Forward Guidance Matters:

Disentangling Monetary Policy Shocks

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Abstract

Central banks have usually employed short-term rates as the main instrument of monetary policy. In the last decades, however, forward guidance has also become a central tool. This paper combines two sources of extraneous information - high frequency surprises and narrative evidence - with sign restrictions in a structural vector autoregressive (VAR) model to disentangle forward guidance from conventional monetary policy. Results show that conventional monetary policy has the expected effects on industrial production even in a recent US sample and that forward guidance is an effective policy tool, being at least as strong as conventional monetary policy.
Keywords: Forward Guidance, Monetary Policy, Narrative Sign Restrictions, High-frequency identification

Resumo

Bancos centrais costumam empregar taxas de juros de curto prazo como o principal instrumento da política monetária. Nas últimas décadas, no entanto, "forward guidance" também se tornou uma ferramenta central para a política monetária. Este artigo combina duas fontes de informações externas - surpresas nos preços de contratos futuros e evidências narrativas - com restrições de sinal em modelo estrutural de vetores autorregressivos (VAR) para separar completamente os efeitos de choques de "forward guidance" dos efeitos de choques de política monetária convencional. Os resultados mostram que a política monetária convencional tem os efeitos esperado, mesmo em uma amostra recente dos EUA e que "forward guidance" é uma ferramenta política efetiva. De fato, é pelo menos tão potente quanto a política monetária convencional.
Keywords: Forward Guidance, Política Monetária, Restrições Narrativas, Identificação em alta frequência
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1 Introduction

Central banks have usually employed short-term interest rates as the main instrument of monetary policy. The extent to which such instrument is effective depends upon its ability to affect the path of expected future short-term real interest rates since, according to standard macroeconomic theory, such as Woodford (2003) and Galí (2015), consumption and output are driven by the sum of all future short-term real rates: the long-term real rate.[1]

In recent years, a prominent alternative way to affect long-term interest rates has been intensively used: the communication about the likely future course of monetary policy, known as forward guidance. In this framework, if central banks can commit to a future path of interest rates, their communication may affect the economy even in the absence of changes in the short-term policy rate. Hence, forward guidance (or more broadly, communication) also becomes a policy tool.

These two policy instruments (short-term interest rates and forward guidance) are obviously intrinsically connected. First, forward guidance matters for the identification of the conventional monetary policy shocks in that such shocks cannot be properly recovered unless anticipated changes in the policy rates are taken into account. Second, forward guidance is one reason why, as pointed out by Ramey (2016), estimating the causal effects of conventional monetary policy has become a challenge. With anticipation effects and monetary policy conducted more systematically, finding truly exogenous monetary policy shocks in recent samples has become increasingly difficult.

On the other hand, forward guidance shocks can be a valuable source of not so systematic policy. This tool became prevalent during the zero lower bound (ZLB) period when the use of the conventional policy rate was constrained and episodes of truly exogenous forward guidance shocks can be found. Campbell et al. (2012) and Campbell et al. (2017) show effectiveness of forward guidance shocks in moving long-term government bond rates. But what about the dynamic responses of macroeconomic and financial variables to these shocks?

This paper tackles this question by disentangling forward guidance and conventional monetary policy shocks in an innovative way: combining two sources of extraneous information with sign restrictions in a structural vector autoregressive (VAR) model estimated using data since the 90s, which is when the Federal Open Market Committee (FOMC) started to issue statements immediately after each meeting.

The first source of extraneous information is based on high-frequency futures prices and it builds on Kuttner (2001) and Gürkaynak et al. (2005). The use of high-frequency surprises around FOMC announcements is important to address endogeneity concerns as well as to help in the decomposition of the shocks. Specifically, the vector of variables of the VAR incorporates Gürkaynak et al. (2005)'s target and path factors, which capture surprises in the current and future rates respectively. Their inclusion together with the other variables in the spirit of Jarociński and Karadi (2020) is an alternative to their use as external instruments in Proxy SVARs.

Jarociński and Karadi (2020) combine sign restrictions and high-frequency surprises to identify monetary policy and information shocks, which is their object of study. In this paper, however, this combination will be used to cleanse the shocks of interest from any informational advantage the

[1] To see the monetary transmission mechanism in the New Keynesian model clearly, it is useful to remember that, iterating forward, the Euler equation becomes:

$$\hat{y_t} = -\frac{1}{\sigma} E_t \sum_{i=0}^{\infty} (\hat{i}_{t+i} - \pi_{t+i+1})$$

where $\hat{x}$ denotes the percentage deviation of a variable X_t around its steady state, y is the output, i is the nominal interest rate, π is the inflation rate, and $\frac{1}{\sigma}$ governs the intertemporal elasticity of substitution.

central bank may have. This is an alternative to the customary use of the Greenbook forecast data, with the advantage of not limiting the sample.[2]

Nonetheless, sometimes sign restrictions may have to be complemented with additional restrictions in order generate a sufficiently rich shock structure as pointed out by Inoue and Kilian (2013) and Arias et al. (2019). The second source of extraneous, which is the narrative account of some particular episodes, is then used to enhance and refine the identification. The idea was formalised by Antolín-Díaz and Rubio-Ramírez (2018) as narrative sign restrictions.[3] First, sign restrictions consistent with economic theory are placed not only on the standard variables but also on the factors in order to properly isolate the shocks of interest. Then, uncontroversial episodes of forward guidance and conventional monetary policy shocks are used to refine the credible set. This is particularly convenient since forward guidance is itself a narrative policy instrument.

Most importantly, following Uhlig (2005), the sign restrictions are agnostic. Therefore, the VAR model does not place any restriction on the responses of the industrial production and lets the data and the adjacent restrictions "decide" them, avoiding the circularity pointed out by Cochrane (1994). As in Uhlig (2005), the idea is to leave the question of interest open, but using prior information about the behaviour of the other variables through the sign and the narrative sign restrictions.

