EUROPEAN CENTRAL BANK

EUROSYSTEM

Working Paper Series

Kai Christoffel, Oliver de Groot,
Falk Mazelis, Carlos Montes-Galdón

Using forecast-augmented VAR evidence to dampen the forward guidance puzzle

No 2495 / November 2020

Abstract

We estimate the effects of interest rate forward guidance (FG) using a parsimonious VAR, augmented with survey forecast data. The identification strategy of FG shocks via sign and zero restrictions is successfully tested by the recovery of true IRFs from simulated data. The identified shocks from the VAR suggest that FG has a stronger effect on macro variables and deviations are more instantaneous compared to the hump-shaped response following unanticipated changes in monetary policy. We apply this evidence to calibrate free parameters of an otherwise estimated DSGE model in order to dampen the FG Puzzle.

JEL Classifications: C54, E43, E58.

Keywords: Survey Forecasts, Bayesian VAR, Monetary Policy, Non-standard Measures, DSGE Models.

Non-technical summary

To find an efficient parameterisation of DSGE model modifications that have been developed to dampen the Forward Guidance (FG) Puzzle, we conduct a matching exercise between model and empirical dynamics. To this end we propose an identification strategy of FG shocks in time-series data, test this identification approach, and align the empirical evidence with the dynamics of a large-scale New-Keynesian model that is an example of models often used in policy analyses.

Sign restrictions are commonly used to identify a standard, unanticipated policy shock, implying e.g. an easing of the contemporary policy rate, which leads to an instantaneous appreciation in output and prices. We contrast this with a FG shock, which includes additional information, encompassing k-period-ahead expectations of the policy rate. Following a FG announcement, expectations of the policy rate indicate an easing. We restrict the contemporary interest rate to stay unchanged during the initial period(s) to distinguish FG from unanticipated policy shocks. We require the macro variables to react on impact due to the expectations of eased policy.

In order to test our identifying assumptions, we first construct an artificial data set that includes FG shocks and then apply the proposed sign and zero restrictions with our VAR. The data are generated with an off-the shelf 3-equation New-Keynesian model that we augment with FG shocks and simulate for 1000 periods. For all variables, the median recovered responses by the VAR are almost identical to the simulated ones. We conclude that, in the chosen setting, our identifying assumptions are successful in recovering the true responses to FG shocks.

Turning to the empirical results, an identified FG shock leaves the short-term rate unchanged on impact. The interest rate only decreases after several periods. Both the price level and output rise on impact and stay elevated for some time, although the credible set does not rule out a return to the baseline after several quarters. Considering median responses, a FG shock that triggers a 13 bps decrease in the interest rate results in an average increase in the price level of around 25 bps and output of around 70 bps over five years. Inflation, measured as the year-on-year change in the price level, increases by 4 bps over five years on average. GDP growth increases by an average of 22 bps year-on-year over the same horizon.

We use two different DSGE model modifications to dampen the effects of the FG Puzzle. The first modification relies on the assumption that agents are only imperfectly attentive to news about the future, including FG shocks, similar to the mechanism described in Coenen and Wieland (2004). In the second modification, we include a discount factor in the household Euler condition, similar to McKay, Nakamura, and Steinsson (2016) or Gabaix (2020), which limits the average planning horizon of the representative household. The two modifications introduce one new parameter each: the share of attentive agents for the first modification and the degree of discounting for the second. We use the New Area Wide Model (NAWM) developed by Christoffel, Coenen, and Warne (2008) as our DSGE laboratory, and augment the monetary reaction function with FG shocks.

Both modifications are able to dampen the power of FG in the DSGE model. The imperfect attentiveness version of the NAWM requires between 50 and 70 percent of households to be inattentive to FG announcements. Discounting of between 0.91 and 0.93 generates simulations that are close to the credible set for output and the price level. This corresponds to an average planning horizon of 2.5 to 4 years for the representative household in the model. The empirical evidence thus supports the assumption of some inattentive agents or limited household planning horizons.

1 Introduction

DSGE models provide an ideal laboratory setting to study the macroeconomic impact of a variety of policies, as they are populated with forward looking, intertemporally smoothing agents and, unlike more reduced-form approaches, are in principle robust to the Lucas critique. Especially in situations where historical precedences are lacking, DSGE models can explore the policy space in a systematic fashion and provide quantitative answers. Unconventional monetary policies, including interest rate forward guidance (FG), present prime candidates for DSGE simulations, as these policies are by definition not part of the traditional monetary authority's toolkit, rely primarily on the expectation channel and data for empirical evaluation is sparse.

However, standard DSGE models suggest that FG effects on output and inflation grow at an accelerating rate with the length of the horizon leading to explosive dynamics. This behavior questions the validity of DSGE estimates and greatly depreciates the value of any quantitative evaluation. Several modifications aimed at resolving or attenuating the issue have been introduced to the literature, but the lack of empirical observations and identification issues with forecast data[1] prevent straightforward estimation of the models.

