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Monetary Policy Shocks for Sweden

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Abstract

This paper estimates monetary policy shocks for Sweden between 1996-2019. I employ the Romer and Romer (2004) (R&R) approach and use annual forecasts of output growth and inflation to estimate monetary policy shocks. I complement the analysis with shocks from a recursive VAR including output, prices, and the repo rate, as well as a set of high-frequency shocks. A comparison of the three sets of shocks shows that the R&R and VAR shocks are similar, while the high-frequency shocks are fewer and smaller in size. Local projections show expected impulse responses on most economic variables, regardless of data frequency, but responses to the recursive VAR shocks are more in line with textbook findings compared to responses to the R&R and high-frequency shocks. Overall, results are robust to alternative model specifications and lag lengths in local projections.

JEL Classification: C22, C32, E32, E43, E52, E58.
Keywords: Monetary policy, monetary policy shocks, vector autoregression, local projections.

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1 Introduction

A common approach to study the impact of monetary policy on economic outcomes is to identify monetary policy shocks, by separating changes in the monetary policy rate that are correlated and uncorrelated to responses to economic conditions. These shocks to monetary policy can capture changing preferences of the policymakers, resulting from e.g., a change in the composition of committee members or updated views of how policy should be conducted, under- and over reactions, or intended policy shocks (Cloyne and Hürtgen, 2016; Sandström, 2018).

The literature suggests several approaches to estimate monetary shocks (see Ramey, 2016, for a review). These include VAR models (Christiano et al., 1999; Faust et al., 2004), high-frequency identification methods (Kuttner, 2001; Gertler and Karadi, 2015), and DSGE models (Smets and Wouters, 2007). Romer and Romer (2004) (R&R) proposes an empirical method that has been widely used in literature (see e.g., Coibion, 2012; Coibion et al., 2017; Leahy and Thapar, 2019; Miranda-Agrippino and Rey, 2020; Tenreyro and Thwaites, 2016; Doniger, 2019).[1] They estimate monetary shocks by first regressing intended fed fund rate changes on the central banks information set, which they model with forecast data on GDP growth, inflation and unemployment, at the time of the policy decision. The residuals represent the exogenous policy shocks not related to the FEDs information about the state of the economy.

In this paper I estimate monetary policy shocks for Sweden between 1996-2019, following the approach by Romer and Romer (2004) (R&R). This method is well known and well used. The main advantage with the R&R approach is the inclusion of forecasts of macroeconomic variables, formed using a multitude of economic variables. The shocks therefore identify changes in policy that are independent of current expectations of future economic conditions (Coibion, 2012). To the best of my knowledge, this is the first paper to identify R&R monetary shocks for Sweden. The method is used to estimate monetary shocks for the UK (Cloyne and Hürtgen, 2016) and for Norway (Holm et al., 2021) though. I use annual forecasts on GDP growth and CPI inflation, and regress them on repo rate changes at each policy meeting. The estimated residuals are the monetary shocks. The number of policy meetings exceed the number of forecast releases in the early part of my sample. I follow Cloyne and Hürtgen (2016) and assign the latest available forecast to each policy meeting.

I complement the analysis with two sets of shocks, and compare them to my R&R shocks. I estimate a structural vector autoregression (VAR) (see e.g., Christiano et al., 1999) including output, CPI, and the repo rate, to identify recursive VAR shocks. Overall the VAR shocks are similar to the R&R shocks, but less volatile. Conceptually, the main difference between the R&R shocks and the recursive VAR

[1] This method is often referred to as a narrative method, since R&R collect some data by reading minutes from the Federal Open Market Committee (FOMC).

shocks is that the former takes expectations about the future into account by including forecast data. These shocks should therefore not be the same, which is confirmed in some years when the two types of shocks identify the opposite sign of the shocks. Some papers estimate monetary shocks for Sweden from a structural VAR-model (see e.g., Lindé et al., 2009; Jacobsson et al., 2002; Di Casola and Iversen, 2019), but these studies use the shocks to evaluate the impact of monetary policy on the economy, and do not present the shocks per se. I therefore add to the literature by visualizing the monetary shocks, and compare the more conventional VAR shocks to other types of shocks.

Last, I compare my R&R shocks with a set of high-frequency shocks for Sweden developed by Sandström (2018). Identification comes from measuring expectations of the Riksbank repo rate, using STINA-swaps, in a three hour window around a monetary policy announcement. This separate the effect of the policy news from other events happening the same day. If market interest rates move in the short time period around the announcement, it should reflect unexpected changes in monetary policy, i.e., shocks to monetary policy. STINA-swaps are available from 2003 so this analysis runs between 2003-2019. The high-frequency (HFI) shocks are fewer but also smaller in size compared to both the R&R and VAR shocks. This is reasonable given that HFI shocks will identify a shock only once if new information occurs, while the R&R and VAR shock will identify a shock for several periods if the same information occurs (Sandström, 2018).

I study the impact of the shocks on various macroeconomic outcomes at different frequencies using local projections (Jordá, 2005). Overall, I obtain expected responses to a contractionary monetary shock as output and consumption falls. However, responses differ when comparing the different types of shocks and there are some puzzles. For example, unemployment falls in response to a contractionary R&R and HFI shock and prices increase for the first two years with all three sets of shocks. The main conclusion is that VAR shocks provide responses that are most in line with "textbook" responses. Most results are robust to alternative model specifications and lag lengths in the local projections, but HFI shocks are sensitive to aggregation and lag lengths.

The literature on the impact of monetary shocks on economic outcomes is mainly restricted to the US (Coibion, 2012), the euro area (Adam and Tzamourani, 2016), and the UK (Cloyne and Hürtgen, 2016) so far. It is important to develop monetary shocks for smaller countries such as Sweden, since the impact of the shocks may differ in such economies. The main contribution of this paper is to provide shocks for Sweden that, in a second stage, can be used to study the effect of monetary policy on the Swedish economy. The effects of Swedish shocks may be relevant for other countries as well, since the central bank of Sweden implements a monetary policy framework similar to the ECB and the FED (Amberg et al., 2022).

The remainder of the papers is organized as follows. Section 2 provides some background information on monetary shocks. Section 3 explains how I estimate R&R

monetary shocks for Sweden, including the model specification and estimation results. Section 4 provides the same analysis but for the recursive VAR. Section 5 explains the high-frequency shocks used in this paper. Section 6 presents the macroeconomic effects of the shocks comparing impulse responses to all three sets of shocks. Section 7 provides a number of robustness checks and section 8 concludes.

2 Monetary policy shocks

The main variation in monetary policy tools are systematic response to current or expected future economic conditions. It is therefore necessary to disentangle endogenous and exogenous changes in the policy instrument to study the impact of monetary policy on the economy (Coibion, 2012). Much of the evidence on the quantitative effects of monetary policy come from the recursive VAR literature, relying on the identifying assumption that the policy rate have no contemporaneous effects on macroeconomic variables (Coibion, 2012). In practice this means that the policy rate is ordered last in a model often including GDP, inflation, commodity prices and sometimes unemployment (see e.g., Christiano et al., 1999). Generally, the effects of monetary shocks on GDP and inflation are found to be small using this method (Coibion, 2012). The VAR approach has developed over the years including factor augmenting VARs (Bernanke et al., 2005), that incorporates more variables, and proxy SVARs using external instruments for shocks (Stock and Watson, 2012; Mertens and Ravn, 2013). There is also a literature identifying monetary shocks using DSGE models (see e.g., Smets and Wouters, 2007; Schmitt-Grohé and Uribe, 2012).

A common method in the recent literature is to use high-frequency financial data to identify monetary shocks. In the high-frequency approach, monetary shocks are changes in interest rates of different maturities, such as fed funds futures or eurodollar futures, over a small window surrounding scheduled announcements from central banks. The identifying assumption is that surprises in interest rates in these small windows (often 30 minutes in an American context) are dominated by the information contained in the announcement, and not other news or movements in economic and financial variables (see e.g., Kuttner, 2001; Gertler and Karadi, 2015; Nakamura and Steinsson, 2018). Sandström (2018) identify monetary shocks from high-frequency financial market data for Sweden between 2003-2014. She measures expectations of the Riksbank repo rate with short-dated STINA-swaps shortly before and after the monetary policy announcement, to separate the effect of monetary policy news on financial market prices from the effects of other events occurring on the same day.

Romer and Romer (2004) propose an empirical method to estimate shocks that has gained in popularity over time and that is widely used in papers studying the effects of monetary policy (see e.g., Coibion, 2012; Coibion et al., 2017; Leahy and Thapar, 2019; Miranda-Agrippino and Rey, 2020; Tenreyro and Thwaites, 2016;

Doniger, 2019). They estimate monetary shocks for the United States by identifying intended fed fund rate changes from FOMC minutes, and regress these changes on the central banks information set, which they model with forecast data on GDP growth, inflation and unemployment, at the time of the policy decision. The residuals represent the exogenous policy shocks not related to the FEDs information about the state of the economy. It is possible to use these shocks in a second stage regression to estimate the effect of monetary policy on various economic outcomes. This method is used to generate shock series for other countries as well (see e.g., Cloyne and Hürtgen, 2016; Holm et al., 2021).

3 Romer and Romer shocks for Sweden

3.1 Model specification and data

I follow the set-up in Romer and Romer (2004) to identify monetary shocks. I estimate the following model to construct the monetary shocks, on a policy meeting (m) frequency:

$$\begin{aligned}\Delta i_m = \alpha_1 + \alpha_2 i_{m-1} + \sum_{k=0}^{1} \beta_k^{\pi} \tilde{\pi}_{m,k} + \sum_{k=0}^{1} \beta_k^{\Delta\pi} \Delta\tilde{\pi}_{m,k} \\ + \sum_{k=0}^{1} \beta_k^{y} \tilde{y}_{m,k} + \sum_{k=0}^{1} \beta_k^{\Delta y} \Delta\tilde{y}_{m,k} + \alpha_3 u_{m,t-1} + \alpha_4 D_m + \epsilon_m^{MP}\end{aligned} \tag{1}$$

where Δi_m is the change in the policy rate at meeting m and i_{m-1} is the policy rate at the previous meeting m. I use the main policy measure for Sweden which is the Riksbank's repo rate.[2] In line with R&R I include central bank forecasts of inflation ($\tilde{\pi}_{m,k}$) and GDP growth ($\tilde{y}_{m,k}$) at meeting m for horizon k, and the corresponding forecast changes ($\Delta\tilde{\pi}_{m,k}$ and $\Delta\tilde{y}_{m,k}$) which are revisions in the forecasts relative to the previous round of forecasts. The forecasts are prepared for each Monetary Policy Report (MPR), and my data consists of forecasts for the current ($k = 0$) and next ($k = 1$) year at each MPR publication date. The number of forecast releases each year is smaller than the number of policy meetings in the early part of the sample, so I assign the latest available forecast to each policy meeting m as explained below. Last, I include the previous month's unemployment rate ($u_{m,t-1}$) where meeting m takes place in month t. I also include a dummy (D_m) taking the value zero from 1996-2006, and one from 2007-2019, to account for a methodological change in repo rate forecasts further explained below. The residual, ϵ_m^{MP}, is the monetary policy shock associated with meeting m.

When constructing the shocks, my approach deviates from the one in Romer and

[2] Romer and Romer (2004) use the intended fed fund rate but Cloyne and Hürtgen (2016) highlight that the intended funds rate is the actual policy rate in most countries.

Romer in the following ways: (i) I use annual forecasts instead of quarterly forecasts, because quarterly forecasts are not available before 2007[3], (ii) I do not include real-time data of the previous period for each variable since such data is not available for the same variable in all years, and (iii) I include a dummy variable in model (1) taking the value zero from 1996-2006, and one from 2007-2019, to account for the change in the assumption of the repo rate in the forecasts explained below.[4]

I collect data on the repo rate from the Minutes of the Executive Board's monetary policy meetings. The Riksbank provided the forecast data and it consists of annual forecasts of output growth, CPI inflation, and the unemployment rate.[5] My sample consists of all policy meetings between 1996-2019.

The Riksbank did not release new forecasts for each policy meeting in the early part of the sample. Between 1996-2007 the Riksbank released forecasts four times a year in connection to each MPR, but there are at least seven policy meetings each year. To address this issue I follow the set-up in Cloyne and Hürtgen (2016) and assign the latest available forecast to each policy meeting, meaning I have the same forecast for some observations. Table 1 illustrates the construction of the data set. The first column lists the date of the policy meeting and the second column specifies MPR publication dates.[6] I denote the forecasts by $\tilde{y}_{\text{Meeting date;Forecast year}}$ where I distinguish between the meeting date and the year the forecast was produced for. For example, the fourth policy meeting in 2000 is held on June 7 and it coincide with the publication of the second MPR. For this meeting I control for the annual forecast of output growth in 2000 ($\tilde{y}_{07/06/00;2000}$), the annual forecast of output growth in 2001 ($\tilde{y}_{07/06/00;2001}$), as well as the change in forecasts from the previous meeting for 2000 ($\tilde{y}_{07/06/00;2000} - \tilde{y}_{22/03/00;2000}$) and 2001 ($\tilde{y}_{07/06/00;2001} - \tilde{y}_{22/03/00;2001}$).[7] The Riksbank releases new forecasts for each policy meeting (six per year) for the years between 2008-2019. I assign a new forecast to each policy meeting (except in 2015 when there were seven meetings but only six forecasts) as shown for 2016 in Table 1.

[3]Holm et al. (2021) use the same set-up to estimate R&R monetary shocks for Norway.

[4]Results are not sensitive to the inclusion of this dummy variable.

[5]I also have data on CPIF inflation which is the CPI with a fixed interest rate. One drawback of using CPI as an inflation measure is that changes in the Riksbanks policy rate have direct short-term effects on inflation. As an example this leads to a fall in inflation after a rate cut, since mortgage rates, and hence housing costs, decline (Johansson, 2015). However, up until 2007 the Riksbank assumed a constant repo rate when setting their forecasts so including forecasts on CPIF inflation is not necessary. Also, the sample is smaller with CPIF because forecast data is available only from 1999.

[6]The Riksbank publishes the MPR and forecasts the day after the policy meeting, because the Executive Board approves the documents at the policy meeting. This is not an issue as the Executive Board base their policy decision on the forecasts in the MPR.

[7]I also control for inflation forecasts and unemployment according to model (1).

