OLS). In the latter specification, we simply use the one period ahead actual values. The estimated rules are as follows:

$$i_t = \underset{(0.217)}{0.125} + \underset{(0.113)}{1.243^{***}} i_{t-1} - \underset{(0.104)}{0.331^{***}} i_{t-2} + \underset{0.056}{0.136^{**}} \pi_t + \underset{(10.110)}{3.519} \Delta Y_t$$

16. Notably, the underlying assumption behind our EBP orthogonalization restriction is that the only shock that moves EBP on impact is the credit supply shocks while other shocks can freely move it afterward. This assumption is reasonable given that Gilchrist and Zakrajšek (2012) constructed their EBP series by purging their credit spread series of any endogenous contemporaneous movements in firms' default risk. Hence, while shocks to the pricing of default risk (i.e., credit supply shocks) can be reasonably assumed to be the only shocks moving EBP on impact, other macroshocks can still affect the risk of default in the economy with a delay and thus play a role in driving the delayed movement in EBP.

17. We thank the anonymous referee for this point.

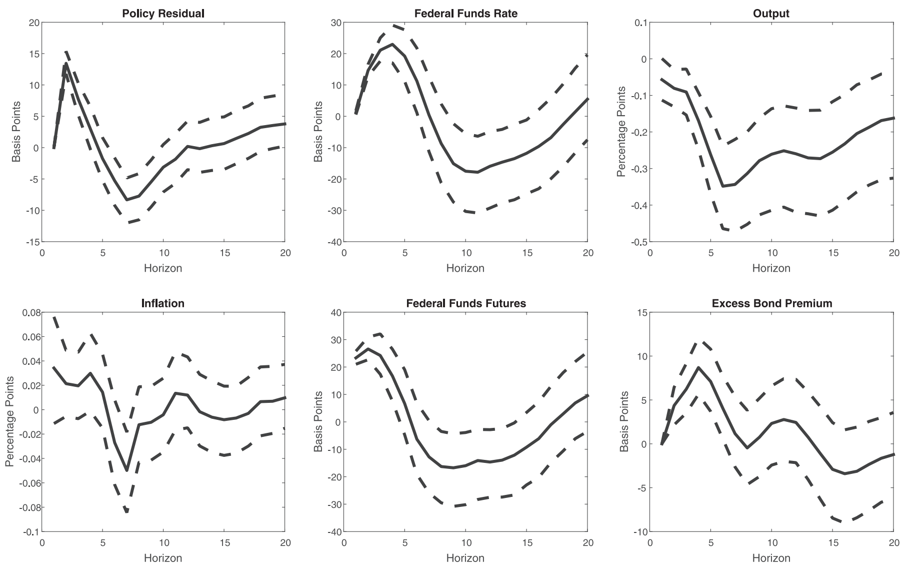


FIG. 9. Instrument Validity Issue in Estimating the Policy Rule.

NOTES: This figure shows the median and 16th and 84th posterior percentiles of the impulse responses to the monetary news shock obtained as the VAR innovation in the monetary policy residual orthogonalized with respect to EBP. The MPR is constructed using $j \geq 4$ lagged instruments (the 4th and the 5th lag are used) in estimating (19).

$$+ \underset{(0.010)}{0.025^{**}} Y_t^{cbo} + \widehat{MPR}_t$$

$$i_t = \underset{(0.218)}{-0.004} + \underset{(0.114)}{1.265^{***}} i_{t-1} \underset{(0.107)}{0.331^{***}} i_{t-2} + \underset{(0.053)}{0.109^{**}} \pi_{t+1} - \underset{(10.147)}{17.879^{*}} \Delta Y_{t+1}$$

$$+ \underset{(0.009)}{0.026^{***}} Y_{t+1}^{cbo} + \widehat{MPR}_t$$

with heteroscedasticity-consistent (Eicker-White) standard errors shown in brackets below the coefficient estimates. We estimate these policy rule specifications via OLS for two reasons. First, Coibion and Gorodnichenko (2011) have pointed out that OLS turns out to be adequate relative to the IV approach with very similar results, suggesting that the exogeneity assumption is likely to be satisfied.[18] Second, more recently, Carvalho, Nechio, and Tristao (2018) have shown that the endogeneity bias in OLS estimator is small as since monetary shocks account for a small fraction in the variables typically included in the policy rule, and that the OLS estimator can be superior to IV in small samples.