This agnostic approach is especially important because, notwithstanding the relevance of the topic, there is still a lack of consensus among researchers and policy-makers about the effects of forward guidance. For example, McKay et al. (2016) find that the effect on GDP in models with incomplete markets is much lower than in models with complete markets.[4] Nonetheless, a few quarters of forward guidance is still powerful enough to effectively prevent recessions. In contrast, after adding several features to McKay et al. (2016)'s model to bring it closer to the data, Hagedorn et al. (2019) find that the effects of forward guidance are, in fact, negligible.

VAR models can then help shed some light on New Keynesian models, providing them with some reference and bringing them even closer to the data. Being Bayesian, it also allows for a formal comparison between the effects of forward guidance and the effects of conventional monetary policy in a high posterior density interval (HPDI) sense.

Therefore, the contribution of this paper is twofold. In terms of identification, following a trend that involves the combination of different strategies to improve inference in SVARs[5], the novelty is to employ in the same agnostic set-up all the available extraneous information, namely futures surprises and narrative evidence, which is useful to identify the structural shocks. This combination sharpens the results and helps in the disentangling of shocks. The economic contribution is to show that, using this identification strategy, forward guidance is an effective policy tool, being at least as strong as conventional monetary policy.

Specifically, results show that the direction of the effect of conventional monetary policy is the expected even in a recent US sample, in contrast with the evidence surveyed by Barakchian and Crowe (2013) and Ramey (2016). Results also show that the effect of forward guidance on industrial production are not different from the effect of conventional monetary policy in a HPDI sense.

[2]The Greenbook forecast data is made available to the public only five years after the end of the year of the forecast.

[3]Narrative information has also been used in different contexts and set-ups, such as in Kilian and Murphy (2014) and in Ben Zeev (2018).

[4]McKay et al. (2016) combine elements from standard New Keynesian models, such as nominal rigidities, with elements from standard incomplete models, such as uninsurable risks and borrowing constraints. See also Del Negro et al. (2012) for a discussion of the forward guidance puzzle.

[5]For instance, Braun and Brüggemann (2020) combine sign restrictions with external instruments, Podstawski et al. (2018) combine heteroskedasticity with external instruments, and Ludvigson et al. (2020) combine covariance and sign restrictions with 'external variable inequality constraints'.

Related Literature

The papers most closely related to this one can be divided into two groups. In the first group, forward guidance is mixed with conventional monetary policy. By using futures contracts whose horizon comprises at least the next FOMC meeting, the shocks coined as monetary policy shocks in the next two papers incorporate the impact of forward guidance. Andrade and Ferroni (2021) employ market-based measures of inflation expectations and future interest rates together with sign restrictions to identify Delphic and Odyssean monetary shocks. In a similar endeavour, Jarociński and Karadi (2020) explore the co-movements of interest rates and stock prices around the announcements combined with sign restrictions to identify monetary policy shocks and central bank information shocks. Debortoli et al. (2019) estimate a time-varying VAR that uses the 10-year government bond rate as a policy indicator and find that the responses to different shocks do not present material differences in the ZLB. The corollary is that unconventional monetary policy (including forward guidance) acted as a substitute for conventional monetary policy.[6]

In the second group, forward guidance is isolated from conventional monetary policy. Similar to this paper, D'Amico and King (2015) combine measures of expectations with sign restrictions. Differently, however, they use survey-based measures of macroeconomic variables, which may respond with some delay as pointed out by Coibion and Gorodnichenko (2012, 2015) and may not fully isolate forward guidance shocks from other shocks affecting expectations. In fact, D'Amico and King (2015) acknowledge that any information, not only the shocks generated by forward guidance, which causes agents to change beliefs about the future course of monetary policy, should be captured in their identification. They see it as an advantage as they seem to be interested in overall anticipated monetary policy. Nevertheless, for the purpose of this paper, disentangling forward guidance shocks from conventional monetary shocks or any other kind, this would be a weakness.

Ben Zeev et al. (2019) identify anticipated monetary shocks following the literature on news shocks. The monetary news shock is orthogonal to current policy residual and maximises the sum of contributions to its forecast error variance over a finite horizon. As in D'Amico and King (2015), this captures the effects of forward guidance shocks but not only. Ben Zeev et al. (2019) also acknowledge that their "approach allows for any channels through which changes in expectations may arise". Moreover, by estimating a quarterly VAR they are not able to capture near-term since the next meeting is approximately half of the time within the quarter.

Lakdawala (2019) uses market-based measures of expectations, specifically the Gürkaynak et al. (2005)'s target and path factors, as external instruments in a VAR to decompose the effects of monetary policy. Here, on the other hand, these factors are incorporated into the vector of variables of the VAR, what makes the inference valid even if the VAR without them is not fully or partially invertible. Moreover, Lakdawala (2019)'s sample starts in 1979 and includes the Volcker disinflation period, what may affect the findings, while this paper focuses on a more recent sample, which corresponds to the period experiencing an increase in FOMC communication.

Bundick and Smith (2020) examine the macroeconomic effects of forward guidance at the ZLB using a modified path factor. They order this measure after real activity and the price level but before the 2-year rate in a recursive VAR. A caveat is that by restricting their sample to the ZLB, their estimation disregard numerous episodes of forward guidance that took place in the periods pre or post-ZLB. They work around this issue by also estimating the model over the pre-ZLB period. They find that forward guidance shocks produce similar results.

Hansen and McMahon (2016) follow a different path. They use tools from computational linguistics

[6]In a similar vein, Swanson (2018) shows the Federal Reserve was not very constrained in its ability to influence medium- and longer-term interest rates and the economy due to effective forward guidance and the large-scale asset purchases.

to extract and measure the information released by the FOMC on the state of economic conditions and on forward guidance, which is inputted in a factor-augmented VAR model identified recursively. Zlobins (2019) studies the effects of ECB's forward guidance and also employs sign, zero and narrative sign restrictions. However, because he covers a period dominated by the ZLB and uses the 3-month EURIBOR rate, which also captures near-term forward guidance, for the identification of conventional monetary policy, shocks may be not properly disentangled.