Table 1: Assignment of forecasts to repo rate changes

Meeting date (m)	MPR	$\tilde{y}_{m,k=0}$	$\tilde{y}_{m,k=1}$	$\Delta\tilde{y}_{m,k=0}$	$\Delta\tilde{y}_{m,k=1}$
03/02/2000		$\tilde{y}_{08/12/99;1999}$	$\tilde{y}_{08/12/99;2000}$	$\tilde{y}_{08/12/99;1999}-\tilde{y}_{05/10/99;1999}$	$\tilde{y}_{08/12/99;2000}-\tilde{y}_{05/10/99;2000}$
22/03/2000	MPR:1	$\tilde{y}_{22/03/00;2000}$	$\tilde{y}_{22/03/00;2001}$	$\tilde{y}_{22/03/00;2000}-\tilde{y}_{08/12/99;1999}$	$\tilde{y}_{22/03/00;2001}-\tilde{y}_{08/12/99;2000}$
04/05/2000		$\tilde{y}_{22/03/00;2000}$	$\tilde{y}_{22/03/00;2001}$	$\tilde{y}_{22/03/00;2000}-\tilde{y}_{08/12/99;1999}$	$\tilde{y}_{22/03/00;2001}-\tilde{y}_{08/12/99;2000}$
07/06/2000	MPR:2	$\tilde{y}_{07/06/00;2000}$	$\tilde{y}_{07/06/00;2001}$	$\tilde{y}_{07/06/00;2000}-\tilde{y}_{22/03/00;2000}$	$\tilde{y}_{07/06/00;2001}-\tilde{y}_{22/03/00;2001}$
06/07/2000		$\tilde{y}_{07/06/00;2000}$	$\tilde{y}_{07/06/00;2001}$	$\tilde{y}_{07/06/00;2000}-\tilde{y}_{22/03/00;2000}$	$\tilde{y}_{07/06/00;2001}-\tilde{y}_{22/03/00;2001}$
16/08/2000		$\tilde{y}_{07/06/00;2000}$	$\tilde{y}_{07/06/00;2001}$	$\tilde{y}_{07/06/00;2000}-\tilde{y}_{22/03/00;2000}$	$\tilde{y}_{07/06/00;2001}-\tilde{y}_{22/03/00;2001}$
09/10/2000	MPR:3	$\tilde{y}_{09/10/00;2000}$	$\tilde{y}_{09/10/00;2001}$	$\tilde{y}_{09/10/00;2000}-\tilde{y}_{07/06/00;2000}$	$\tilde{y}_{09/10/00;2001}-\tilde{y}_{07/06/00;2001}$
06/12/2000	MPR:4	$\tilde{y}_{06/12/00;2000}$	$\tilde{y}_{06/12/00;2001}$	$\tilde{y}_{06/12/00;2000}-\tilde{y}_{09/10/00;2000}$	$\tilde{y}_{06/12/00;2001}-\tilde{y}_{09/10/00;2001}$
⋮					
10/02/2016	MPR:1	$\tilde{y}_{10/02/16;2016}$	$\tilde{y}_{10/02/16;2017}$	$\tilde{y}_{10/02/16;2016}-\tilde{y}_{14/12/15;2015}$	$\tilde{y}_{10/02/16;2017}-\tilde{y}_{14/12/15;2016}$
20/04/2016	MPR:2	$\tilde{y}_{20/04/16;2016}$	$\tilde{y}_{20/04/16;2017}$	$\tilde{y}_{20/04/16;2016}-\tilde{y}_{10/02/16;2016}$	$\tilde{y}_{20/04/16;2017}-\tilde{y}_{10/02/16;2017}$
05/07/2016	MPR:3	$\tilde{y}_{05/07/16;2016}$	$\tilde{y}_{05/07/16;2017}$	$\tilde{y}_{05/07/16;2016}-\tilde{y}_{20/04/16;2016}$	$\tilde{y}_{05/07/16;2017}-\tilde{y}_{20/04/16;2017}$
06/09/2016	MPR:4	$\tilde{y}_{06/09/16;2016}$	$\tilde{y}_{06/09/16;2017}$	$\tilde{y}_{06/09/16;2016}-\tilde{y}_{05/07/16;2016}$	$\tilde{y}_{06/09/16;2017}-\tilde{y}_{05/07/16;2017}$
26/10/2016	MPR:5	$\tilde{y}_{26/10/16;2016}$	$\tilde{y}_{26/10/16;2017}$	$\tilde{y}_{26/10/16;2016}-\tilde{y}_{06/09/16;2016}$	$\tilde{y}_{26/10/16;2017}-\tilde{y}_{06/09/16;2017}$
20/12/2016	MPR:6	$\tilde{y}_{20/12/16;2016}$	$\tilde{y}_{20/12/16;2017}$	$\tilde{y}_{20/12/16;2016}-\tilde{y}_{26/10/16;2016}$	$\tilde{y}_{20/12/16;2017}-\tilde{y}_{26/10/16;2017}$
⋮					

Notes: The table exemplifies with forecasts for output growth only. I denote forecasts with $\tilde{y}_{m;k}$, where m is the meeting date (dd/mm/yy) the forecast was released and k is the year the forecast refer to. The second column presents which date the forecasts are published in the *Monetary Policy Report* (MPR). Before 2007, I assign the forecasts from the MPR in December to the first meetings in January and February, before the new forecasts are released (usually) in March.

The estimated monetary shocks in model (1) is at a meeting frequency. I convert the series into a monthly, quarterly, and annual frequency. If there are several meetings in one period, I sum the shocks in that period and if there are no meetings in one period, I set the shocks to zero. Monthly series run from 1996:M10-2019:M12, quarterly series from 1996:4-2019:4 and annual series from 1997-2019. See Appendix Figure A2 for a description of the forecast variables included in the shock estimation.

The timing of forecast releases is important since forecasts need to be uncorrelated with the monetary shocks (Cloyne and Hürtgen, 2016). There is one important methodological change in how the Riksbank construct the forecasts during the period included in this paper. Before 2007, forecasts are based on an assumption of a constant repo rate (up until 2005) or that the repo rate follows the market price of interest rates (2005-2007). From the first MPR in 2007 and forward, the forecasts are based on the Riksbank's own forecasts of the repo rate (Riksbanken, 2018). After this methodological change, the identification scheme is potentially threatened because Governors are involved in the process of creating the forecasts and forecasters take into account changes in interest rates in inflation forecasts (Lindé and Reslow, 2017; Giavazzi and Mishkin, 2006; Iversen et al., 2016). However, staff learn about the actual policy change when they are officially announced removing the threat to identification. To check the sensitivity of my findings with regards to this methodological change, I estimate a shorter sample of monetary shocks with model (1). This sample ends in 2006. In section 3.2 and 7 I show that monetary shocks from the two different samples are similar and produce similar responses to various outcome variables.

3.2 Estimation result

Table 2 presents results from estimating model (1). The estimated coefficients have the expected sign (positive) for most of the variables, and all variables that are statistically different from zero are positive. In line with Romer and Romer (2004) and Holm et al. (2021), the overall conclusion is that the Riksbank behave countercyclically. A one percentage point increase in the repo rate at the previous meeting date results in a 0.053 percentage points lower repo rate at the current meeting date. I find that if the change in the inflation forecast for the current year increases with one percentage points ($\Delta\tilde{\pi}_{m,k=0}$), the repo rate significantly rise with 0.083 percentage points. Only the GDP growth forecast for the next year ($\tilde{y}_{m,k=1}$) is significantly different from zero. A one percentage point increase in the GDP growth forecast for the next year, increases the repo rate with 0.160 percentage points. Last I find that a higher unemployment rate in the month before a policy meeting results in a lower repo rate, which is in line with Romer and Romer. The coefficient is insignificant though. The R-squared value is similar to the ones found in Romer and Romer (2004), Cloyne and Hürtgen (2016), and Holm et al. (2021), as well as the number of significant coefficients. The model explains 36% of the variation in the policy rate, meaning that 64% of the variation is a monetary shock.

Table 2: Determinants of the change in the repo rate

Variables	
i_{m-1}	-0.053**
	(0.022)
$\tilde{\pi}_{m,k=0}$	0.033
	(0.036)
$\tilde{\pi}_{m,k=1}$	0.062
	(0.066)
$\Delta\tilde{\pi}_{m,k=0}$	0.083*
	(0.046)
$\Delta\tilde{\pi}_{m,k=1}$	0.029
	(0.056)
$\tilde{y}_{m,k=0}$	0.002
	(0.014)
$\tilde{y}_{m,k=1}$	0.160**
	(0.062)
$\Delta\tilde{y}_{m,k=0}$	-0.012
	(0.025)
$\Delta\tilde{y}_{m,k=1}$	-0.077
	(0.056)
$u_{m,t-1}$	-0.025
	(0.022)
Dummy 2007	-0.095
	(0.061)
Constant	-0.257
	(0.246)
Observations	167
R-squared	0.362

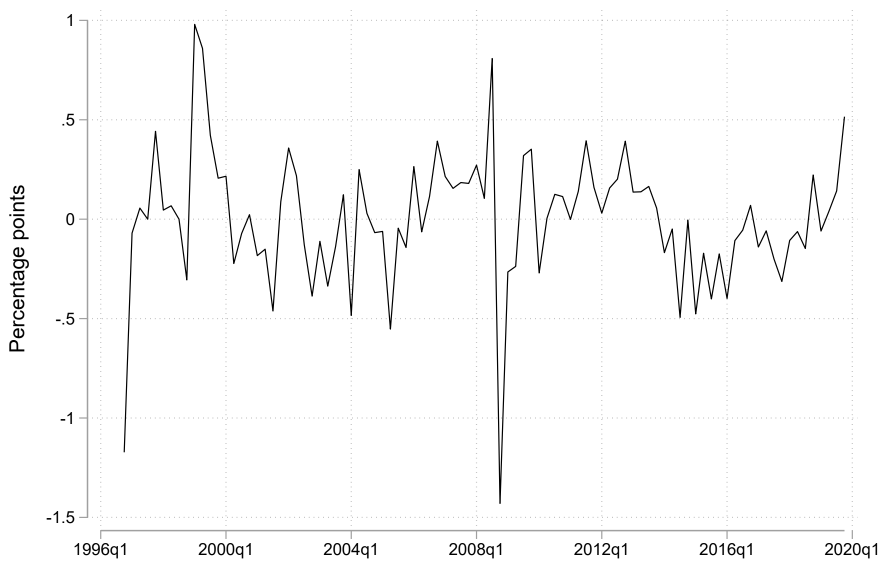
Notes: The table presents estimation results for model (1). i_{m-1} is the repo rate at the previous meeting date. $\tilde{\pi}_{m,k}$ and $\tilde{y}_{m,k}$ are the inflation and output forecast for the current (k=0) and next year (k=1). Inflation is CPI inflation and output is GDP growth. $u_{m,t-1}$ is the previous month's unemployment rate where meeting m takes place in month t. Levels of significance: p<0.01, *** p<0.05, ** p<0.1 *.

Figure 1 presents the quarterly series of the monetary shocks, ϵ_m^{MP}. Figure A1 and A2 in the Appendix presents the monthly and annual series of the shocks. A positive shock means that monetary policy was more contractionary than expected given the information set of the central bank, and a negative shock means that monetary policy was more expansionary than expected.

The shocks are fairly volatile throughout the sample and capture many important economic events. The large negative shock in 1996 is surprising since policy was kept tight in 1995-1996 due to a fear of returning to high inflation (Andersson and Jonung, 2018). There is also a large positive shock in 1999 of one percentage points. According to minutes from a policy meeting in March 1999, inflation forecasts indicated that inflation would not reach the target of 2%. The Board cut policy rates with 0.25 percentage points but given the forecast data this cut was actually contractionary policy (Riksbanken, 1999). One potential explanation is that Governors worried about the impact of lower policy rates on the exchange rate, despite the shifted focus to inflation expectations, and did not want to loosen policy too much (Giavazzi and Mishkin, 2006). Monetary policy is also tighter than expected in 2002 as unemployment rose and inflation was below its target of 2%, calling for lower rates (Giavazzi and Mishkin, 2006). The unexpectedly loose policy from

2003 likely relates to the Riksbank cutting rates to follow declining global rates, despite forecasts indicating uncertainty about the future. Prior to the financial crisis, policy is tighter than expected, relating to increasing worry about household debt (Andersson and Jonung, 2018). The largest negative shock of 1.4 percentage points occur during the financial crisis in 2008. The Swedish economy recovered quickly after the financial crisis and the Riksbank tightened policy to reduce the ongoing debt build-up, illustrated with mostly positive shocks to monetary policy between 2010 and 2015. Policy was kept tight even though inflation fell and both the FED and the ECB implemented expansionary policy, which spurred criticism (see e.g., Svensson, 2015). Between 2015-2019, monetary shocks are mostly negative explained by the negative policy rates and quantitative easing implemented by the Riksbank in this period. Policy was more expansionary than expected since both output growth and employment was high in Sweden during this period (Andersson and Jonung, 2018).

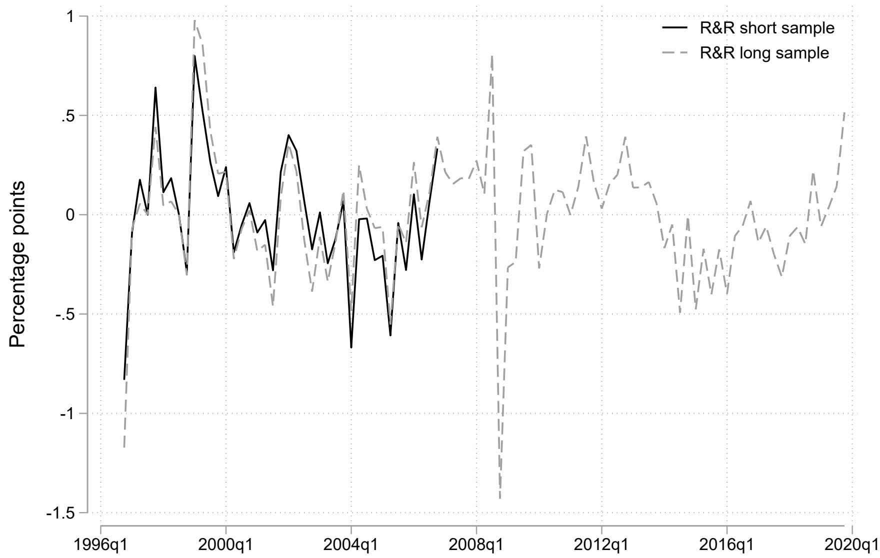
Figure 1: Quarterly series of R&R monetary shocks



Appendix Figure A3 compares the monetary shocks with the actual repo rate changes. They often move in the same direction but there are some differences over the sample period. The repo rate declined before 2000 while the policy shock was positive. One possibility is that even lower interest rates was called for, but the Riksbank was reluctant to cut rates too quickly given the history of high inflation. The policy rate was lowered in 2012-2013, but the shocks are contractionary meaning that policy was not expansionary enough given the state of the economy at the time (explained by the Riksbank's worry about household debt). In line with Cloyne and Hürtgen (2016), I also test whether the monthly shock series is predictable based on past data. I regress the monetary shocks on three or six lagged values of industrial production, CPI inflation and the unemployment rate. Appendix Table A1 confirms unpredictability. Overall, I cannot reject the null hypothesis that the policy shocks are unpredictable from lags of these macroeconomic variables.

