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The Macroeconomic Effects of Forward Communication*

Leif Brubakk, Saskia ter Ellen, Ørjan Robstad and Hong Xu†

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Abstract

This paper provides an empirical assessment of the power of forward guidance at different horizons, shedding new light on the strength of the "forward guidance puzzle". Our identification strategy allows us to disentangle the change in future interest rates stemming from deviations from the systematic part of monetary policy ("target" and "forward guidance" shocks) and changes in future interest rates that are due to unanticipated revisions in the central bank's economic outlook ("information" shocks). This enables us to make a qualitative assessment of the relative importance of forward guidance. We investigate to what extent the horizon of guidance matters for its macroeconomic effects, and find that the more forward the shock is, the weaker is its impact on output and inflation. This runs contrary to the prediction from standard New Keynesian models that the power of forward guidance increases with its horizon.

Keywords: [monetary policy, forward guidance puzzle, high-frequency identification, structural VAR, central bank information]

JEL classification codes: E43; E44; E52; E58

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1 Introduction

In New Keynesian models, promises regarding future policy rates potentially have very strong effects on output and inflation — even in the very short run – through the expectations channel. The size of the effects of forward guidance crucially depends on the degree of forward-looking behavior. McKay et al. (2016) observe that, in a standard New Keynesian model, a promise to lower interest rates by one percentage point five years into the future has an effect on inflation that is 18 times higher than the effect of changing the interest rate by the same amount today, a finding termed the "forward guidance puzzle" in Del Negro et al. (2015). Even more extreme effects are found in Carlstrom et al. (2015), who show that keeping rates below the natural rate of interest for two years leads to unstable dynamics for inflation and output in the Smets and Wouters (2007) model. Gali (2017) shows that the forward guidance puzzle also emerges in an open economy setting. In particular, he demonstrates that the effect on both the current real and nominal exchange rate, following an anticipated change in the interest rate, increases with the horizon of implementation. Although there is some general agreement that the predictions from simple New Keynesian models do not seem very plausible,[1] how strong the effects of signaling the path of future policy rates really are ultimately remains an empirical question. This paper provides an answer to that question.

The aim of this paper is to empirically investigate the effects of forward guidance surprises on inflation and macroeconomic aggregates. In particular, we test whether guidance on policy rates further into the future is more effective in moving current target variables than guidance relating to the shorter end of the yield curve, and as such evaluate whether there is empirical evidence of a forward guidance puzzle. There are several challenges to empirically identifying forward guidance shocks, as not all *forward communication* is regarded as *forward guidance*. First of all, we need to make sure that we abstract from the systematic component of (communication about future) monetary policy: central banks adjust their current policy rate, or guidance of future policy rates, in response to changing prospects for economic fundamentals. To the extent that market

[1]There are also numerous theoretical papers that show how relaxing some of the strict assumptions underlying simple New Keynesians models would lead to more 'realistic' theoretical predictions of the macroeconomic effects of forward guidance. These include, among others, sticky information (e.g. Carlstrom et al., 2015), myopia (e.g. Gabaix, 2019), and incomplete markets (e.g. McKay et al., 2016; Hagedorn et al., 2019).

participants have full information, controlling for this systematic component can be done by applying high frequency identification (HFI) techniques, i.e. using changes in market rates within a reasonably narrow window around monetary policy announcements. The second challenge arises from the fact that there may be asymmetric information between the central bank and market participants. In that case, monetary policy announcements also reveal information about the central bank's assessment of the economic outlook that may in turn affect the financial market's view about the economic outlook. Earlier work has shown that it is crucial to account for this information effect when evaluating the macroeconomic effects of policy surprises extracted from financial data, as failing to properly account for it could potentially lead to biased inference regarding the effects of monetary policy shocks (Campbell et al., 2012; Nakamura and Steinsson, 2018; Andrade and Ferroni, 2019; Jarocinski and Karadi, 2019).[2] Throughout the paper, we will use the term "forward communication" for all communication about future rates, and "forward guidance" when this communication is identified to be related to policy updates, i.e. deviations from systematic monetary policy.

We use and extend the identification approach suggested by Jarocinski and Karadi (2019) to differentiate between surprises related to policy updates and surprises related to the central bank releasing private information about its economic outlook. The approach combines high frequency responses in interest rates and stock prices with sign restrictions to identify policy surprises. The intuition is rather simple: a conventional monetary policy shock implies a negative correlation between stock prices and interest rates, as a contractionary shock would depress future output and dividends, and increase the discount factor. At the same time, when a surprise increase in the interest rate is interpreted as a signal that the economic outlook is better than what was expected (the information effect), this leads to higher expected future earnings and hence a positive response of stock prices. Jarocinski and Karadi (2019) do not distinguish between a "target" shock and a "forward guidance" shock, which is crucial for our analysis. We therefore add an additional zero-restriction to their identification scheme, based on the assumptions from Gürkaynak et al. (2005): forward guidance shocks should not move

[2] Campbell et al. (2012) use high-frequency data to estimate the effects of forward guidance in the post-crisis period and find that a negative "forward guidance" shock (i.e. a signal of lower future policy rates) leads to an decrease in expected output and inflation – the opposite of what theory would suggest. A possible explanation put forward by the authors is that signals of lower policy rates to come might be interpreted by market participants as revealed information about the future state of the economy.

the current short-term rate, but only longer maturity interest rates. Finally, we use this extended framework to estimate the effects of forward guidance shocks at different horizons, by utilizing forward rates of different maturities. This allows us to evaluate the slope of the forward guidance effect as a function of the horizon, thus ultimately being able to shed light on whether forward guidance is indeed more effective the further into the future it relates to.

The empirical analysis is based on data for Sweden and Norway, two countries that publish conditional forecasts of future policy rates along with projections of other key macro variables.[3] Hence, these central banks have a history with forward guidance that goes beyond forward guidance in zero-lower-bound periods, allowing us to make more general statements about the effectiveness of such policies. More importantly, these published policy rate paths provide the public with *horizon-specific* forward communication, making these countries the perfect case study for evaluating the effect of forward guidance over different horizons.

Our results confirm the findings of Jarocinski and Karadi (2019) that an information shock is followed by an increase in activity and inflation. Moreover, we find that it leads to an appreciation of the exchange rate. These findings are consistent with the interpretation that market participants update their views on current and future demand conditions based on the central bank's assessment of the economic outlook. The impulse responses are very different following conventional monetary policy and forward guidance shocks. Both shocks indicate that a monetary policy contraction (either now or in the future) will lead to a currency appreciation and a drop in output and inflation. Most importantly though, the macroeconomic effects of a forward guidance shock decrease with the horizon of the guidance. Hence, our results do not support the theoretical predictions from standard New Keynesian models.

Although forward guidance seems to be effective in moving medium- to long-term interest rates at high frequencies,[4] the empirical evidence on its effectiveness in mov-

[3] In the case of Norway, we cannot assess the relative effectiveness of forward guidance over different horizons as for Sweden, due to data limitations.

[4] There is now a large number of empirical works that investigate the effects of forward guidance on yields and other asset prices. Borio and Zabai (2016) provide an extensive survey of this literature and an overview of the quantitative effects. The overall impression is that these measures have been successful in moving asset prices. However, the majority of these studies focus exclusively on the various post-crisis variants of forward guidance as practiced by central banks in the US, UK, Euro area and Japan, and it has been difficult to distinguish between the effects of forward guidance and asset purchase programs.

ing key macroeconomic variables is still relatively scarce. Some exceptions are Andrade and Ferroni (2019), Smith and Becker (2015), Bundick and Smith (2018) and Ben Zeev et al. (2019). Andrade and Ferroni (2019) find that the ECB was successful in stimulating the economy when it was surprising the market with Odyssean signals of future policy accommodation. Smith and Becker (2015) find that forward guidance yields quantitatively similar effects on US employment and inflation as conventional policy shocks. Bundick and Smith (2018) find no disconnect between the empirical effects of forward guidance shocks and the predictions from a standard theoretical model. Even though they do not control for the information effect, they still find very strong economic effects of forward guidance. However, these papers evaluate the effects of forward guidance shocks in a more general sense, typically for a one- to two-year horizon, rather than for varying horizons, and are therefore not able to empirically evaluate the essence of the forward guidance puzzle, namely that the effects increase with the horizon. In terms of assessing the macroeconomic effects of forward guidance over varying horizons, the paper that comes closest to ours is D'Amico and King (2017), who add survey forecasts to an otherwise standard VAR for the US. They use a mixture of sign and zero restrictions to identify the economic effects of news about future monetary policy, their equivalence of forward guidance shocks. In contrast to our results, they find quite sizable effects of forward guidance, and the effects increase with the horizon – in line with the predictions from standard New Keynesian models.