This paper complements this recent literature by combining the advantages of high-frequency identification with the appeal of narrative sign restrictions to identify the dynamic responses of important macroeconomic and financial variables to conventional monetary policy and forward guidance shocks. The rest of the paper is organised as follows. Section 2 describes the econometric approach. Section 3 presents the results. Section 4 concludes.

2 Econometric Framework

The point of departure for the analysis is a VAR model of the form:

$$\begin{pmatrix} m_t \\ y_t \end{pmatrix} = c + \sum_{p=1}^{P} \beta^p \begin{pmatrix} m_{t-p} \\ y_{t-p} \end{pmatrix} + A_0 \varepsilon_t, \tag{1}$$

where m_t is a vector of N_m surprises. The monthly series are built by adding up the intra-day surprises occurring in month t on the days of FOMC meetings and letting the series take a value of zero in months without FOMC announcements. y_t is a vector of N_y monthly macroeconomic and financial variables. p denotes the lags, with $p = 1, ..., P$. The structural shocks ε_t are related to the reduced-form innovations u_t via $u_t = A_0 \varepsilon_t$ where A_0 is a decomposition of the the covariance matrix Σ such that $Var(u_t) = A_0 A_0' = \Sigma$.

The baseline Bayesian VAR is estimated for the US using a flat prior and 5 lags[7] on 7 macroeconomic and financial variables (2 high-frequency variables (m_t) and 5 low-frequency variables (y_t)) spanning the period from 1993M01 to 2017M12. m_t includes the target and path factors. y_t consists of the consumer price index (CPI), the industrial production index (IP), the fed funds rate (FF), the 2-year government bond rate (GS2), and the excess bond premium (EBP) computed by Gilchrist and Zakrajšek (2012). The first two variables of y_t are in log levels.

The target and path factors are constructed based on the methodology of Gürkaynak et al. (2005). Surprises in the prices of fed funds futures and Eurodollar futures are computed for a 30-minute window around 220 scheduled and unscheduled FOMC meetings to estimate these two factors.[8] By construction, the target factor accounts for most of the surprise in the futures rates for the current month (FF1) and the path factor influences only expected future rates.[9]

Gürkaynak et al. (2005) show the path factor is closely related with FOMC statements.[10] Such forward-looking statements provide agents with news on future information about changes in short-term

[7] This choice was based on the Akaike information criterion (AIC), which is considered the most accurate criterion for monthly VARs by Ivanov and Kilian (2005).

[8] Following Campbell et al. (2012), however, the outlier meetings in September 2001 (9/11) and March 2009 (QE1) were dropped.

[9] See Gürkaynak et al. (2005) for the constructions of the factors.

[10] Gürkaynak et al. (2018) provide further evidence in this regard. They show there is a close correspondence between the path factor and a latent factor that captures non-headline news.

interest rates. Furthermore, as a market-based measure of expectations, the path factor is robust to concerns usually associated with survey-based measures of expectations, such as staleness and insufficient skin in the game (Coibion and Gorodnichenko, 2012, 2015).

Due to its characteristics, in order to address the effects of anticipation in monetary policy, the path factor is incorporated into the vector of the variables in the VAR and not used as an external instrument.[11] In a model with news shocks, the inclusion of variables that reflect views on the future path of the economy is even more relevant since their omission can potentially introduce non-fundamentalness, altering the mapping between the true news that agents observe and the identified shocks (D'Amico and King, 2015; Leeper et al., 2013).

The excess bond premium, introduced by Gilchrist and Zakrajšek (2012), is a corporate bond credit spread purged from the default risk, with a high informational content about the economy. As pointed out by Caldara and Herbst (2019), the inclusion of credit spreads is of paramount importance and can result in large differences in the effects found in VAR models. This happens because an increase in credit spreads generates a persistent decrease in real activity and a failure to account for this endogenous reaction induces an attenuation in the response of all variables to monetary shocks.[12]

The use of two policy indicators (the fed funds rate and the 2-year government bond rate) is crucial to the decomposition of monetary policy shocks into conventional and forward guidance shocks. Moreover, the sample does not stop in 2007 or 2008, as it is typical in VAR models of monetary policy due to the turbulence caused by the financial crisis and the following ZLB period, because this would jeopardise the objective of this paper since forward guidance was intensively used during the ZLB period. The 2-year government bond rate was chosen because it is consistent with the horizon of forward guidance. The other variables are standard: CPI and IP.[13]

2.1 Identification

This subsection explains how high-frequency data are combined with sign restrictions and narrative information within this econometric framework to identify the two shocks of interest: forward guidance and conventional monetary policy shocks.

2.1.1 Sign restrictions and high-frequency identification

Following Rubio-Ramirez et al. (2010) and Arias et al. (2018), a candidate A_0 is found by calculating $\tilde{A}_0$, an arbitrary matrix square root of Σ, using Cholesky and multiplying it with a rotation matrix Q. The impulse responses using this candidate structural impact matrix are then checked and kept if the restrictions are satisfied.

There has been increasing concern about the informativeness of priors. Giacomini and Kitagawa (2018), for instance, propose imposing posterior bounds on the impulse response functions that are robust to the choice of priors. An alternative is proposed by Baumeister and Hamilton (2015) who directly draw in the structural parametrisation, requiring the use of Metropolis-Hastings. As the implementation of these procedures would imply additional computational burden and many thousands of draws will be necessary in this paper, the approach of Rubio-Ramirez et al. (2010) and Arias et al. (2018) is preferred.

[11] Section 2.2 further elaborates on this issue.

[12] See also Section 9 of Miranda-Agrippino and Ricco (2019).

[13] Results are similar when the sample period ends in 2012 as shown in the Online Appendix. This span reduces the influence of the zero lower bound in the estimation while it still includes an important episode of forward guidance used in the identification.

