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Measuring Riksbank Monetary Policy: Shocks and Macroeconomic Transmission

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Abstract. We construct and make available a new monetary policy event study database with high-frequency financial market reactions to Riksbank communications, spanning a period of 20 years. Using these data as instruments, we estimate the macroeconomic effects of monetary policy shocks in Sweden. A temporary, unexpected policy rate tightening induces an immediate and persistent appreciation of the krona exchange rate, as well as a gradual, negative response in output and consumer prices. These results are statistically significant, economically meaningful and robust to a number of variations in our econometric specification. In particular, we consider the possibility that financial market reactions to Riksbank communications may consist not only of pure monetary policy shocks, but could also reflect market participants' updates concerning the central bank's reaction function.

Keywords: monetary policy surprise database, monetary policy shocks, intraday, event study, proxy VAR, macroeconomic effects

JEL classification: E43, E44, E52, E58, G14

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1 Introduction

What are the effects of monetary policy on key macroeconomic variables such as output, inflation and unemployment? This is a longstanding and frequently revisited question in the monetary economics literature. Following important contributions in the early 2000s, e.g. by Kuttner (2001) and Faust et al. (2004), it has become standard to use high-frequency (HF) data from financial markets to identify the effects of monetary policy, since such instruments-based analysis can convincingly say something about the causal effects of changes in the stance of monetary policy. While an extensive literature has used HF instruments to study the effects of U.S. monetary policy, comparatively less research has been devoted to other monetary jurisdictions, partly because of data availability issues. In recent years, however, researchers have constructed novel monetary policy event study databases in order to facilitate a systematic analysis of monetary policy in the euro area (EA) and the United Kingdom (UK).[2]

This paper contributes to this literature in several ways. First, we construct and make available a Riksbank monetary policy event study database, featuring financial market reactions during short time windows from days when the Riksbank, Sweden's central bank, announced monetary policy decisions or released minutes from monetary policy meetings. We include reactions in seven different interest rate instruments, two exchange rates and an index of the Nasdaq Stockholm stock exchange. The database spans a period of 20 years, from 2004 to 2024, and we expect it to be continually updated going forward, thereby facilitating and stimulating research into the effects of monetary policy in Sweden.

Second, we use the new database to identify monetary policy shocks and estimate how these impact key macroeconomic variables. Following Swanson (2021) and Gürkaynak et al. (2005b), we apply factor analysis to the set of seven interest rate swaps of different maturities to identify and distinguish different types of shocks: shocks to the current level of the policy rate, shocks to its expected future level and shocks related to the Riksbank's use of quantitative monetary policy measures. We focus on the first two of these types of unexpected changes in Riksbank monetary policy and use them as external instruments in a structural VAR-model.

Concerning shocks to the current level of the policy interest rate (factor 1), the results show that an unexpected, temporary tightening (loosening) of the policy rate induces an immediate and persistent appreciation (depreciation) of the krona exchange rate, as well as a more gradual, negative (positive) effect on output and consumer prices. These effects are statistically

[2] See Altavilla et al. (2019) and Braun et al. (2024).

significant, economically meaningful and robust to a number of variations in our econometric specification.

According to our baseline estimate, shocks to the future expected level of the policy interest rate (factor 2) imply a gradual increase (decrease) of the policy interest rate over a period of about 18 months, followed by a gradual decrease (increase). The effects on output and consumer prices are similar to those of an unexpected, temporary change in the current level of the policy rate (factor 1). In the case of shocks to the expected future level of the policy rate (factor 2), the instrument is however on the weak side, and the results are less robust.

Besides usual robustness exercises, e.g. such related to the specification of the VAR-model, we take special care to investigate robustness to alternative interpretations of the financial market reactions embedded in the new event study database. Several studies document that financial market reactions – or surprises – to Federal Reserve announcements are autocorrelated, and also correlated with macro-financial information that was publicly available to market participants prior to the announcements (e.g. Cieslak (2018), Miranda-Agrippino and Ricco (2021), Bauer and Swanson (2023)). These findings call into question the exogeneity of these surprises, and thus the validity of the practice of using them as instruments for monetary policy shocks. The literature has proposed different interpretations of these correlations. Two prominent such interpretations are the "Fed information effect"-hypothesis, as in Campbell et al. (2012), Nakamura and Steinsson (2018) and Miranda-Agrippino and Ricco (2021), and the "Fed response to news channel", proposed by Bauer and Swanson (2023a and 2023b).[3]

The Fed information effect-hypothesis starts from the assumption that the central bank may have private information about the state of the economy, and that this information may be disseminated to market participants through announcements of monetary policy decisions. If such an information channel exists, monetary policy surprises may derive not only from true monetary policy shocks, but could also be the result of news about such private information. Laséen (2020) investigates if any such "Riksbank information effect" is relevant in the case of Swedish monetary policy surprises. Using Riksbank forecasts to construct an informationally-robust HF instrument for Swedish monetary policy shocks, Laséen (2020) finds that central bank information shocks do not materially confound VAR-estimates of the macroeconomic transmission of Swedish monetary policy shocks, and suggests that the lack of a clear

[3] The idea that the central bank may have private information about the state of the economy, and that such information may be transmitted to market participants through central bank announcements, was suggested by Romer and Romer (2000). Ellingsen and Söderström (2001) investigated the same idea, both theoretically and empirically, with a focus on the response of long-maturity interest rates to the release of central bank information.

information channel may be related to the Riksbank's transparency and communication strategies.

In this study, we instead focus on another potential source of bias when financial market surprises are used as instruments for monetary policy shocks, namely the "Fed response to news channel", proposed by Bauer and Swanson (2023a and 2023b). The basic idea is that market participants only have imperfect knowledge of the true parameters of the central bank's reaction function. Using a simple theoretical model of learning, Bauer and Swanson (2023b) show that if those parameters change over time, the learning process can be a source of systematic surprises. In the model, market participants continually use central bank communications to update their estimates of the parameters of the central bank's monetary policy rule, thus creating *ex post* correlation between surprises and information that was publicly available at the time of those communications.

We investigate the relevance of such a "Riksbank response to news" channel for Sweden, thereby complementing the work of Laséen (2020). In order to distinguish true Riksbank monetary policy shocks from possible surprises due to updating, we construct a dataset of real-time macro-financial data that was available to market participants at each individual communication event that we use in our estimations. We find evidence of statistically significant correlation between the surprises and such real-time data, most notably with the krona exchange rate and with foreign rates of inflation. As a robustness exercise, and following Bauer and Swanson (2023b), we use as our instrument only that component of surprises that is orthogonal to these correlated variables. We find that cleaning our monetary policy surprises in such a way does not alter the conclusions about the macroeconomic effects of Riksbank monetary policy in any substantial way.

Our paper relates to other studies that use a HF approach to estimate the transmission of Swedish monetary policy shocks. As previously mentioned, Laséen (2020) studies the effects of monetary policy on economic activity and asset prices in Sweden, separately identifying the effects of a surprise change in the policy rate from effects of new information about economic fundamentals. Other studies that focus on macroeconomic responses are Brubakk et al. (2022), Amberg et al. (2022), Kilman (2022) and Laséen and Nilsson (2024). Other studies focus on the effect of monetary policy on financial variables: Fransson and Tysklind (2016), Iversen and Tysklind (2017), Åhl (2017), De Rezende (2017), Sandström (2018), Natvik et al. (2020) and Brubakk et al. (2021). Similar dynamics in other small open economies are examined by, for example, Braun et al. (2023), Cesa-Bianchi et al. (2020), Hambur and Haque (2023) and Soosalu (2024).

The rest of the paper is organised as follows. Section 2 contains a description of the Riksbank monetary policy event study database, including information about the monetary policy decision and communication cycle, and how monetary policy surprises are constructed. Section 3 describes how we use the database to identify monetary policy shocks in Sweden. Section 4 presents the effects of monetary policy shocks on macroeconomic variables, including the results of a few robustness exercises. Finally, section 5 concludes.

2 The Riksbank monetary policy event study database

This section describes the data and procedure used to extract financial market surprises (HF surprises) on days when the Riksbank released communication about monetary policy. It also includes a short description of the Riksbank's schedule for deciding and communicating Swedish monetary policy. The first vintage of the database, made available together with this paper, spans a period of 20 years, from August 20, 2004 through August 26, 2024.[4] It includes surprises in interest rates from 269 communication events, including announcements from 121 regular monetary policy meetings, 24 extraordinary meetings, as well as the release of minutes from 124 meetings.[5] In the database, we also include reactions of the SEK/USD and the SEK/EUR exchange rates, as well as the OMX Stockholm all-share index, which includes all the shares listed on the Nasdaq OMX Nordic Exchange Stockholm.

Throughout the period covered by the database, Swedish monetary policy was characterized by an official, announced 2 per cent inflation target and a flexible exchange rate regime. The Riksbank announced the inflation target in 1993, following the abrupt abandonment in 1992 of the previous fixed exchange rate regime.[6] Credibility for the new regime increased gradually in the following years and was formally codified in 1999 with the introduction of new legislation, granting the central bank a high degree of institutional independence.[7]

[4] The database on Riksbank monetary policy surprises can be found here: https://www.riksbank.se/en-gb/about-the-riksbank/the-tasks-of-the-riksbank/research/database-for-event-studies-of-swedish-monetary-policy/

[5] On two of the 269 dates, 2024-03-13 and 2020-03-26, an announcement from an extraordinary meeting was released on the same day as the release of minutes. We treat those two dates as two communication events.

[6] In January 1993, the Riksbank announced that a 2 per cent inflation target would apply, starting from 1995.

[7] The Riksbank Act from 1999 stipulated a single mandate of price stability for Swedish monetary policy. However, wordings included in the preparatory work of the Act were interpreted by the Riksbank as a mandate for flexible inflation targeting. A new Riksbank Act came into force in January of 2023. The new legislation provides a non-ambiguous support for a regime of flexible inflation targeting. The 2023 Act stipulates that the overriding objective of the Swedish central bank is to maintain permanently low and stable inflation, but the Act also states: "Without neglecting the price stability objective, the Riksbank shall also contribute to a balanced development of production and employment (consideration for the real economy)". For further details, see Sveriges Riksbank (2023a).

2.1 The Riksbank monetary policy decision and communication cycle

While the number of pre-announced, regular monetary policy meetings has changed somewhat over the years, the schedule for the communication of the monetary policy decisions has remained fairly stable. From 2004 to 2006, seven to eight regular, pre-announced monetary policy meetings where scheduled per year, with a report being prepared by staff for every second meeting. Since 2007, a monetary policy report (MPR) or a shorter monetary policy update (MPU) has been prepared for every regular meeting, while the number of such regular meetings has varied between five and eight. The current practice, introduced this year, involves eight regular meetings, with four MPRs and four MPUs.

In the morning, the day after a regular meeting, normally at 09:30 a.m., the decision is announced in a press release that contains a brief motivation (one to two pages). The press release also contains information about any formal reservations entered against the decisions, if such exist.[8] The MPR or MPU is released at the same time as the press release, giving the public immediate access to in-depth information about the economic outlook, risk assessments and other information that was relevant for the decision. Later in the day, usually at 11:00 a.m., a press conference is held with the governor and the head of the monetary policy department. One to two weeks after the meeting, minutes from the meeting are released, usually also at 9:30 a.m.[9]

In addition to reactions to the announcement of 121 regular monetary policy meetings, the database also contains announcements of 24 extraordinary meetings, most of which were held during the financial crisis of 2008-09 and the coronavirus pandemic (2020-21). The communication of decisions taken at those extraordinary meetings did not, in general, follow the communication schedule used for regular meetings. Instead, those decisions were announced on more of an *ad hoc* basis.

Previous studies that use HF surprises from Riksbank announcements have focused only on days when monetary policy decisions were communicated. Because we want to study the multidimensional nature of the Riksbank's monetary policy communication, there is a need to increase the number of observations relative to those of previous studies. Therefore, we also

[8] For all but five of the regular meetings in the database, the decision was announced at 09:30 a.m. on the day after the meeting was held. On one occasion in 2004 (October meeting), two occasions in 2005 (March and October meetings), as well as two occasions in 2006 (February and October meetings), the announcement happened at an earlier time. The reason was that on those occasions, the governor was scheduled to appear at committee hearings in the Riksdag, the Swedish Parliament, the same morning.