Figure 2 compare the baseline R&R shocks (R&R long sample) that runs between 1996-2019, and the R&R shocks ending in 2006 (R&R short sample). I end the sample in 2006 due to the methodological change in forecasts explained in section 3.1. The two sets of shocks are similar and for most quarters I draw the same conclusion on whether the shocks are contractionary or expansionary. The correlation between the two sets of shocks is 0.93.

Figure 2: Comparison of two sets of R&R shocks



4 VAR shocks to monetary policy for Sweden

4.1 Model specification and data

Previous literature highlight that different types of shocks may produce contrasting responses on the economy, making it important to compare different shocks (Coibion, 2012; Miranda-Agrippino and Ricco, 2021; Wolf, 2020). I therefore complement the R&R shocks with recursive VAR shocks. It is common to use VAR models to identify monetary shocks and to study the effects of monetary policy (see e.g., Bernanke and Blinder, 1992, for an early contribution). I estimate a structural VAR model for the Swedish economy at a monthly, quarterly and annual frequency (monthly series run from 1996:M10-2019:M12, quarterly series from 1996:4-2019:4 and annual series from 1997-2019). I specify the following reduced-form VAR:

$$X_t = \delta_0 + \sum_{i=1}^{p} B_i X_{t-i} + \epsilon_t \tag{2}$$

where p represents one year of lags (p = 12 if monthly data and p = 4 if quarterly data) and two years of lags (p=2) if yearly frequency, in line with the Akaike and Bayesian information criteria.[8] The variables in X_t are $X_t = [y_t, \pi_t, i_t]$ where y_t is the log of output, π_t is the log of the CPI, and i_t is the repo rate. I measure output with industrial production if data is at a monthly frequency, and with GDP if data is at a quarterly or annual frequency. Section 7 shows that shocks produce similar responses to various outcomes if I include additional variables in the VAR such as unemployment, property prices or the SEK/EUR exchange rate. I follow Romer and Romer (2004) and cumulate the repo rate since VAR models usually include interest rates in levels. For more information on the data included, see Appendix Table A2.

I impose the recursiveness assumption to identify the monetary shocks (see e.g., Christiano et al., 1999; Ramey, 2016). By ordering the policy rate after output and prices, I assume that output and prices have a contemporaneous impact on the policy rate but that the policy rate only have a lagged impact on output and prices. Conceptually, the main difference between the R&R shocks and the recursive VAR shocks is that the R&R shocks takes expectations about the future into account. The novelty of R&R shocks is the usage of forecast data, which include more information compared to standard data. The R&R shocks therefore incorporates more information than the recursive VAR shocks. A positive R&R shock to monetary policy means that policy was tighter than expected given the current and future state of the economy, while a positive VAR shock to monetary policy means that policy was tighter than expected given the current state of the economy. Hence, these shocks should not always be similar.

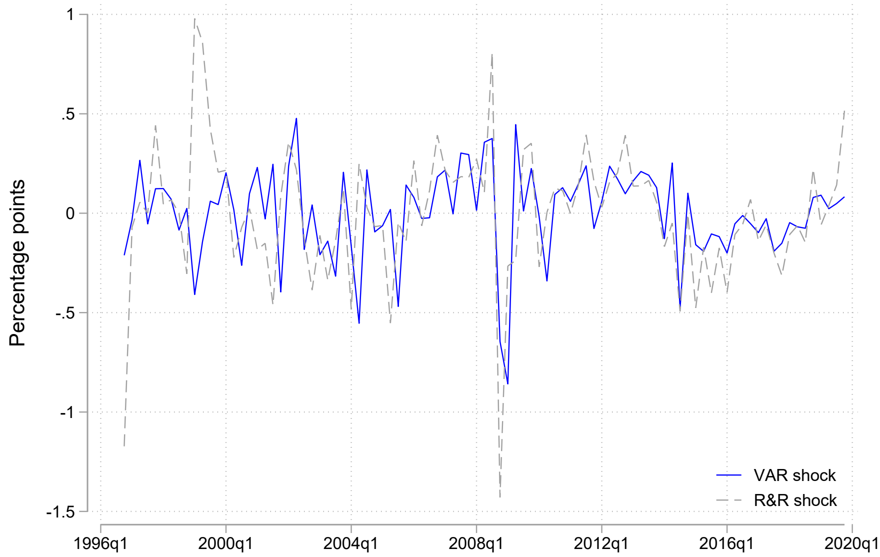
4.2 Estimation results

Figure 3 presents the quarterly series of the recursive VAR shocks. The blue line illustrates the VAR shocks and the dashed grey line illustrates the R&R shocks for comparison. Appendix Figures A4 and A5 illustrate the same comparison at a monthly and annual frequency. Similar to the R&R shocks, the VAR shocks capture some important economic events during the sample period. They are contractionary around 2002, expansionary between 2003-2006, contractionary prior to the financial crisis and expansionary during the crisis. The shocks are mostly positive between 2010-2014 when the Riksbank worried about increasing debt levels, and mostly expansionary between 2015-2019 when the Riksbank implemented unconventional monetary policy.[9]

[8] Appendix Figure A17 shows that the recursive VAR shock is robust to alternative lag lengths.

[9] For a further explanation to these shocks and events, see section 3.2 where I discuss them for the R&R shocks.

Figure 3: Quarterly series of VAR monetary shocks



Notes: The VAR shock refers to the residuals from the interest rate equation in the recursive VAR.

I draw the same conclusion on whether shocks are contractionary or expansionary in most cases when comparing the VAR shocks and the R&R shocks, but the VAR shocks are smaller in size and of different sign in some cases. The VAR shock is smaller than the R&R shock in 1996. In this case the VAR shock is more reasonable since policy was kept tight in this period to anchor inflation expectations and keep the inflation target of 2% (Andersson and Jonung, 2018). In 1999 the R&R shock is positive while the VAR shock is negative. The R&R shocks is likely more reasonable in this case since forecasts indicated lower inflation (see e.g., Riksbanken, 1999), and hence the looser policy implemented was not enough given the forecasts. The VAR shocks are not based on forecast data, meaning that given the current data on CPI and output, the shock is expansionary in 1999. Whether the larger R&R shocks are more "correct" than the smaller VAR shocks is difficult to say. The R&R shocks incorporate more information but that does not necessarily mean larger shocks since VAR shocks can capture events that are not actual shocks to monetary policy. The correlation between the shocks is 0.45 so they are fairly correlated.

5 High-frequency shocks to monetary policy for Sweden

Last, I complement the analysis with the high-frequency shocks for Sweden by Sandström (2018). The high-frequency approach use financial market data to extract surprises in interest rate changes around policy announcements, and has become a popular method to identify monetary shocks (see e.g., Kuttner, 2001; Gertler and Karadi, 2015). The efficient market hypothesis states that asset prices reflect all available information, including expected future monetary policy. To identify unexpected changes in monetary policy, it is necessary to measure monetary policy expectations of financial market participants. This is done using market interest rates that are close proxies for forecasts of monetary policy. By measuring monetary policy expectations in a short window around policy announcements, the announcement is the only new information available to financial market participants in the chosen period. If market interest rates move in the short period around the announcement, it should reflect unexpected changes in monetary policy (Sandström, 2018).

To identify high-frequency shocks for Sweden, Sandström (2018) use the short-dated STINA-swaps (Stockholm Tomorrow Next Interbank Average) to measure expectations of the repo rate. The STINA-swaps are available intraday and she observes changes in the STINA rate in a three hour window around the policy announcement.[10] The swaps are available from 2003 so the sample period runs between 2003-2019 for the HFI shocks.[11] The original shock series is at a daily frequency. I convert the series into a monthly frequency by setting the shock to zero in the months with no policy announcements (there are never two announcements in one month). To convert the series into a quarterly and annual frequency, I sum the shocks in each quarter or year in line with Amberg et al. (2022) and Flodén et al. (2021). Monthly series run from 2003:M1-2019:4, quarterly series from 2003:Q1-2019:Q1, and annual series from 2003-2019.[12]

Figure 4 illustrates the quarterly series of the HFI shocks. The green line is the HFI shocks and the dashed grey line is the R&R shock for comparison. Appendix Figure A6 and Appendix Figure A7 illustrate the same comparison at a monthly and annual frequency. The high-frequency shocks are smaller in size compared to the R&R shocks and they differ considerably in some years. Prior to the financial crisis in 2007, the HFI shock is expansionary while the R&R shock is contractionary. This means that the information provided at the policy announcement was considered a loosening of policy, given the information the market participants had, while it was considered a tightening of policy given forecasts. Hence, the difference between the shocks lies in what market participants know before a policy announcements. If the Riksbank announce or hint a shift in policy preferences before a policy meeting, the HFI shocks will not identify the changed preference as a monetary shock at the actual policy announcement (since they will adjust before the meeting). The R&R shocks will identify the change as a monetary shock though. This means that

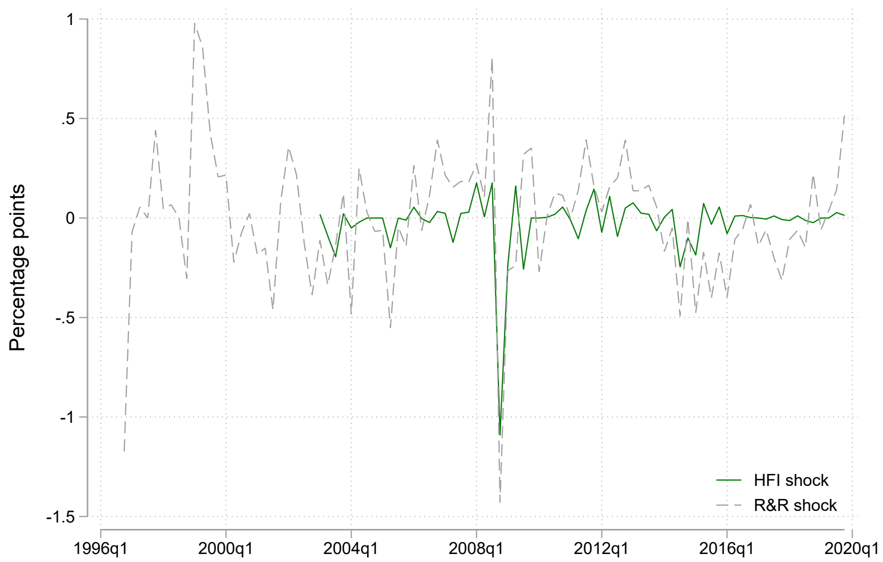
[10]The STINA swaps are not as liquid as financial market data in some other countries (e.g., the federal fund futures used in papers studying the United States). This require a larger window around the policy announcements when identifying shocks for Sweden, to capture the full adjustment. When identifying monetary shocks for the United States a common window is 30 minutes around the policy announcement. Amberg et al. (2022) and Flodén et al. (2021) use the yield at a daily frequency of a one-month Swedish Treasury bill instead, which are more liquid but not futures.

[11]See Sandström (2018) for more detailed information on the shocks. The Riksbank use the same identification strategy and data to construct high-frequency shocks for Sweden.

[12]The original series from Sandström (2018) ends in 2015, but I received an updated shock series from the Riksbank running to 2019.

the HFI shocks will likely identify smaller and fewer shocks compared to the R&R (or VAR) approach (Sandström, 2018), which is also what we see in Figure 4. The HFI approach identify only one large shock, which occurs during the financial crisis. Therefore, I mainly capture this event with the HFI shocks.

Figure 4: Quarterly series of HFI monetary shocks



The high-frequency method does not identify any monetary shocks after 2016, while the R&R approach identifies several expansionary socks between 2016-2018. In 2015, the Riksbank implemented a negative repo rate and quantitative easing. The R&R method identify these measures as an expansionary monetary shock almost consistently between 20015-2019. The HFI method identify these measures as expansionary shocks in 2015, but shocks are close to zero for the rest of the sample. This means that the subsequent changes in policy were already adjusted for in financial markets, and no unexpected information was given at the policy announcements. Appendix Figure A8 compare all shocks in one figure. The HFI shocks are smaller in magnitude and fewer compared to the VAR shocks as well. The correlation between the HFI shocks and the R&R shocks is 0.67 and between the HFI shocks and VAR shocks 0.53.

Appendix Table A3 presents the descriptive statistics of all three sets of monetary shocks. The mean is zero for the R&R and VAR shocks while it is slightly negative for the HFI shocks.[13]

[13] Sandström (2018) also finds a negative mean of the HFI shocks.

6 Macroeconomic effects of monetary shocks

To study the impact of monetary shocks on macroeconomic variables, I run a series of local projections in line with Holm et al. (2021).[14] I estimate the local projections at a quarterly frequency, since the number of outcome variables increase. Appendix Figure A10 and A11 presents the findings at a monthly and annual frequency. Following Jordá (2005) I estimate:

$$Y_{t+h} - Y_{t-1} = \alpha^h + \beta^h \epsilon_t^{MP} + \sum_{k=1}^{K} \gamma_k^h X_{t-k} + u_t^h \tag{3}$$

where Y_t is the outcome variable at time t, such as the log of real GDP, and $h =$ 0,1, ..., 16 for quarterly data.[15] The estimated coefficients β^h give the percentage (point) change at horizon h to a one percentage point contractionary monetary shock. X_t denotes a vector of controls where I include one year of lagged values of the monetary policy shock at the monthly and quarterly frequency, and two years of lagged values of the monetary shock at the yearly frequency.[16] I correct for serial correlation and heteroskedasticity in the error terms by including robust standard errors. I consider six main outcome variables chosen in line with Holm et al. (2021). Appendix Table A2 provides details on the macroeconomic variables used in the analysis. All series, except from the policy rate, is obtained from Statistics Sweden. Most variables are in real units, seasonally adjusted and provided for the full length of the sample.[17]

When estimating the impact of the HFI shocks on outcomes, I follow Sandström (2018) and run a local projection IV. I instrument the change in the repo rate with the estimated shock series and run a 2SLS to estimate the model parameters. Specifically, I run model (3) where ϵ_t^{MP} is the change in the repo rate, instrumented with the HFI shock series.