Sign restrictions are then placed on high- and low-frequency variables. Nevertheless, similar to Uhlig (2005)'s proposal, the procedure is agnostic about the response of the industrial production after both shocks. This is robust to the mixed evidence for the importance of monetary shocks found by Ramey (2016) and compatible with the absence of effects of monetary policy on real activity in regressions run for the Great Moderation period. Following Uhlig (2005), however, to compensate for that agnostic approach, restrictions are applied to a longer period.[14]

It is postulated that a monetary policy shock increases the fed funds rate and the EBP and reduces the CPI for periods 0 to 5 months. In order to disentangle monetary policy shocks and prevent them from being a combination of other underlying shocks that satisfy the restrictions placed on the low-frequency variables, it is further assumed the target factor moves up on impact.[15]

A forward guidance shock is defined as a shock that increases the 2-year government bond rate and the EBP and decreases the CPI for period 0 to 5 months. Because forward guidance shocks are assumed to have no contemporaneous effect on the fed funds rate, the response of the fed funds rate is zero on impact. Furthermore, the path factor rises on impact. Once more, the inclusion of the factor is important to isolate the shock of interest from other shocks that might affect similarly the 2-year government bond rate, the CPI, and the EBP. Table 1 summarises the restrictions.[16]

[INSERT TABLE 1 HERE]

The restrictions on the lower-frequency variables are standard and motivated by the New Keynesian set-up. Several sources (e.g. Smets and Wouters (2007), Gertler and Karadi (2011), McKay et al. (2016), Hagedorn et al. (2019)) show that Table 1 describes the expected responses to monetary and forward guidance shocks.[17] The restrictions on the high-frequency variables are such that the shock of interest is isolated. Because the window around the release is very narrow, it is assumed the surprises are not affected by macroeconomic news other than the announcement.

Moreover, since, as aforementioned, the path factor is closely related to FOMC statements, which telegraph not only forward guidance but also central bank private information, the sign restrictions on the EBP and the CPI are important to cleanse, by construction, the forward guidance shock from any informational advantage the central bank may have. As shown by Jarociński and Karadi (2020)'s results, information shocks have the opposite effect on the EBP and the CPI. The combination of sign restrictions and high-frequency data then lends itself to an ideal way to properly disentangle pure monetary and forward guidance shocks.

However, the set of admissible structural parameters implied by sign restrictions can sometimes be too large with very different or implausible implications for the results. Arias et al. (2019) pointed out this is the case in Uhlig (2005), for instance, in which the posterior probability bands of the impulse responses are very wide and structural parameters incompatible with the systematic response of monetary policy to output are retained.

[14] Canova and Paustian (2011) call dynamic sign restrictions into questions. Uhlig (2017) addresses these issues and concludes that sign restrictions beyond the initial impact can make a difference and should be used whenever plausible. Kilian and Lütkepohl (2017) also agree that such restrictions can be useful in restricting further the space of admissible models.

[15] Uhlig (2005) restricted the response of the nonborrowed reserves with the same objective.

[16] No zero restrictions were placed on the factors as this would increase the burden on the importance sampling.

[17] Despite the conflicting quantitative results for forward guidance shocks, the different models agree on the direction of the responses.

2.1.2 Narrative information

In order to refine the set of admissible structural parameters, the narrative account of a small number of key and uncontroversial events will be used to motivate further restrictions when estimating sign-identified VAR models as in Antolín-Díaz and Rubio-Ramírez (2018). This approach brings some flavour of the historical case studies pioneered by Friedman and Schwartz (1963), which are seen by Ramey (2016) as the best sources of evidence regarding the effects of monetary policy shocks.

In practice, to check if the narrative sign restrictions are satisfied, evaluate the following inequalities:

$$\varepsilon_{j,t}(\Theta) < 0 \tag{2}$$

$$|H_{i,j,t}(\Theta, \varepsilon_t(\Theta))| > \max_{j' \neq j} |H_{i,j',t}(\Theta, \varepsilon_t(\Theta))| \tag{3}$$

where Θ collects the values of all structural parameters, the first inequality implies jth shocks must be negative at time t and the second inequality implies the contribution H of the jth shock to variable i at time t must be greater than the contribution of any other shocks to variable i at time t.[18] The full algorithm is described in the Online Appendix.

Inspired by Ludvigson et al. (2020), an alternative type of shock-based constrained will also be exploited:

$$\varepsilon_{j,t}(\Theta) < \bar{k} \tag{4}$$

This condition requires $\varepsilon_{j,t}(\Theta)$ to be less than $\bar{k}$ standard deviations below zero. Such condition is in-between the restrictions placed by equations (2) and (3), so it will be useful for the cases whereby a restriction on the historical decomposition would be considered too strong, and a restriction just on the sign of the shock would be considered too weak. A variant of it, however, in which $\bar{k}$ denotes the standard deviations above zero is weaker. It is easy to see that the restriction in equation (2) is a special case of the condition in equation (4) when $\bar{k} = 0$. One has to choose the type of restriction according to their confidence in the episodes.

For the monetary policy shocks, the main source is Antolín-Díaz and Rubio-Ramírez (2018), who examined in detail episodes that are good candidates to have been conventional monetary policy. The dates that are comprised in the shorter sample period here considered are: February 1994, October 1998, April 2001 and November 2002. Antolín-Díaz and Rubio-Ramírez (2018) also point out it is possible to obtain qualitatively similar results imposing narrative restrictions in February 1994 on its own.[19] Particularly, February 1994 was the month the FOMC began a series of tightening moves and caught the market by surprise.

For the forward guidance shocks, the main references are the site of the Federal Reserve Board as well as Gürkaynak et al. (2005), Campbell et al. (2012), and Borio and Zabai (2018), who scrutinised the FOMC statements and highlighted some important episodes of forward guidance. Some examples are:

August 2011, when the FOMC specified the intended time length of the stimulus and replaced "extended period" with "mid-2013": "The Committee currently anticipates that economic conditions ... are likely to warrant exceptionally low levels for the federal funds rate at least through mid-2013."