[9] The time lag between regular meetings and the publication of minutes has also varied over the years. The current practice involves a lag of one week.

include HF surprises from days when minutes were released. The minutes normally contain a fairly detailed account of the motivations that lead to the decisions that were taken, as well as information about the differences in views that may exist within the executive board. This type of information is of obvious relevance for financial market participants and analysts. Other types of communication from the Riksbank, e.g. the press conferences and speeches given by executive board members, are likely to contain additional information that is relevant for financial markets. We leave it to future research to further enrich the database and analysis in this dimension.

2.2 Data and the construction of surprises

We construct our HF monetary policy surprise database by using intraday tick data for seven different interest swap instruments reflecting expected interest rates at different horizons: the 1-month, 3-month and 6-month SEK overnight index swap (STINA) rates, as well as the 1-year, 2-year, 5-year and 10-year swap rates.[10,11] This data comes from Datascope Tick History, provided by the London Stock Exchange Group (LSEG). STINA swap rates, which settle on the *Tomorrow/Next Stockholm interbank offered rate* (STIBOR), reflect short-term interest rate expectations among SEK money market participants. However, the STINA market was generally not very liquid in the early 2000s and it is therefore not meaningful to include Riksbank announcements before August 2004. Even within our 2004-2024 sample, there are announcement days and STINA contracts for which only a limited number of quotes exists, particularly in the early years of the sample. The longer maturity swap rates (1-10 year) settle on the 3-month STIBOR and the market for these contracts is considerably more liquid.

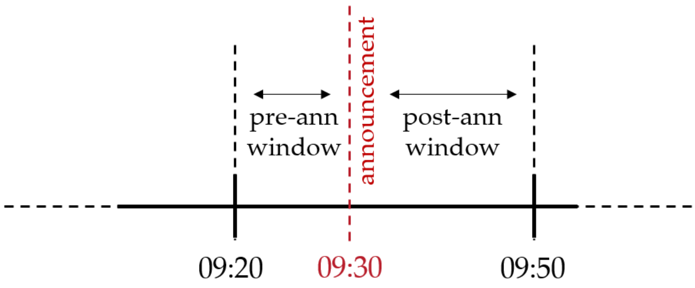
We follow a simple event study approach where we observe how the seven different swap rates adjust around a narrow window of time in each of our communication events. Specifically, we have two event windows around each communication event: one pre-communication window that starts 10 minutes before the actual announcement or release, and

[10] To be more precise, swap rates may reflect both an interest rate expectation and a (possibly time varying) premium. When constructing surprises, we compute the difference between the market rates prevailing in a tight window after and before the relevant Riksbank announcement. Following Gertler and Karadi (2014) and others, we assume this premium does not change materially in such a short window of time, and we may thus think of these differences in swap rates as measures of market surprises in interest rate expectations. The 1-month STINA contract (and the calculated surprises in this instrument on the day of a regular monetary policy announcement) reflects an average over the next month, meaning that part of the period is influenced by the old policy rate and part by the new rate just announced. To isolate the portion of the surprise that reflects the market's reaction to the new announced policy rate, the surprise is scaled using an adjustment factor. The adjustment factor represents the proportion of time (out of the total contract length, i.e. 30 days) during which the new announced policy rate applies, i.e. *adjustment factor = (30-(days between announcement and implementation))/30.*

[11] An interest rate swap is a financial instrument where parties exchange interest flows with each other. Most commonly, the parties exchange a fixed rate with a floating rate, which is determined by a reference rate. In Swedish kronor, there are OIS contracts against two reference rates, STIBOR T/N and SWESTR. The swaps against STIBOR T/N are usually referred to as STINA swaps. Other than OIS contracts, there are interest rate swaps against other reference rates. In Sweden, most interest rate swaps (which are not OIS contracts) are against STIBOR 3m.

ends at the actual announcement, which normally takes place at 9:30 a.m.; and one post-event window starting at the time of the announcement and ending 20 minutes later. We pick the median price within each window and then exploit the discontinuity in the (median of the) quoted prices of our seven financial instruments, calculating the difference between the price in the post-announcement window and the pre-announcement window.[12] Figure 1 illustrates the measurement windows used when calculating the monetary policy surprises.

Figure 1: Measurement windows for monetary policy surprises

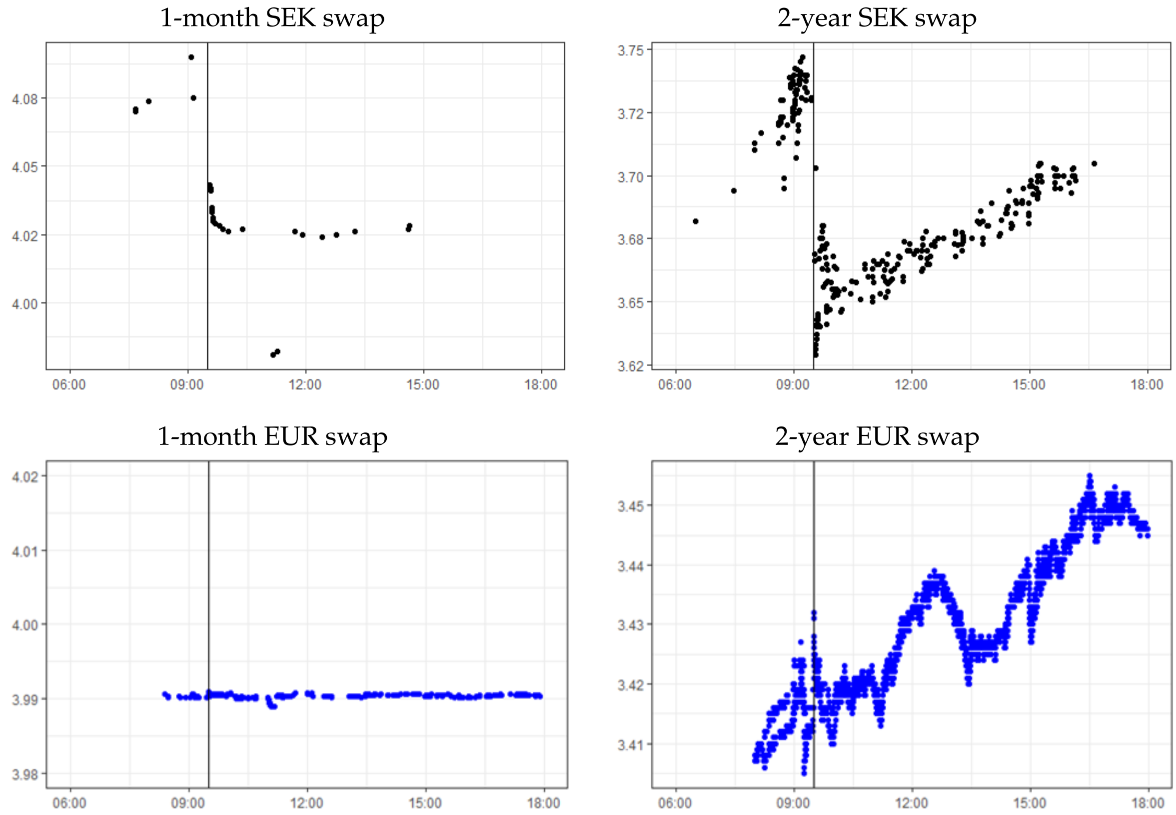


Note. The figure sketches the measurement windows used for calculating the monetary policy surprises. We use two windows a pre-announcement window starting 10 minutes before the announcement, and a post-announcement window, starting 20 minutes after the announcement. The median price (average of the bid and ask prices) for each of the instruments in each window is used as the pre and post announcement price.

To illustrate the importance of using intraday data, and to get a sense of how the raw data looks like, Figure 2 shows the changes in two of our instruments on November 23, 2023. On that day, at 09:30 a.m. the Riksbank announced the decision from its last monetary policy meeting of that year, which had taken place the day before, on November 22. Prior to the announcement, most analysts expected the Riksbank to hold the policy rate unchanged at 4.00 per cent, after a year and a half of successive rate hikes. However, some Swedish economists argued that, given the high inflation and the relatively weak exchange rate, a further increase to 4.25 per cent would be appropriate.

[12] As already mentioned previously, the seven swap instruments are not equally liquid. For the long term interest rates, like the 1-10 year swap rates, there is a sufficient number of quotes in our data to enable us to look at short event windows of 10 and 20 minutes. For the shortest swap contracts, however, we have to adapt by expanding the window somewhat in order to capture any movement in prices. In some cases, the daily close and opening prices are used instead to calculate the change. In the cases where the window needs to be expanded, our criterion is that there has to be at least three quotes in each window to calculate a value for that window (a median quote will be calculated). If there are less than three quotes the window will expand until the criterion of three quotes is met.

Figure 2: Intraday movements of interest rate swaps on November 23, 2023



Note: The figure shows intraday quotes for two SEK and EUR interest rate swaps on November 23, 2023 when the Riksbank announced its decision to hold its policy rate at 4 per cent. Each dot is a quote from a market maker and the vertical line shows the timestamp of the announcement (9:30 am).
Source: LSEG Datascope Tick History.

Before the announcement on November 23, market prices also indicated a high probability of the policy rate being kept unchanged at 4.00 per cent. This expectation is reflected in the price of the 1-month OIS contract. The quotes from the morning of November 23, which were slightly above 4.00 per cent, indicated that market participants saw some probability of an additional 25 basis point hike to 4.25 per cent. At 09:30, the Riksbank announced that the policy rate would be kept unchanged at 4.00 per cent. The accompanying monetary policy report made only small adjustments to the Riksbank's policy rate forecast. As shown in both figures, both the 1-month OIS and the 2-year swap rates fell immediately after the announcement, indicating that market participants perceived the Riksbank's communication as being slightly dovish.

Figure 2 also shows, in the two lower panes, how comparable interest rates in the euro area moved during the same day. Not surprisingly, there was no movement at all in the 1-month Euro OIS rate.[13] However, the same morning, several European purchasing managers' indices

[13] The 1-month OIS contract is closely tied to expectations of how the ECB deposit rate will evolve in the coming 30 days, and since there was no relevant news on that day that shifted market expectations concerning the ECBs December rate decision, the OIS-rate stayed completely flat.

(PMI) were released, with a surprisingly strong reading of the euro area PMI becoming public at 10 a.m. Shortly thereafter, medium- and long-term euro area and Swedish rates started to drift upwards. The parallel movements of the euro area and Swedish 2-year swap rates, as shown in Figure 2, highlights the strong connection between Swedish medium- to long-term rates and those of the euro area, Sweden's major trading partner. The figure illustrates the potential importance of using intraday data for measuring financial market surprises in Sweden, especially for durations beyond 6 to 12 months. The top-right pane in Figure 2 clearly shows how the market reacted to the 09:30 a.m. Riksbank announcement – an effect that would have been missed if daily data were used instead.

3 Using the database to identify monetary policy shocks in Sweden

3.1 Identifying shocks to monetary policy

For U.S. monetary policy, Gürkaynak et al. (2005b) and Swanson (2021) argue that monetary policy decisions and communications of the Federal Reserve affect asset prices in a multidimensional way. For example, some decisions and communications may have a relatively large effect on short-run interest rate expectations and only small effects on longer-run expectations; other decisions and communications may have a relatively large effect only on longer-run expectations, etc. Gürkaynak et al. (2005b) and Swanson (2021) use a static factor model to analyse the systematic part of these effects, and we apply the same method on our dataset of Swedish monetary policy surprises. The aim is to identify different types of monetary policy shocks.[14] We estimate the following model

$$X = F\Lambda + \varepsilon$$

where X is a $T \times N$ matrix containing the calculated surprises of N=7 interest rate instruments during $T = 265$ monetary policy communication events in our sample (see section 2.2 for a description of the instruments), F is a $T \times m$ matrix of unobserved factors ($m \leq N$), Λ is a $m \times N$ matrix of unobserved factor loadings and ε is a $T \times N$ matrix of white noise disturbances.