The rest of this paper is set up as follows. Sections 2 and 3 elaborate on our data and methodology, respectively. Section 4 presents the results, and Section 5 concludes.

2 Data

The empirical analysis is based on data for Sweden and Norway, two countries that publish conditional forecasts of future quarterly policy rates along with projections of other key macro variables. Hence, these central banks have a history with forward communication that goes beyond zero-lower-bound periods, potentially allowing us to make more general statements about the effectiveness of forward guidance policies. Moreover, the policy rate forecasts are horizon-specific, as they can vary for each individual quarter between meetings. Hence, there is potential variation in the forward guidance horizon that we can utilize empirically.[5] Figure A.1 in Appendix A illustrates this, by showing examples of how level, slope, and curvature of the forecasted path of interest rates can change (considerably) from report to report.

Our data set consists of two parts: asset price changes on monetary policy announcement days, converted into monthly series through appropriate calander adjustments, and monthly data on macroeconomic variables. The former will enter the VAR as exogenous variables, whereas the macroeconomic variables will be endogenous variables in the VAR. Our sample covers the period from 2000M1 to 2018M11. The Norwegian sample starts in 2001M4, when Norges Bank officially became an inflation-targeter. How the data is used for identification is explained in the Methodology section.

2.1 High-frequency data

In order to extract monetary policy surprises from interest rates, we use intra-day and daily changes in interest rates on announcement days. We also extract intra-day and daily changes in equity indices. All intra-day data are obtained from the Thomson Reuters Tick History (TRTH) database, daily data from Bloomberg, Nasdaq, and Oslo Børs. We follow the literature (Gürkaynak et al., 2005; Gertler and Karadi, 2015; Jarocinski and Karadi, 2019, among others), and extract monetary policy surprises for a 30-minute window around the announcement, i.e. we take the change in the one-month interest rate from 10 minutes before until 20 minutes after the announcement. As in Brubakk et al. (2017) and Natvik et al. (2019), we use one-month rates implied by foreign exchange forward contracts.[6] We choose to use day-long windows for the longer maturity interest rates, as we expect that most forward guidance will come from the published report (including interest rate projections) and the press conference. It can take some time for financial markets to digest all this information and revise expectations accordingly, which we allow for by using day-long event windows.[7]

Forward rate agreements (FRAs) are used to measure interest rate changes over dif-

[5]For Norway, we cannot assess the effectiveness of forward guidance over as many periods into the future as for Sweden, due to data limitations.

[6]Ideally, we would like to use a one-month OIS/futures contract to extract unexpected changes in the key policy rate. However, although Sweden has an OIS market now, it did not have one during the first few years of our sample. Norway does not have an OIS market.

[7]Brubakk et al. (2017) evaluate several event windows and report that a short window is sufficient to measure the monetary policy surprise, but that this would not capture the full response to communication.

ferent horizons. These rates reflect market participants' expectations of the three-month money market rate on a specific date in the future (the International Money Market, or IMM, date), plus a potential forward premium. More precisely, the first FRA (hereafter FRA1) reflects the expected three-month money market rate at the first upcoming IMM-date, FRA2 for the second upcoming IMM-date, etc.[8] For Sweden, there is data available for FRA contracts up to 12 quarters ahead. Norway has only had conrtacts for the upcoming four quarters since the start of the sample, with contracts for longer horizons being introduced at several stages throughout the sample.

The equity index used for Sweden is the headline index, OMXSBGI (OMX Stockholm Index). In Norway, the headline index is heavily influenced by movements in oil prices. We therefore use a sub-index that has historically shown to co-move more closely with the domestic business cycle, rather than with international developments, as it mostly consists of consumer goods producers (OSE25GI – OSE Consumer Discretionary GI Index). Intraday data on these equity indices is available from 2005 for Sweden and 2001 for Norway. We therefore use daily changes for our benchmark estimation, for which data is available for our full sample from 2000 to 2018.[9]

2.2 Monthly data

The baseline VAR includes five endogenous monthly variables: the key policy rate, a one-year money market rate, core inflation, an activity factor, and the nominal exchange rate. As a measure of core inflation we use CPI with fixed interest rate (CPIF) excluding energy in Sweden, and CPI adjusted for energy and taxes (CPI-ATE) for Norway, the core inflation measures used by respectively Sveriges Riksbank and Norges Bank. To obtain a monthly series on activity, we use the factor model described in Aastveit et al. (2016): we extract the principal component of a data set consisting of three frequently used monthly economic activity indicators (industrial production, retail sales and unemployment), and label this the "activity factor".[10] The one-year money market rate is calculated as the average of the first four FRA contracts. The exchange rates used are measured as trade

[8]The International Money Market dates are the third Wednesday in March, June, September and December.

[9]We performed robustness checks using intra-day (rather than daily) data on stock prices and FRAs, and results are robust to this.

[10]The activity factor is rescaled to have approximately the same variance as an HP-filter of (log) GDP with $\lambda = 40000$.

weighted indices, the TCW-index for Sweden and the I44 for Norway. For these indices, an increase in value indicates a weakening of the domestic currency.[11]

3 Methodology

In this section, we present the empirical approach for identifying and estimating the effect of the three policy surprises (conventional monetary policy, forward guidance, and information). The set-up is based on Jarocinski and Karadi (2019), and extended in order to trace out the effects of forward guidance and its effectiveness for different horizons.

In particular, we add variables reflecting high-frequency movements in various financial variables around monetary policy announcements to an otherwise standard open economy VAR. In order to achieve identification, we impose a combination of sign and zero restrictions. Jarocinski and Karadi (2019) utilize the high-frequency co-movements of both interest rates and stock prices in order to disentangle monetary policy shocks from information shocks. Theory dictates a negative relation between stock prices and monetary policy shocks: a monetary tightening will reduce the value of expected future pay-offs by both increasing the discount rate and potentially reducing future revenues due to an economic slowdown. However, when the central bank tightens monetary policy because its outlook on the future is better than expected, this can be considered a positive information shock if this also shifts the economic outlook of market participants in the same direction. Positive information about the economy increases expected future revenues, and hence has a positive effect on stock prices. The correlation between stock prices and interest rate changes is therefore informative for the type of shock that drives the interest rate changes, and can be used to impose sign restrictions.

Because we are interested in splitting the monetary policy shock further into a target and forward guidance shock, we extend the sign restricted exo-VAR from Jarocinski and Karadi (2019) with a zero restriction on the impact of forward guidance. The rationale for this restriction comes from Gürkaynak et al. (2005), who argue that forward guidance, being about future monetary policy by definition, does not affect rates on instruments

[11] For these monthly series, the following data sources were used: Norway: activity factor (Statistics Norway and Norwegian Labour and Welfare Administration), inflation (Statistics Norway), policy rate (Norges Bank), and exchange rate (Norges Bank). Sweden: activity factor (Statistics Sweden and Swedish Public Employment Service), inflation (Statistics Sweden), policy rate (Riksbanken), and exchange rate (Riksbanken). Monthly data on FRA contracts is obtained from Thomson Reuters Eikon for both countries.

that mature before the next interest rate meeting. How short this maturity should be depends on the central bank and how often it has the opportunity to change interest rates.[12] For most central banks, there is at least one month between rate meetings, and thus a commonly used maturity for the shortest end of the yield curve in this setting is a one-month interest rate.

For the identification scheme, we use a combination of sign and zero restrictions, following an approach similar to Binning (2013) and Arias et al. (2018). The model is estimated using a Bayesian approach with a flat prior. The prior is described in appendix B. The baseline VAR can be expressed as follows:

$$y_t = \alpha_y + \sum_{k=1}^{K} \beta_k^y y_{t-k} + \sum_{k=1}^{K} \beta_k^m m_{t-k} + \gamma_m \varepsilon_t^m + u_t^y \tag{1}$$

where m_t denotes a vector of changes in N_m financial instruments around a policy announcement in month t and y_t is a vector of N_y macro economic variables.[13] The vector of reduced-form residuals are given by u_t^y. Changes in financial instruments on announcement days, m_t, are assumed to be *iid*, so that $m_t = u_t^m, u_t^m \sim N\left[0, \Sigma^m\right]$.