Figure 5 illustrates the impact of a one percentage point contractionary shock to monetary policy on five outcome variables. R&R shocks are to the left, VAR shocks in the middle, and HFI shocks to the right.

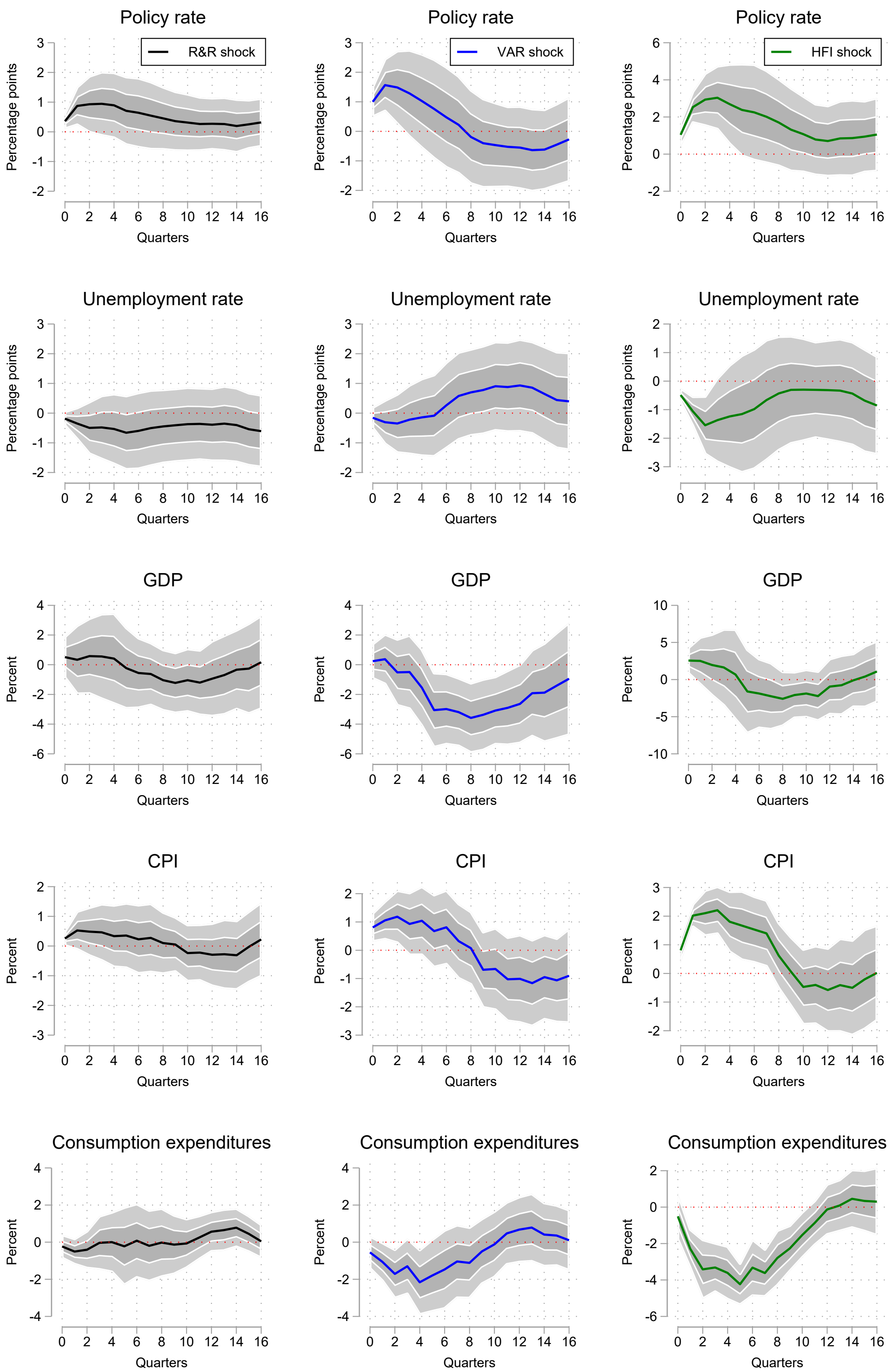
[14] The literature focusing on macroeconomic effects of monetary shocks usually use a VAR approach or a local projection approach to retrieve impulse responses. Impulse responses from a local projection method is more robust to misspecification compared to impulse responses from a VAR. The downside is higher estimation uncertainty in smaller samples though (Miranda-Agrippino and Ricco, 2021).

[15] h = 0,1, ..., 48 for monthly data and h = 0,1, ..., 4 for annual data.

[16] I use the Akaike and Bayesian information criteria to decide on the lag length for the monetary policy shocks. In general, the information criteria chooses longer lags of the monetary policy shock for near-term impulse responses (approximately two years of lags for monthly data) and shorter lags for impulse responses further away (approximately half a year to one year of lags), across all outcome variables. One year of lags is therefore a compromise. At the yearly frequency, the information criteria more uniformly chooses two years of lags (see Holm et al., 2021, for a similar reasoning). I confirm the robustness of the results by testing different lag lengths in Appendix Figure A13 and A14. I do not include lagged shocks as controls in the equation for the policy rate in line with Holm et al. (2021).

[17] If a series is not seasonally adjusted, I adjust them using the US Cencus Bureau's X-13 program.

Figure 5: Impulse responses at a quarterly frequency



Notes: The graph illustrates responses to a one percentage point contractionary monetary shock, estimated from model (3). The R&R and VAR sample is 1996:Q4 - 2019:Q4 and the HFI sample is 2003:Q1 - 2019:Q4. Light and dark grey shaded areas are 95% and 68% confidence bands. Scaling is different for HFI responses, since those responses are bigger (mainly capture the financial crisis in 2008 as further explained below). See Appendix Table A2 for more information on the macroeconomic variables. Appendix Figure A9 presents additional impulse responses at a quarterly frequency.

Impulse responses differs when comparing the shocks. The responses to R&R shocks illustrate some puzzles. A contractionary R&R monetary policy shock significantly decrease unemployment the first two quarters after the shock (in the 68% error bands), and the response is negative for all horizons contrary to expectations. The impact on GDP is slightly positive for the first year and then falls. Prices increase up to two years after a contractionary shock, and then falls. I include a commodity price index in line with Cloyne and Hürtgen (2016) and Romer and Romer (2004) to correct for the price puzzle, but results do not change for any of the shocks. Consumption significantly falls in the 68% error bands one quarter after the shock in line with expectations, but the effect size is small and around zero for the first ten quarters. The policy rate increases after a contractionary shock and decreases slowly thereafter.

The responses to a VAR shock is more in line with textbook responses to monetary shocks. Unemployment falls when the shock hits but significantly increases at the 68% confidence level after approximately two years. GDP significantly falls at the 95% confidence level after five quarters and consumption significantly falls on impact and for the first year after the contractionary shock. There is still a price puzzle as consumer prices increase for the first eight quarters and then significantly (68% level) falls ten quarters after the shock. The policy rate increases in response to the shock but decreases below the initial level after approximately two years. This suggests that policymakers ease policy after a contractionary shock, possibly to correct for the unexpectedly strong tightening of policy (Holm et al., 2021).

Responses to the HFI shocks are more in line with the responses to the R&R shocks. Unemployment falls and prices increase (largely) in response to a contractionary shock, opposite expectations. GDP falls after two years and consumption significantly falls (at the 95% level) up to two years, which is more in line with expected responses. The response to GDP is similar to the one found in Sandström (2018). However, she finds a smaller impact on prices and prices fall after four quarters, compared to nine quarters in my case. My sample of shocks run to 2019 though, compared to 2015.

The central bank's reaction function and information set must be estimated since they are not fully observable. This creates an error that can bias responses to monetary shocks. This paper presents three different approaches to estimating policy shocks, and estimated effects of the shocks do differ. HFI shocks produce larger responses compared to R&R and VAR shocks. This relates to the smaller and fewer shocks identified with the HFI shocks. The HFI approach captures only one large shock, which was a crisis shock. Therefore, the impulse responses mainly capture the impact of the financial crisis in 2008. The R&R approach captures more and larger shocks since 64% of the model accounts for shocks, which also may result in larger measurement errors. That responses to unemployment and consumption differs for R&R and VAR shocks likely relate to the discrepancy of the shocks in 1996 and 1999. Also, the VAR shocks are not based on forecast data, leaving out important information. The VAR shocks are smaller compared to the R&R shocks (Figure 3), which may explain the larger impulse responses. This suggests that even a few number of observations can create a bias. It is not possible to decide which approach is the correct one, but my findings confirm the importance of comparing different approaches.

Appendix Figure A9 presents responses of additional variables at the quarterly frequency. The patterns are similar as I find more puzzles for the R&R and HFI shocks. Wages fall to a contractionary R&R and VAR shock, but increase in response to the HFI shock. Industrial production, house prices and commodity prices significantly fall after approximately one year with a recursive VAR shock, while the impact is smaller and insignificant for the R&R shocks. Industrial production and house prices fall one year after a HFI shock, but the GDP deflator and the commodity prices illustrate large puzzles.

The responses are similar if I estimate the impulse responses at a monthly and annual frequency (see Appendix Figure A10 and A11). The responses at the annual frequency are smaller in size, which is not surprising since the impact of the shock is averaged over each year. The HFI shocks generate more uncertain impulse response at the annual frequency, as confidence bands are larger. The same holds for the additional outcome variables in Appendix Figure A12. This suggests that the HFI shocks are more sensitive to aggregation.

7 Robustness

Previous research shows that the choice of controls and number of lags in local projections matters for the responses (see e.g., Coibion, 2012; Miranda-Agrippino and Ricco, 2021). Appendix Figure A13 shows that the impulse responses are not sensitive to including two years of lagged monetary shocks (8 quarters) as controls in the local projections (opposed to one year of lags), for any of the shocks. The responses are most similar for VAR shocks when comparing the two lag lengths, indicating that VAR shocks provide more stable impulse responses on macro variables. Appendix Figure A14 shows that responses are close to identical for R&R and VAR shocks if including one year of lags instead of two years when using yearly data. HFI shocks are sensitive to the lag length as responses vary considerably.

The literature provides several alternations to the original Romer and Romer (2004) approach to estimate monetary policy shocks. I consider three alternations as robustness checks: (i) excluding the control for unemployment in model (1) (HPT shock) (Holm et al., 2021), (ii) including the unemployment rate in the three previous months in model (1) (CH shock) (Cloyne and Hürtgen, 2016)[18], and (iii)

[18]Cloyne and Hürtgen (2016) also assign the latest available forecast to each policy meeting, but control for developments between the last forecast and the policy decision by including three lags of real-time unemployment data. I do not have real-time data on unemployment for the entire sample so I include revised unemployment data.

including German GDP and CPI in model (1) to account for foreign business cycles (GE shock), since Sweden is a small open economy. All three alternations show a high correlation with the baseline R&R shock (approximately 0.98 for all three shocks) and the impulse responses at the quarterly frequency are similar as shown in Appendix Figure A15.

Appendix Figure A16 presents impulse responses for a sample of the R&R shocks ending in 2006, and compare them with the baseline R&R shocks ending in 2019. In the short sample I exclude the period when the Riksbank base their forecasts on their own forecasts of the repo rate. Responses to unemployment, GDP and CPI are similar when comparing the two set of shocks. Responses to consumption and wages are different and lies outside the confidence bands of the baseline shock. The discrepancy should relate to the different sample lengths of the outcome variables though, not the actual shocks, since responses are similar to the other outcome variables.

Previous research shows that the chosen lag length in VAR models may be important (see e.g., Boivin et al., 2010; Coibion, 2012; Ramey, 2016). Appendix Figure A17 shows that impulse responses are not sensitive to including VAR shocks estimated with different lag lengths in my sample. Responses are similar for VAR shocks estimated with two, four, six or eights lags. Responses are also robust to a larger specification in model (2) when estimating the recursive VAR shocks, as shown in Appendix Figures A18. Responses are similar if I include (i) the unemployment rate in line with Cloyne and Hürtgen (2016) so that $X_t = [y_t, \pi_t, u_t, i_t]$ where y_t is the log of GDP, π_t is the log of the CPI, u_t is the unemployment rate and i_t is the repo rate, (ii) property prices since it has been an important factor for monetary policy in Sweden over the sample period (Giavazzi and Mishkin, 2006), so that $X_t = [y_t, \pi_t, pp_t, i_t]$ where pp_t is the log of a property price index, and (iii) the log of the SEK/EUR exchange rate in line with Lindé et al. (2009), so that $X_t = [y_t, \pi_t, i_t, e_t]$ where e_t is the exchange rate. I allow the nominal exchange rate to respond to the policy rate contemporaneously by ordering it last.[19] The shocks are highly correlated with the baseline VAR shocks (approximately 0.98 when I include unemployment and property prices and 0.82 when I include the exchange rate). The shock including the exchange rate produce smaller responses to unemployment and GDP, compared to the baseline VAR shocks.

The VAR shocks include the repo rate and the sample runs over a period where the policy rate was zero. When interest rates hit the zero lower bound, it is common to use a shadow rate that corresponds to the unobserved short-term interest rate that would have occurred if the lower bound was not binding (see e.g., Wu and Xia, 2016). De Rezende and Ristiniemi (2020) estimates a shadow rate for Sweden that captures monetary policy even when the lower bound is not binding (the Swedish

[19] I also include a vector Z_t in model (2) when estimating the shock with the exchange rate to account for foreign business cycles. I set $Z_t = [y_t^f, \pi_t^f]$ were y_t^f and π_t^f is GDP growth and the log of CPI in Germany.

repo rate went below zero between 2015 and 2019).[20] Appendix Figure A19 shows that responses are not sensitive to including the shadow rate instead of the repo rate when estimating the VAR shocks.

A last robustness check is to exclude the financial crisis from the sample (2007-2009). Appendix Figure A19 presents the responses and they are fairly sensitive to excluding the financial crisis. The response to unemployment and GDP is weaker compared to baseline, while the response to prices shows a smaller puzzle.