We then apply the Cragg and Donald (1997) matrix rank test and find evidence for the presence of three distinct factors in our dataset of Swedish monetary policy surprises.[15] These factors remain abstract until we impose an economic interpretation, based on the types of shocks we believe may arise. The aim is therefore to structurally identify the factors without changing the original statistical decomposition. We do this by finding an orthogonal matrix U and rotated factors $\tilde{F}$ such that $X = FUU^{-1}\Lambda + \varepsilon$.[16]

[14] Before using the surprises from the database in our analysis, we remove four dates: 2008-10-08, 2008-10-15, 2020-09-15 and 2021-03-10. The announcement on October 8, 2008, was part of a co-ordinated easing of monetary policy by several central banks in the world, including the Riksbank. The minutes from this meeting were released a week later on October 15. On September 15, 2020 and March 10, 2021, the Riksbank decided to continue to offer its monetary policy counterparties loans in US dollars against collateral up to March 31, 2021. On March 10, 2021, this decision was extended until September 2021. Both these dates are excluded from our analysis due to the fact that this agreement was part of a swap arrangement between the Federal Reserve and a number of other central banks around the world, aimed at improving liquidity conditions in global financial markets, and hence not a decision aimed to affect monetary policy in Sweden per se.

[15] See Appendix B for details of the test.

[16] We tested for autocorrelation in the factors using the Durbin-Watson, Breusch-Godfrey, and Ljung-Box tests (up to 10 lags). In all cases, we failed to reject the null hypothesis of no autocorrelation, indicating that the data does not exhibit significant evidence of autocorrelation.

By defining $\tilde{F} = FU$ and $\hat{\Lambda} = U^{-1}\Lambda$, we identify the rotated factors and loadings. We impose the following restrictions on U to distinguish between different, orthogonal types of monetary policy shocks:

1. The second factor is restricted to only influence future rate expectations, i.e. it cannot load on the 1-month OIS rate. We name this factor the **path factor.**[17]
2. The third factor is also not allowed to load on the 1-month OIS rate. Furthermore, the variance of the third factor is minimized during the periods 2004-08 to 2008-09, 2010-10 to 2014-04 and 2017-04 to 2020-02. We name this factor **quantitative measures factor.**
3. The first factor is associated with immediate policy rate changes. We therefore name this factor the **target factor.**[18]

The exact formulation of the second restriction may be viewed as an adaptation to Swedish conditions of the restrictions applied in Swanson (2021). During the period covered by our sample, the Riksbank has repeatedly used its balance sheet for monetary policy purposes, e.g. by extending special loans to its monetary policy counterparts and by conducting QE and QT operations. We therefore choose to interpret the third factor in a somewhat different way, compared to Swanson (2021), and accordingly label it 'quantitative measures factor'. Table 1 presents the factor loadings of the target factor, the path factor and the quantitative measures factor that result from the above identifying assumptions.

Table 1. Estimated factor loadings

	1-month OIS	3-month OIS	6-month OIS	1-year swap	2-year swap	5-year swap	10-year swap
Target factor	4.87	4.00	2.03	2.24	2.05	1.63	0.97
Path factor	0.00	0.26	1.01	1.67	2.03	1.86	1.43
Quantitative measures factor	0.00	1.34	2.59	1.02	0.76	0.22	0.00

Note. Basis points. The table shows the factor loadings for our sample of 265 Riksbank announcements used in our analysis. The factor loadings are obtained by regressing the surprises onto the factors. The factor loading represents the effect, in basis points, of a one standard deviation shock to the factor. The 1-, 3- and 6-month OIS rates settle on STIBOR T/N, the 1, 2, 5 and 10-year swap rates settle on STIBOR 3m.

Based on the estimated factor loadings in Table 1, the target factor exhibits the largest effect at the short end of the yield curve, particularly on the 1-month OIS rate with a loading of 4.87. This means that a one standard deviation increase in the target rate factor is estimated to increase the current 1-month OIS rate by almost five basis points. This effect gradually diminishes along the curve, reducing to 0.97 for the 10-year swap rate. This pattern aligns with

[17] The assumption that the second factor does not load on the 1-month OIS rate is due to the fact that this rate is priced as the compounded average overnight rate over 30 days. Since the Riksbank almost never, possibly except for extraordinary meetings, has two monetary policy meetings within a 30 day period, the 1-month OIS rate therefore cannot be impacted by what the Riksbank expects to do in the near-medium term (i.e. forward guidance).

[18] No restrictions are placed on this factor (factor 1).

expectations, as changes in the current level of the policy rate primarily impact short-term interest rates before their influence tapers off over longer maturities. The results are also broadly consistent with the estimates in Gürkaynak et al. (2005b) and Swanson (2021). Shocks to the path factor have no effect on the 1-month OIS rate, by construction. Such shocks primarily affect the longer end of the yield curve, peaking around the 2-year horizon with a loading of 2.03. Also, these results are in line with previous studies. The quantitative measures factor yields somewhat different results compared to the first two factors. Like the path factor, the effect of a shock to the quantitative measures factor is zero on the current 1-month OIS by construction. A shock to this factor increases short-term yields on average and the effect diminishes at the longer end of the yield curve.

3.2 Validity of the factors as instruments for monetary policy shocks

Many commonly used HF financial market surprises, similarly extracted from central bank communication events, have been found to be predictable, autocorrelated and also correlated with the central bank's own macroeconomic forecasts. It is therefore reasonable to question whether or not the three identified factors constitute valid instruments for shocks to Riksbank monetary policy. One commonly used indicator of instrument validity in this context is the reaction of asset prices that takes place in the same narrow time window around central bank communications. Following Jarociński and Karadi (2020), several recent studies have focused on the movement of stock market prices. According to economic theory, the stock market should weaken following a monetary policy tightening. However, if the central bank has more information about the state of the economy than the public, and this information is released simultaneously with the monetary policy decision, the resulting monetary policy surprise might move the stock market in the opposite direction. As discussed in the introduction, this channel is sometimes called the Fed information effect. It is not evident to us, however, that prices listed on the Stockholm stock exchange should be expected to react to Riksbank monetary policy shocks in the same way as New York stock prices react to announcements from the Federal Reserve. The Nasdaq Stockholm stock market all share index is heavily influenced by a number of large, multinational corporations who derive most of their revenue from markets outside of Sweden.

Another possibility would be to focus on the sign in the reaction of the krona exchange rate, an asset that can be expected to move in a predictable way to surprises in the Riksbank's announcements. If a tightening (loosening) surprise is associated with an immediate depreciation (appreciation) of the krona, one might suspect that the surprise in question was not caused by a true monetary policy shock. It is not clear to us, however, that such a conclusion would be valid, given the multi-dimensional nature of Riksbank communications, as analysed in the previous section. An unexpected reaction in the exchange rate could be due to, for example, a combination of a target and a path factor shock affecting the market simultaneously. We find some evidence in support of this view, as discussed in Appendix E.

Laséen (2020) investigates the relevance of a Riksbank information effect when estimating the effects of monetary policy in Sweden. Using the Riksbank's own macroeconomic projections, including projections of the policy interest rate, Laséen (2020) constructs an informationally-robust instrument for Swedish monetary policy shocks. The results suggest that in the case of Riksbank announcements, the information channel is not important enough to materially affect the estimated effects of monetary policy.

The other explanation put forth in the literature by Bauer and Swanson (2023a, 2023b), instead focuses on a 'Fed-response-to-news' channel, where market participants continually learn about the central bank's reaction function, as it responds to incoming macroeconomic news. Bauer and Swanson (2023a) show that under the realistic assumption that market participants have only imperfect information about the central bank's reaction function, i.e. about the systematic part of monetary policy, HF financial market surprises may contain two separate components, only one of which is due to true monetary policy shocks. In the simple model of incomplete information proposed by Bauer and Swansson (2023a), the central bank's reaction function is time-varying and not directly observed by market participants. Market participants therefore have to infer information about the reaction function from the central bank's actions, as it responds to macroeconomic news. The second component of financial market surprises is due to market participants updating their knowledge – essentially learning – about the central bank's reaction function.

Bauer and Swanson (2023a) argue that when estimating the effects of monetary policy, it is important to disentangle the two components of financial market surprises and to only use, as an instrument, the component that is due to true monetary policy shocks. The second component, the updating process, is by nature correlated with macroeconomic news and is therefore likely to bias any estimate of the effects of monetary policy on macroeconomic variables. Bauer and Swanson (2023a) show exactly this in their simple model of incomplete information: market surprises may be correlated *ex post* with information that is publicly available prior to the central bank announcement. As a robustness exercise, we make an orthogonalization exercise similar to Bauer and Swanson (2023a) when estimating the effects on the macroeconomy in section 4.

4 Using the identified monetary policy shocks to measure effects on economic activity and inflation

In the previous section, we described how the monetary policy surprises were transformed into a measure of monetary policy shocks using a factor model. We identified three different factors, representing the multi-dimensional nature of monetary policy. In this section, we use the first two factors, the target factor and the path factor, to measure the causal effect of monetary policy on the price level and economic activity in Sweden.[19, 20]

We follow Gertler and Karadi (2014), and use a proxy VAR in the estimation. In other words, we first estimate the dynamic relationship between the macroeconomic variables in a VAR. We then use the factors as proxies for monetary policy shocks, and estimate the immediate impact effect of these shocks on the macroeconomic variables by regressing the two factors on the reduced form residuals from the VAR estimation.

An alternative to the selected estimation approach would be to either use a local projection IV approach, which directly estimates the effect of the shock on the variable of interest. Another alternative would be to insert the factors as the first variables in a SVAR and use Cholesky identification.[21] Our selected method does however have one important advantage compared to these methods. We have macroeconomic data on monthly frequency that goes back to January 2000. Our shock sample is however shorter. It only stretches back to August 2004. With the selected approach, we estimate the dynamic relationship between the macroeconomic variables separately from the direct impact of the shocks. This means that we can exploit the full sample, 2000m1-2024m6, when estimating the dynamic relationship, while we use a shorter sample, 2004m8-2024m6, in the estimation of the impact effect.

In addition to using Swedish macroeconomic variables in the estimation, we also control for the foreign economy by including trade-weighted foreign variables as exogenous variables. As Sweden is a small open economy, it is reasonable to assume that changes in economic activity in Sweden have no impact on the global economy. Furthermore, by treating the foreign economy as exogenous, we gain degrees of freedom in the estimation, which is important given our limited sample. The estimated model can be described as:

$$A_0 Y_t = C_t + A_1 Y_{t-1} + \cdots A_M Y_{t-M} + B_0 X_t + \cdots + B_M X_{t-M} + \varepsilon_t \quad (1)$$

---

[19] See Stock and Watson (2018) for a discussion about using instruments to identify causal effects in dynamic macroeconomics.

[20] Since the third factor is defined to capture quantitative measures, we can interpret the second factor solely as changes in the path of the policy rate, excluding any other measures that might change the long end of the yield curve.

[21] It might be worth pointing out that Plagborg-Møller and Wolf (2021) show that SVAR estimation methods are asymptotically equivalent to local projections.

where Y_t contains the endogenous macroeconomic variables, X_t contains the exogenous macroeconomic variables, and ε_t contains the structural shocks. C_t includes a constant and some dummies, explained later. We first estimate the reduced form VAR relationship and then regress the instruments on the reduced form residuals u_t:

$$u_t = A_0^{-1}\varepsilon_t, \tag{2}$$

using OLS in both estimation procedures. Under the assumption that the monetary policy shocks are orthogonal to other shocks, it is enough to include only a monetary policy shock in the second stage regression, omitting all other structural shocks. Furthermore, the two factors are orthogonal to each other by construction, implying that we can separately estimate also their impact effects.