January 2012, when the FOMC replaced "mid-2013" with "late 2014": "the Committee ... currently anticipates that economic conditions ... are likely to warrant exceptionally low levels for the federal funds rate at least through late 2014."

[18] To have positive narrative sign restrictions, just impose equation (2) with a negative sign on the left-hand side.

[19] It is worth noting, however, that when their sample is shortened to 1993-2007, such restriction is no longer sufficient to imply that contractionary monetary policy shocks cause output to fall (not even using a Minnesota prior).

September 2012, when "late 2014" was replaced with "mid-2015": "the Committee ... currently anticipates that exceptionally low levels for the federal funds rate are likely to be warranted at least through mid-2015."

December 2012, when forward guidance became based on the state of the economy: "the Committee ... currently anticipates that this exceptionally low range for the federal funds rate will be appropriate at least as long as the unemployment rate remains above 6-1/2 percent, inflation between one and two years ahead is projected to be no more than a half percentage point above the Committee's 2 percent longer-run goal, and longer-term inflation expectations continue to be well anchored."

December 2014, when the FOMC moved a step closer to the beginning of the normalisation: "Based on its current assessment, the Committee judges that it can be patient in beginning to normalize the stance of monetary policy."

October 2015, when the FOMC replaced the clause "how long it will be appropriate to maintain [the target range]" with "whether it will be appropriate to raise the target range at its next meeting."

Because restrictions are placed on both shocks, parsimony is required.[20] So, only the most informative episodes will be selected as restrictions for the benchmark. Alternative combinations will the presented in the robustness subsection. August 2011 marks the change to date-based forward guidance. Before that, the Committee used to be relatively more vague and write expressions such as "for a considerable period" (December 2003), "for some time" (December 2008) or "for an extended period" (March 2009). August 2011 is the announcement Bundick and Smith (2020) use in their model implied-responses and it is also the episode on which Bundick et al. (2017) focus. That is a good candidate, despite being classified by Del Negro (2018) as a possible example of Delphic forward guidance.

In fact, the posterior distribution of the forward guidance shock implied by the VAR identified with sign restrictions during that month is already very concentrated on the left side of the histogram. Figure 1 shows the posterior distribution of the forward guidance shock during that month. Grey represents the posterior distribution with only sign restrictions, and pink represents the distribution after the imposition of narrative sign restrictions. On the one hand, this implies sign restrictions are being effective in recovering forward guidance shocks, on the other hand it means informing the model that a expansionary forward guidance shock occurred in that particular month does not bring much refinement. Nonetheless, combining such restriction with a restriction on the historical decomposition proves to be informative. Therefore, even though most of the distribution already has negative support even before the imposition of narrative sign restrictions, the new restriction increases the weight in the negative region in line with the narrative account. This will be the benchmark restriction.

[INSERT FIGURE 1 HERE]

In January 2012, the period of exceptionally low interest rates was extended considerably. This is also considered a strong episode of forward guidance, being even the benchmark for the simulation in Campbell et al. (2012). As in the previous episode, surprises in S&P 500 and in the path factor are consistent with that narrative account. Once more, however, the posterior distribution of the forward guidance shock during that month using only sign restrictions is already concentrated below zero, albeit less than in August 2011. This episode will be explored in the robustness subsection.

September 2012 is considered by Del Negro (2018) an episode of Odyssean forward guidance. The statement declared that the period of low interest rates was going to be further lengthened. Nevertheless,

[20]The computational aspects of the estimation are described in the Online Appendix.

this was also the meeting in which QE3 was announced. So, results could be dominated by large-scale asset purchases (LSAP).[21] In December 2012, there was a switch to state-contingent forward guidance. This episode is harder to interpret in that it represents a change in the nature of forward guidance from calendar-based to one that conditioned the path of interest rates on specific numbers of inflation and unemployment. Also, calendar-based forward guidance is more in line with the experiments conducted in New Keynesian Models for which this paper is the empirical counterpart. Moreover, the was also the announcement of the extension of large scale asset purchases.

In December 2014, the FOMC announced the intention to patiently begin the normalisation. This introduced a message more specific that the contained in the statement from October 2014 in which the FOMC had stated that increases in the target range for the federal funds rate could "occur sooner than currently anticipated" or "later than currently anticipated". However, the Chairwoman Janet Yellen said in the press conference that "The committee considers it unlikely to begin the normalization process for at least the next couple of meetings."

In October 2015, the FOMC hinted that a hike might happen in the next meeting. Responding to that the path factor went up and the S&P 500 went down. Even though there is not much literature about this meeting, it will be explored as robustness since, in addition to the market reaction, news at the time are consistent with the narrative account of this episode as a contractionary forward guidance shock. This episode also highlights the importance of the monthly frequency to assess forward guidance since models estimated at the quarterly frequency would aggregate data from October to December, confounding forward guidance and conventional monetary policy shocks.

To sum up, restrictions are based on the confidence in the episodes as well as in their informativeness. After cross-checking news, the market reaction, and the literature, the following episodes were selected as the benchmark restrictions:

Narrative Sign Restriction 1. The monetary policy shock must be positive for the observation corresponding to February 1994.

Narrative Sign Restriction 2. For the period specified by Restriction 1, the monetary policy shock is the most important contributor to the observed unexpected movements in the federal funds rate. In other words, the absolute value of the contribution of monetary policy shocks is greater than the absolute value of the contribution of any other structural shock.[22]

Narrative Sign Restriction 3. The forward guidance shock must be negative for the observation corresponding to August 2011.

Narrative Sign Restriction 4. For the period specified by Restriction 3, the forward policy shock is the most important contributor to the observed unexpected movements in the 2-year rate.

2.2 Potential Advantages over Proxy SVARs

Proxy SVARs rely on external instruments correlated with the shock of interest, and uncorrelated with other structural shocks. Moreover, to address the issue of whether the high-frequency surprises are truly exogenous or just reflect the Fed's private information, the measures or surprises are regressed on measures of the Fed's private information. The results, however, are dependent on the way this

[21] The interaction between LSAP and forward guidance will be further explored in the robustness subsection.