In order to trace out the effect of the policy shocks in the baseline VAR-model we need to transform the reduced form residuals from u_t^m into structural policy shocks. The mapping between the reduced form residuals and the structural shocks can be expressed as:

$$u_t^m = Z_m \varepsilon_t^m$$

where Z_m is a matrix of structural parameters and ε_t^m represents the structural shocks assumed to account for movements in financial instruments on announcement dates. We impose zero and sign restrictions on the impact matrix Z_m following Arias et al. (2018). The restrictions, which follow from our identifying assumptions, are summarized in Table 1:

[12] In principle, a central bank has the possibility to change the interest rate at any time, but under normal circumstances will only do so at scheduled announcement dates.

[13] To generate a monthly series based on the event-based series of policy surprises we follow Gertler and Karadi (2015): we generate a daily series of cumulated surprises the last 31 days, and obtain a monthly series by averaging the 31-day cumulated daily series over calendar months.

Table 1: Identifying restrictions

	shock		
	Monetary policy (target)	Monetary policy (forward)	Information
Short rate	+	0	NA
Longer rate	+	+	+
Stock market	-	-	+

Notes: Restrictions imposed on the impact effects of the three structural shocks of interest. The short interest rate refers to an instrument that matures before the next interest rate meeting (here a one-month interest rate).

In order to compute the posterior draws of the structural shocks and the corresponding impulse responses, we start by calculating a 3x3 matrix C, which is the lower triangular Choleski decomposition of Σ^m. Next, we post-multiply C by a 3x3 orthogonal matrix, Q, taken from the QR decomposition of a randomly drawn matrix, and rotated such that CQ satisfies the sign and zero restrictions.[14] We store each draw and repeat the procedure until we have 10 000 rotations where both the zero and sign restrictions are satisfied. As Jarocinski and Karadi (2019) describe, the prior on the rotations is uniform in the subspace where the restrictions are satisfied. Each draw of the structural parameters will yield a unique time series for the structural policy shocks (ε_t^m). For each rotation we draw model parameters from the posterior and calculate the corresponding impulse responses. Since the restrictions imposed are not sufficient to uniquely identify the structural shocks of interest, we have what is often called set identification, i.e. there will be a set of admissible parameter vectors that are consistent with both the zero and sign restrictions. When computing uncertainty bounds we take all the draws into account weighting them according to the uniform prior on rotations.

So far we primarily focus on identifying one forward guidance shock (or path factor) pertaining to the whole yield curve. Ultimately, we are interested in the power of forward

[14] 2x2 in Jarocinski and Karadi (2019), as they only distinguish between a monetary policy shock an information shock.

guidance shocks aimed at different horizons.[15] In order to investigate this, we identify forward guidance shocks for different parts of the yield curve, by using announcement-day surprises based on all available FRAs and estimating the corresponding impulse responses. We do this successively, by maintaining the one-month rate and stock prices and replacing one FRA surprise at the time. Hence, we start by identifying the three shocks based on the announcement-day surprise in the one-month rate, stock prices and FRA2 and the corresponding impulse-responses from the monthly VAR. We then replace the FRA2 with FRA3, identify the shocks and corresponding impulse responses, et cetera. This allows us to compare the impulse responses for our variables of interest for the different forward guidance shocks and hence to evaluate whether the macroeconomic consequences of the forward guidance shock depends on the horizon to which it pertains.

4 Analysis and results

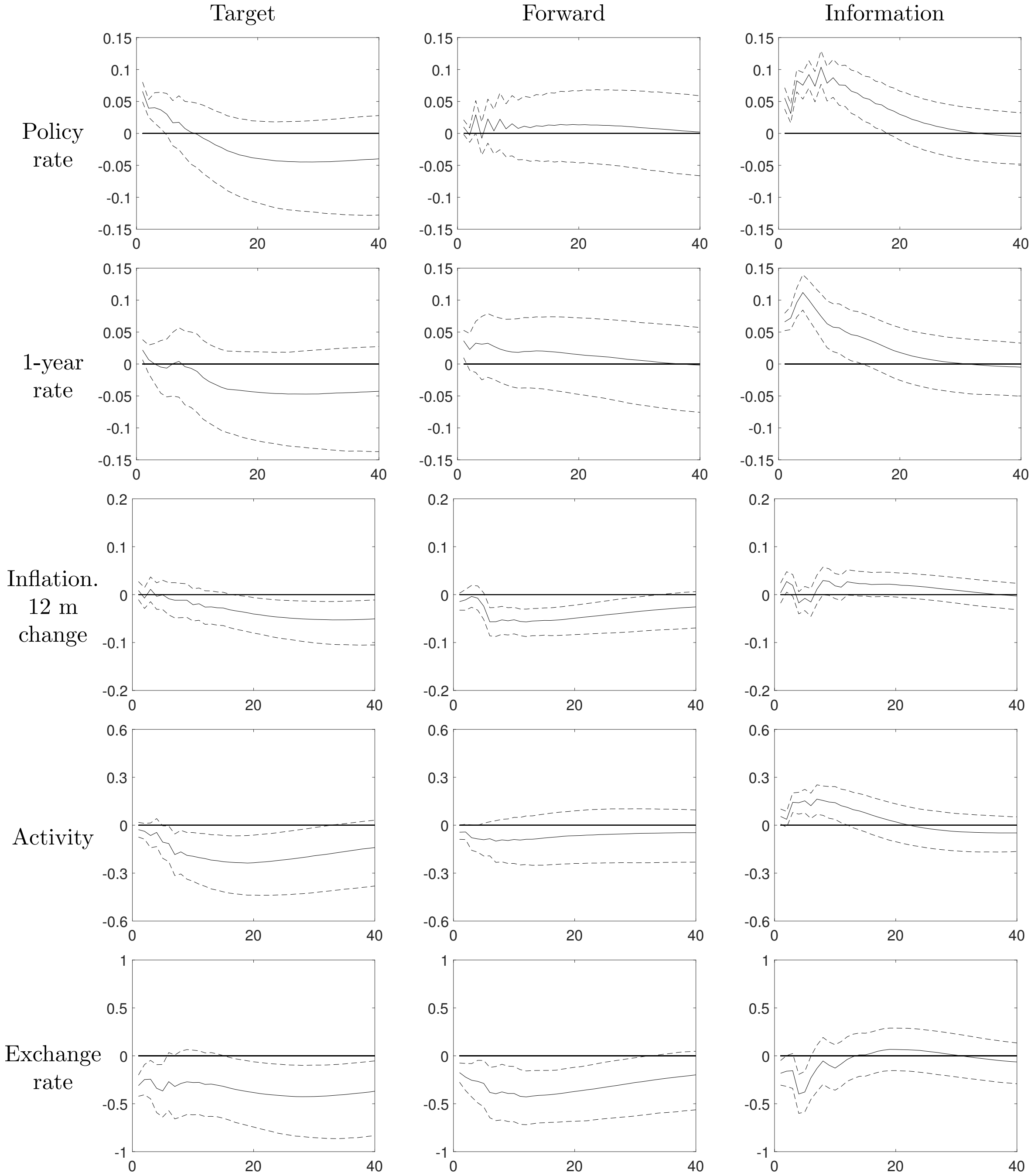
4.1 Forward communication in Sweden and Norway: guidance and information

In this section, we report the impulse responses of three shocks identified using a mixture of sign and zero restrictions. Furthermore, we also highlight the relative importance of the three identified disturbances by means of variance decompositions. Our starting point is an estimated reduced form monthly VAR with six lags. The baseline specification includes monthly data on the policy rate, a one-year money market rate, core inflation, the activity factor and the nominal exchange rate, as discussed in the data section. For the benchmark high frequency identification, we use 30-minute changes in the one-month rate and daily changes in stock prices and the FRA3 contract.