8 Conclusion

To study the impact of monetary policy on economic outcomes, it is necessary to use an exogenous measure of monetary policy. A common approach is to identify shocks to monetary policy by isolating shifts in monetary policy instruments that are independent to systematic responses to economic conditions. In this paper I estimate monetary shocks for Sweden between 1996-2019 using the Romer and Romer (2004) framework. I compare them to shocks estimated with either a recursive VAR or a high-frequency data approach. Local projections show expected impulse responses on most economic variables, regardless of data frequency, but responses are more in line with textbook findings when using VAR shocks compared to R&R and HFI shocks. Most results are robust to alternative model specifications and lag lengths, but the HFI shocks are sensitive to lag lengths in the local projections and aggregation. My findings confirm that it is informative to use different types of shocks when estimating the impact of monetary shocks on economic outcomes, since they can provide different responses.

[20] The shadow rate is the short-term STINA (Stockholm Tomorrow Next Interbank Average) rate when monetary policy is conventional, while the shadow rate is a function of factors extracted from the government bond yield curve when policy is unconventional. For more details, see De Rezende and Ristiniemi (2020).

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Appendix

Figure A1: Monthly series of R&R monetary shocks

Figure A2: Annual series of R&R monetary shocks

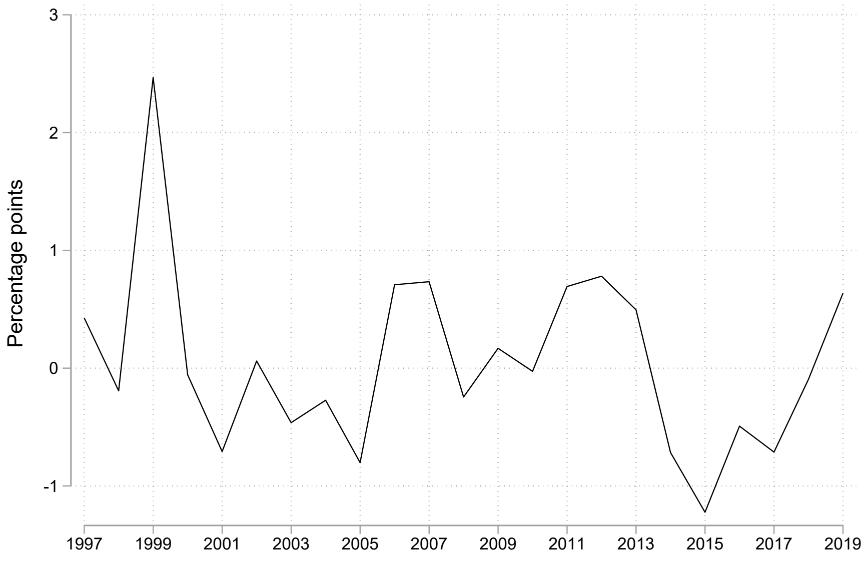


Figure A3: Comparison of R&R policy shocks and repo rate changes

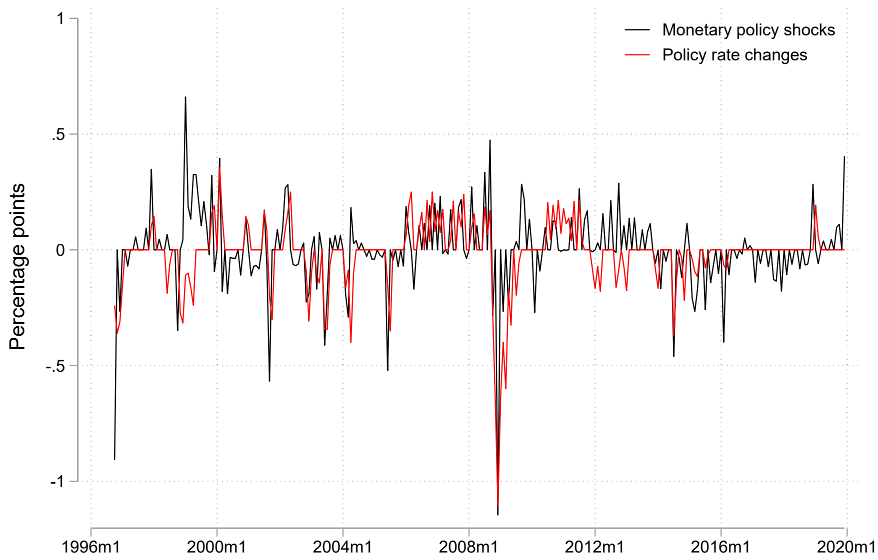


Table A1: Predictability of R&R monetary shocks

	3 lags		6 lags	
Varibales	F-statistic	P-value	F-statistic	P-value
Industrial production	1.48	0.22	0.76	0.60
CPI inflation	1.14	0.33	0.76	0.60
Unemployment rate	0.81	0.49	1.17	0.32
All of the above	1.07	0.38	0.81	0.69

Notes: The dependent variables are the monthly series of policy shocks from model (1) in section 3.1. The regressors are three or six lags of the growth rate in industrial production, CPI inflation, or the change in the unemployment rate. I also add a joint regression with all three regressors. I report F-statistics and p-values for the null hypothesis that all coefficients are equal to zero. I use robust standard errors.

Table A2: Description of variables included in the analysis

Variables	Source	Definition	Comments	Start of sample	Frequency	Deflated with
Shock data						
Reporate	Riksbank					
GDP growth forecast	Riksbank	y/y change, GDP at market prices		1996:M6	In each MPR	
CPI inflation forecast	Riksbank	y/y change, all items index		1996:M6	In each MPR	
CPIF inflation forecast	Riksbank	y/y change, CPI w/ fixed interest rate		1999:M3	In each MPR	
Unemployment forecast	Riksbank	% of labor force		1996:M6	In each MPR	
HFI shocks	Sandström (2018)			2003:M1	M, Q, A	
Macroeconomic variables						
Reporate	Riksbank			1994:M6	M, Q, A	
Unemployment	SCB	% of labor force, 16-64 years	SA	1987:M1	M, Q, A	
Real GDP	SCB	million SEK	SA	1981:Q1	Q, A	GDP-deflator
CPI	SCB	All items index		1980:M1	M, Q, A	
Real wages	SCB	million SEK	SA with XA-13	2001:Q1	Q, A	CPI
Real household consumption	SCB	million SEK	SA	1981:Q1	Q, A	CPI
GDP-deflator	SCB	From real and nominal GDP	SA	1981:Q1	Q, A	
CPIF	SCB	All items index		1987:M1	M, Q, A	
Commodity prices	Datastream	PPI index for commodities		1971:Q1	Q, A	
Industrial production index	SCB		SA, manufacturing production	1980:M1	M, Q, A	
Property price index	SCB	For permanent residential houses	SA with XA-13 (addative)	1986:Q1	Q, A	
Exchange rate SEK/USD	SCB	SEK/USD		1990:M1	M, Q, A	
Real GDP Germany	FRED		SA	1991:Q1	Q, A	GDP-deflator
CPI Germany	FRED	All items index		1991:Q1	Q, A	

Notes: See section 3 on how I estimate monetary shocks with the forecast data. HFI shocks are shocks identified with a high-frequency approach explained in section 5. All price indices have the base year 2005:M1, 2005:Q1 or 2005 depending on the frequency of the data. SCB stands for Statistics Sweden, FRED is the database from the Federal Reserve Bank of St. Louis, and MPR is the Monetary Policy Report published for Sweden.