We set the number of lags to $M = 9$. The most common choice in the literature is the use of twelve lags, as is the case in for example Gertler and Karadi (2014) as well as Bauer and Swanson (2023b). There are, however, examples of studies using shorter lag lengths, for example Brennan et al. (2024) who use eight lags, and Cesa-Bianchi et al. (2020) use two.[22] The reason for choosing nine instead of twelve is to gain degrees of freedom, which is important since our sample is relatively short. As a robustness exercise, we include results with $M = 6$ and $M = 12$ in Appendix G.

The macroeconomic data in the estimation spans the period 2000m1–2024m6. We use data in levels, following Sims et al. (1990), Cesa-Bianchi et al. (2020) and Braun et al. (2024). We aggregate the intraday shock data into monthly data by summing all shocks over each month. When estimating the effects of the target factor, we include six endogenous variables in the model: the Swedish policy rate (end-of-period), a measure of monthly GDP distributed by Statistics Sweden (in log level), the unemployment rate for ages 16–64, the CPIF price index (in log level), the real effective exchange rate (in log level), and a measure of financial conditions.[23] Financial conditions are measured by the financial conditions index described in Alsterlind et al. (2020). The financial conditions index is adjusted to accommodate the fact that some of the variables in the index are already part of the VAR.[24] When we estimate the effects

[22] The authors of the latter study choose their lag length based on an information criterion.
[23] The CPIF is a measure of prices where the interest rate is held constant over time in the index. This is the target variable for the Riksbank. Monthly GDP is also called the *GDP indicator* by statistics Sweden. We measure the monthly policy rate as the end-of-month interest rate level to be consistent with the aggregation method of the monetary policy shocks, in which all shocks over the month are summed up. Another shock aggregation method would be to average the shocks over the month. This would however induce autocorrelation in the shocks (due to parts of the shock spilling over to the next month), which is not consistent with the nature of structural shocks.
[24] The financial conditions index consists of a combination of five different indicators: one that captures the housing market, one that captures the stock market, one that captures the bond market, one that captures the money market, and one that captures the foreign exchange market. The last two are removed from the index used in the VAR while the three remaining factors are included

of the path factor on the macroeconomic variables, we add an additional endogenous variable to the estimation: the 2-year swap rate. See Appendix F for a descriptions and sources of the data used in the model.

The foreign variables included in the estimation are the following: a global energy price index, constructed by the IMF, the foreign policy rate, the foreign price level, and foreign industrial production.[25] We use industrial production instead of GDP due to data limitations, but also because investment goods have a higher weight in Swedish exports compared to consumption goods.[26] In addition to the foreign time series variables, we also include dummies for the pandemic in our estimation, following Bisgaard Larsen and Jessen Weissert (2024), who in turn based their decision to include such dummies on Lenza and Primiceri (2022). We include three dummies in the model, for March, April, and May 2020. The pandemic did not significantly affect the Swedish economy until March 2020, when restrictions were put in place to limit the spread of the disease.[27]

The F-statistics for the two factors as instruments are 27.8 for the estimation with the target factor, and 7.5 for the path factor. Hence, the path factor instrument is a bit weak, relative to the threshold of 10 suggested by Stock and Watson (2012). The F-statistic for the target factor is well above 10, indicating a strong instrument.[28] We calculate the confidence bands around the point estimates using bootstrapping techniques, following Amberg et al. (2022), who use the moving blocks bootstrap technique recommended by Jentsch and Lunsford (2019).

4.1 The effect of monetary policy shocks on the macroeconomy

Figure 4 illustrates the effects of a *target shock* on the macroeconomic variables. The blue line shows the point estimates of the effects. The blue field shows the 68 per cent confidence interval and the dashed blue lines show the outer bounds of the 90 per cent confidence intervals. The shock is normalized such that the impact effect on the policy rate is 1 percentage point.

in the index with equal weights. The reason for the removal of the money market indicator is that it includes the three month STIBOR rate, a variable tightly linked to the Swedish policy rate. The policy rate is already included in the VAR. The reason for why the foreign exchange market is removed is that it includes the nominal exchange rate, which is also included in the VAR.

[25] The foreign economy is represented by a trade-weighted average of the US and the Euro Area, of which the Euro Area carries the highest weight.

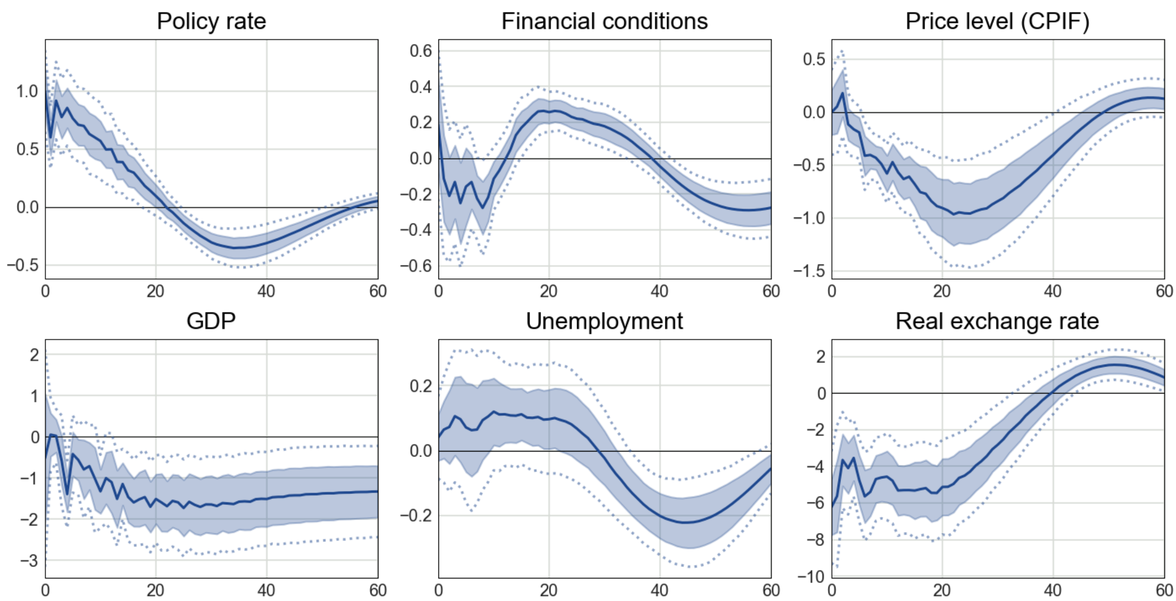
[26] Indirect evidence of this can be found in Corbo and Strid (2020), who estimate a DSGE model of the Swedish and foreign economy and finds a weight of 0.73 on foreign investment and 0.27 on foreign consumption in their export demand function.

[27] For more information about the Swedish response to the Covid-19-pandemic and its effect on the economy, see for example National Institute of Economic Research (2020).

[28] The F-test is constructed by estimating a regression with the reduced form residual of the target variable (the policy rate for the target factor and the 2-year swap rate for the path factor) on the left-hand-side and its respective instrument together with M lags of the reduced form residual on the right-hand-side, then squaring the t-value of the instrument coefficient. The t-values are calculated using MacKinnon and White (1985) robust standard errors.

All impulse responses have the expected signs, with the effect on GDP and the price level being quite small on impact. The effect on the policy rate is transient, but quite persistent, being above zero for about two years. Both financial conditions and the exchange rate react quickly. Financial conditions tighten while the exchange rate appreciates. Both of these results are as expected. Financial conditions capture housing prices, the stock market and a credit spread. A higher policy rate should, ceteris paribus, lead to lower asset prices (lower housing prices and a lower stock market index), and hence to tighter financial conditions. The effect on the real exchange rate is strong, stronger than what is implied by a regular UIP calculation. Furthermore, it takes a hump shaped form, in line with previous studies (see for example Lindé et al. (2009)).[29]

Figure 4: Effect on macroeconomic variables of a target factor shock



Note: Data is monthly. The policy rate is measured at its end-of-period value. The solid lines show the point estimates of the impulse response functions following a target factor shock. The impulse responses are normalised to yield a 1 pp. higher policy rate on impact. The shaded areas show 68 per cent bootstrapped confidence intervals around the point estimates and the dotted lines show the edges of the 90 per cent confidence intervals. The policy rate and unemployment rate are measured in percentage point deviations. Financial conditions are measured in index point deviations. The rest of the series are measured in per cent deviations.

The point estimate of GDP during the first months after the shock is close to zero. The effect does however increase over time. GDP reaches its trough after more than two years. Hence, the impulse response implies a sustained period of sluggish growth after a target rate shock. As is the case for GDP, it takes some time for the price level to react in any economically meaningful way. However, once it has started to decline, it does so until about two years after the shock. The trough of the point estimate of the price level is close to -1 per cent, after which

[29] Furthermore, impact value on the real exchange rate is well in-line with a regression on intraday data with the shock on the right-hand-side and the EUR/SEK exchange rate on the left-hand-side.

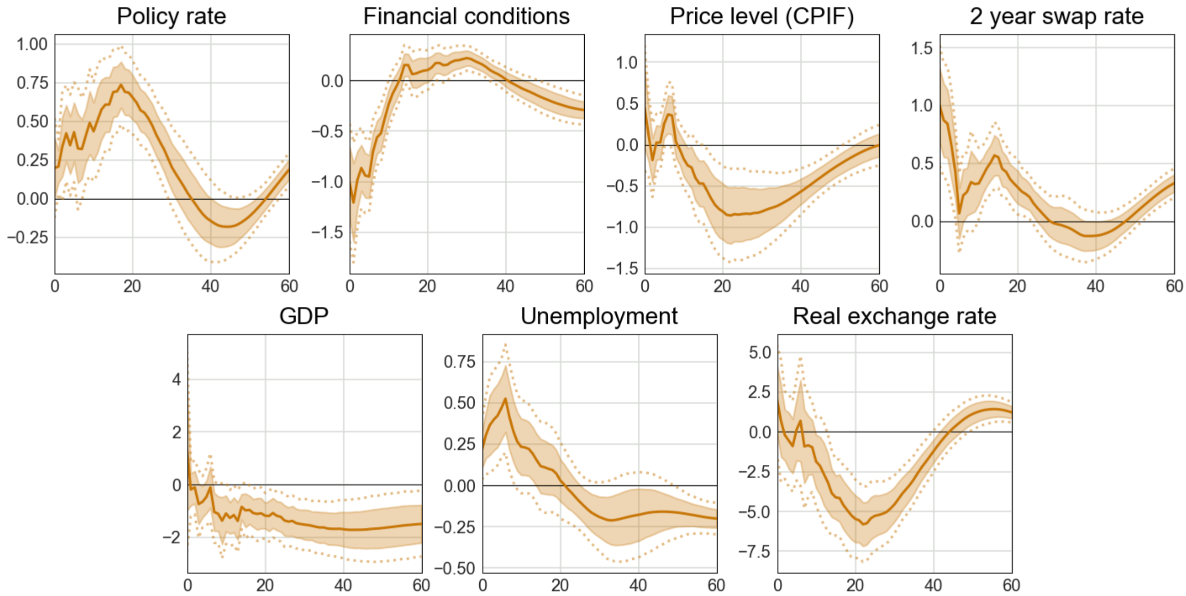
it starts to increase again. The maximum effect on the price level is about 50-60 per cent of the maximum effect on the level of GDP. In contrast, the increase in unemployment arrives faster. The effect on unemployment is small; the unemployment rate increases somewhat in the months following the shock and continues to be on slightly elevated levels for about two years.

We now turn to the effect of a *path factor shock* on the macroeconomic variables. The shock is normalized such that the 2-year swap rate increases by 1 percentage point on impact, representing credible but unexpected communication by the central bank that monetary policy will be tighter in the future. Different central banks use different communication strategies regarding the future path of the policy rate. In the case of the Riksbank, such communication consists of a combination of a published interest rate path together with written communication. Our identification scheme does however not allow us to separate the effects of written communication from the published policy rate path.[30]

The effects of a path factor shock are illustrated in Figure 5. As shown in the figure, there is a relatively fast downward correction of the swap rate towards zero. It does however stay at elevated levels for about two years.