Figure 1 presents the impulse responses for the three identified shocks based on Swedish data. Tracing out the responses from a shock to the current policy rate (first col-

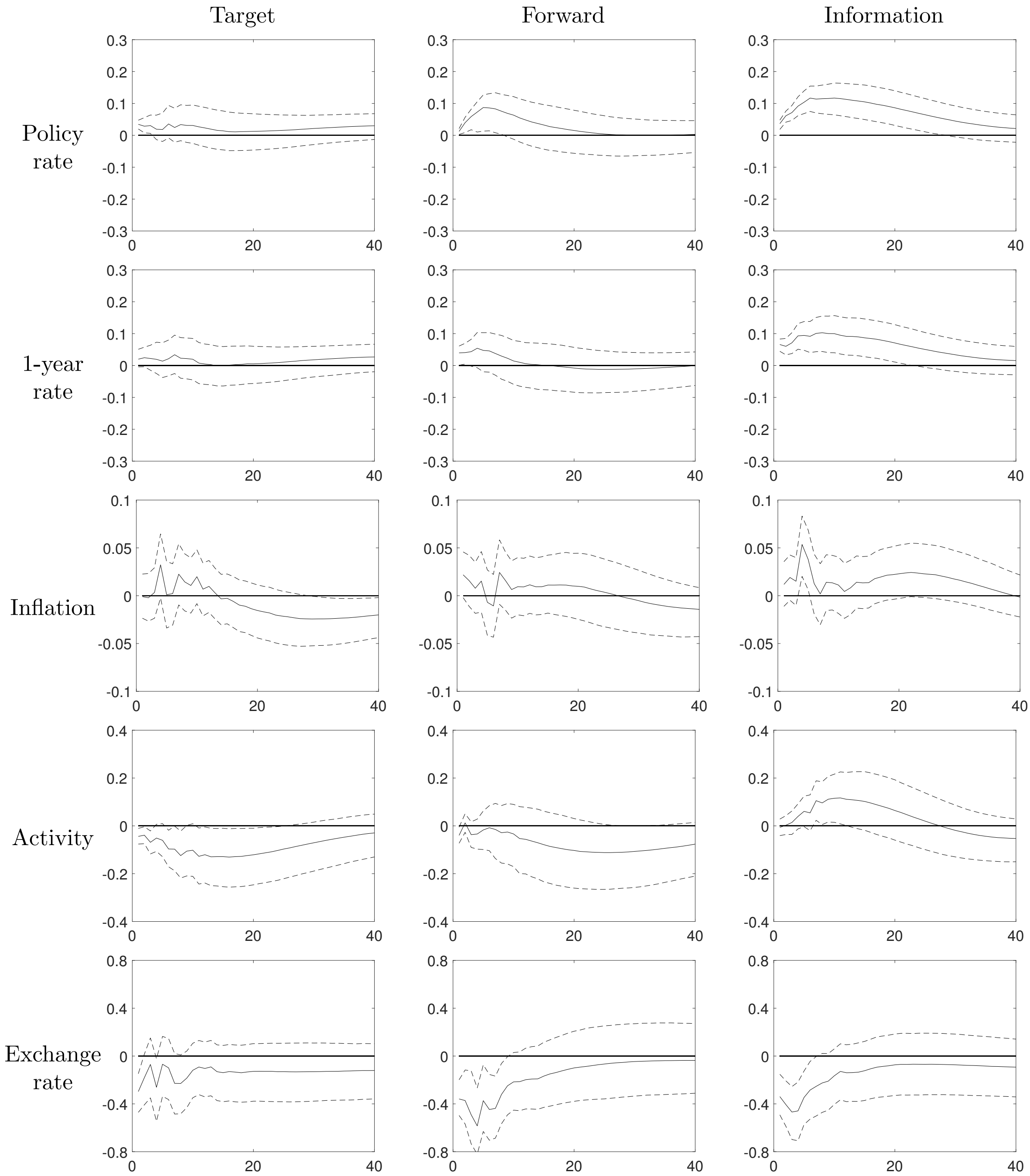
[15]Some might argue that there is no empirical parallel for the theoretical experiment of varying the forward guidance horizon. However, the response on both the slope and curvature of the yield curve can vary substantially between the different policy meetings (see e.g Inoue and Rossi (2018). Some of this variation could stem from noise in data or the information shocks (although this is not what we find), but it is reasonable to assume that some of this variation is related to forward guidance shocks, especially in central banks that publish interest rate paths. Even central banks that do not publish such policy rate projections could in principle use projections of key macro variables and other means of communication, such as oral statements, to guide market expectations at different horizons, justifying the assumption of horizon specific forward guidance shocks.

Figure 1: Macroeconomic responses to three shocks - Sweden



Notes: This figure shows the impulse responses from estimating our baseline VAR for Sweden, with five endogenous variables and three identified shocks: a target rate shock, a forward guidance shock, and an information shock. Sample: 2000M1-2018M11. The dotted lines show the 68th posterior probability region of the estimated impulse responses. Responses in the policy rate, one-year rate and inflation are measured in percentage points, activity and exchange rate in percent.

Figure 2: Macroeconomic responses to three shocks - Norway



Notes: This figure shows the impulse responses from estimating our baseline VAR for Norway, with five endogenous variables and three identified shocks: a target rate shock, a forward guidance shock, and an information shock. Sample: 2001M4-2018M11. The dotted lines show the 68th posterior probability region of the estimated impulse responses. Responses in the policy rate, one-year rate and inflation are measured in percentage points, activity and exchange rate in percent.

umn), we can observe that a surprise tightening leads to an appreciation of the exchange rate and a slowdown in economic activity. Inflation is relatively unaffected on impact, but the mean-adjusted rate turns negative after roughly three months. A conventional monetary policy shock does not seem to have a very strong effect on the longer rates. The effects of a surprise signal of a future tightening, i.e. a forward guidance shock, are shown in the second column of Figure 1, and look quite similar to the effects of a target shock. A positive forward guidance shock is followed by a slowdown in activity, an appreciation of the currency and drop in the inflation rate. Hence, in summary, both a positive conventional monetary policy shock and a positive forward guidance shock lead to a textbook contraction of the economy.

The impulse responses from an information shock can be found in the third column in Figure 1. A positive information shock is followed by an increase in both the current rate and the one-year rate. Presumably as a result the exchange rate appreciates. Despite tighter financial conditions, both activity and inflation increase.

Results for Norway are shown in Figure 2. Qualitatively, the results are similar to those for Sweden for all shocks. However, inflation is much less responsive to either conventional monetary policy or forward guidance shocks. A surprise increase in the key policy rate lifts the one-year rate and leads to a slowdown in activity and a strengthening of the exchange rate. The inflation rate does not respond much in the short run before eventually falling below its sample mean. A positive forward guidance shock looks qualitatively similar to a shock to the current rate, albeit having a stronger effect on the exchange rate.

For both Norway and Sweden, the responses we see from an information shock are the type of responses one would expect from a demand shock. However, the information shock is not a demand shock in the standard sense. Rather, it results from a revision of agents' expectations of the (future) state of the economy. One interpretation is that the information shock reflects new assessments or news communicated by the central bank on announcement days which are internalized by market participants. Our results for both countries emphasize the importance of controlling for central bank information revealed in policy announcements when evaluating the macroeconomic effects of monetary policy using HFI techniques.

The identified monetary policy shocks for both Norway and Sweden have a standard deviation of roughly five basis points, which is quite modest compared to what is typically found using more conventional identification strategies. Intuitively, teasing out the economic effects from such minor disturbances is somewhat more challenging. The variables constituting our VAR are driven by a large number of disturbances beyond surprises following interest rate announcements. Still, especially in the case of Sweden, the effects of both monetary policy shocks seem to yield non-zero effects on the variables of interest in the direction suggested by theory.

Throughout our sample, Norwegian policy rates have been above their zero lower bound and there have been no explicit unconventional monetary policies such as asset purchase programs. In contrast, some of Riksbanken's statements have contained calender-based forward guidance. Moreover, at the meeting of February 17, 2015, Riksbanken started purchasing Swedish government bonds and lowered its key policy rate below zero. As Krishnamurthy and Vissing-Jorgensen (2011) argue, asset purchase policies can strengthen the effect of forward guidance policies by lowering expectations of future policy rates. All of these policies can have contributed to the stronger effects of forward guidance observed in Sweden.[16]

4.1.1 Variance decompositions

In order to get a better understanding of the relative importance of the three identified disturbances in driving the variation in both the high- and low-frequency variables, we calculate a set of forecast error variance decompositions. This is not straightforward, given the fact that we rely on sign restrictions when identifying the structural shocks. In the case of weak identification, the identified disturbances are not unique. In fact, we identify a vector of shocks for each rotation of the C-matrix. Hence, in principle we would have a set of variance decompositions, i.e. one for each rotation. Here, we report the forecast error variance decomposition based on the median impulse responses.[17]

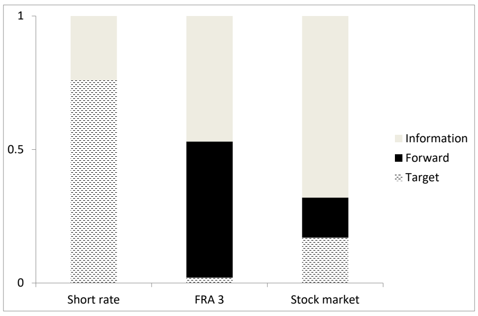
Figure 3 presents the relative contributions of the three identified disturbances on

[16] However, we do not expect the asset purchase programs to have a dominant effect in our sample. As shown by Diez de los Rios et al. (2017), asset purchase programs in small open economies (SOE) are much less effective in moving rates than asset purchase programs from major central banks such as the Federal Reserve and the ECB, as SOE central banks are unable to affect the global term premium.