Figures 11(a) and 11(b) present the results for these alternative measures of $\widehat{MPR}_t$. The similarity with the baseline responses of inflation and output is evident when we look at a response of inflation and output between the 5- to 10-quarter horizon.

18. See footnote 17 in Coibion and Gorodnichenko (2011).

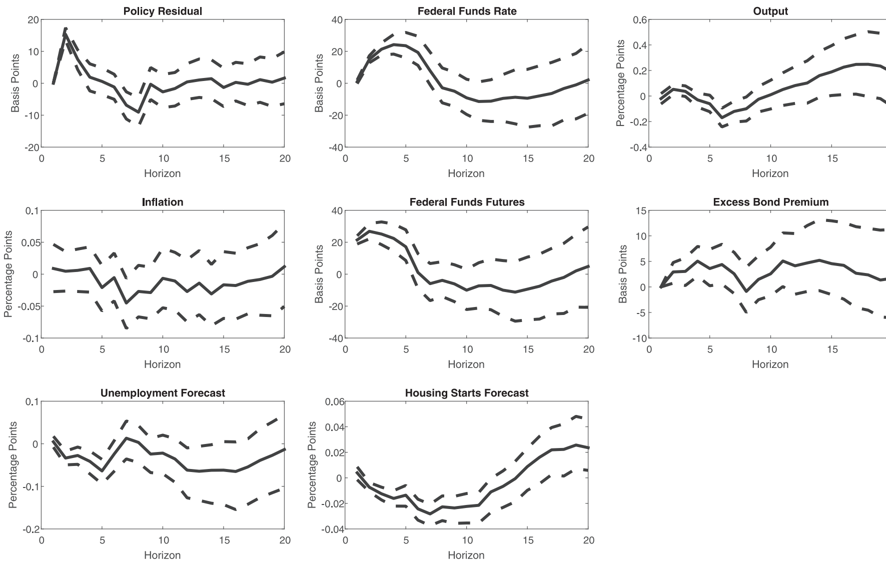


FIG. 10. Additional Forward-Looking Variables in the VAR

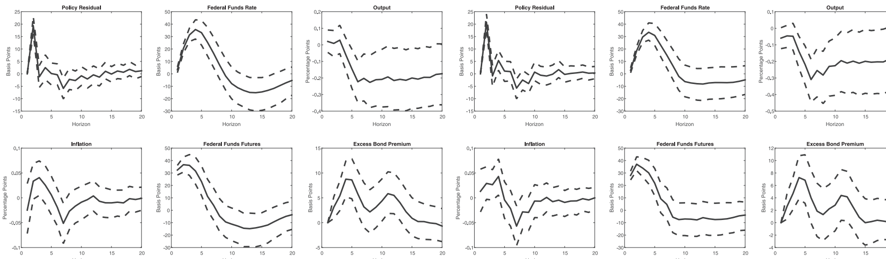
NOTES: This figure shows the median and 16th and 84th posterior percentiles of the impulse responses to the monetary news shock obtained as the VAR innovation in the monetary policy residual orthogonalized with respect to EBP. FOMC's unemployment forecasts and SPF's housing starts forecasts are included in the VAR.

While the initial response of output resembles the baseline, the main difference is with the initial response of inflation. For these alternative measures, inflation tends to increase initially. Thus, the sensitivity to alternative measures of $\widehat{MPR_t}$ occurs mainly on the very short-term effects of monetary news shocks on inflation.

4.6 Additional Forward-Looking Variables in the VAR

To explore whether including additional forward-looking variables in the VAR helps with the identification of monetary news shocks, we consider forecasts of the economy by policymakers, in particular those of FOMC.[19] Information contained in such forecasts may provide signals on policymakers plans to deviate from the usual monetary policy behavior. We include the six-quarter ahead FOMC unemployment forecasts. In addition, we also consider another popular forward-looking variable, namely, housing starts forecast from the Survey of Professional Forecasters in the VAR. Figure 10 shows the results. Output gradually declines and reaches a trough after six quarters, which is statistically significant. The confidence bands are certainly tighter around the output response. Moreover, inflation declines significantly roughly in tandem with the trough in the output response.

19. We thank David Romer for making the FOMC forecasts data available on his website.



(a) contemporaneous rule. (b) forecast-based rule.

FIG. 11. Alternative Monetary Policy Rule Specifications: (a) Current Output Gap; (b) Forecasts-Based Rule.