[22] Slightly deviating from Antolín-Díaz and Rubio-Ramírez (2018), the restriction placed on the historical decomposition in February 1994 imposes that the forward guidance shock be the most important contributor, not greater than the sum of the contribution of all other shocks. This change is motivated by the fact that a strong restriction would increase the number of required draws without changing the results.

measure is built and can be puzzling (Miranda-Agrippino and Ricco, 2019; Ramey, 2016). In the hybrid approach of this paper, however, even when forward guidance shocks are accompanied by information shocks, there is no need to purge the path factor from central bank private information since this is achieved by construction through the sign restrictions as already pointed out.

Another potential advantage is related to the invertibility assumption. Plagborg-Møller and Wolf (2021), Miranda-Agrippino and Ricco (2019) and Paul (2020) show that, under some conditions, the impulse responses obtained with Proxy VARs are equivalent to the ones obtained with a recursive scheme that includes the instrument as an endogenous variable and orders it first. Nonetheless, with news shocks, or more specifically forward guidance shocks, invertibility concerns become even more serious (Plagborg-Møller and Wolf, 2018; Ramey, 2016). Incorporating the path factor into the vector of variables of the VAR makes the inference valid even if the VAR without it is not fully or partially invertible.

This is in line with and exemplified in D'Amico and King (2015). They show that, for the specific case of forward guidance, measures of expectations should be included in the VAR to avoid misspecification even when there is no special interest in these variables. Including the path factor in the VAR as a variable tackles this issue.

3 Results

3.1 Impulse Responses

Figure 2 compares the impulse responses after a conventional monetary policy shock when only sign restrictions are imposed to the case where Narrative Sign Restrictions 1, 2, 3, and 4 are imposed (on top of sign restrictions). Grey and blue represent the results with only sign restrictions, and pink and red represent the narrative sign restrictions. Unless otherwise stated, the estimates discussed in this section refer to the red line.

The impulse responses are computed after a one-standard-deviation conventional monetary policy shock in the narrative sign restrictions scheme, an increase of approximately 5 basis points in the fed funds rate (FF). In order to make the impulse responses comparable, the impulse responses of 'sign restrictions only' are normalised so that the initial median impact on FF is the same as in the case with narrative sign restrictions. As in Nakamura and Steinsson (2018) and Jarociński and Karadi (2020), monetary shocks are quite small.[23] Overall, the narrative restrictions narrow down the set of responses substantially.

[INSERT FIGURE 2 HERE]

Industrial production falls on impact and this effect is persistent. This result is stronger than Antolín-Díaz and Rubio-Ramírez (2018) re-estimated for a post-90 sample and subject to Narrative Sign Restriction 1 and 2 as their VAR would not have found any effect of monetary policy on industrial production for this new specification. The "significant" decrease of industrial production also contrasts with the evidence surveyed by Barakchian and Crowe (2013) and Ramey (2016), who find that several specifications and identification schemes do not lead to the expected responses when estimated for recent periods. On the other hand, the behaviour of industrial production is similar to Caldara and Herbst (2019), who find a persistent decline in real activity for a recent sample after incorporating credit spreads. Coupled with the imposition of restrictions for 6 periods, this leads to rather persistent effects.[24]

[23] Their monetary shocks, however, comprise conventional monetary policy shocks and forward guidance shocks.

[24] In a recent contribution, Jordà et al. (2020) also find that the effects of monetary policy are very persistent.

Specifically, the posterior median falls 0.2% in the second quarter following the shock, an order of magnitude in line with some studies that employ high-frequency or narrative identification to study the effects of monetary policy, such as Paul (2020) and Gertler and Karadi (2015), after cleansing their measure of policy surprises of the Fed's private information.[25] After some time, however, this movement is attenuated and the effect drops by almost half. CPI decreases on impact and slightly more than 0.07% in the long run, a value consistent with previous studies. The excess bond premium goes up 6 basis points and GS2 increases a little less than half of the magnitude of the initial impact on FF, but 0 is within the interval.[26]

Figure 3 compares the impulse responses after a forward guidance shock. The impulse responses are computed to a one-standard-deviation forward guidance shock in the narrative sign restrictions scheme, an increase of 8.4 basis points in the 2-year rate (GS2). The impulse responses of the case with 'sign restrictions only' are then normalised so that the initial median impact on GS2 is the same across the identification schemes. Industrial production falls more than 0.3% after some time, but uncertainty is higher even after the refinement provided by the narrative restriction. Furthermore, the effect is lessened in the medium run. CPI goes down almost 0.1% and the excess bond premium increases 7 basis points. The fed funds rate goes up in 12 months by a magnitude slightly lower than the initial impact on GS2.

[INSERT FIGURE 3 HERE]

The credible sets do not shrink as much as in the conventional monetary policy case. This happens because, as aforementioned, most of the posterior for August 2011 was already in negative terrain. Still, the narrative restrictions help reduce the HPDI. Lastly, it should be noted that the response of the industrial production to a forward guidance shock is at least as strong as its response to a conventional monetary policy shock in a HPDI sense as displayed in Figure 4.

[INSERT FIGURE 4 HERE]

Benchmarks for the effect of forward guidance shock in VARs are more scarce. Bundick and Smith (2020) find that expansionary forward guidance shocks lead to moderate increases in output and the price level. Nevertheless, because they do not cleanse their modified path factor of information shocks, their estimates of the effects of forward guidance capture only the net-effect of FOMC communication. Despite not being able to formally compare the results with the effects of conventional monetary policy shocks due to their focus on forward guidance shocks, they find, as in here, that forward guidance shocks share many empirical features with conventional monetary policy shocks.