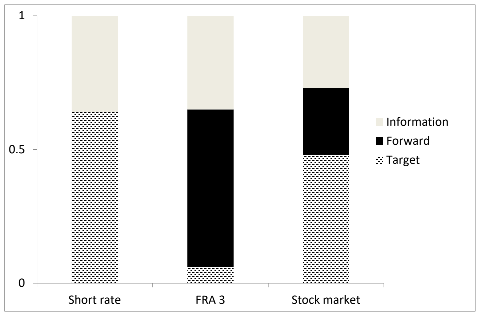
[17] Other approaches followed in the literature include applying the impulse responses that comes closest to the median or, restricted to the Bayesian case, using the impulse responses from the most likely (mode) model. We tested these alternative approaches and find that our conclusions are qualitatively robust to this particular choice of impulse responses.

Figure 3: Variance decomposition high-frequency data

(a) Sweden



(b) Norway



Notes: Variance decompositions based on the median rotation.

the changes in the high-frequency variables on policy announcement days. For both countries, most of the high-frequency variation in the one-month rate (short rate) is driven by conventional monetary policy shocks. Surprise revisions in the short rate due to revisions in fundamentals, i.e. driven by information shocks, appear to be slightly more important in Norway than in Sweden.[18] At least half the variation in changes to the forward three-month rate three quarters out (FRA3) on announcement days can be attributed to the forward guidance shock, whereas the remaining variation is due to the information shock. The effect of the conventional monetary policy shock on the FRA3 is strikingly small. The results are quite similar for the two countries. Although the stock market is not the focus of this study, we note that variation in stock prices on announcement days are driven to a large extent by the information shock in Sweden, whereas conventional monetary policy shocks are relatively more important in Norway.

Table 2: Forecast error variance decomposition: Sweden

	Target			Forward guidance			Information		
	CPI	Act.	FX	CPI	Act.	FX	CPI	Act.	FX
1	0.5	0.7	6.8	0.6	1.0	2.2	0.5	1.4	2.3
6	2.4	3.1	5.1	4.3	2.8	4.2	3.1	6.3	4.2
24	8.3	10.7	10.5	15.1	3.6	10.8	4.9	3.9	3.9
Inf	15.3	14.5	15.3	11.0	6.8	9.9	4.6	4.5	4.2

Notes: Forecast error variance decomposition of identified shocks for inflation, activity and the exchange rate at different horizons in per cent. Based on the median shocks at each announcement.

Tables 2 and 3 contain the forecast error variance decomposition for the low-frequency

[18]Due to the imposed zero-restriction in the high-frequency VAR, the forward guidance shock cannot explain high-frequency movements in the short rate.

Table 3: Forecast error variance decomposition: Norway

	Target			Forward guidance			Information		
	CPI	Act.	FX	CPI	Act.	FX	CPI	Act.	FX
1	1.6	1.6	5.3	0.9	1.3	7.7	0.6	0.5	7.2
6	2.6	3.1	3.3	2.8	1.9	11.9	4.2	1.7	9.5
24	3.9	5.0	3.4	4.2	4.2	7.1	4.8	3.7	5.2
inf	6.3	6.3	5.6	6.9	7.4	7.4	6.6	5.9	6.2

Notes: Forecast error variance decomposition of identified shocks for inflation, activity and the exchange rate at different horizons in per cent. Based on the median shocks at each announcement.

variables in Sweden and Norway respectively, at various horizons. Not very surprisingly, the contributions of all three shocks for variation in inflation and activity are quite moderate at short horizons, but generally increase for longer horizons. For Sweden, the three disturbances account for roughly 30 percent of total monthly variation in inflation and 25 percent of the variation in activity. The corresponding number for Norway is close to 20 percent for both inflation and activity. Focusing on the two monetary policy shocks, we see that their relative importance is roughly equal for Norwegian variables, whereas the conventional monetary policy shock seems to dominate for Swedish variables, accounting for roughly two thirds of the combined contribution to the variation in inflation and activity. With respect to currency movements, target shocks explain most of the variation in Swedish krone compared to the other two shocks, while the forward guidance shock is relatively more important for Norwegian krone.

4.2 A forward guidance puzzle?

Ultimately, we are interested in the power of forward guidance aimed at different horizons. We focus on Sweden in this section, as there are data available for forward rate agreements that cover all successive three month rates three years out for the whole sample.[19] Recall that we identify forward guidance shocks for different parts of the yield curve by replacing the FRA announcement-day surprise in the high-frequency VAR one at a time, after which we estimate the corresponding impulse responses.

The results are summarized in Figure 4. The first column presents the response in inflation, activity, and the exchange rate in six months time, to a forward guidance shock pertaining to two (FRA2) to 12 (FRA12) quarters ahead. We consider this the short

[19] Norway only has forward rate contracts for the first four quarters ahead for our full sample, and thus the data for Norway is too limited to analyze the effects of forward guidance for several horizons.

run response to forward guidance shocks of different horizons. The second column of Figure 4 presents the maximum (in absolute terms) response of inflation, activity, and the exchange rate, to forward guidance shocks pertaining to two to 12 quarters ahead.

The general message conveyed by our results is clear. Whether looking at the six-month or maximum impact of forward guidance shocks, the effects on inflation, activity and the exchange rate are weaker the more forward the shock is. Overall, the results indicate that forward guidance aimed at moving expectations about policy rates in the near term is more effective than forward guidance pertaining to policy rates further out on the horizon.[20] This runs contrary to the implications from the standard New Keynesian model, where the exact opposite holds true.[21]

4.2.1 Robustness

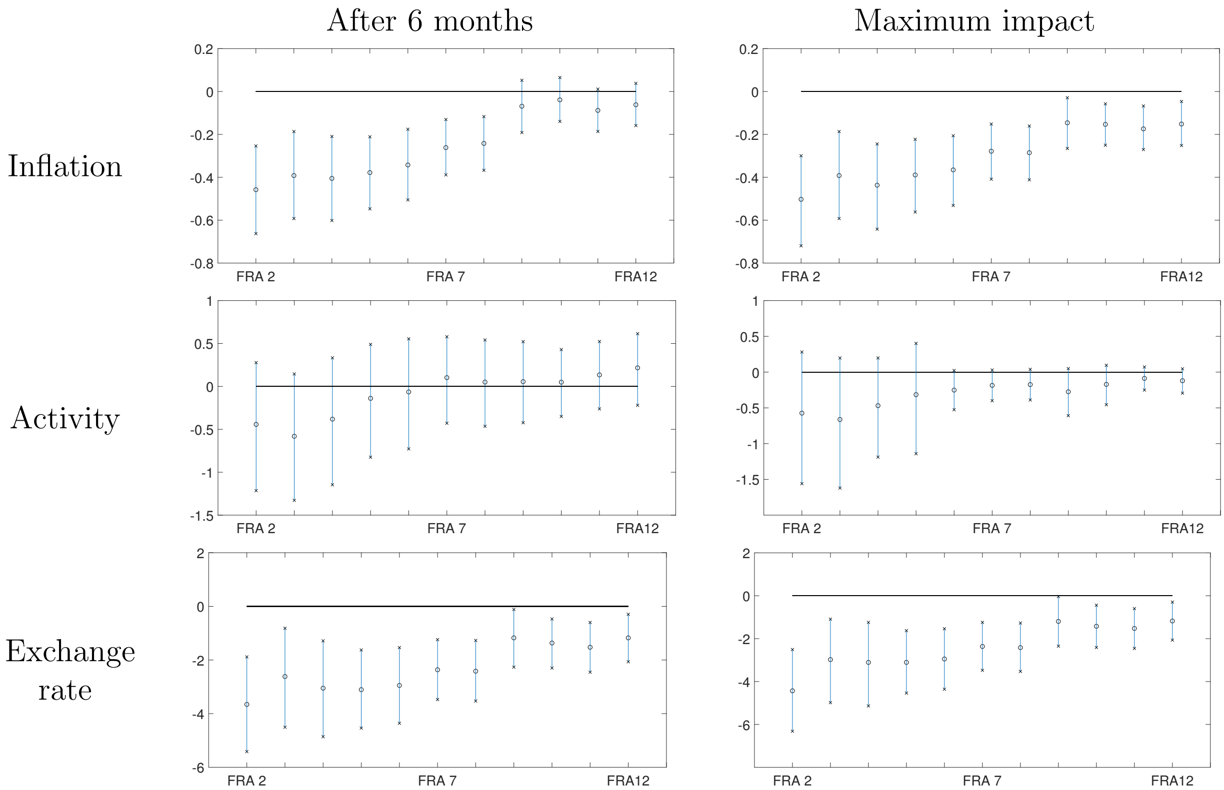
In the exercise reported above, the monthly VAR is kept unchanged as we vary the FRAs used for the high-frequency identification. The benchmark monthly VAR employs the one-year rate, which, by construction, is more correlated with FRA2 to FRA4 than the FRAs further out on the yield curve. Hence, one reason for finding weaker effects of the longer FRAs could be that the longer FRAs explain less of the variation in the monthly one-year rate in general. We perform two robustness checks in which we slightly change the setup, to understand if this is driving our results. First, we repeat the above exercise while replacing the one-year rate with a two-year rate.[22] The results, as shown in Figure C.1, are almost identical to the results obtained with the one-year rate. Alternatively, we also estimate impulse responses using matching FRAs in both the monthly and high-frequency VAR. Hence, when using e.g. the FRA2 in the high-frequency VAR, we also replace the one-year rate in the benchmark monthly VAR with the FRA2 rate. The results in Figure C.2 show that results are also robust to this: although the effect obtained with FRA4 to FRA8 seem a bit stronger in this case, the difference is small, and there is no impact of forward guidance that exceeds the two-year horizon. Hence, we reach the same conclusion as in the benchmark estimation: the effects on the target variables resulting