Figure A4: Comparison VAR and R&R shocks at a monthly frequency

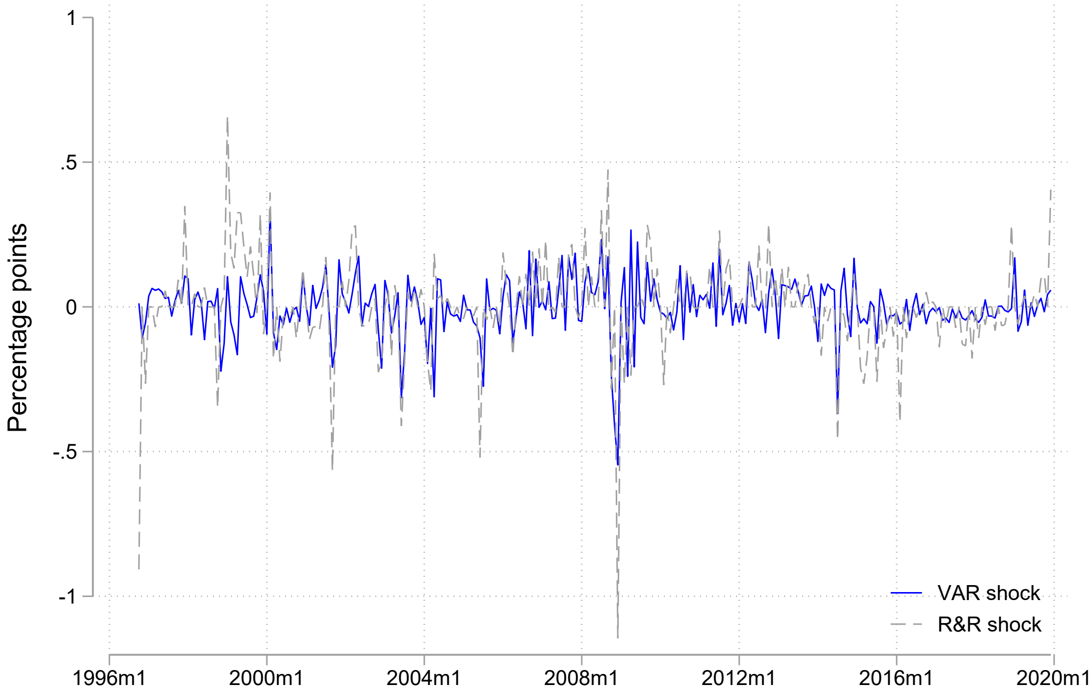


Figure A5: Comparison VAR and R&R shocks at an annual frequency

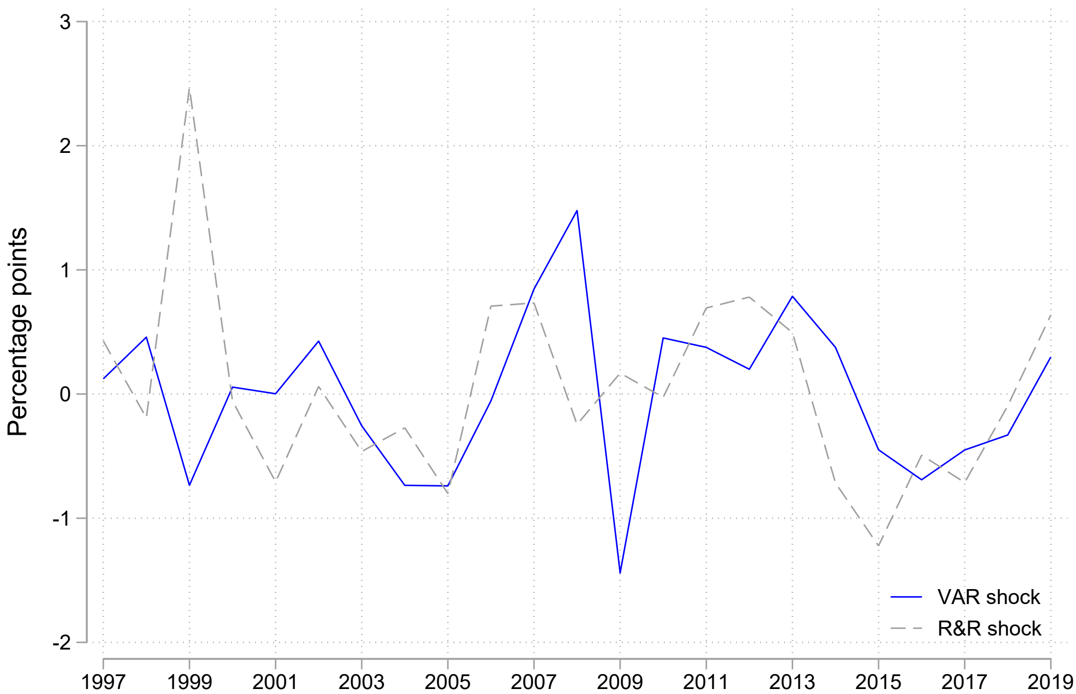


Figure A6: Comparison HFI and R&R shocks at a monthly frequency

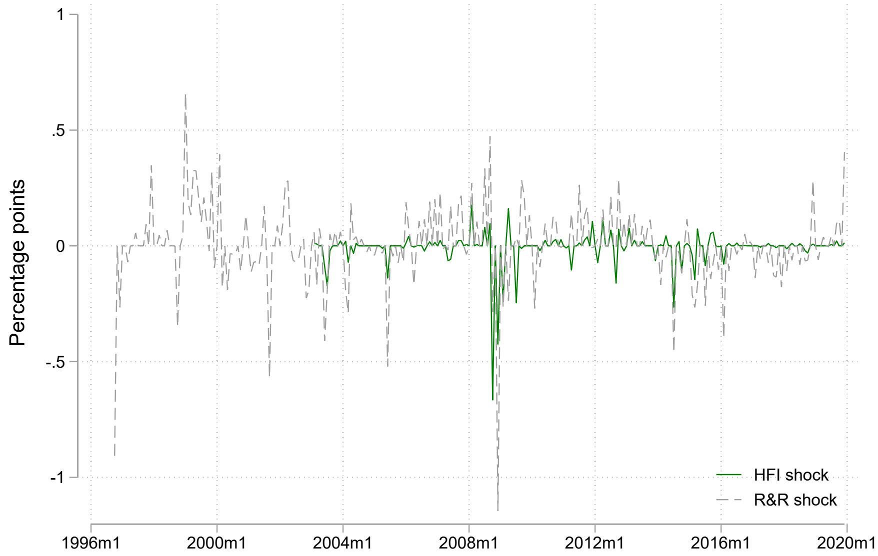


Figure A7: Comparison HFI and R&R shocks at an annual frequency

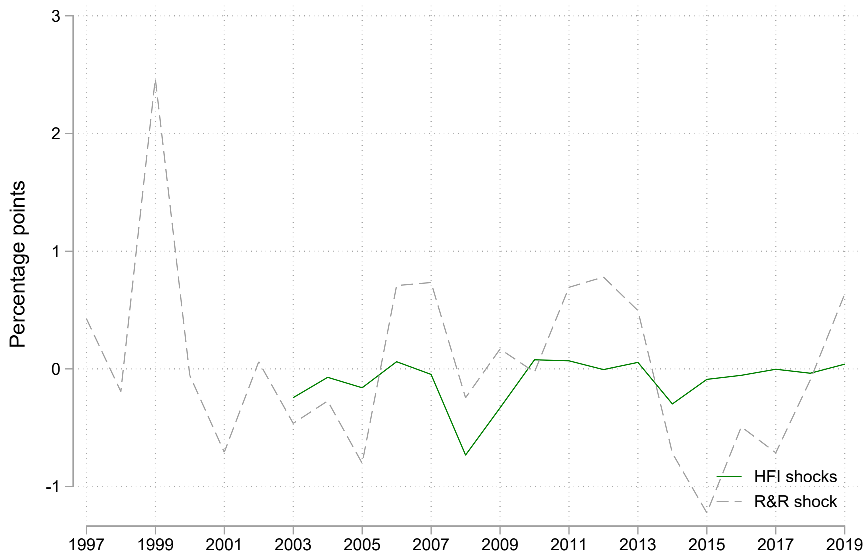


Figure A8: Comparison of all shocks at a quarterly frequency

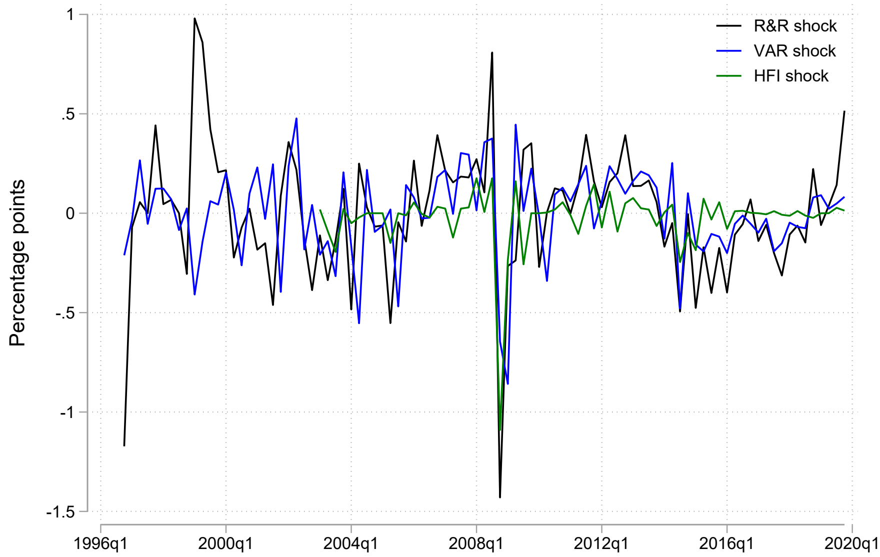
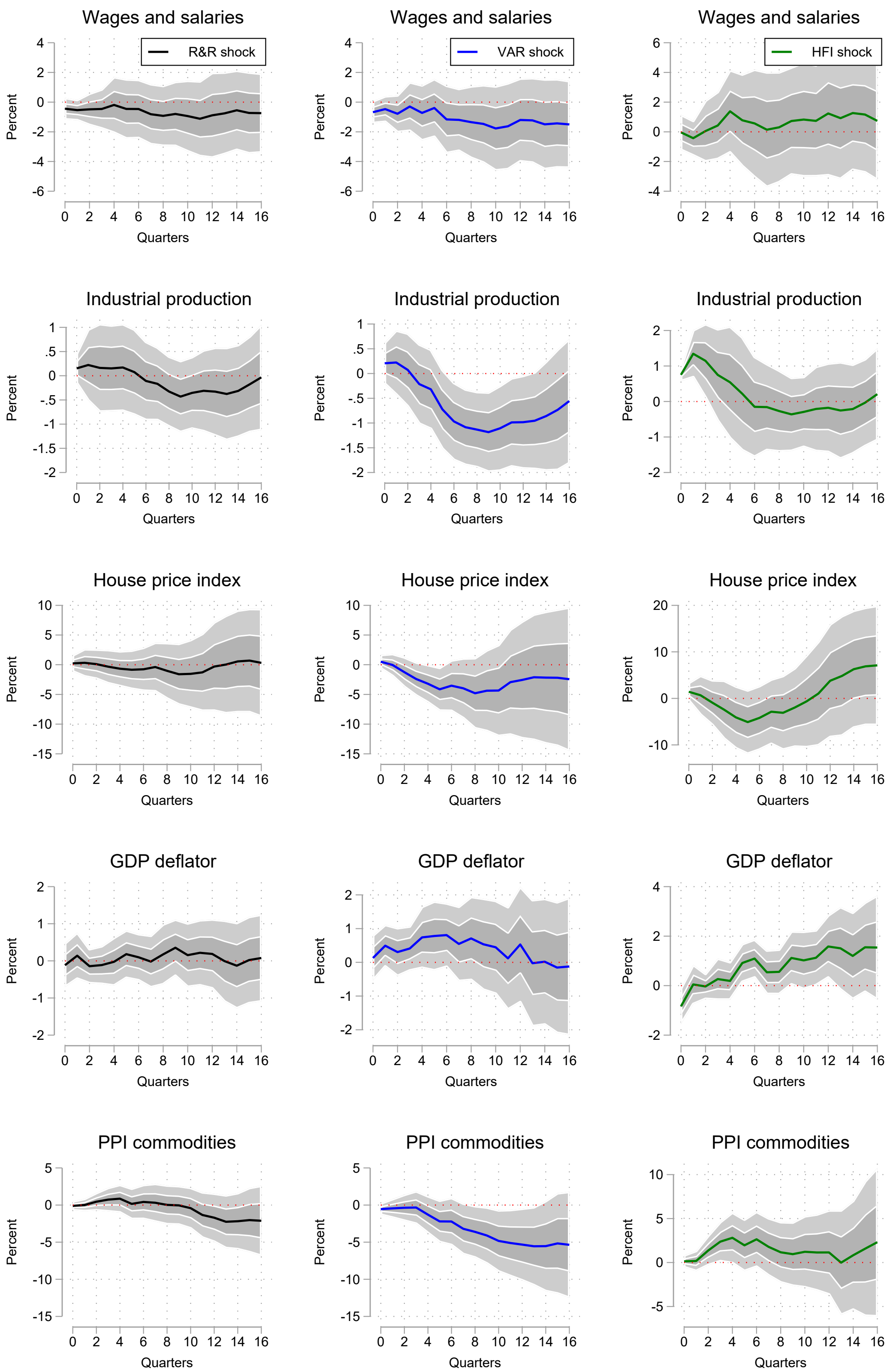


Table A3: Descriptive statistics of shocks

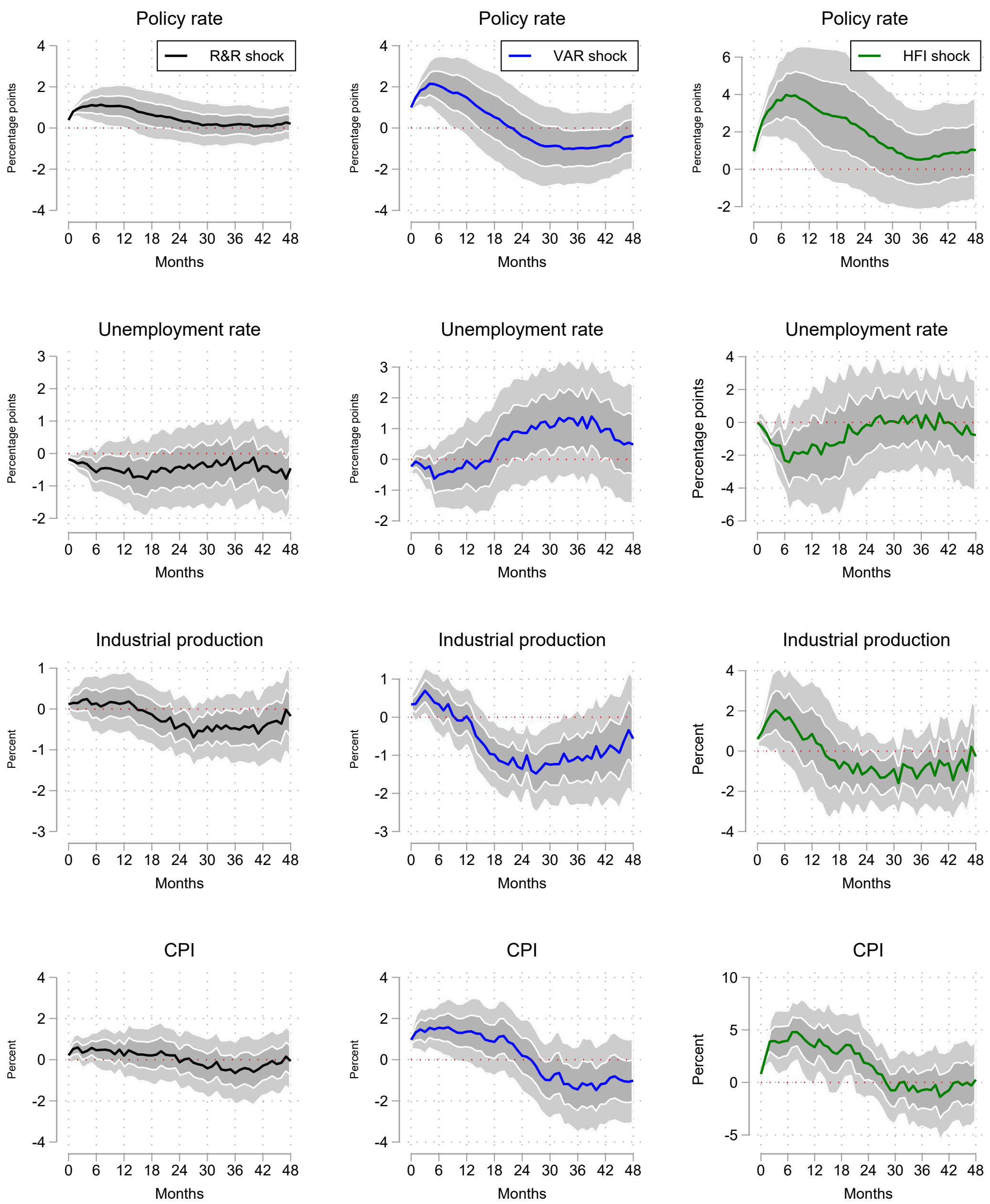
	Observations	Mean	SD	Min	Max
R&R shock	279	0	0.166	-1.145	0.660
VAR shock	279	0	0.102	-0.546	0.332
HFI shock	224	-0.007	0.071	-0.665	0.176

Figure A9: Additional impulse responses at a quarterly frequency



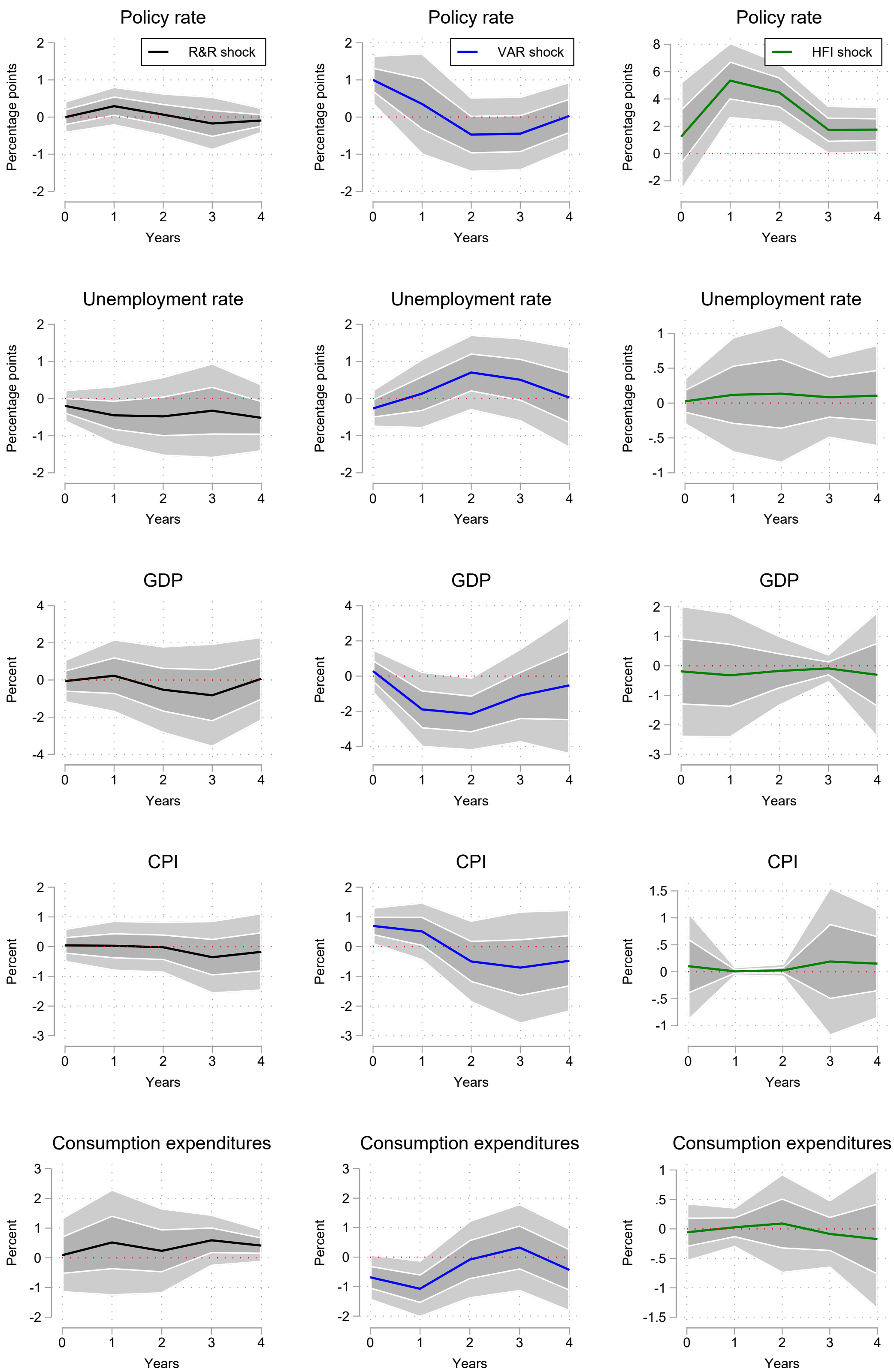
Notes: The graph illustrates the response of macroeconomic variables to a one percentage point contractionary monetary shock. The responses are from estimating model (3) and the sample is 1996:Q4 - 2019:Q4 for impulses with the R&R and VAR shocks and 2003:Q1 - 2019:Q4 for impulses with the HFI shocks (except for wages where the sample starts in 2001:Q1 and the house price index where the sample starts in 1998:Q1). Light and dark grey shaded areas are 95% and 68% confidence bands. See Appendix Table A2 for more information on the macroeconomic variables.