We propose a method to allow for an efficient parameterisation of modifications developed to dampen the FG Puzzle. We estimate a Bayesian Vector Autoregression with three commonly used variables: the interest rate, output, and the price index. In addition, we include forecast data on the interest rate at different future horizons. The forecasts allow us to identify anticipated future rate changes that divert from the current policy stance, which qualifies as FG.[2]

[1] Although Schmitt-Grohe and Uribe (2012) estimate DSGE models including news and demonstrated the importance of news as a driving force of DSGE dynamics, the proper incorporation and interpretation of forecast data in an estimation poses important conceptual difficulties (Sims, 2016). Nonetheless, Müller, Christoffel, Mazelis, and Montes-Galdón (2020) estimate a DSGE model with forecast data and succeed in dampening the FG Puzzle to a considerable degree.

[2] We understand policy makers to communicate a "future path of policy" that may differ from the "current policy target", a distinction introduced by Gürkaynak, Sack, and Swansonc (2005), which allows us to broaden the sample beyond the period of explicit FG. The empirical identification is close to D'Amico and King (2015), but we employ a more parsimonious data set that is nonetheless able to identify FG shocks, as demonstrated using artificially generated data.

Following the identification of FG effects in time-series data, we align the empirical evidence with the dynamics of a large-scale DSGE model that is an example of models often used in policy analyses. We present two modifications to the DSGE model that introduce free parameters, which are difficult to estimate, but can be calibrated by impulse response function matching. As the dynamics of the augmented DSGE model compare more closely to the empirical evidence, this allows the modeler to explore situations beyond those captured by the data.

Our main contribution to the literature consist in the novel approach of calibrating free parameters introduced to improve on the dynamics of DSGE models prone to the FG Puzzle. Our approach can be applied to models of any type, but is especially useful for large-scale models that are employed in policy analyses and provide otherwise reliable quantitative estimates. Although we demonstrate the approach on two modifications that introduce free parameters, it can be applied to any other modification and is especially suited for those that do not allow straightforward estimation of parameters (e.g., models including crucial non-linearities, certain types of bounded rationality, prohibitively large state spaces, latent time-series, etc.).

Additionally, we provide macro elasticities and time-series evidence to FG shocks that are purely based on data. Although our identifying assumptions for FG shocks are not yet established, we test our strategy on artificially generated data to build confidence in our approach. Lastly, we also provide the results on the effects of unanticipated monetary policy shocks on macro variables.

The remainder of the paper is structured as follows. Section 2 describes the econometric methodology, including the data set as well as the identification strategy. Section 3 tests the methodology on simulated data. Section 4 presents the main results from the VAR using survey forecasts. Section 5 applies the empirical evidence to a DSGE model to determine modifications (and their corresponding calibrations) that dampen the FG Puzzle and align model dynamics with their empirical counterparts. The last Section concludes.

2 Methodology

We employ a Bayesian VAR with survey data to identify the impacts of FG on macro variables. The prior distribution is a normal-Wishart with hyperparameters as given in Table 1. A lag length of four periods is chosen to capture the dynamics of the quarterly data. We use the Bayesian Estimation, Analysis and Regression toolbox (BEAR) developed by Dieppe, van Roye, and Legrand (2016) for estimation of the VAR.

Table 1: Hyperparameters

Parameter	Value
Auto-regressive coefficient	1
Overall tightness	0.1
Cross-variable weighting	0.5
Lag decay	1

2.1 Identification Strategy

The top row in Table 2 displays the sign restrictions commonly used to identify an unanticipated monetary policy shock: rate easing (i_t) leads to an instantaneous improvement in output (Y_t) and the price index (P_t).

We identify four different FG shocks based on the horizon k at which an easing is announced ($\mathbb{E}_k\{i_t\}$). We restrict the interest rate to stay unchanged during the initial period(s) to distinguish FG from unanticipated policy shocks. The macro variables appreciate on impact due to the expectations of easier policy.

The identification strategy ensures inclusion of historical examples only when policy makers delivered on their implicit announcements of easier policy, in the spirit of Odyssean FG (Campbell, Evans, Fisher, and Justiniano, 2012). Note that our identification does not capture those episodes where the macro worsened following expectations of easier policy. This allows us to exclude Delphic FG, where the policy maker announces an easing due to their expectations of a deterioration in the macro economy.