[20] Brubakk et al. (2017) show that this is also the case when one directly looks at the impact of policy projections on financial variables.

[21] We have checked whether the strength of the information component varies in a similar way, and found quite stable effects of the information component over varying horizons.

[22] Similar to the construction of the one-year rate, the two-year rate is constructed by averaging FRA1 to FRA8.

Figure 4: Macroeconomic responses to a forward guidance shock for different horizons - Sweden



Notes: This figure shows the effect of forward guidance after six months (left panel) or its maximum impact (right panel) on inflation, activity, and the exchange rate for Sweden. Sample: 2000M1-2018M11. The x-axis shows which contract has been used to extract the forward guidance shock (FRA 2 to 12), in order to gauge the effectiveness of forward guidance for various horizons. The dotted lines show the 68th posterior probability region of the estimated impulse responses. The responses have been normalized so that the maximum impact is 25 basis points on the one-year rate. Responses in inflation are measured in percentage points, activity and exchange rate in percent.

from horizon specific forward guidance shocks decrease the more forward the shock is.

Intuitively, one would expect the identified forward guidance shocks based on different FRA surprises to be correlated. Indeed, looking at the median draws of the forward guidance shocks based on the different FRAs, there is a clear indication of a positive correlation. In other words, there seems to be at least one common factor driving the forward guidance shocks at different horizons, in line with what Gürkaynak et al. (2005) would call a "path factor". Hence, one could think of the horizon specific forward guidance shocks as consisting of a common component and an idiosyncratic part. As a robustness exercise we therefore remove the common factor for each set of draws from the separably identified forward guidance shocks and compute the impulse response to the idiosyncratic part of the forward guidance shock at the different horizons.[23] The impulse responses from using the common component in the VAR are shown in Figure C.3. Subsequently, Figure C.4 summarizes the impulse response to the idiosyncratic part of the forward guidance shock at the different horizons. Note that this is the horizon-specific effect on top of the effect of the common forward guidance component. As can be seen from this exercise as well, the relative effectiveness of forward guidance decreases with the horizon of guidance.

4.2.2 Discussion

As our findings suggest decreasing economic responses to horizons, we reach a different conclusion than D'Amico and King (2017), who instead find that the economic responses grow larger as the horizon of the guidance moves further into the future. These contrasting results may be explained by methodological differences, such as their use of survey data for identifying the anticipated shocks, and the restriction that the effect on the current short-term interest rate should have the opposite sign of the forward guidance shock. In addition, they impose rational expectations on the part of the agents in the economy, implying that expectations on average are in line with actual outcomes. Finally, institutional differences regarding the prevalence of adjustable versus fixed rates may contribute.

[23]Ideally we would like to simultaneously include all the FRAs in the high-frequency identification, allowing for both a common factor and horizon specific forward guidance shocks. However, identifying all the idiosyncratic forward guidance shocks and the common factor would require at least one additional identifying assumption. Furthermore, as a practical matter, the mere size of the resulting high-frequency residuals would potentially lead to computational challenges.

Conventional wisdom dictates that monetary policy affects target variables mainly through its effect on longer-term rates. While that might be true for a country like the US, it is not necessarily the case in countries like Sweden and Norway, where most debt contracts are based on adjustable rates linked to the three-month interbank rate. Hence, economic decisions may be more sensitive to movements in money market rates, and expectations thereof. This is consistent with our results for Sweden, where interest rates covering horizons up to two years appear to be more important for the exchange rate, activity and inflation than interest rates further out on the yield curve.[24]

5 Conclusion

In this paper we empirically assess the impact of forward guidance on key macroeconomic aggregates and to what extent these effects depend on the forwardness of guidance. To this aim, we estimate a VAR in which target, forward guidance, and information shocks are identified by means of combining sign and zero restrictions on the impact matrix. We find that the macroeconomic effects of a forward guidance shock are smaller as the horizon of the guidance lengthens. Hence, our results indicate that forward guidance aimed at moving expectations about policy rates in the near term is more effective than forward guidance pertaining to policy rates further out on the horizon. This runs contrary to the prediction from standard New Keynesian models, where the power of forward guidance increases with the horizon.

The results further underline the importance of controlling for the information component of monetary policy surprises obtained from high frequency identification (HFI). In line with recent findings in the literature, surprises based on information shocks have impulse responses that are very similar to those for demand shocks, and the opposite of a typical monetary policy shock: target and forward guidance shocks that increase interest rates lead to an economic contraction, while information shocks that increase interest rates have an expansionary effect. Hence, not controlling for this information effect mutes impulse responses from target and forward guidance shocks obtained by HFI techniques.

[24]It might be the case that movements further out on the yield curve are mainly noise-driven and to a lesser extent reflect changes in expectations. Moreover, Ellen, ter et al. (2019) find that spillovers from monetary policy in the euro area are strong for longer maturities in Norway and Sweden.

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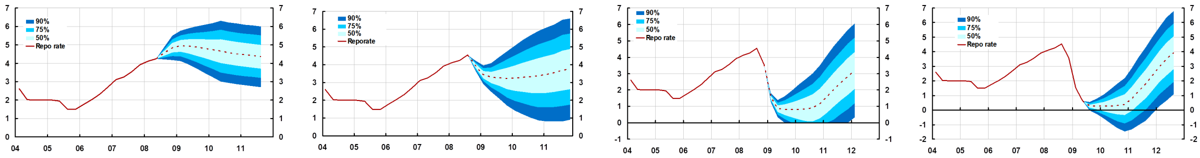
A Horizon-specific forward communication

Figure A.1: Repo-rate projections for four consecutive MPRs Riksbanken

(a) MPR 2008-2 (b) MPR 2008-3 (c) MPR 2009-1 (d) MPR 2009-2



Notes: These figures show the published projections for the repo rate for respectively the second and third monetary policy report (MPR) published in 2008, and the first and second MPR published in 2009, by the Riksbank. Source: The Riksbank.