D'Amico and King (2015) find a significant reduction on impact for both CPI and output. They find that responses to the policy-expectations shock are stronger than the responses to the unanticipated shock. Lakdawala (2019) reports an increase in CPI and industrial production. Nevertheless, after cleansing the path factor of Fed private information, there is a small but insignificant decline in output while the price puzzle remains. In addition to the distinct sample period, part of the difference in the results derive from the fact that his benchmark VAR does not include the EBP, which induces an attenuation effect also in the response of the variables to forward guidance shocks. The fact that the response of industrial production in Lakdawala (2019) is less puzzling when the EBP is incorporated in his baseline VAR is consistent with that.

To sum up, the results show forward guidance matters for macroeconomic outcomes, including industrial production, being an effective policy tool. In fact, it may be an important part of shocks

[25] Holm et al. (2020) also find new evidence of strong effects on industrial production at a monthly frequency for Norway.

[26] Even though factors are built to be unconditionally uncorrelated, their correlation conditional on the other variables in the system differs from zero.

labelled as monetary policy shocks. Nakamura and Steinsson (2018) and Jarociński and Karadi (2020), for instance, acknowledge that their monetary policy indicator/surprises capture the effects of "forward guidance" whereas here the monetary policy shock captures only the conventional monetary policy shock.

3.2 Informational Sufficiency

A common concern about VARs is whether the structural shocks are fundamental. In a model with shocks that may be anticipated by economic agents, such concern is even more important. To check this, the orthogonality F-test proposed by Forni and Gambetti (2014) is conducted. It consists of a regression of the shocks on a large dataset capturing agents' information set and an F-test for the significance of the regression. In practice, the agents' information set is summarised by the past values of principal components of the FRED-MD database (McCracken and Ng, 2016).

The idea is that if the shocks are predicted by past available information, the structural MA representation of the variables included in the VAR is non-fundamental and the VAR is misspecified, in the sense that there is not sufficient information to recover the structural shocks. Such an approach is appealing in that it does not require a well-defined theoretical model of reference.

Table 2 presents the results of the test for different combinations of the number of lags and principal components. The hypothesis that the shocks are not predicted by past available information is not rejected for either of shocks or number of lags, when the choice of principal components is based on the Bai and Ng (2002)'s criteria (PC=7). Such result is robust to different numbers of PCs. This orthogonality to the past of the "state variables" associated with a correct identification scheme implies both shocks are indeed the desired object of interest: conventional monetary shocks and forward guidance shocks.

[INSERT TABLE 2 HERE]

3.3 Alternative Narrative Restrictions and Other Robustness Exercises

The benchmark results relied on the information provided by August 2011. Other potentially good candidates are January 2012, which was also used by previous literature, and October 2015. A restriction on the sign for the observation corresponding to January 2012 refines just a little the set of admissible parameters. In fact, as shown in the Online Appendix when such restriction is added on top of NSR 1, 2, 3, and 4, results are almost the same. On the other hand, a restriction on the historical decomposition does not work well, being too restrictive and decreasing substantially the effective sample size as a consequence.

That is when the type of restriction inspired by Ludvigson et al. (2020) can be helpful. Making $\bar{k} = 0.3$, jointly with NSR 1 and 2, gives results very similar to Figure 3. This restriction is convenient because it brings more information than a restriction on the sign while one has only to be confident that a forward guidance shock occurred regardless of what happened to the other shocks. Results are presented in the Online Appendix. Finally, placing a restriction on the sign of the forward guidance shock in October 2015 does not help reduce identification uncertainty, even though it changes the posterior distribution for this shock in this particular month.

Henceforth, NSR 1, 2, 3, and 4 are always imposed, and the robustness exercises involve other types of modifications. To account for the fact that even the 2-year government bond rate may have been affected by the ZLB, the sample period is also ended in 2012. The results are qualitatively the same. Furthermore, Bauer and Rudebusch (2013) find evidence that the main effect of the Federal Reserve

bond purchases was via "signaling effects that lower expected future short-term interest rates", namely forward guidance. To check whether results are consistent with that, the path factor from November 2010 (QE2), September 2011 (MEP), and September 2012 (QE3) are also dropped. The impulse responses are similar to the baseline estimates. Overall, the main message is still the same: forward guidance is an effective policy tool.

4 Conclusion

This paper has addressed the identification of conventional monetary policy and forward guidance shocks. In order to do that, two sources of extraneous information – high-frequency surprises and narrative evidence – were combined with sign restriction in a structural VAR. The factors allow for a proper isolation of conventional monetary and forward guidance shocks from other shocks (or a combination of shocks) that satisfy the sign restrictions placed on the low-frequency variables. The narrative restrictions help further refine the credible set.

Results show that, in contrast with the evidence surveyed by Barakchian and Crowe (2013) and Ramey (2016), the identification scheme leads to the expected responses for output following a conventional monetary policy shock even when the model is estimated for a recent sample: 1993-2017. In fact, a strong effect emerges from the refinements in the identification.

Results also show that forward guidance has been an effective policy tool. Therefore, forward guidance matters not only to the proper identification of conventional monetary policy shocks but also due to its effect on output and other macroeconomic variables. Specifically, its effects on industrial production are at least as strong as the effects of conventional monetary policy.

Several robustness exercises show that the results hold under alternative specifications. An important implication of such results is that they provide additional support for the view that the Federal Reserve may not be so constrained even during ZLB periods.