Table 2: Identifying Restrictions

	$\mathbb{E}_{4Q}\{i_t\}$	$\mathbb{E}_{3Q}\{i_t\}$	$\mathbb{E}_{2Q}\{i_t\}$	$\mathbb{E}_{1Q}\{i_t\}$	i_t	Y_t	P_t
Unanticipated policy					$-$	$+$	$+$
1q ahead FG				$-$	$n-$	$+$	$+$
2q ahead FG			$-$		$0n-$	$+$	$+$
3q ahead FG		$-$			$00n-$	$+$	$+$
4q ahead FG	$-$				$000n-$	$+$	$+$

Note: *A '+' indicates an increase, a '-' indicates a decrease, a '0' indicates no change in the data, blank cells and 'n' indicate no restriction. A cell that contains more than one symbol indicates a sequence of restrictions starting from the initial period.*

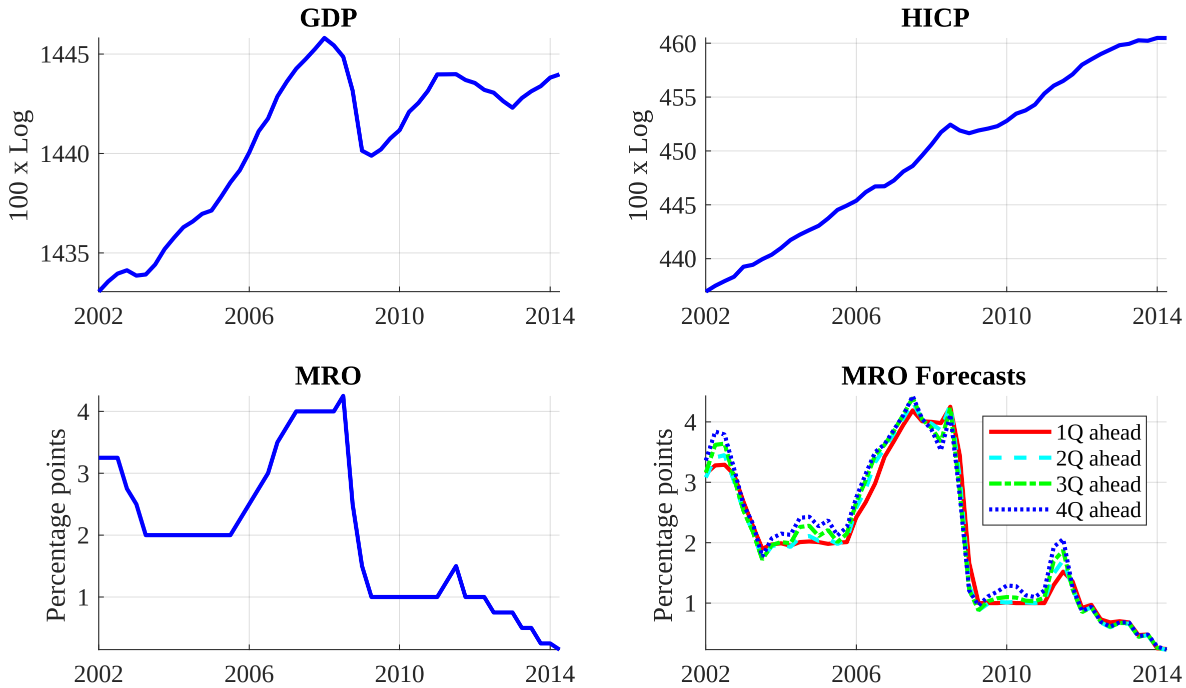
2.2 Data

Our sample consists of quarterly euro area data from 2002Q1 to 2014Q2. We are limited in the start date of the sample by the beginning of a comprehensible forecast data set. The end date is given by the lack of movement in our choice of the interest rate post-2014Q2.

We therefore aim to capture FG not in an explicit form like the expectation to keep rates "at their present levels at least through the summer of 2019 and in any case for as long as necessary to ensure that the evolution of inflation remains aligned with [...] current expectations of a sustained adjustment path", as announced by the ECB in the introductory statement to the press conference following the June 2018 Governing Council meeting. Instead we assume that forecasters may change their rate expectations based on *any* type of communication, and this implicit announcement may lead to expectations of future changes in the policy stance.

For the interest rate we use the ECB main refinancing rate (MRO) from the Statistical Data Warehouse, see Figure 1. Output and the price index are log of real GDP (calendar and seasonally adjusted) and the log of HICP (Working day and seasonally adjusted), both from the latest Area Wide Model database (Fagan, Henry, and Mestre, 2001). Rate forecasts are the median of the k-quarter-ahead MRO forecast from the Survey of Profes-

Figure 1: Data used in the VAR



Sources: *ECB Statistical Data Warehouse, Area Wide Model database, Survey of Professional Forecasters.*

sional Forecasters, for $k = 1, 2, 3, 4$.

3 Testing the FG identification with simulated data

In order to test our identifying assumptions, we first construct a data set that includes FG shocks and then apply the proposed sign and zero restrictions with our VAR. The data are generated with an off-the-shelf 3-equation New-Keynesian model that we augment with FG shocks. This analysis is similar in spirit to Carlstrom, Fuerst, and Paustian (2009) who test the standard Choleski assumption for unanticipated monetary policy shocks with a basic New-Keynesian model.