[30] This is in contrast to Natvik et al. (2020), who explicitly investigate how changes in the published policy rate forecast affects the expectations of future policy rates by the market.

Figure 5: Effect on macroeconomic variables of a path factor shock



Note: Data is monthly. The policy rate and the 2-year swap rate are measured at their end-of-period values. The solid lines show the point estimates of the impulse response functions following a path factor shock. The impulse responses are normalized such that the initial impact on the 2-year swap rate is 1 pp. The shaded areas show 68 per cent bootstrapped confidence intervals around the point estimates and the dotted lines show the edges of the 90 per cent confidence intervals. The policy rate, 2-year swap rate, and unemployment rate are all measured in percentage point deviations. Financial conditions are measured in index point deviations. The rest of the series are measured in per cent deviations.

The path factor shock leads to an immediate tightening of financial conditions. However, in contrast to a target factor shock, the point estimate of the real exchange rate does not depreciate immediately following the shock. Instead, the real exchange becomes materially stronger than baseline only after about half a year.

The policy rate increases immediately following the shock, despite the chosen identification strategy. One reason for this could be that we aggregate data from intraday to monthly by taking the sum over the month. After impact, the policy rate continues to increase, reaching its maximum after about one and a half years. It then stays at elevated levels for another year and a half.

The effect on GDP is similar to that of a target factor shock. This is also the case for the price level, except that it takes a longer time for the price level to start to decrease. The ratio between the maximum effect of the point estimate on the price level and the maximum point estimate effect of the level of GDP is around 50 per cent, somewhat lower than that for the target factor shock.

We now proceed by comparing our results to those of some other studies that also use high frequency methods to identify Swedish monetary policy shocks. Amberg et al. (2022) use daily shock data from financial markets, and find smaller effects on inflation than we do. Their sample does however end in 2018m12. In Appendix G, we show results from a robustness exercise where we re-estimate our model on a shorter sample, ending in 2019m12. That exercise yields a smaller effect on prices than our baseline estimation, though it is still somewhat stronger than those of Amberg et al. (2022). Another study that uses similar methods is Laséen (2020), who also has a shorter sample period relative ours. He also finds a smaller effect on the price level in the short run compared to us. The dynamics of the price index do differ, however, with a more persistent decrease in Laséen (2020). Laséen and Nilsson (2024) use a sample period that is more similar to ours, ending in 2023m8. In contrast to the previously mentioned studies, they find stronger effects than we do. Their identification strategy is however slightly different, and they identify more persistent changes in the policy interest rate, compared to us. This could explain their relatively strong effect on prices.[31]

How do our results compare to the results estimated for other small open economies? One study which is methodologically close to ours is Braun et al. (2024), reporting results for both a target factor shock and a path factor shock. Their results differ somewhat from ours. The policy rate in the case of a target factor shock reverts faster down towards zero in their study. Their effects on prices from a target rate shock are also smaller than what we find. The maximum effect does however arrive around the same time in both studies. The magnitude of the effect on GDP is more similar to our study, but the maximum effect arrives earlier.

Regarding the path factor shock in Braun et al. (2024), they report a fairly quick response on GDP, which then reverts back to zero relatively quickly. In the case of the price level, Braun et al. (2024) find that it is continuously decreasing over the whole period represented in their graphs; according to our estimates, the price level instead reaches a trough after around two years.

Another study related to the effects on small open economies is Soosalu (2024), who uses a HF change of the Canadian three-month contract BAX as an instrument for Canadian monetary policy shocks. Soosalu (2024) finds a persistent effect on both GDP and prices, just as we do. The relationship ratio between the maximum effect of prices and GDP is also quite close to the one in our study.

An additional study for small open economies is Bisgaard Larsen and Jessen Weissert (2024) who find larger effects on the economy compared to us, using local projections. One reason for this could be that they are studying an economy with a fixed exchange rate, looking at the

[31] A recent study that looks at Swedish data, but that uses a standard Cholesky identification scheme instead of HF methods are Berggren et al. (2024) who find effects on prices that are fairly similar to ours.

effects of euro area monetary policy shocks on economic outcomes in Denmark. Euro area monetary policy shocks also have an effect on the European economy, which spills over on the Danish economy, leading to stronger effects.

4.2 Robustness

We now continue by investigating how our results change if we change certain assumptions and adjust the number of observations when we construct the monetary policy shocks. In Appendix G, we also investigate how our results are affected by changes in the specification of the VAR model, finding that our main results are robust to several such changes.

In this section, however, we focus on robustness to the specification of the monetary policy shocks. Taking into consideration the robustness exercises, including those in the Appendix, we can draw the following conclusions: i) all variables are qualitatively behaving according to theoretical predictions following a monetary policy shock; there is no price puzzle in our estimations, as is frequently found in the literature, and ii) GDP and prices respond with a lag. The maximum effect on GDP and the price level comes after more than one year but less than three years. Finally, iii) unemployment responds quickly, and less than GDP.

A common concern when using instruments in estimations is their relevance and exogeneity. The relevance criterion is usually handled by measures of instrument strength (we use the F-statistic to measure the strength of the instrument, as is standard in the literature). To ensure exogeneity, different approaches are used in the literature. Furthermore, different hypotheses are introduced in the literature to why monetary policy surprises might not reflect true monetary policy shocks. Two such hypotheses are the Fed information effect and the Fed responding to news channel. The two effects are discussed in more detail in Section 3. Laséen (2020) investigates if central bank information shocks affect the results when estimating effects of Swedish monetary policy shocks, finding no evidence for this. Bauer and Swanson (2023a, 2023b) introduces the Fed responding to news channel as a possible concern for monetary policy shocks, and proposes a way to clean the monetary policy surprises from any such effects.

As a first robustness exercise, we follow their suggestion and orthogonalize the monetary policy surprises by regressing them on real time data that is correlated with the monetary policy surprises and that were publicly available on the day prior to each monetary policy announcement. We then use the residuals from that regression as the cleaned monetary policy surprises. Appendix C contains more details on the cleaning procedure, and also contains a table with correlations which we use to determine which variables should be included in the cleaning procedure. The results from this exercise are shown in Figure 6. Concerning shocks to the target factor, the initial response of the real exchange rate is somewhat weaker when orthogonalized surprises are used as instruments, compared to the baseline results. The effect is however still quite large, and over time the point estimate converges towards that of the baseline estimation. Financial conditions and the unemployment rate reacts somewhat stronger in the first 6 to 12 months following the shock, but the results are otherwise similar to baseline. For the path factor, the maximum effects on both inflation and GDP are weaker, but the results are qualitatively similar. We conclude that imperfect knowledge of the true parameters of the Riksbank's reaction function does not seem to systematically affect estimates of the macroeconomic transmission of monetary policy shocks in Sweden.[32]

Second, we investigate how the results are altered when we use monetary policy shocks that are based on monetary policy surprises constructed using daily data, in contrast to the intraday data we use in the baseline estimation. The resulting IRFs are shown in Figure 7.[33] The dashed red line shows the point estimate from the baseline estimation. As shown in the figure, the impact effect on financial conditions and the real exchange rate are stronger in the case of a target factor shock. This does in turn lead the maximum effects of the price level and GDP to somewhat stronger.

The impact effect on financial conditions for the path factor estimation is instead substantially weaker than in the baseline case. Furthermore, the dynamics of the policy rate differ significantly, the maximum effect arriving quickly after the initial shock. There is also a substantial change in the path of unemployment, GDP and the exchange rate in this exercise. One possible conclusion is that it is more important to use intraday data when estimating effects of shocks to the path factor, compared to estimations of shocks to the target factor. As is illustrated in Section 2, the daily movements in Swedish interest rate instruments with longer maturities are highly correlated with international interest rates, a fact that may introduce noise into the estimation.

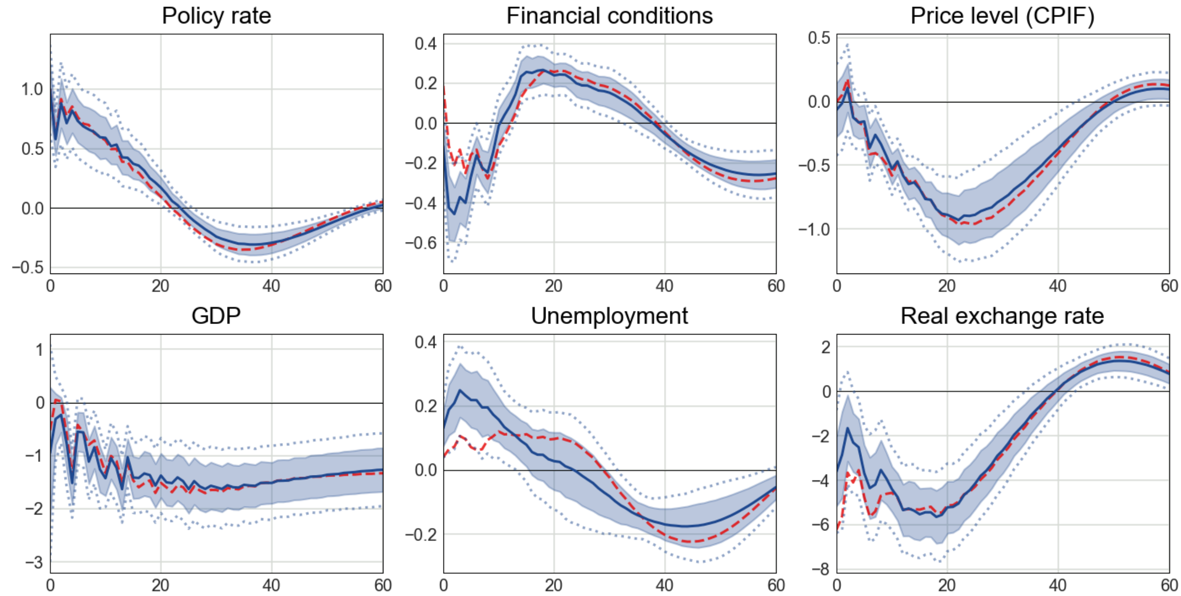
In a third robustness exercise, reported in Figure 8, we investigate how the exclusion of minutes and extraordinary meetings affect the results. The target factor instrument is strong, with an F-statistic above 30, while for the path factor, the instrument is fairly weak, with an F-statistic of 5.4. This suggests that the inclusion of extraordinary meetings and minutes are important for the strength of the path factor. The results for the target shock are practically

[32] The F-test statistic of the target factor and the path factor in the exercises are 15.1 and 9.6 respectively, suggesting that both instruments are strong enough, even if the path factor lies slightly below the threshold of 10.
[33] The F-test statistics of the target factor and the path factor in the exercises are 17.0 and 15.4 respectively.