NOTES: Panel (a): This figure shows the median and 16th and 84th posterior percentiles of the impulse responses to the monetary news shock obtained as the VAR innovation in the MPR orthogonalized with respect to EBP. MPR is based on Coibion and Gorodnichenko (2011) specification with contemporaneous activity measures. Panel (b): This figure shows the median and 16th and 84th posterior percentiles of the impulse responses to the monetary news shock obtained as the VAR innovation in the MPR orthogonalized with respect to EBP. MPR is based on Coibion and Gorodnichenko (2011) specification with forecast-based activity measures.

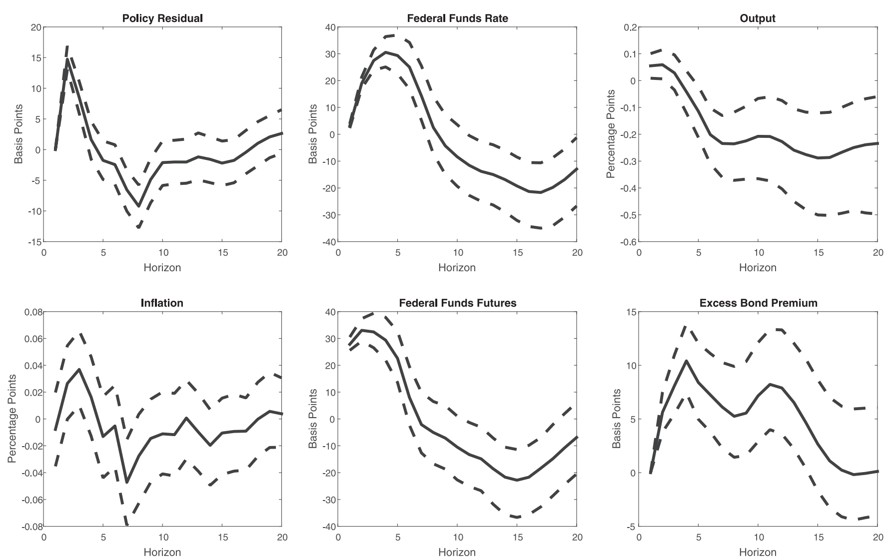


FIG. 12. An Alternative Identification Approach.

NOTES: This figure shows the median and 16th and 84th posterior percentiles of the impulse responses to the monetary news shock obtained as the VAR innovation in the federal funds futures rate orthogonalized with respect to EBP and MPR.

4.7 An Alternative Identification Approach Based on the Federal Funds Futures

We consider an alternative identification approach that relies on the federal funds futures rate. Specifically, we label the monetary news shock as one that is orthogonal to *EBP* and $\widehat{MPR}_t$. Figure 12 presents the impulse responses. Notably, output now

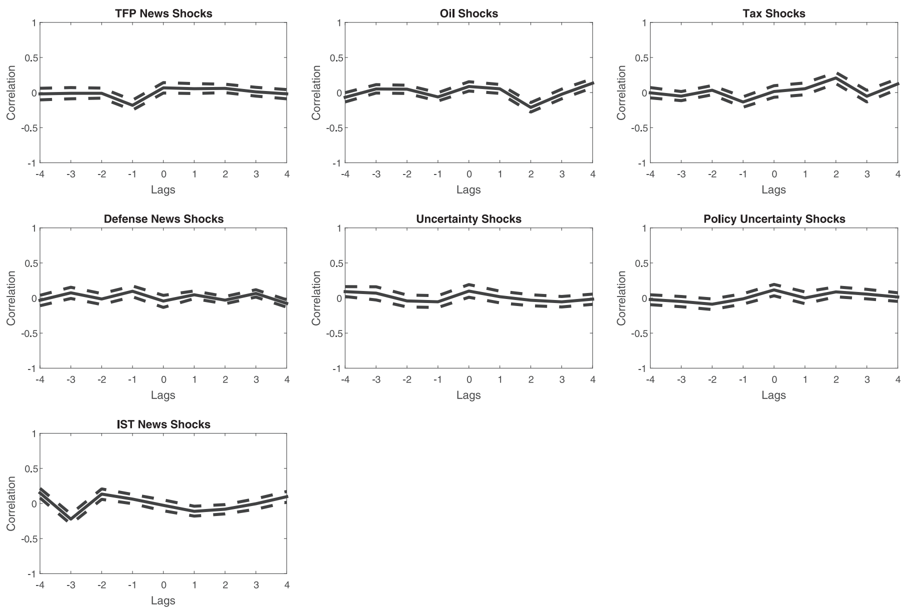


FIG. 13. Cross-Correlations between Monetary News Shock and Other Macro-Economic Shocks.