3.1 The basic 3-equation New-Keynesian model

We begin with the basic 3-equation New-Keynesian model (NK3) from Woodford (2003) and Galí (2015) given by

$$\pi_t = \beta \mathbb{E}_t \pi_{t+1} + \kappa y_t + \varepsilon_t^{\pi}, \tag{PC}$$

$$y_t = \mathbb{E}_t y_{t+1} - \sigma \left(i_t - \mathbb{E}_t \pi_{t+1} \right) + u_t^y, \tag{IS}$$

$$i_t = (1 - \rho) \left(\phi_\pi \pi_t + \phi_y y_t \right) + \rho i_{t-1} + \varepsilon_t^i + \sum_{k=1}^{4} \varepsilon_{k,t-k}^i, \tag{TR}$$

where π_t is inflation, y_t is the output gap, and i_t is the nominal short-term policy rate. Equation (PC) is the Phillips curve, equation (IS) is the IS equation, and equation (TR) is a Taylor rule. The PC is affected by cost-push shocks modeled as white-noise disturbances in the form of ε_t^{π} and the IS equation follows the exogeneous process u_t^y.[3] The standard Taylor rule is augmented with a set of anticipated monetary policy shocks, $\varepsilon_{k,t-k}^i$, that are used to engineer the FG scenarios we study in this section. Since these shocks do not capture any information about the development of macro variables, they are best

[3] $u_t^Y = a_t(\rho^a - 1)\sigma(1 + \eta)/(\sigma + \eta)$ with an auto-regressive process $a_t = \rho^a a_{t-1} + \varepsilon_t^y$.

understood as Odyssean FG.

We use a standard parameterization of the model, given in Table 3. The slope of the Phillips curve, κ, is a composite of deep structural parameters. In particular, under Calvo pricing, $\kappa = \frac{(1-\theta)(1-\theta\beta)}{\theta}\left(\frac{1}{\sigma} + \eta\nu\right)$, or under Rotemberg pricing, $\kappa = \frac{\epsilon-1}{\psi}\left(\frac{1}{\sigma} + \eta\nu\right)$, where $\nu = N/\left(1-N\right)$.[4]

Table 3: Parameter values for the basic 3-equation NK model

Parameter		Value
β	Discount factor	0.99
σ	Intertemporal elasticity of substitution	1
N, η	Labor supply parameters	0.25, 1
ϵ	Price elasticity of demand	10
θ, ψ	Calvo parameter	0.8
ϕ_π, ϕ_y, ρ	Taylor rule parameters	1.5, 0.5/4, 0.8
κ	Slope of the Phillips curve	0.267

We simulate the model for 1000 periods, assuming a standard deviation for unanticipated monetary policy shocks of $\sigma^i = 0.01$. To ensure that unanticipated policy shocks are the dominant source of fluctuations stemming from the monetary authority, we assume that FG shocks are only a fraction as volatile: $\sigma^i_k = \sigma^i/4$ for $k = 1, 2, 3, 4$. The standard deviations of supply and cost-push shocks are $\sigma^y = \sigma^\pi = \sigma^i$. The value of the auto-regressive coefficient in the supply shock is $\rho^a = 0.9$.