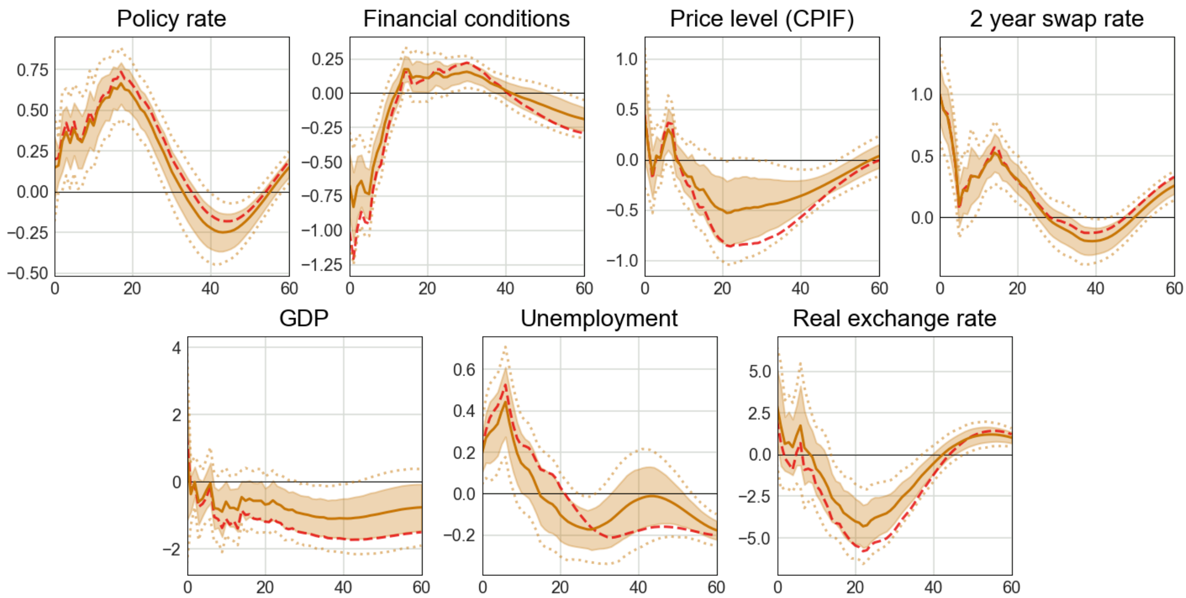
unchanged compared to the baseline estimation, while the differences are somewhat larger for the path factor shock. This is however to be expected. The minutes do not contain any new information about the current policy rate, since they are related to policy rate decisions that have already been announced. However, the minutes are likely to contain information about possible future changes in the monetary policy stance, suggesting that adding surprises related to the release of minutes be important for the results of the path factor shock. In general, the macroeconomic results following a path factor shock are qualitatively similar to the baseline case, but stronger when minutes and extraordinary meetings are excluded.

Figure 6: Robustness – effect on macroeconomic variables when surprises are orthogonalized

Panel A: Effect of target factor shock



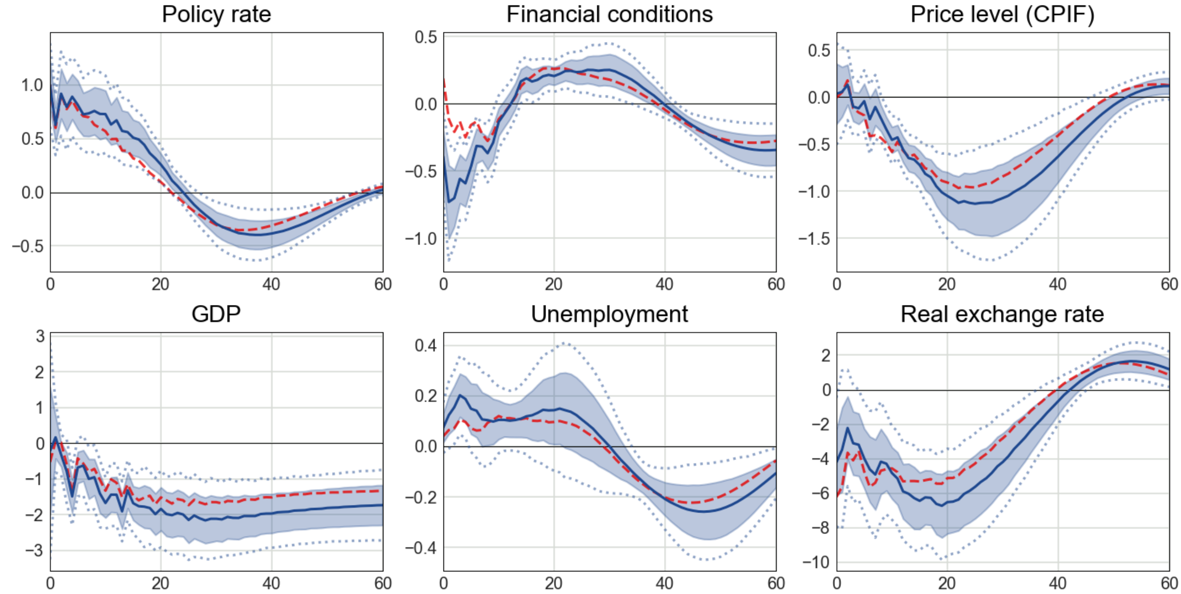
Panel B: Effect of path factor shock



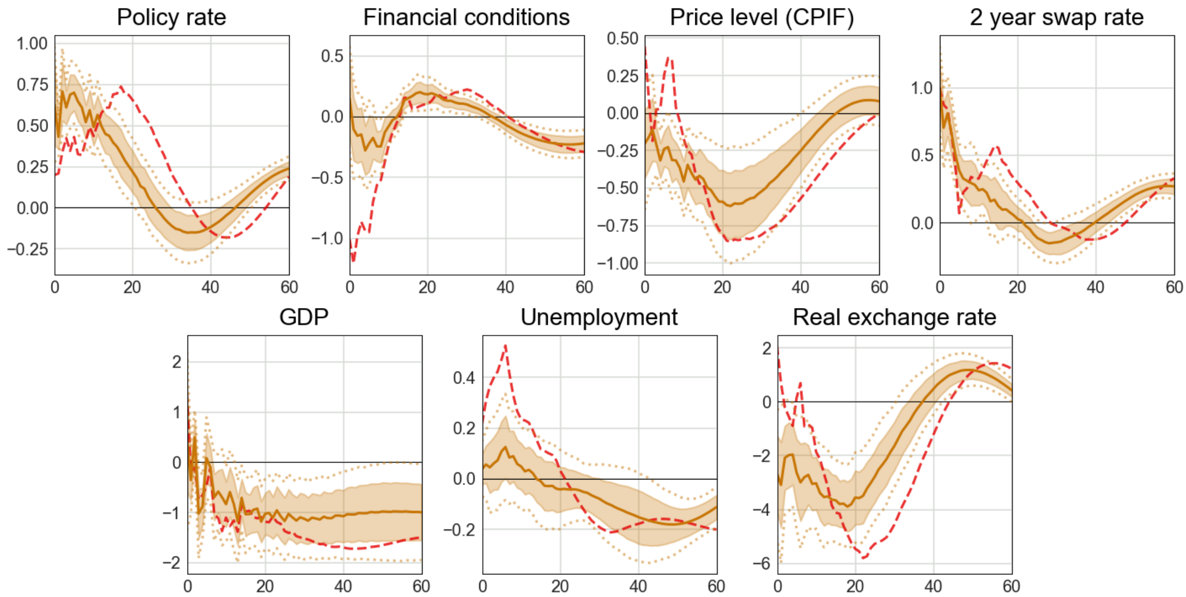
Note: The policy rate and the 2-year swap rate are measured at their end-of-period values. The dashed red lines show the point estimates in the baseline estimation. The solid lines show the point estimates of the impulse responses functions normalized to yield a 1 pp. higher policy rate on impact for the target factor shock, and 1 pp. higher 2-year swap rate on impact for the path factor shock. The shaded areas show 68 per cent bootstrapped confidence intervals around the point estimates and the dotted lines show the edges of the 90 per cent confidence intervals. The policy rate, 2-year swap rate, and unemployment rate are measured in percentage point deviations. Financial conditions are measured in index point deviations. The rest of the series are measured as per cent deviations.

Figure 7: Robustness – effect on macroeconomic variables when daily shock data is used

Panel A: Effect of target factor shock



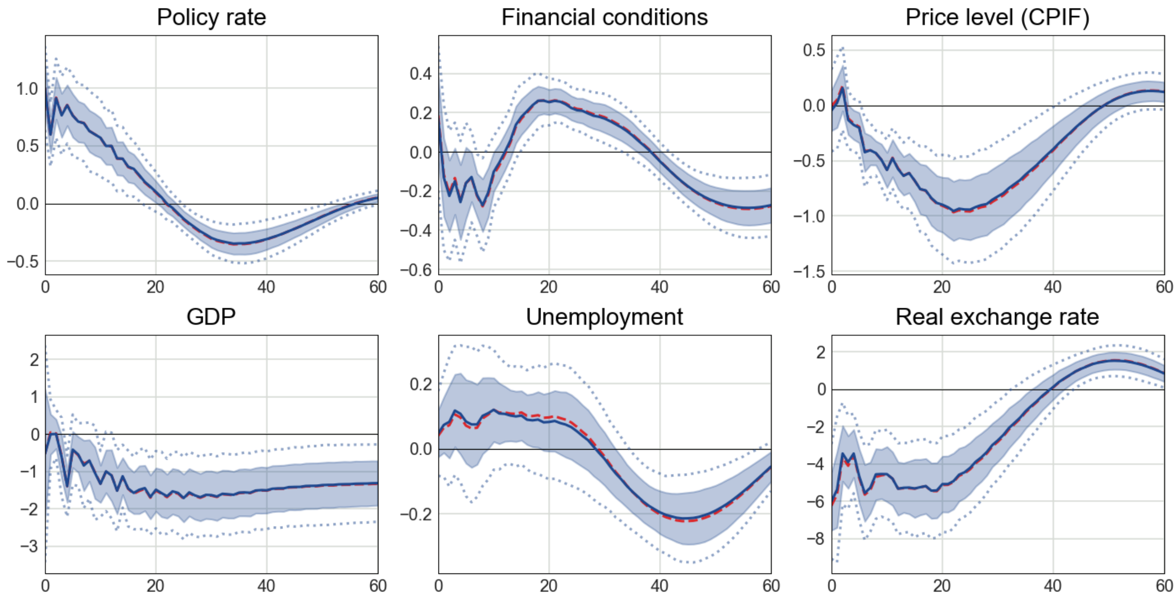
Panel B: Effect of path factor shock



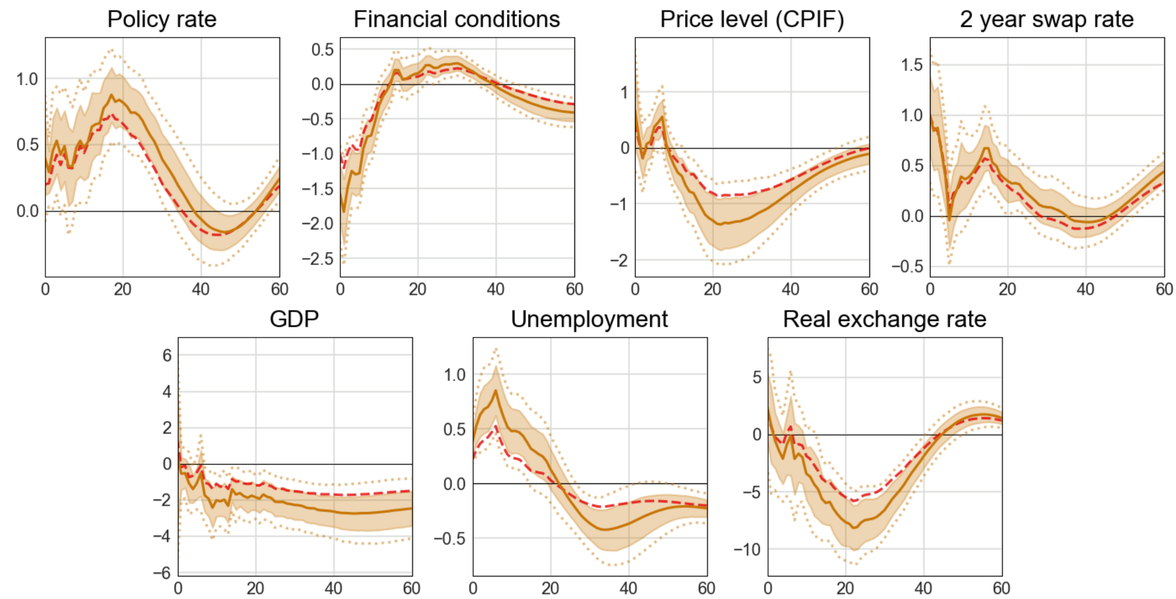
Note: The policy rate and the 2-year swap rate are measured at their end-of-period values. The dashed red lines show the point estimates in the baseline estimation. The solid lines show the point estimates of the impulse responses functions normalized to yield a 1 pp. higher policy rate on impact for the target factor shock, and 1 pp. higher 2-year swap rate on impact for the path factor shock. The shaded areas show 68 per cent bootstrapped confidence intervals around the point estimates and the dotted lines show the edges of the 90 per cent confidence intervals. The policy rate, 2-year swap rate, and unemployment rate are measured in percentage point deviations. Financial conditions are measured in index point deviations. The rest of the series are measured as per cent deviations.