Figure A10: Impulse responses at a monthly frequency



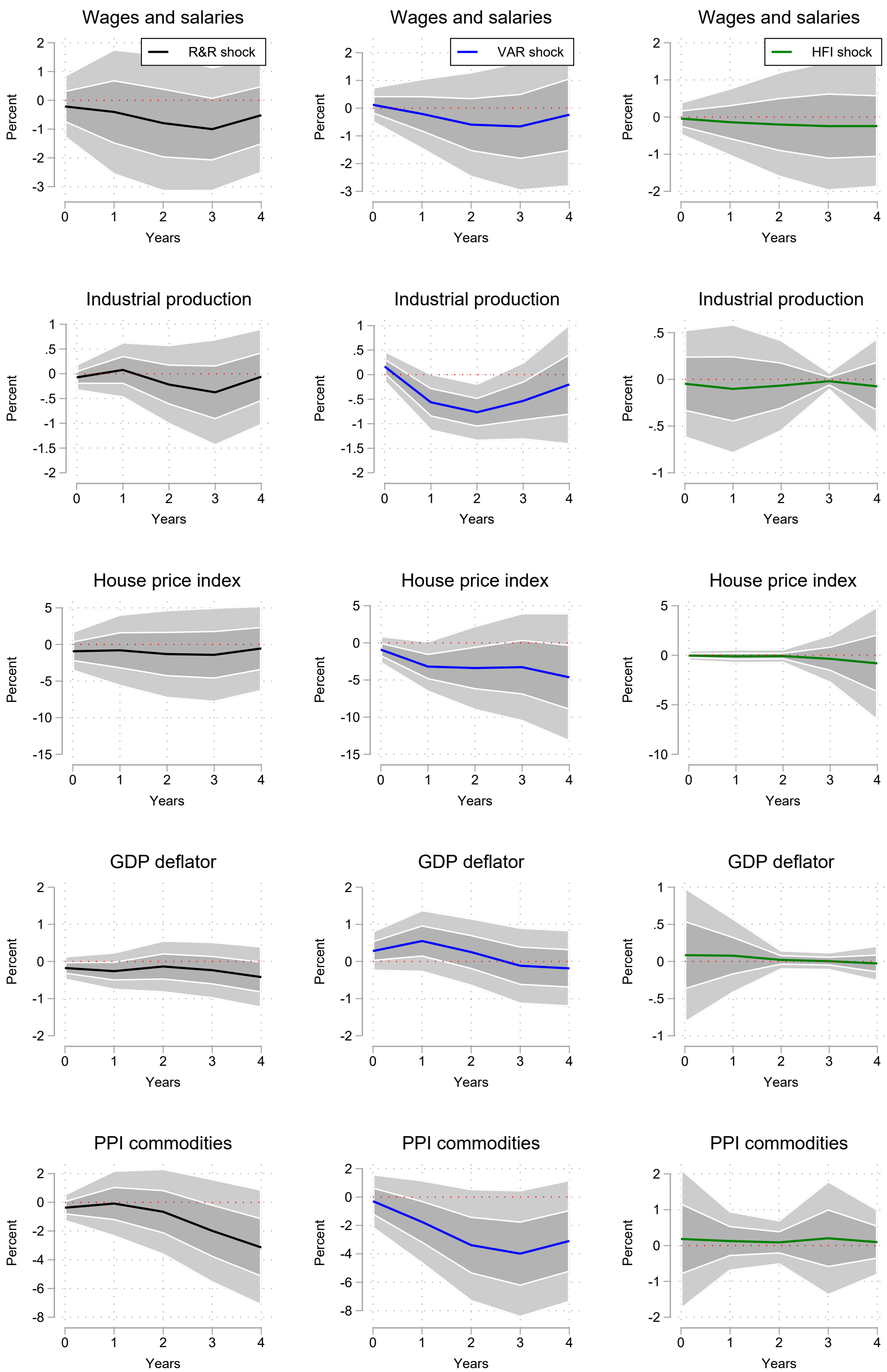
Notes: The graph illustrates the response of macroeconomic variables to a one percentage point contractionary monetary shock. The responses are from estimating model (3) and the sample is 1996:M10 - 2019:M12 for impulses with the R&R and VAR shocks and 2003:M1 - 2019:M12 for impulses with the HFI shocks. Light and dark grey shaded areas are 95% and 68% confidence bands. See Appendix Table A2 for more information on the macroeconomic variables.

Figure A11: Impulse responses at an annual frequency



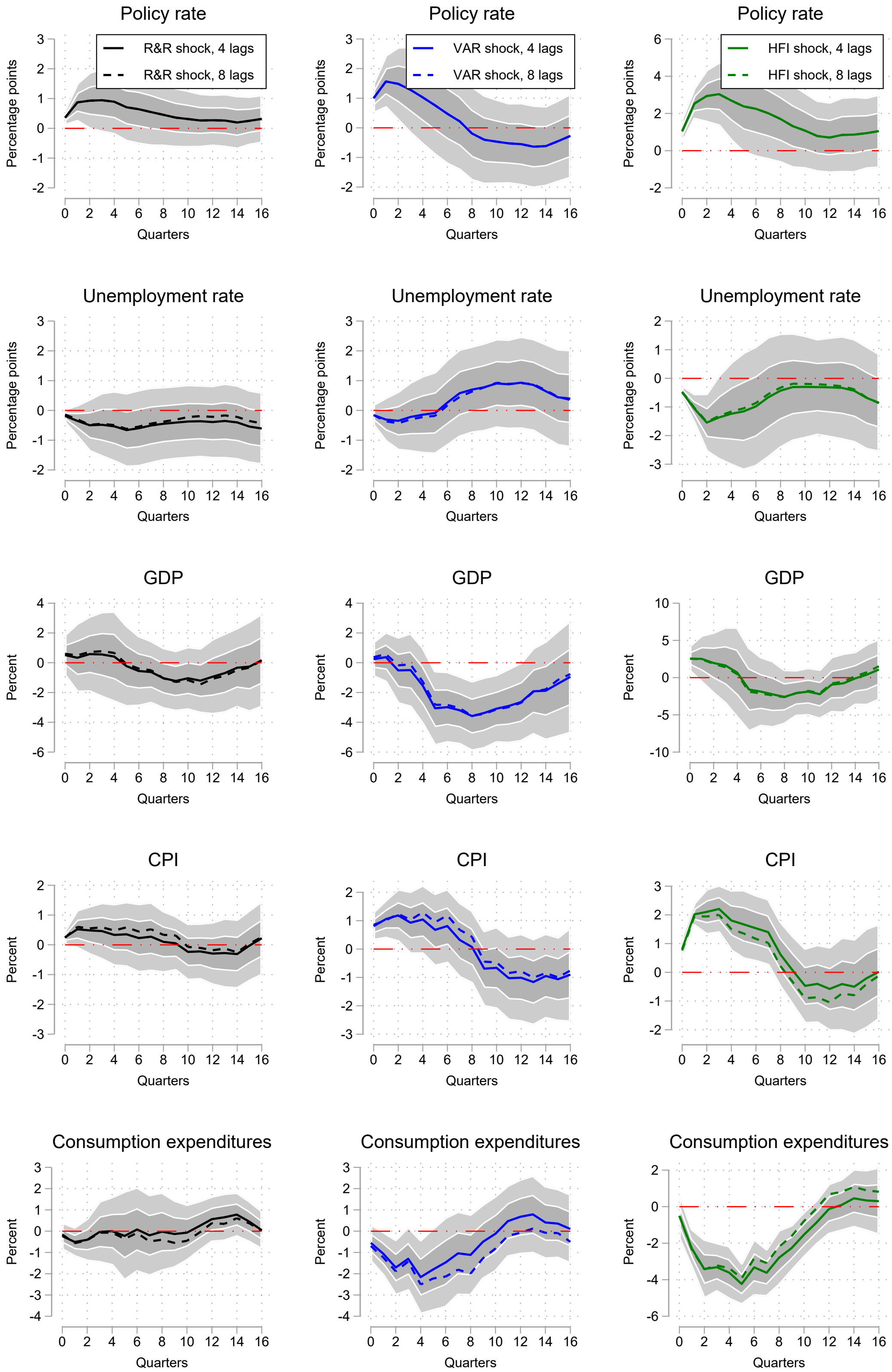
Notes: The graph illustrates the response of macroeconomic variables to a one percentage point contractionary monetary shock. The responses are from estimating model (3) and the sample is 1997 - 2019 for impulses with the R&R and VAR shocks and 2003 - 2019 for impulses with the HFI shocks. Light and dark grey shaded areas are 95% and 68% confidence bands. See Appendix Table A2 for more information on the macroeconomic variables.

Figure A12: Additional impulse responses at an annual frequency



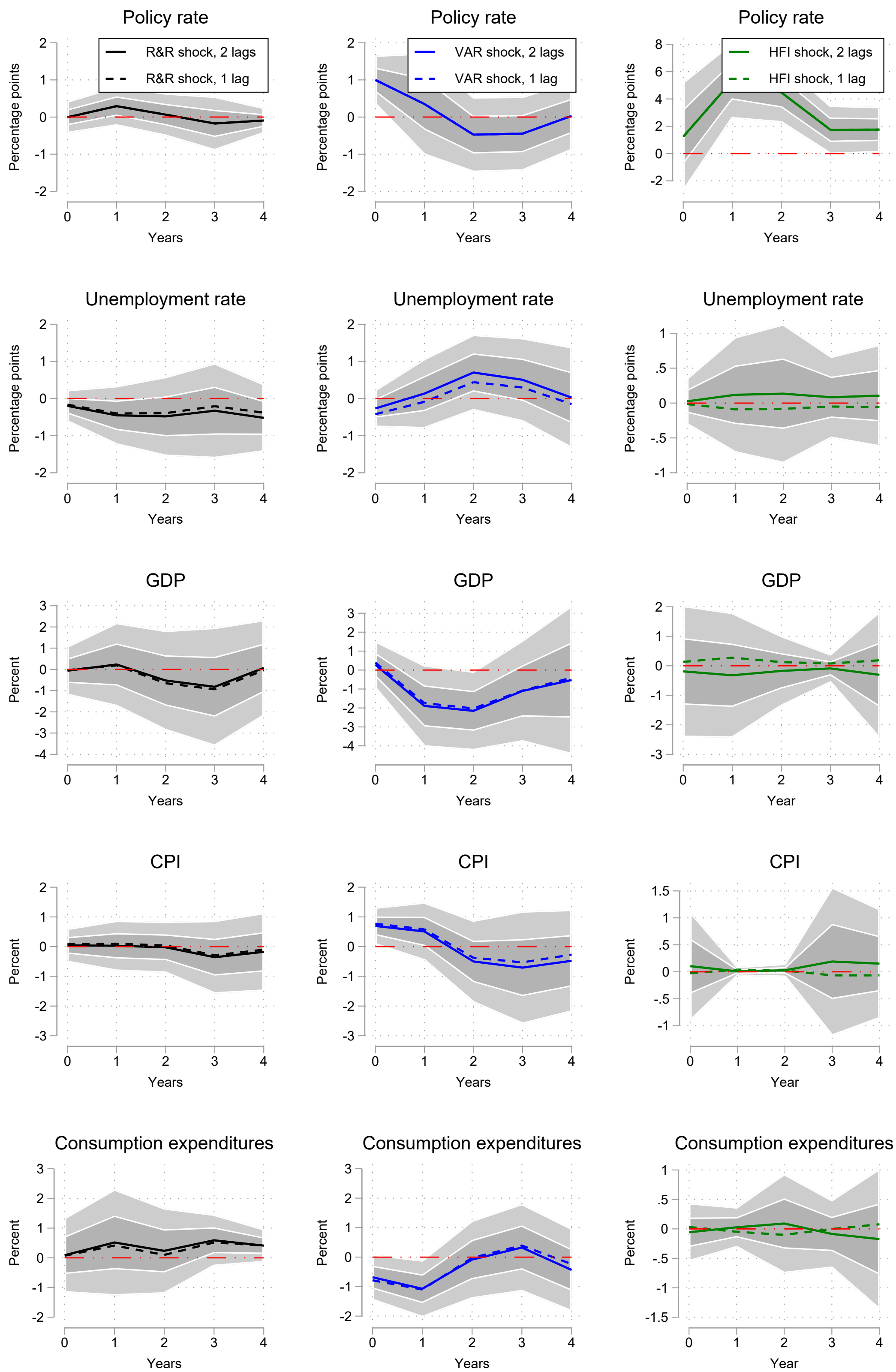
Notes: The graph illustrates the response of macroeconomic variables to a one percentage point contractionary monetary shock. I estimate model (3) and the sample is 1997 - 2019 for impulses with the R&R and VAR shocks and 2003 - 2019 for impulses with the HFI shocks (except for wages where the sample starts in 2001 and the house price index where the sample starts in 1998). Light and dark grey shaded areas are 95% and 68% confidence bands. See Appendix Table A2 for more information on the macroeconomic variables.

Figure A13: Impulse responses at a quarterly frequency - lag length of controls



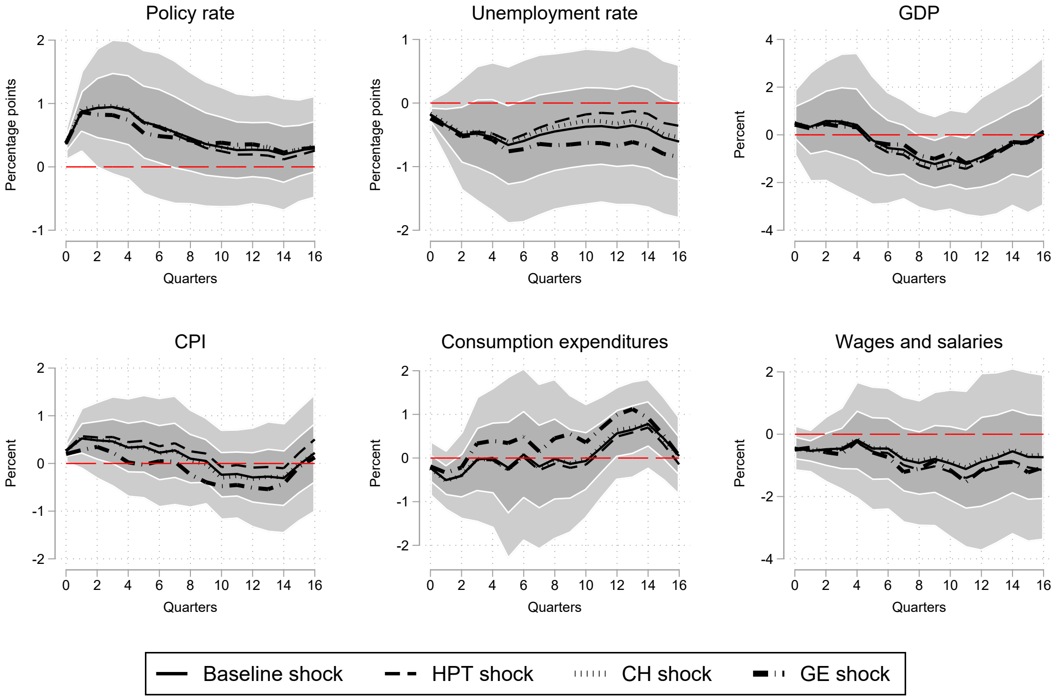
Notes: The graph illustrates the response of macroeconomic variables to a one percentage point contractionary monetary shock. I obtain responses from estimating model (3) including two years of lagged shocks (dashed lines) as controls, opposed to one year as in baseline (solid lines). The sample is 1996:Q4 - 2019:Q4 for impulses with the R&R and VAR shocks and 2003:Q1 - 2019:Q4 for impulses with HFI shocks. Light and dark grey shaded areas are 95% and 68% confidence bands. See Appendix Table A2 for more information on the macroeconomic variables.