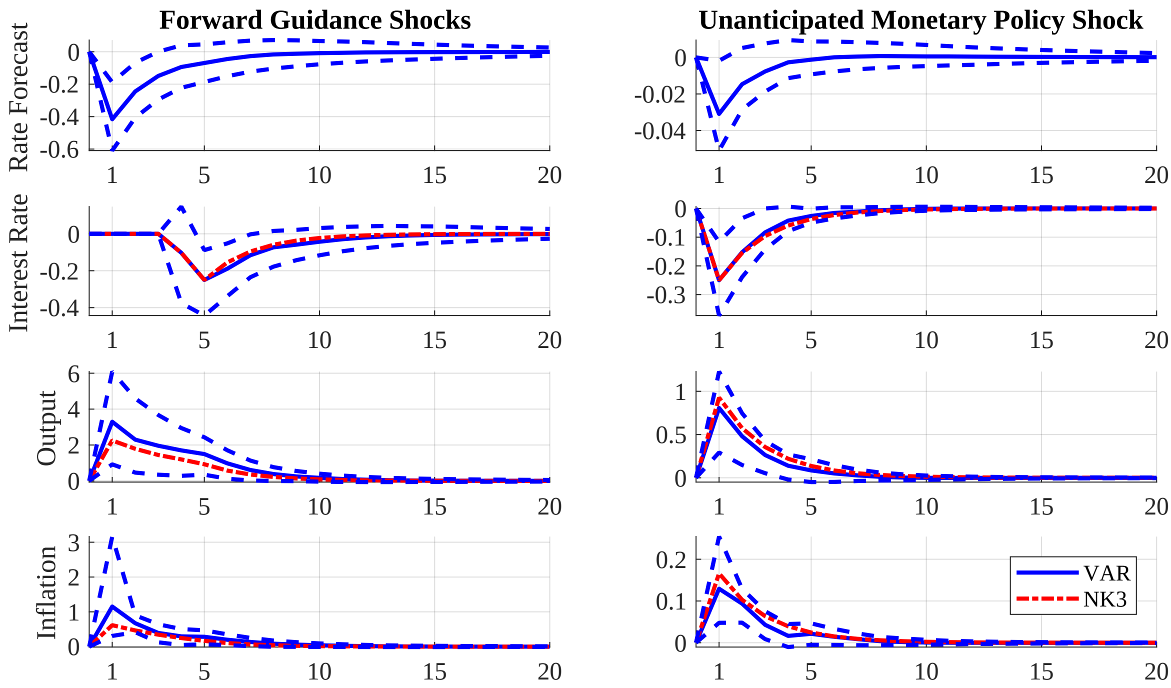
3.2 Results from simulated data

We estimate the VAR and compare the recovered responses to the ones from the NK3. Since FG is modeled as news shocks, there is an endogenous response of the macro economy due to the expectation of a rate change: a single impulse of a FG shock about an easing in the interest rate four quarters ahead would lead to an improvement of the macro already today. As contemporary macro variables enter the policy reaction function, the

[4]The per-period utility function is given by $U\left(C_t, N_t\right) = \frac{C_t^{1-1/\sigma}}{1-1/\sigma} + \chi\frac{(1-N_t)^{1-\eta}}{1-\eta}$. The parameter χ is chosen to match steady state N. The mapping from the Calvo to the Rotemberg parameter is given by $\psi = \frac{(\epsilon-1)\theta}{(1-\theta)(1-\beta\theta)}$.

monetary authority would respond with tightening today. Since our identifying restrictions exclude any change of the interest rate in the initial periods, we abstract from simple impulse response functions in favor of a simulated interest rate path in the case of FG shocks: we invert the path of the interest rate recovered from the VAR for the initial ten periods to identify the combination of contemporaneous FG and unanticipated shocks in the NK3. As we are interested in the reaction of macro variables to FG announcements, the exact form of the interest rate path plays a minor role.

Figure 2: Simulated and recovered reactions to FG and unanticipated policy shocks



Note: *Simulated and recovered reactions to a 4-quarter ahead FG shock are scaled to a rate easing of 25 bps. Deviations are in annualized percentage points for rates and in percent for macro variables; periods are in quarters and shocks realize in period 1. VAR responses depict the median response and 68% bands.*

Figure 2 depicts the responses from the simulated NK3 to the recovered responses from the VAR for a 4-quarter ahead FG shock and an unanticipated monetary policy shock. For all variables, the median recovered responses are almost identical to the simulated ones. We conclude that our identifying assumptions are successful in recovering the true responses to FG shocks. This result differs from the findings of Carlstrom, Fuerst, and Paustian (2009), who demonstrate severe distortions of unanticipated monetary policy shocks via the standard Choleski assumption in a similar model.

Note that our identifying assumptions restrict the reaction of macro variables during the initial period only. In principle, the restriction is therefore valid for macro data in levels as well as in growth rates. Additionally, the simulated data contain an output gap series, while our identification assumes observable output. Since FG is understood as a policy that affects the nominal interest rate path, potential output should remain unaffected.