B Bayesian estimation and priors

We use an uninformative version of the natural conjugate priors described in Koop and Korobilis (2009). For simplicity, assume Equation 1 is rewritten in the following form:

$$Y = XA + E \tag{B.1}$$

where X is all the regressors in Equation 1 and E has a variance covariance matrix Σ. The natural conjugate prior has the following form:

$$\alpha|\Sigma \sim \mathcal{N}(\underline{\alpha}, \Sigma \otimes \underline{V}) \tag{B.2}$$

where $\alpha = vec(A)$ and

$$\Sigma^{-1} \sim \mathcal{W}(\underline{S}^{-1}, \underline{\nu}) \tag{B.3}$$

where $\underline{\alpha}$, $\underline{V}$, $\underline{\nu}$ and $\underline{S}$ are hyperparameters. Noninformativeness is then achieved by setting $\underline{\nu} = \underline{S} = \underline{V}^{-1} = cI$ and letting $c \to 0$. With this prior the posterior becomes:

$$\alpha|\Sigma, y \sim \mathcal{N}(\overline{\alpha}, \Sigma \otimes \overline{V}) \tag{B.4}$$

and

$$(\Sigma^{-1}|y) \sim \mathcal{W}(\overline{S}^{-1}, \overline{\nu}) \tag{B.5}$$

where

$$\overline{V} = (\underline{V}^{-1} + X'X)^{-1}, \tag{B.6}$$

$$\overline{A} = \overline{V}(\underline{V}^{-1}\underline{A} + X'X\hat{A}), \tag{B.7}$$

$$\overline{\alpha} = vec(\overline{A}), \tag{B.8}$$

$$\overline{S} = S + \underline{S} + \hat{A}'X'X\hat{A} + \underline{A}'\underline{V}^{-1}\underline{A} - \overline{A}'(\underline{V}^{-1} + X'X)\overline{A} \tag{B.9}$$

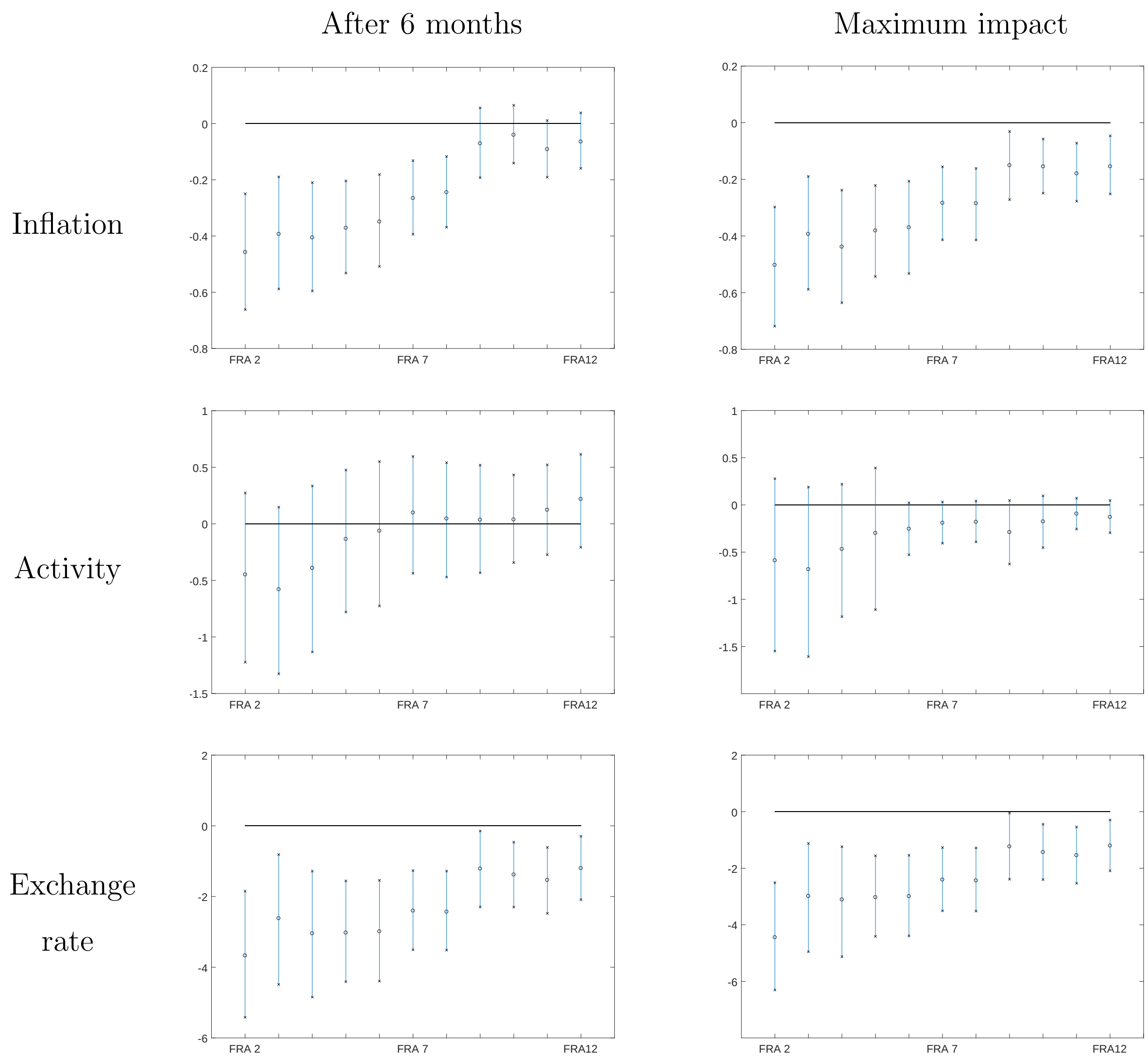
and

$$\overline{\nu} = T + \underline{\nu} \tag{B.10}$$

Where T is the number of observations and $\hat{A} = (X'X)^{-1}X'Y$ is the OLS estimate of A.

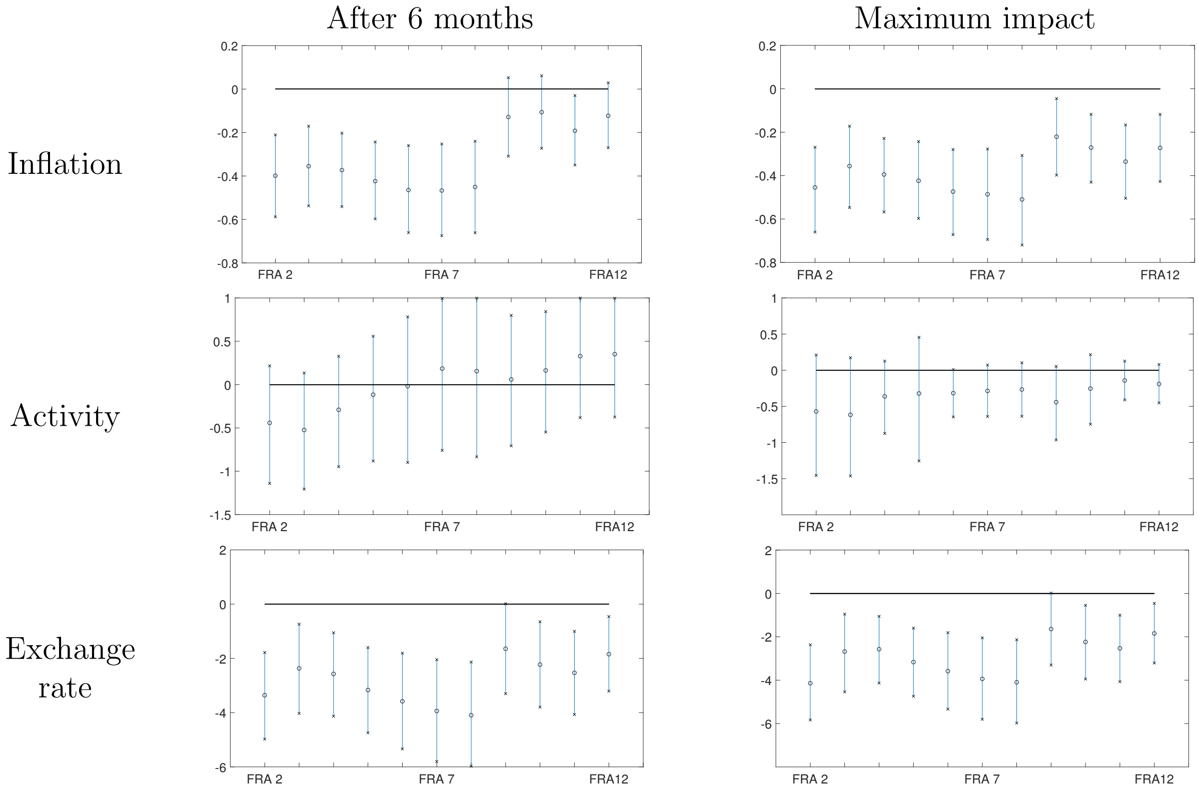
C Additional figures

Figure C.1: Macroeconomic responses to a forward guidance shock for different horizons (two-year rate in VAR) - Sweden