NOTES: The solid line is the median cross-correlation and the dashed lines are the 84th and 16th percentiles of the posterior distribution of cross-correlations. The other shocks are the Barsky and Sims (2011) TFP news shock, shock to the real price of oil, Romer and Romer (2010) exogenous tax shock measure, Ramey (2011) defense news shock, the uncertainty shock from Bloom (2009) (that appears in his figure 1), the innovation to the U.S. economic policy uncertainty index of Baker, Bloom, and Davis (2016), and the investment-specific technology (IST) news shock from Ben Zeev and Khan (2015). The *x*-axis gives the lags/leads of the of the MFEV monetary news shock for which the correlation with the other macroshocks is computed.

significantly rises in the first two quarters, and inflation significantly rises in the second and third quarters. Moreover, the response of *MPR* is somewhat weaker than the one obtained in the baseline case.[20]

4.8 Relationship with Other Macro-Economic Shocks

We now assess whether our monetary news shock is related to other important identified macro-economic shocks normally considered to be potentially important sources of business cycle fluctuations: the TFP news shock identified in Barsky and Sims (2011); shock to the real price of oil, Romer and Romer (2010) exogenous tax shock measure, Ramey (2011) defense news shock, the uncertainty shock from Bloom (2009) (that appears in Bloom's (2009) figure 1), the innovation to the U.S. economic policy uncertainty index of Baker, Bloom, and Davis (2013), and the

20. The federal funds futures rate shock accounts for only 34% of the 1-year variation in *MPR*, compared to 39% accounted for by the MFEV news shock. The results on the forecast error variance contributions of the federal funds futures rate shock are available upon request from the authors.

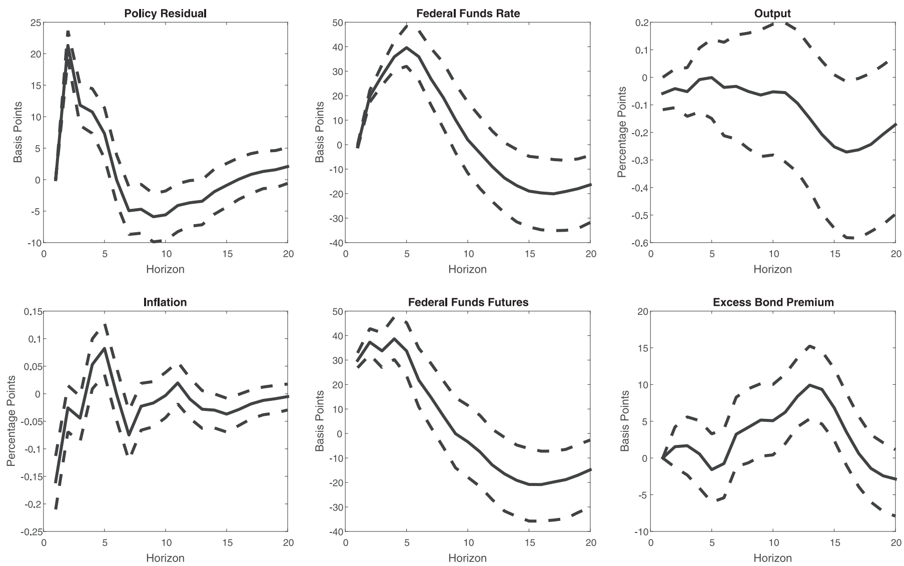


FIG. 14. Full Sample (Including the ZLB period).

NOTES: This figure shows the median and 16th and 84th posterior percentiles of the impulse responses to the monetary news shock obtained from applying our baseline MFEV method to a sample that includes the Great Recession period (1988–2012).