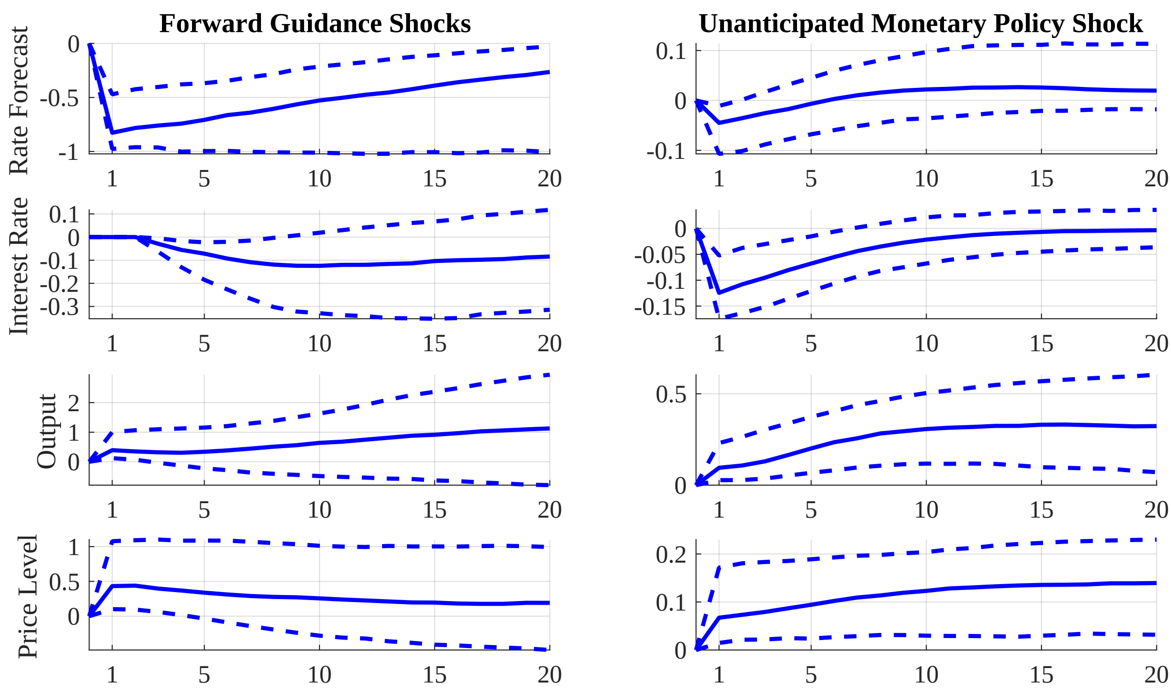
4 Empirical results

Turning to the VAR results, an identified FG shock leaves the short-term rate unchanged on impact, see Figure 3 left-hand side panels. Only after several periods does the actual interest rate decrease. Both the CPI and output rise on impact and stay elevated for some time, although the credible set does not rule out a return to the baseline after several quarters.

Considering median responses, a FG shock that triggers a 13 bps decrease in the interest rate results in an average increase in the level of the CPI of around 25 bps and output of around 70 bps over five years. Inflation, measured as the year-on-year change in the CPI, increases by 4 bps over five years on average. GDP growth increases by an average of 22 bps year-on-year over the same horizon.

These responses are sizeable, but not explosive, when compared to unanticipated shocks, see the right-hand side panels in Figure 3. An unanticipated policy decrease of 13 bps results in an increase in the CPI of around 12 bps and output of around 27 bps. Inflation increases by about 3 bps and GDP growth increases by 7 bps. FG shocks display an effect on GDP growth that is around three times more powerful than unanticipated shocks.

Figure 3: Impulse Response Functions from forecast-augmented VAR



Note: *Impulse responses to a 3-quarters ahead FG shock showing median response and 68% bands. Deviations are in annualized percentage points for rates and in percent for macro variables; periods are in quarters and shocks realize in period 1. IRFs to the FG shock are scaled to the same maximal easing as in the unanticipated shock.*

The dynamics of the response are also of interest, as the macro variables tend to react strongly in the initial period after the FG shock, but their slope is somewhat flat or even reduced during the following two years. This contrasts with the unanticipated shock, where both macro variables continue to increase over the following three to four years. While output eventually returns to the baseline, the price level appears to be permanently elevated, in line with the understanding of long-run monetary neutrality.

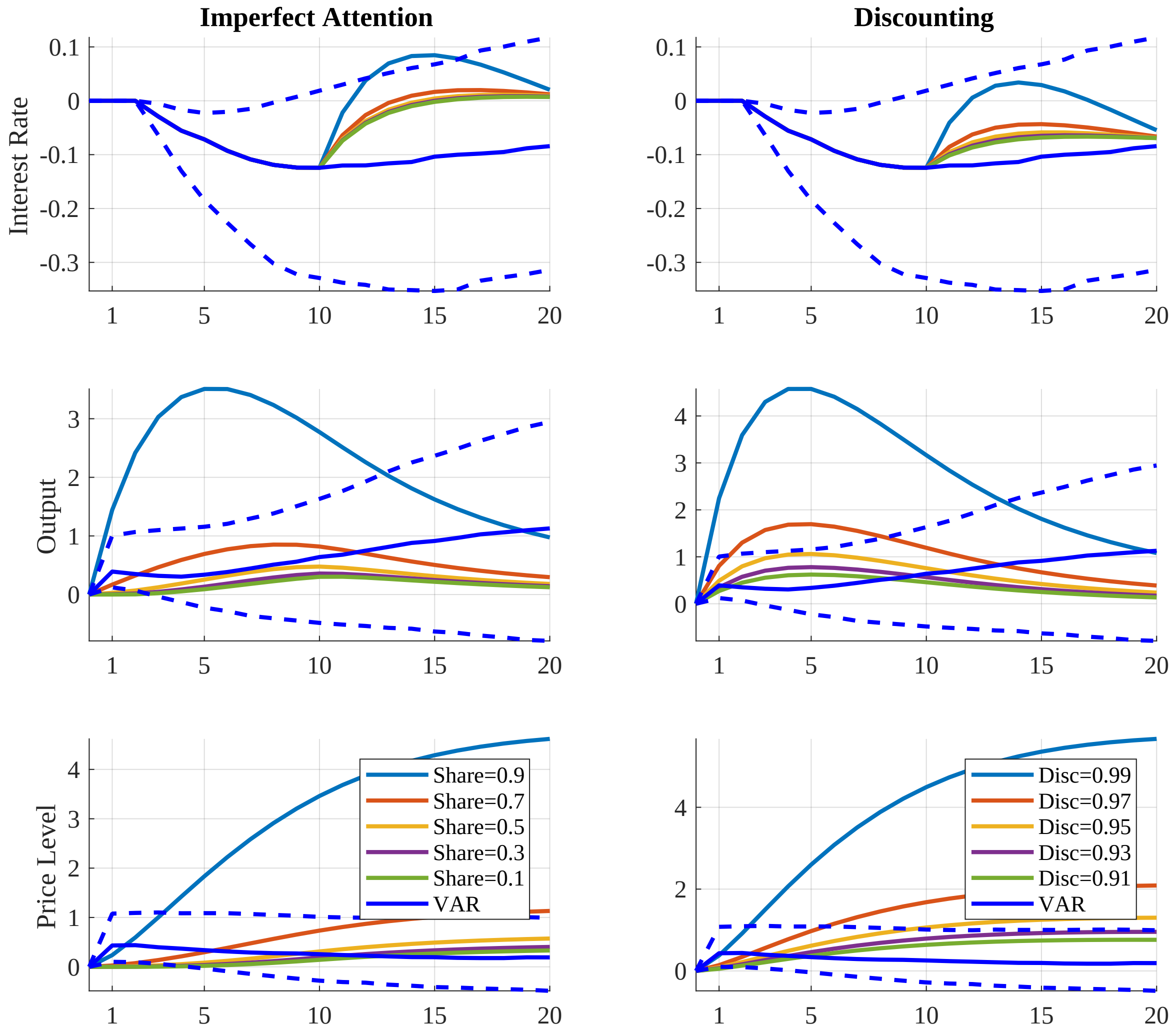
5 Disciplining a DSGE model with VAR evidence