Figure 8: Robustness – effect on macroeconomic variables when only regular meetings are included

Panel A: effect of target factor shock



Panel B: effect of path factor shock



Note: The policy rate and the 2-year swap rate are measured at their end-of-period values. The dashed red lines show the point estimates in the baseline estimation. The solid lines show the point estimates of the impulse responses functions normalized to yield a 1 pp. higher policy rate on impact for the target factor shock, and 1 pp. higher 2-year swap rate on impact for the path factor shock. The shaded areas show 68 per cent bootstrapped confidence intervals around the point estimates and the dotted lines show the edges of the 90 per cent confidence intervals. The policy rate, 2-year swap rate, and unemployment rate are measured in percentage point deviations. Financial conditions are measured in index point deviations. The rest of the series are measured as per cent deviations.

5 Conclusions

What are the effects of monetary policy on key macroeconomic variables such as output, inflation and unemployment? This paper attempts to answer this question by estimating the macroeconomic effects of monetary policy shocks in Sweden using a novel monetary policy event study database with high-frequency financial market reactions to Riksbank communications, spanning a period of 20 years. These reactions are constructed using intraday tick data for seven different swap instruments that reflect expected interest rates at different horizons: the 1-month, 3-month and 6-month SEK overnight index swap (STINA) rates, as well as the 1-year, 2-year, 5-year and 10-year swap rates. We follow a simple event study approach where we observe how the swap rates change around a 30-minute window at the time of Riksbank monetary policy communication events.

Following the methodology of Gürkaynak et al. (2005b) and Swanson (2021), we decompose the estimated reactions and identify three types of monetary policy shocks: shocks to the current level of the policy rate, shocks to its expected future level and shocks related to the Riksbank's use of quantitative monetary policy measures. We focus on the first two of these types of unexpected changes in Riksbank monetary policy and use them as external instruments in a proxy VAR-model to estimate their effects on key macroeconomic variables. We find that an unexpected, temporary tightening (loosening) of the policy rate induces an immediate and persistent appreciation (depreciation) of the krona exchange rate, as well as a gradual, persistent, negative (positive) effect on output and consumer prices. These effects are statistically significant, economically meaningful and robust to a number of variations in our econometric specification. We also estimate the effects of shocks to market participants' expectations about the future level of the policy interest rate. The effects on output and consumer prices are similar to those of an unexpected, temporary change in the current level of the policy rate. However, in the case of shocks to the expected future level of the policy rate, the instrument is on the weak side, and the results are less robust.

To conclude, the contribution of this paper is threefold. First, we make available a new event study database with intraday financial market reactions to Riksbank communications, covering both regular and extraordinary monetary policy announcements as well as minutes of monetary policy meetings. This more than doubles the sample size available to identify monetary policy shocks compared to previous Swedish studies. The database hence provides a valuable resource for researchers and we hope that it will facilitate more research on the effects of monetary policy in Sweden. Second, using this database, we are able to decompose the monetary policy surprises into three different types of monetary policy shocks: shocks to the current level of the policy rate, shocks to its expected future level and shocks related to the Riksbank's use of quantitative monetary policy measures. Third, we make use of these shocks to estimate the effects on key macroeconomic variables, contributing to a better understanding of how monetary policy transmits through the Swedish economy.

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APPENDIX A

The table shows the Riksbank communication events that we use in the analysis. This differs by four dates compared to the published database. See footnote 14 in section 3 for details on the dates that we exclude and why.

Date	Type of Riksbank announcement	Time
2004-08-20	Regular Announcement	09:30 CET
2004-09-02	Minutes	09:30 CET
2004-10-14	Regular Announcement	08:00 CET
2004-10-27	Minutes	09:30 CET
2004-12-09	Regular Announcement	09:30 CET
2004-12-22	Minutes	09:30 CET
2005-01-28	Regular Announcement	09:30 CET
2005-02-10	Minutes	09:30 CET
2005-03-15	Regular Announcement	09:00 CET
2005-04-01	Minutes	09:30 CET
2005-04-29	Regular Announcement	09:30 CET
2005-05-17	Minutes	09:30 CET
2005-06-21	Regular Announcement	09:30 CET
2005-07-05	Minutes	09:30 CET
2005-08-24	Regular Announcement	09:30 CET
2005-09-12	Minutes	09:30 CET
2005-10-20	Regular Announcement	08:00 CET
2005-10-31	Minutes	09:30 CET
2005-12-02	Regular Announcement	09:30 CET
2005-12-15	Minutes	09:30 CET
2006-01-20	Regular Announcement	09:30 CET
2006-02-02	Minutes	09:30 CET
2006-02-23	Regular Announcement	08:00 CET
2006-03-08	Minutes	09:30 CET
2006-04-28	Regular Announcement	09:30 CET
2006-05-11	Minutes	09:30 CET
2006-06-20	Regular Announcement	09:30 CET
2006-07-03	Minutes	09:30 CET
2006-08-30	Regular Announcement	09:30 CET
2006-09-12	Minutes	09:30 CET
2006-10-26	Regular Announcement	08:00 CET
2006-11-15	Minutes	09:30 CET
2006-12-15	Regular Announcement	09:30 CET
2007-01-02	Minutes	09:30 CET
2007-02-15	Regular Announcement	09:30 CET
2007-02-28	Minutes	09:30 CET
2007-03-30	Regular Announcement	09:30 CET
2007-04-16	Minutes	09:30 CET
2007-05-04	Regular Announcement	09:30 CET
2007-05-18	Minutes	09:30 CET
2007-06-20	Regular Announcement	09:30 CET
2007-07-04	Minutes	09:30 CET
2007-09-07	Regular Announcement	09:30 CET
2007-09-20	Minutes	09:30 CET
2007-10-30	Regular Announcement	09:30 CET
2007-11-13	Minutes	09:30 CET
2007-12-19	Regular Announcement	09:30 CET
2008-01-08	Minutes	09:30 CET
2008-02-13	Regular Announcement	09:30 CET
2008-02-25	Minutes	09:30 CET
2008-04-23	Regular Announcement	09:30 CET
2008-05-07	Minutes	09:30 CET
2008-07-03	Regular Announcement	09:30 CET
2008-07-16	Minutes	09:30 CET
2008-09-04	Regular Announcement	09:30 CET
2008-09-17	Minutes	09:30 CET
2008-10-02	Extraordinary Announcement	09:30 CET
2008-10-06	Extraordinary Announcement	09:30 CET
2008-10-13	Extraordinary Announcement	09:30 CET
2008-10-23	Regular Announcement	09:30 CET
2008-10-24	Extraordinary Announcement	09:30 CET
2008-10-29	Extraordinary Announcement	09:30 CET
2008-11-05	Minutes	09:30 CET
2008-12-01	Extraordinary Announcement	09:30 CET
2008-12-04	Regular Announcement	09:30 CET
2008-12-17	Minutes	09:30 CET
2009-02-11	Regular Announcement	09:30 CET
2009-02-13	Extraordinary Announcement	09:30 CET
2009-02-25	Minutes	09:30 CET
2009-04-21	Regular Announcement	09:30 CET
2009-05-05	Minutes	09:30 CET
2009-05-07	Extraordinary Announcement	09:30 CET
2009-07-02	Regular Announcement	09:30 CET
2009-07-16	Minutes	09:30 CET
2009-09-03	Regular Announcement	09:30 CET
2009-09-16	Minutes	09:30 CET
2009-10-22	Regular Announcement	09:30 CET
2009-11-04	Minutues	09:30 CET
2009-11-05	Extraordinary Announcement	09:30 CET
2009-12-16	Regular Announcement	09:30 CET
2010-01-04	Minutes	09:30 CET
2010-02-11	Regular Announcement	09:30 CET
2010-02-24	Minutes	09:30 CET
2010-04-20	Regular Announcement	09:30 CET
2010-05-03	Minutes	09:30 CET
2010-07-01	Regular Announcement	09:30 CET
2010-07-15	Minutes	09:30 CET
2010-09-02	Regular Announcement	09:30 CET
2010-09-15	Minutes	09:30 CET
2010-10-26	Regular Announcement	09:30 CET
2010-11-08	Minutes	09:30 CET
2010-12-15	Regular Announcement	09:30 CET
2011-01-03	Minutes	09:30 CET
2011-02-15	Regular Announcement	09:30 CET
2011-02-28	Minutes	09:30 CET
2011-04-20	Regular Announcement	09:30 CET
2011-05-03	Minutes	09:30 CET
2011-07-05	Regular Announcement	09:30 CET
2011-07-18	Minutes	09:30 CET
2011-09-07	Regular Announcement	09:30 CET
2011-09-20	Minutes	09:30 CET
2011-10-27	Regular Announcement	09:30 CET
2011-11-09	Minutes	09:30 CET
2011-12-20	Regular Announcement	09:30 CET
2012-01-03	Minutes	09:30 CET
2012-02-16	Regular Announcement	09:30 CET
2012-02-29	Minutes	09:30 CET
2012-04-18	Regular Announcement	09:30 CET
2012-05-02	Minutes	09:30 CET
2012-07-04	Regular Announcement	09:30 CET
2012-07-17	Minutes	09:30 CET
2012-09-06	Regular Announcement	09:30 CET
2012-09-18	Minutes	09:30 CET
2012-10-25	Regular Announcement	09:30 CET
2012-11-07	Minutes	09:30 CET
2012-12-18	Regular Announcement	09:30 CET
2013-01-08	Minutes	09:30 CET
2013-02-13	Regular Announcement	09:30 CET
2013-02-26	Minutes	09:30 CET
2013-04-17	Regular Announcement	09:30 CET
2013-04-29	Minutes	09:30 CET
2013-07-03	Regular Announcement	09:30 CET
2013-07-16	Minutes	09:30 CET
2013-09-05	Regular Announcement	09:30 CET
2013-09-18	Minutes	09:30 CET
2013-10-24	Regular Announcement	09:30 CET
2013-11-06	Minutes	09:30 CET
2013-12-17	Regular Announcement	09:30 CET
2014-01-08	Minutes	09:30 CET
2014-02-13	Regular Announcement	09:30 CET
2014-02-26	Minutes	09:30 CET