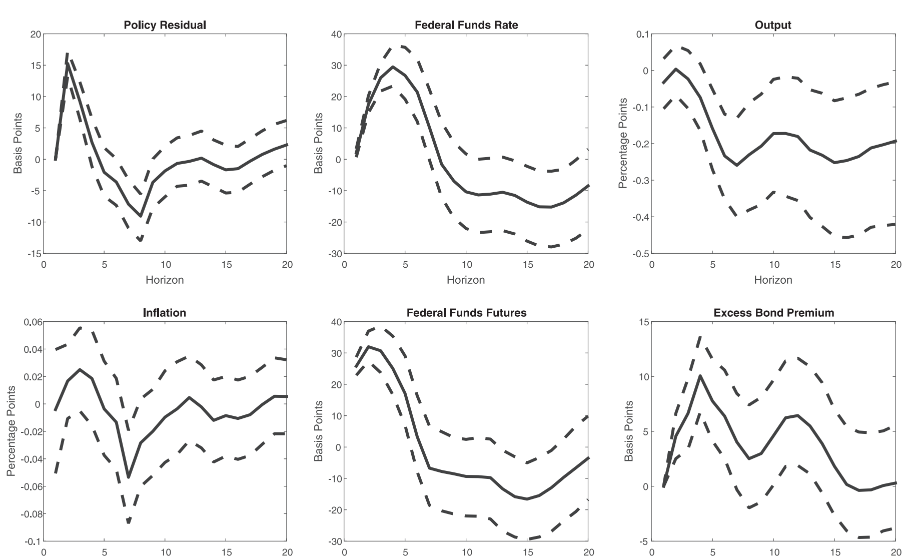


FIG. 15. An Alternative Truncation Horizon.

NOTES: This figure shows the median and 16th and 84th posterior percentiles of the impulse responses to the monetary news shock identified using a truncation horizon of $H = 9$.

investment-specific technology (IST) news shock from Ben Zeev and Khan (2015).[21] We report the correlation between up to four lags and leads of our identified monetary news shock and these other shocks. The results are presented in Figure 13, where the median and 16th and 84th percentiles of the correlations between up to four lags and leads of our news shock and the other macroshocks are shown. The results indicate that the cross-correlations are small, with all median correlations lower than 22% in absolute value. This exercise confirms that our results are not driven by other macro-economic shocks.

4.9 Including the Great Recession Period

We apply our identification method to the sample period of 1988Q4–2014Q2, where the ending date is dictated by the availability of the updated credit spread series of Gilchrist and Zakrajšek (2012). We use the shadow federal funds rate series for the ZLB period constructed in Wu and Xia (2016). Figure 14 presents the impulse responses obtained from this estimation exercise. Output declines significantly both on impact as well as for a year starting from 3.5 years after the shock. While inflation does briefly rise significantly for two periods a year after the shock, it mostly drops with its decline being significant for the first three quarters, the 7th quarter, and for a year beginning 3 years after the shock. Hence, overall, the results from this exercise are also broadly consistent with monetary news shocks operating as demand shocks to the economy.

4.10 Longer Truncation Horizons

Figure 15 shows the median and 84th and 16th percentiles of the posterior distribution of impulse responses to a positive one standard deviation monetary news shock obtained from setting the truncation horizons to $H = 9$, that is, a 2-year operative anticipation horizon over which forward guidance is conducted. Our view, which is also consistent with that of Campbell et al. (2012), is that the baseline 1-year horizon is very much reflective of the horizon over which forward guidance is relevant. It is clear from Figure 15 that the longer horizon of 2 years has no bearing on both the quantitative and qualitative nature of our baseline results.

5. CONCLUSION

We pursue a novel empirical strategy to identify monetary news shocks and determine their effects on the U.S. economy during 1988–2007. Using an estimated policy rule we construct MPRs. Using the MFEV approach, we then identify a monetary news shock as the linear combination of reduced-form innovations that is orthogonal

21. Apart from the Barsky and Sims (2011) TFP news and Ben Zeev and Khan (2015) IST news shock series, which we used in their raw form, all other shocks were constructed as the residuals of univariate regressions of each of the five raw shock measures on four own lags.

to the current residual and that maximizes the sum of contributions to its forecast error variance over a finite horizon. Real GDP declines in a persistent manner after a positive monetary news shock. This contraction in economic activity is accompanied by a fall in inflation and a rapid increase in the nominal interest rate. These effects of monetary news shocks are qualitatively similar even when the sample is extended to include the Great Recession. We conducted a variety of robustness checks to discuss how our baseline results get modified. One caveat is that the effects are less precisely estimated over short horizon. This is likely due to the short sample period of our analysis. Overall, our findings are useful for assessing whether the effects of monetary news shocks in DSGE models are consistent with their empirical counterparts.

Our results suggest that market participants' expectations about the stance of monetary policy are affected by signals about future monetary policy. Moreover, an important component of the Fed's determination of the interest rate is anticipated in advance. The sharp increase in the excess bond premium after a positive monetary news shock points to the important role of financial frictions in the transmission of this shock.

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