Figure A14: Impulse responses at a yearly frequency - lag length of controls



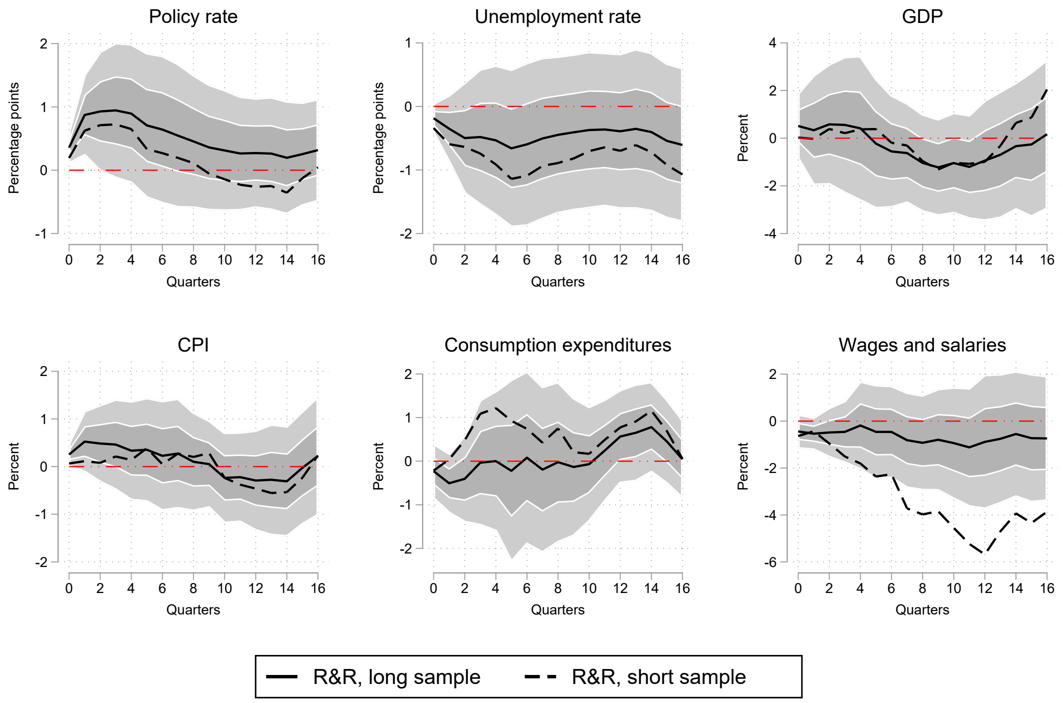
Notes: The graph illustrates the response of macroeconomic variables to a one percentage point contractionary monetary shock. I obtain responses from estimating model (3) including one year of lagged shocks (dashed lines) as controls, opposed to two years as in baseline (solid lines). The sample is 1997 - 2019 for impulses with the R&R and VAR shocks and 2003 - 2019 for impulses with HFI shocks. Light and dark grey shaded areas are 95% and 68% confidence bands. See Appendix Table A2 for more information on the macroeconomic variables.

Figure A15: Impulse responses with R&R shocks - alternative specifications of the shock



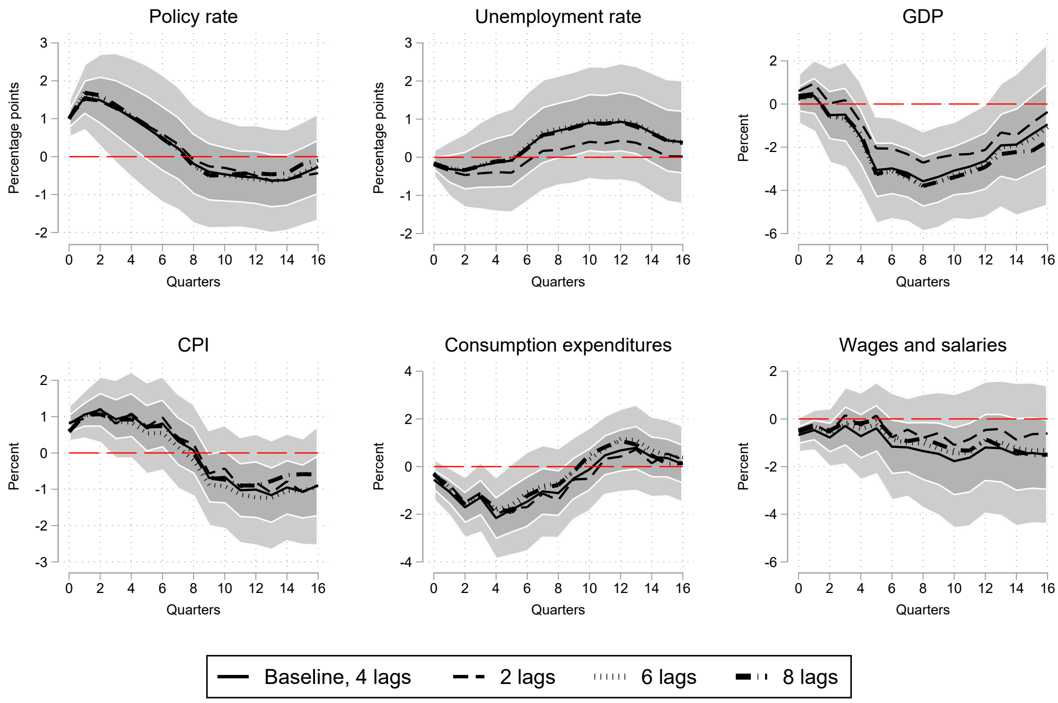
Notes: The graph illustrates the response of macroeconomic variables to a one percentage point contractionary monetary shock. Baseline shock is the R&R shock estimated in model (1). HPT shock is the R&R shock estimated in model (1) but excluding unemployment. CH shock is the R&R shock estimated in model (1) but including three months of lagged unemployment. GE shock is the R&R shock estimated in model (1) but including controls for Germany's GDP and CPI. The sample is 1996:Q4 - 2019:Q4 (except for wages where the sample starts in 2001:Q1). Light and dark grey shaded areas are 95% and 68% confidence bands. See Appendix Table A2 for more information on the macroeconomic variables.

Figure A16: Impulse responses with R&R shocks - short and long sample



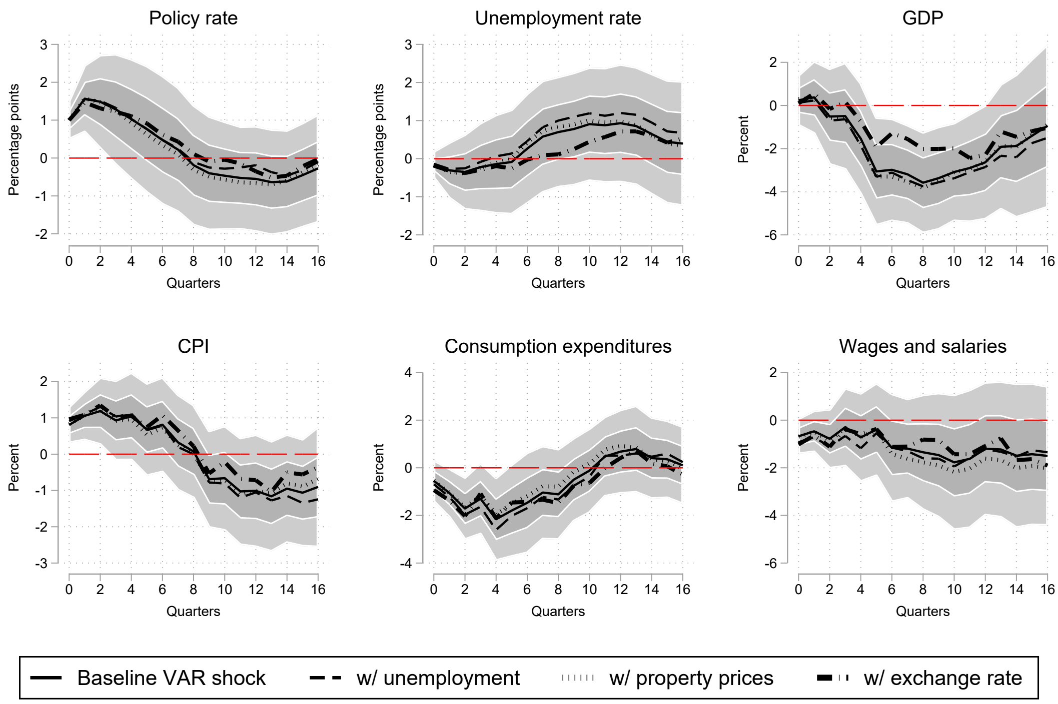
Notes: The graph illustrates the response of macroeconomic variables to a one percentage point contractionary monetary shock. R&R long sample is the baseline shock estimated in model (1) that runs between 1996-20019. R&R short sample is the same shock ending in 2006. Light and dark grey shaded areas are 95% and 68% confidence bands. See Appendix Table A2 for more information on the macroeconomic variables.

Figure A17: Impulse responses with VAR shocks - lag length in VAR specification



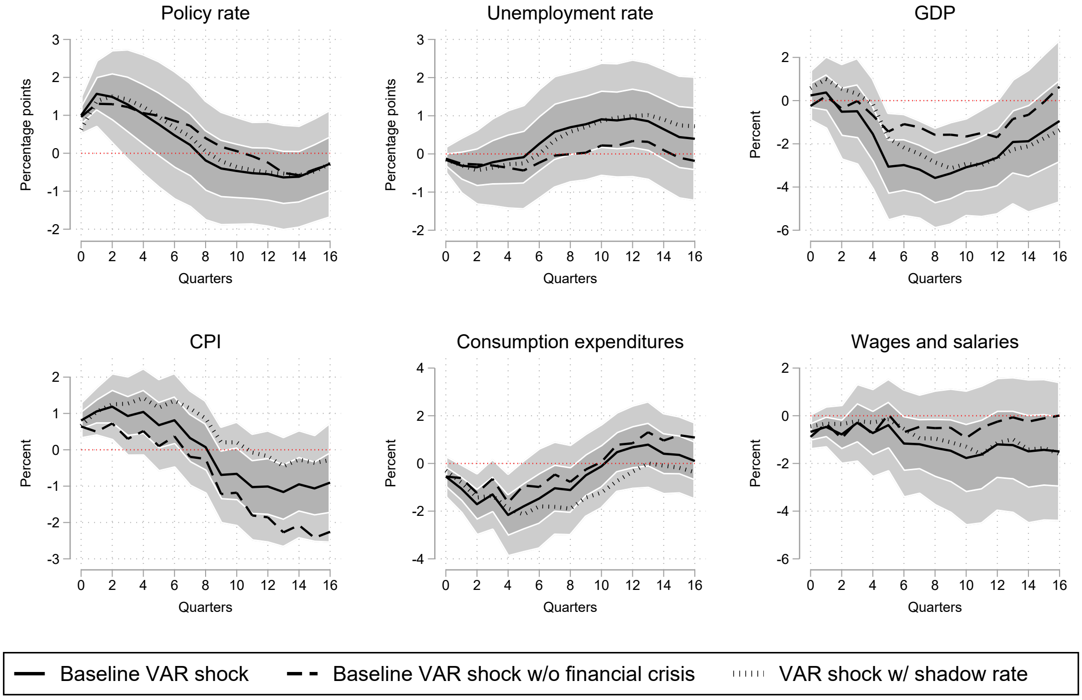
Notes: The graph illustrates the response of macroeconomic variables to a one percentage point contractionary monetary shock. When estimating the VAR shock in model (2) I include p = 4 lags (quarters) in the baseline estimation. The figure shows the results when including 2 lags, 6 lags and 8 lags as well. The sample is 1996:Q4 - 2019:Q4 (except for wages where the sample starts in 2001:Q1). Light and dark grey shaded areas are 95% and 68% confidence bands. See Appendix Table A2 for more information on the macroeconomic variables.

Figure A18: Impulse responses with VAR shocks - alternative specifications of the shock



Notes: The graph illustrates the response of macroeconomic variables to a one percentage point contractionary monetary shock. I estimate the baseline recursive VAR shock with model (2) and include GDP, CPI and the repo rate. In addition, the figure shows responses to a VAR shock with additional variables included in the specification; unemployment (dashed line), property prices (dotted line) and the SEK/EUR exchange rate together with controls for German GDP and CPI (dash-dotted line). The sample is 1996:Q4 - 2019:Q4 (except for wages where the sample starts in 2001:Q1). Light and dark grey shaded areas are 95% and 68% confidence bands. See Appendix Table A2 for more information on the macroeconomic variables.

Figure A19: Impulse responses with VAR shocks at a quarterly frequency, excluding the financial crisis and including a shadow rate



Notes: The graph illustrates the response of macroeconomic variables to a one percentage point contractionary monetary shock. The solid line is the baseline VAR shock estimated in model (2). The dashed line is the baseline shock excluding years 2007-2008. The dotted line includes a shadow rate instead of the repo rate in model (2). The sample is 1996:Q4 - 2019:Q4 (except for wages where the sample starts in 2001:Q1). Light and dark grey shaded areas are 95% and 68% confidence bands. See Appendix Table A2 for more information on the macroeconomic variables.