DSGE models are commonly used to evaluate the effects of various policies and are in principle well equipped to study the effects of policies that are designed to affect the expectations of private sector agents, as they are populated with forward looking, intertemporally smoothing agents. However, standard DSGE models suggest that FG effects on output and inflation grow at an accelerating rate with the length of the horizon, making this a problematic approach (Del Negro, Giannoni, and Patterson, 2016).

We use two different modifications to dampen the effects of the FG Puzzle. The first modification relies on the assumption that agents are only imperfectly attentive to news about the future, including FG shocks, similar to the mechanism described in Coenen and Wieland (2004). In the second modification, we include a discount factor in the household Euler condition, similar to McKay, Nakamura, and Steinsson (2016) or Gabaix (2020), which limits the average planning horizon of the representative household.

The two modifications introduce (at least) one new parameter each: the share of attentive agents α for the first modification and the degree of discounting μ for the second. The aim of the exercise is to find the value of the free parameters that most closely aligns the dynamics of the DSGE model to the empirical evidence. Note that discounting modifies the dynamic properties of the model, while attentiveness only affects the impact of FG announcements.

Figure 4: Impulse Response Function Matching of NAWM with VAR results



Note: *Model simulations are conducted by pegging the interest rate response to a FG shock recovered from the VAR with the NAWM for the first 10 periods. Deviations are in annualized percentage points for rates and in percent for macro variables; periods are in quarters and shocks realize in period 1.*

We use the New Area Wide Model (NAWM) as our DSGE laboratory. We choose this model as it provides a benchmark in the literature that includes a number of features to replicate realistic dynamics, but is nonetheless plagued by the FG Puzzle. The structure and parameterization of the NAWM is identical to the one in Christoffel, Coenen, and Warne (2008), with the exception of the monetary reaction function, which is augmented with FG shocks (similar to the NK3 in Subsection 3.1):

$$\begin{aligned}\hat{r}_t =&\phi_R \hat{r}_{t-1} + (1-\phi_R)(\hat{\bar{\pi}}_t + \phi_\Pi(\hat{\pi}_{C,t-1} - \hat{\bar{\pi}}_t) + \phi_Y \hat{y}_t) \\ &+ \phi_{\Delta\Pi}(\hat{\pi}_{C,t} - \hat{\pi}_{C,t-1}) + \phi_{\Delta Y}(\hat{y}_t - \hat{y}_{t-1}) + \hat{\varepsilon}^R_t + \sum_{k=1}^{10} \varepsilon^R_{k,t-k}.\end{aligned}$$

We use the path of the short-term interest rate from the estimated VAR and replicate this path for 10 quarters with the NAWM. In the baseline calibration, all agents are perfectly attentive to news shocks ($\alpha = 1$) and do not additionally discount the future ($\mu = 1$). We weaken these assumptions by either varying the share of attentive agents ($\alpha \in (0,1)$) or by adjusting the discount factor ($\mu \in (0.9, 1)$). Note that in the limiting case of perfectly inattentive agents ($\alpha = 0$) FG shocks will be perceived as unanticipated monetary policy shocks by the agents in the model. We implement this mechanism computationally as described in de Groot and Mazelis (2020). Discounting may be interpreted as affecting the average planning horizon of the representative household (via the geometric series), which we vary between 2.5 years ($\mu = 0.9$) and an infinite planning horizon ($\mu = 1$).