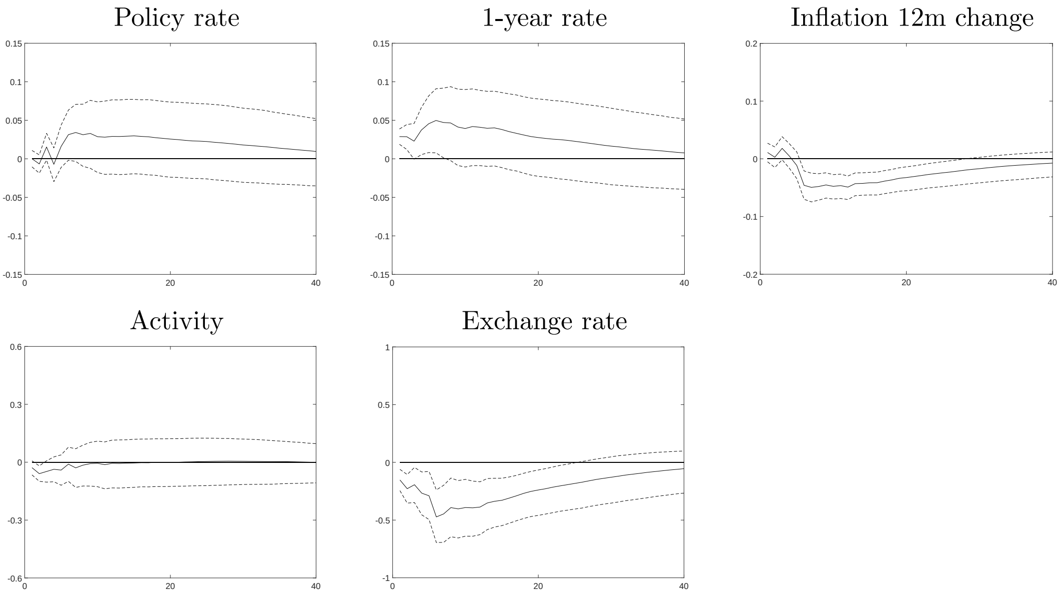
Notes: This figure shows the effect of forward guidance after six months (left panel) or its maximum impact (right panel) on inflation, activity, and the exchange rate for Sweden, as in Figure 4. The difference from Figure 4 is that the one-year rate is replaced by a two-year rate in the VAR. Sample: 2000M1-2018M11. The x-axis shows which contract has been used to extract the forward guidance shock (FRA 2 to 12), in order to gauge the effectiveness of forward guidance for various horizons. The dotted lines show the 68th posterior probability region of the estimated impulse responses.The responses have been normalized so that the maximum impact is 25 basis points on the two-year rate. Responses in inflation are measured in percentage points, activity and exchange rate in percent.

Figure C.2: Macroeconomic responses to a forward guidance shock for different horizons (using matching FRAs in VAR) - Sweden



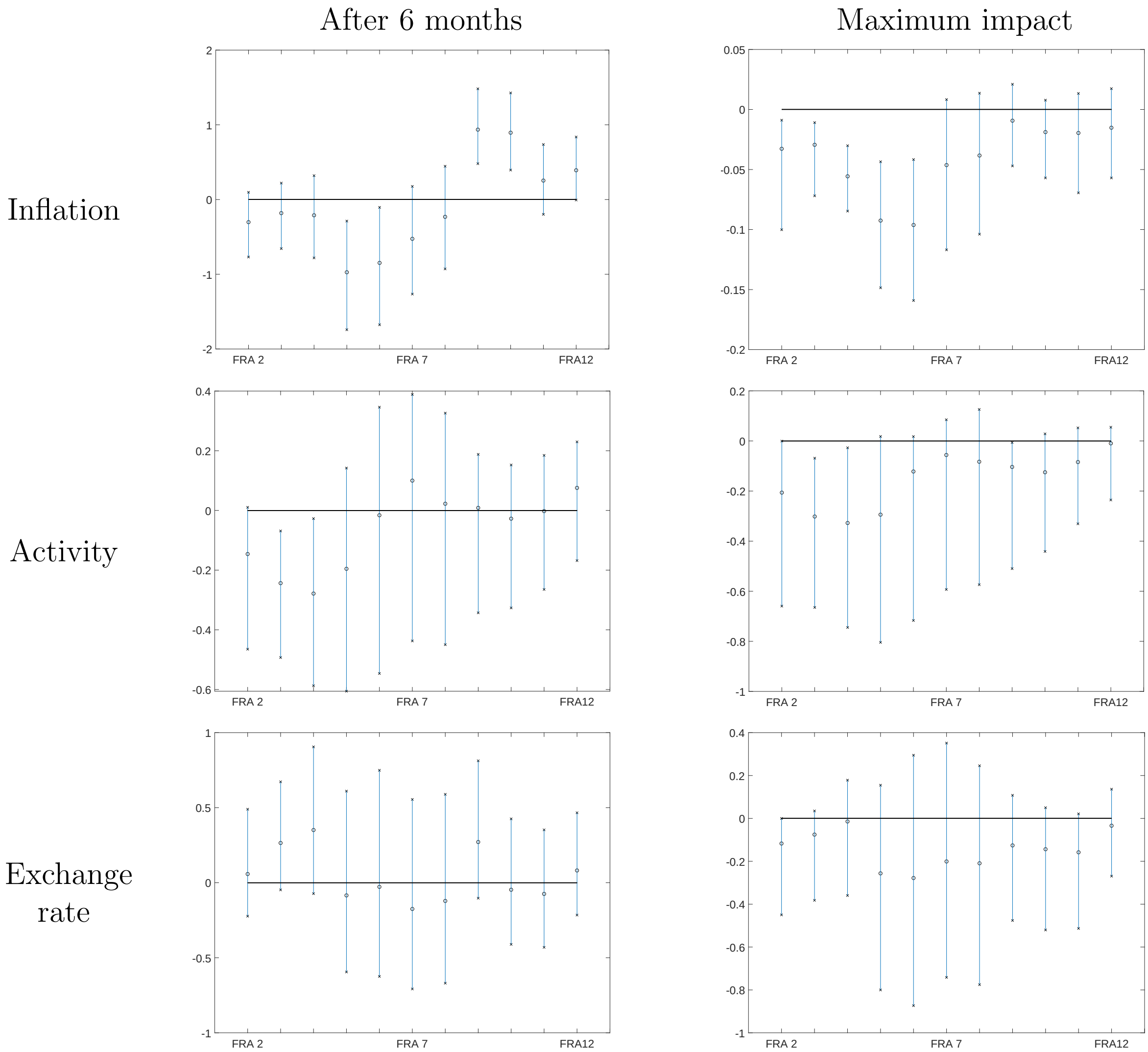
Notes: This figure shows the effect of forward guidance after six months (left panel) or its maximum impact (right panel) on inflation, activity, and the exchange rate for Sweden, as in Figure 4. The difference from Figure 4 is that the one-year rate in the VAR is replaced by the monthly version of the same FRA that is used to identify the forward guidance shock (i.e. the monthly average of FRA2 is used in the VAR when FRA2 is used in the high-frequency identification and so on). Sample: 2000M1-2018M11. The x-axis shows which contract has been used to extract the forward guidance shock (FRA 2 to 12), in order to gauge the effectiveness of forward guidance for various horizons. The dotted lines show the 68th posterior probability region of the estimated impulse responses. The responses have been normalized so that the maximum impact is 25 basis points on the respective FRA-rate. Responses in inflation are measured in percentage points, activity and exchange rate in percent.

Figure C.3: Macroeconomic responses to a “principal component” forward guidance shock - Sweden



Notes: This figure shows the impulse responses from estimating our baseline VAR for Sweden, with a common component forward guidance shock (one standard deviation). The forward guidance shock is identified as the principal component of the horizon-specific forward guidance shocks. Sample: 2000M1-2018M11. The dotted lines show the 68th posterior probability region of the estimated impulse responses. Responses in the policy rate, one-year rate and inflation are measured in percentage points, activity and exchange rate in percent.

Figure C.4: Macroeconomic responses to a forward guidance shock for different horizons (idiosyncratic forward guidance shock) - Sweden



Notes: This figure shows the effect of forward guidance after six months (left panel) or its maximum impact (right panel) on inflation, activity, and the exchange rate for Sweden, as in Figure 4. The difference from Figure 4 is that a principal component of the identified forward guidance shocks using the various FRA contracts is removed before the VARs are estimated. The figure therefore shows the impulse responses of horizon-specific forward guidance relative to the "common" forward guidance shock. Sample: 2000M1-2018M11. The x-axis shows which contract has been used to extract the forward guidance shock (FRA 2 to 12), in order to gauge the effectiveness of forward guidance for various horizons. The dotted lines show the 68th posterior probability region of the estimated impulse responses. The responses have been normalized so that the increase in the idiosyncratic part is equal among the different horizons. Responses in inflation are measured in percentage points, activity and exchange rate in percent.