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Tables

Table 1: Zero and sign restrictions on responses

	MP shock	FG shock
target factor	+	
path factor		+
IP		
CPI	-	-
EBP	+	+
fed funds	+	0
2-year rate		+

Table 2: p-Values of the orthogonality F-test proposed by Forni and Gambetti (2014)

	2 lags			4 lags		
	PC=4	PC=7	PC=10	PC=4	PC=7	PC=10
MP shock	0.98	0.80	0.37	1.00	0.77	0.14
FG shock	0.86	0.27	0.30	0.94	0.52	0.23

Figures

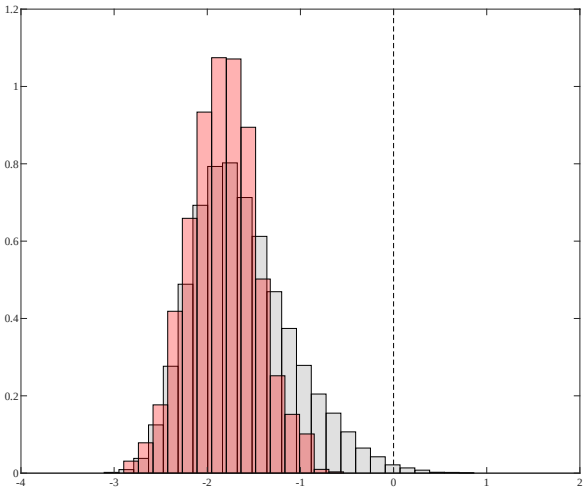

Figure 1: Forward Guidance shock for August 2011

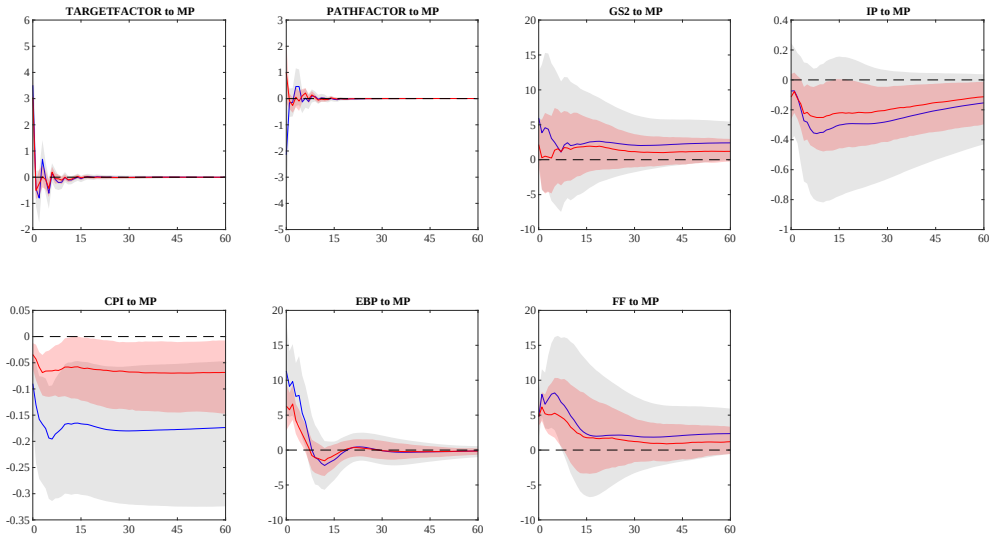

Figure 2: Impulse Responses to a Conventional Monetary Policy Shock

Notes: The grey shaded area represents the 68 percent (point-wise) HPD credible sets for the IRFs and the blue lines are the median IRFs using sign restrictions. The pink shaded areas and the red lines display the equivalent quantities for the models that additionally satisfy narrative sign restrictions.

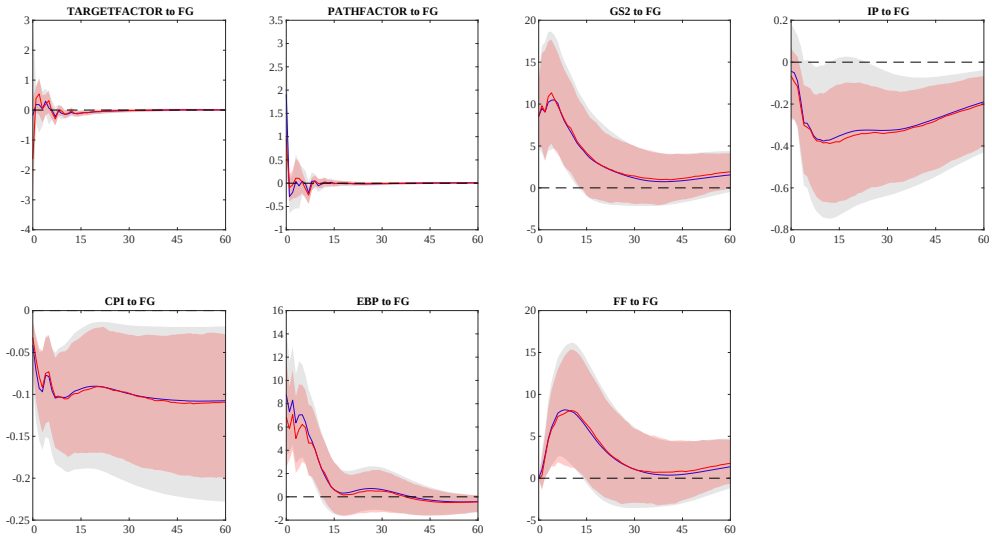

Figure 3: Impulse Responses to a Forward Guidance Shock

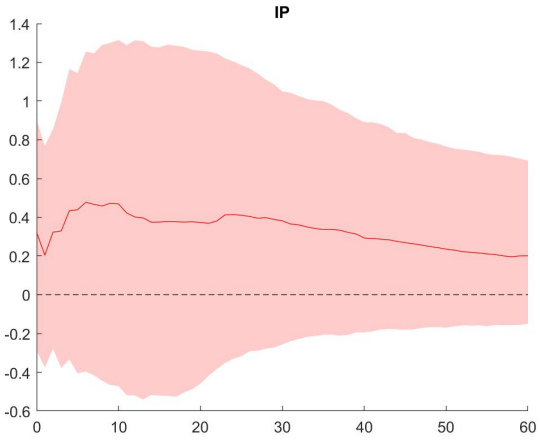

Figure 4: Difference in Impulse Responses of IP

Notes: The pink shaded area represents the 68 percent (point-wise) HPD credible sets for the difference between the IRFs of IP after a FG shock and after a MP shock. In order to make the original impulse responses comparable, they are normalised so that the initial impact on GS2 is the same after both shocks: 8.4 basis points.