Figure 4 displays the results. Both modifications are able to govern the power of FG in the DSGE model. The imperfect attentiveness version of the NAWM requires between 50 and 70 percent of households to be inattentive to FG announcements. Discounting of between 0.91 and 0.93 generates impulse responses that are close to the credible set for output and the price level. This corresponds to an average planning horizon of 2.5 to 4 years for the representative household in the model. The empirical evidence thus supports the assumption of some inattentive agents or limited household planning horizons.

6 Conclusion

VARs augmented with forecast survey data allow the identification of FG shocks via sign and zero restrictions, as demonstrated by the successful recovery of true responses to FG shocks in simulated data. Based on euro area data from 2002 – 2014, we find that a 13 bp decrease in the policy rate announced three quarters ahead results in an average increase in inflation of around 4 bps and in output growth around 22 bps (over a horizon of five years).

Applying this evidence to a large-scale DSGE model used in policy analyses allows the calibration of parameters that are otherwise difficult to estimate due to identification issues with forecast data. We find that the empirical evidence supports the assumption that not all agents in the model are fully attentive to FG announcements, or that not all households have an infinite planning horizon. Including modifications that apply these assumptions to the DSGE model helps dampen the FG Puzzle.

References

Campbell, J. R., C. L. Evans, J. D. Fisher, and A. Justiniano (2012): "Macroeconomic Effects of Federal Reserve Forward Guidance," *Brookings Papers on Economic Activity*, 43, 1–80.

Carlstrom, C. T., T. S. Fuerst, and M. Paustian (2009): "Monetary policy shocks, Choleski identification, and DNK models," *Journal of Monetary Economics*, 56, 1014–1021.

Christoffel, K., G. Coenen, and A. Warne (2008): "The new area-wide model of the euro area: a micro-founded open-economy model for forecasting and policy analysis," Working Paper Series 944, European Central Bank.

Coenen, G. and V. W. Wieland (2004): "Exchange-Rate Policy and the Zero Bound on Nominal Interest Rates," *American Economic Review*, 94, 80–84.

D'Amico, S. and T. B. King (2015): "What Does Anticipated Monetary Policy Do?" Working Paper Series WP-2015-10, Federal Reserve Bank of Chicago.

de Groot, O. and F. Mazelis (2020): "Mitigating the forward guidance puzzle: inattention, credibility, finite planning horizons and learning," Working Paper Series 2426, European Central Bank.

Del Negro, M., M. P. Giannoni, and C. Patterson (2016): "The forward guidance puzzle," Federal reserve bank of new york staff report no. 574.

Dieppe, A., B. van Roye, and R. Legrand (2016): "The BEAR toolbox," Working Paper Series 1934, European Central Bank.

Fagan, G., J. Henry, and R. Mestre (2001): "An area-wide model (AWM) for the euro area," Working Paper Series 42, European Central Bank.

Gabaix, X. (2020): "A Behavioral New Keynesian Model," *American Economic Review*, 110, 2271–2327.

Galí, J. (2015): *Monetary policy, inflation, and the business cycle: an introduction to the new Keynesian framework and its applications*, Princeton University Press.

Gürkaynak, R. S., B. Sack, and E. T. Swansonc (2005): "Do Actions Speak

Louder Than Words? The Response of Asset Prices to Monetary Policy Actions and Statements," *International Journal of Central Banking.*

McKay, A., E. Nakamura, and J. Steinsson (2016): "The power of forward guidance revisited," *The American Economic Review*, 106, 3133–3158.

Müller, T., K. Christoffel, F. Mazelis, and C. Montes-Galdón (2020): "Disciplining Expectations and the Forward Guidance Puzzle," Working Paper Series 2424, European Central Bank.

Schmitt-Grohe, S. and M. Uribe (2012): "What's News in Business Cycles," *Econometrica*, 80, 2733–2764.

Sims, E. (2016): "What's news in News? A cautionary note on using a variance decomposition to assess the quantitative importance of news shocks," *Journal of Economic Dynamics and Control*, 73, 41–60.

Woodford, M. (2003): *Interest rate and prices*, Princeton University Press Princeton, NJ, and Oxford.

Acknowledgements

We thank Marta Banbura, Günter Coenen, Roberto Motto and Roberto De Santis for comments and discussions that improved the paper.

Kai Christoffel
European Central Bank, Frankfurt am Main, Germany; email: kai.christoffel@ecb.europa.eu

Oliver de Groot
University of Liverpool, Liverpool, United Kingdom; email: oliver.de-groot@liverpool.ac.uk

Falk Mazelis
European Central Bank, Frankfurt am Main, Germany; email: falk.mazelis@ecb.europa.eu

Carlos Montes-Galdón
European Central Bank, Frankfurt am Main, Germany; email: carlos.montes-galdon@ecb.europa.eu

Postal address 60640 Frankfurt am Main, Germany
Telephone +49 69 1344 0
Website www.ecb.europa.eu

PDF ISBN 978-92-899-4412-0 ISSN 1725-2806 doi:10.2866/38381 QB-AR-20-147-EN-N