2014-04-09	Regular Announcement	09:30 CET
2014-04-24	Minutes	09:30 CET
2014-07-03	Regular Announcement	09:30 CET
2014-07-16	Minutes	09:30 CET
2014-09-04	Regular Announcement	09:30 CET
2014-09-17	Minutes	09:30 CET
2014-10-28	Regular Announcement	09:30 CET
2014-11-11	Minutes	09:30 CET
2014-12-16	Regular Announcement	09:30 CET
2015-01-08	Minutes	09:30 CET
2015-02-12	Regular Announcement	09:30 CET
2015-02-25	Minutes	09:30 CET
2015-03-18	Extraordinary Announcement	09:30 CET
2015-04-29	Regular Announcement	09:30 CET
2015-05-12	Minutes	09:30 CET
2015-07-02	Regular Announcement	09:30 CET
2015-07-15	Minutes	09:30 CET
2015-09-03	Regular Announcement	09:30 CET
2015-09-16	Minutes	09:30 CET
2015-10-28	Regular Announcement	09:30 CET
2015-11-10	Minutes	09:30 CET
2015-12-15	Regular Announcement	09:30 CET
2016-01-04	Extraordinary Announcement	09:30 CET
2016-01-08	Minutes	09:30 CET
2016-02-11	Regular Announcement	09:30 CET
2016-02-22	Minutes	09:30 CET
2016-04-21	Regular Announcement	09:30 CET
2016-05-04	Minutes	09:30 CET
2016-07-06	Regular Announcement	09:30 CET
2016-07-19	Minutes	09:30 CET
2016-09-07	Regular Announcement	09:30 CET
2016-09-21	Minutes	09:30 CET
2016-10-27	Regular Announcement	09:30 CET
2016-11-09	Minutes	09:30 CET
2016-12-21	Regular Announcement	09:30 CET
2017-01-12	Minutes	09:30 CET
2017-02-15	Regular Announcement	09:30 CET
2017-03-01	Minutes	09:30 CET
2017-04-27	Regular Announcement	09:30 CET
2017-05-10	Minutes	09:30 CET
2017-07-04	Regular Announcement	09:30 CET
2017-07-18	Minutes	09:30 CET
2017-09-07	Regular Announcement	09:30 CET
2017-09-21	Minutes	09:30 CET
2017-10-26	Regular Announcement	09:30 CET
2017-11-09	Minutes	09:30 CET
2017-12-20	Regular Announcement	09:30 CET
2018-02-14	Regular Announcement	09:30 CET
2018-02-23	Minutes	09:30 CET
2018-04-26	Regular Announcement	09:30 CET
2018-05-08	Minutes	09:30 CET
2018-07-03	Regular Announcement	09:30 CET
2018-07-12	Minutes	09:30 CET
2018-09-06	Regular Announcement	09:30 CET
2018-09-17	Minutes	09:30 CET
2018-10-24	Regular Announcement	09:30 CET
2018-11-02	Minutes	09:30 CET
2018-12-20	Regular Announcement	09:30 CET
2019-01-09	Minutes	09:30 CET
2019-02-13	Regular Announcement	09:30 CET
2019-02-22	Minutes	09:30 CET
2019-04-25	Regular Announcement	09:30 CET
2019-05-07	Minutes	09:30 CET
2019-07-03	Regular Announcement	09:30 CET
2019-07-12	Minutes	09:30 CET
2019-09-05	Regular Announcement	09:30 CET
2019-09-17	Minutes	09:30 CET
2019-10-24	Regular Announcement	09:30 CET
2019-11-05	Minutes	09:30 CET

2019-12-19	Regular Announcement	09:30 CET
2020-01-08	Minutes	09:30 CET
2020-02-12	Regular Announcement	09:30 CET
2020-02-21	Minutes	09:30 CET
2020-03-13	Extraordinary Announcement and Minutes	09:30 CET
2020-03-16	Extraordinary Announcement	09:30 CET
2020-03-19	Extraordinary Announcement	09:30 CET
2020-03-26	Extraordinary Announcement and Minutes	09:30 CET
2020-03-27	Extraordinary Announcement	09:30 CET
2020-03-30	Minutes	09:30 CET
2020-04-06	Extraordinary Announcement	09:30 CET
2020-04-07	Minutes	09:30 CET
2020-04-22	Extraordinary Announcement	09:30 CET
2020-04-28	Regular Announcement	09:30 CET
2020-05-04	Minutes	09:30 CET
2020-05-08	Extraordinary Announcement	09:30 CET
2020-05-11	Minutes	09:30 CET
2020-05-15	Extraordinary Announcement	09:30 CET
2020-07-01	Regular Announcement	09:30 CET
2020-07-10	Minutes	09:30 CET
2020-09-01	Extraordinary Announcement	09:30 CET
2020-09-22	Regular Announcement	09:30 CET
2020-10-01	Minutes	09:30 CET
2020-11-26	Regular Announcement	09:30 CET
2020-12-07	Minutes	09:30 CET
2021-02-10	Regular Announcement	09:30 CET
2021-02-19	Minutes	09:30 CET
2021-04-27	Regular Announcement	09:30 CET
2021-05-10	Minutes	09:30 CET
2021-07-01	Regular Announcement	09:30 CET
2021-07-12	Minutes	09:30 CET
2021-09-21	Regular Announcement	09:30 CET
2021-09-30	Minutes	09:30 CET
2021-11-25	Regular Announcement	09:30 CET
2021-12-06	Minutes	09:30 CET
2022-02-10	Regular Announcement	09:30 CET
2022-02-21	Minutes	09:30 CET
2022-04-28	Regular Announcement	09:30 CET
2022-05-06	Minutes	09:30 CET
2022-06-30	Regular Announcement	09:30 CET
2022-07-11	Minutes	09:30 CET
2022-09-20	Regular Announcement	09:30 CET
2022-09-29	Minutes	09:30 CET
2022-11-24	Regular Announcement	09:30 CET
2022-12-05	Minutes	09:30 CET
2023-02-09	Regular Announcement	09:30 CET
2023-02-20	Minutes	09:30 CET
2023-04-26	Regular Announcement	09:30 CET
2023-05-09	Minutes	09:30 CET
2023-06-29	Regular Announcement	09:30 CET
2023-07-10	Minutes	09:30 CET
2023-09-21	Regular Announcement	09:30 CET
2023-10-02	Minutes	09:30 CET
2023-11-23	Regular Announcement	09:30 CET
2023-12-04	Minutes	09:30 CET
2024-02-01	Regular Announcement	09:30 CET
2024-02-07	Minutes	09:30 CET
2024-03-27	Regular Announcement	09:30 CET
2024-04-04	Minutes	09:30 CET
2024-05-08	Regular Announcement	09:30 CET
2024-05-15	Minutes	09:30 CET
2024-06-27	Regular Announcement	09:30 CET
2024-07-03	Minutes	09:30 CET
2024-08-20	Regular Announcement	09:30 CET
2024-08-26	Minutes	09:30 CET

APPENDIX B

Table B.1 Tests of number of factors characterizing Riksbank announcements

H_0: number of factors equals	Wald statistic	p-value
0	32.7	0.000
1	23.7	0.001
2	15.5	0.013
3	7.8	0.249

Note: The table shows the results from the Cragg and Donald (1997) matrix rank test. It tests the null hypothesis of m_0 common factors against the alternative of $m > m_0$ common factors.

APPENDIX C

Orthogonalizing the surprises with respect to financial and macroeconomic news

To ensure that our instruments of Swedish monetary policy shocks are not contaminated by markets updating their information concerning the Riksbank's reaction function, we investigate whether or not financial market surprises around Riksbank communications are correlated with information that was publicly available at the time of those announcements. To this end, we construct a real-time set of financial and macroeconomic data covering both domestic and international economic conditions. This real-time data set includes 14 different variables. For each of the 265 observations in our sample of Riksbank communication events, we collect, for each of these 14 variables, the last vintage time series that was publicly available on the day preceding the event. We then compute the change in each variable over a number of different periods preceding the event. In the case of Swedish and foreign government bonds, for example, we compute changes in yields over a 30 day, 60 day and 90 day window. For Swedish and foreign GDP, we look at one and two quarter growth rates. We then proceed to compute correlations with our seven different series of interest rate surprises, presented in Table C.1. Here, we simply conclude that we establish statistically significant correlations in the case of the 30, 60 and 90-day changes of EUR/SEK and USD/SEK exchange rates, as well as the 3-month changes in US and euro area inflation. We thus settle on those four variables and orthogonalize all our seven series of surprises with respect to those variables in the following way: with X_{t-} collecting the chosen variables we estimate the following regression for each of our seven monetary policy surprise series: $surprise_t = \alpha + \beta' X_{t-} + \varepsilon_t$. The resulting residual ε_t now represents the orthogonalized monetary policy surprises.

Table C.1 Correlations between macro variables and calculated surprises

	1 month	3 month	6 month	1 year	2 year	5 year	10 year
SE - 10y Δ30	0.04	-0.05	-0.03	0.01	0.00	0.01	0.01
SE - 10y Δ60	-0.03	-0.02	-0.05	-0.02	-0.03	-0.03	-0.01
SE - 10y Δ90	0.03	0.02	0.00	0.03	0.01	0.04	0.05
SE - 1y Δ30	-0.04	-0.09	-0.07	-0.07	-0.09	-0.08	-0.07
SE - 1y Δ60	0.01	**0.18**	0.04	0.03	0.06	0.02	-0.00
SE - 1y Δ90	-0.02	0.01	0.00	-0.05	-0.07	-0.09	-0.09
US - 10y Δ30	-0.01	0.02	-0.05	-0.01	-0.01	0.03	0.05
US - 10y Δ60	0.02	0.06	-0.01	0.03	0.01	0.05	0.07
US - 10y Δ90	0.08	0.11	0.04	0.05	0.03	0.05	0.08
SE - OMXS price index Δ30	0.03	0.07	-0.01	-0.02	-0.03	0.01	0.03
SE - OMXS price index Δ60	0.06	0.05	-0.08	-0.01	-0.02	0.04	0.03
SE - OMXS price index Δ90	0.06	0.06	-0.05	-0.04	-0.05	0.01	-0.00
EUR/SEK Δ30	**-0.23**	**-0.25**	**-0.16**	**-0.22**	**-0.21**	**-0.24**	**-0.20**
EUR/SEK Δ60	**-0.17**	**-0.17**	-0.09	**-0.16**	**-0.14**	**-0.14**	-0.11
EUR/SEK Δ90	**-0.21**	**-0.26**	**-0.17**	**-0.19**	**-0.15**	**-0.13**	-0.10
USD/SEK Δ30	**-0.18**	**-0.22**	-0.08	**-0.13**	-0.08	-0.09	-0.03
USD/SEK Δ60	**-0.19**	**-0.20**	-0.02	-0.09	-0.08	-0.09	-0.05
USD/SEK Δ90	**-0.25**	**-0.26**	-0.09	**-0.15**	**-0.12**	**-0.14**	-0.11
Global energy prices log30	0.05	0.01	0.03	0.03	0.01	0.03	0.08
Global energy prices log60	-0.01	-0.05	-0.01	-0.04	-0.05	-0.02	0.03
Global energy prices log90	-0.03	-0.07	-0.03	-0.05	-0.05	-0.03	0.02
SE - inflation Δ1m	0.07	-0.03	-0.03	0.04	0.03	0.05	0.06
SE - inflation Δ2m	0.09	-0.00	0.01	0.07	0.05	0.05	0.08
SE - inflation Δ3m	**0.13**	0.08	0.04	0.09	0.08	0.10	**0.14**
EU - inflation Δ1m	0.08	0.01	0.07	0.10	0.10	0.09	0.08
EU - inflation Δ2m	**0.15**	0.10	0.10	**0.13**	**0.12**	0.11	0.11
EU - inflation Δ3m	**0.18**	**0.15**	0.11	**0.15**	**0.12**	0.11	0.10
US - inflation Δ1m	0.11	0.06	-0.04	0.10	0.06	0.10	0.06
US - inflation Δ2m	**0.16**	0.07	-0.05	0.11	0.08	**0.12**	0.10
US - inflation Δ3m	**0.22**	**0.15**	0.02	**0.15**	0.11	**0.14**	**0.12**
SE - employment Δ1m	-0.06	-0.03	-0.03	0.03	0.00	-0.01	-0.02
SE - employment Δ2m	0.02	0.04	0.04	0.08	0.05	0.06	0.04
SE - employment Δ3m	-0.02	0.04	0.05	0.07	0.03	0.02	0.01
SE - GDP Δ1q	-0.00	-0.01	-0.08	-0.01	-0.05	-0.07	-0.11
SE - GDP Δ2q	-0.01	0.02	-0.05	0.01	-0.03	-0.04	-0.08
EU - GDP Δ1q	-0.05	-0.06	-0.10	-0.04	-0.06	-0.08	-0.11
EU - GDP Δ2q	-0.04	-0.02	-0.05	-0.00	-0.04	-0.06	-0.09
US - GDP Δ1q	0.00	0.02	0.01	0.01	0.02	0.04	0.05
US - GDP Δ2q	-0.02	-0.04	-0.08	-0.00	0.02	0.06	0.05

Note**:** The table shows calculated pairwise correlations between economic and financial variables and monetary policy surprises based on the seven Swedish instruments (1-month OIS, 3-month OIS, 6-month OIS, 1-year swap, 2-year swap, 5-year swap and the 10-year swap). Correlations in bold are statistically significant. For variables with revision history, such as GDP and employment, we use the vintage of the data that was available one day before the monetary policy announcement. Numbers following the delta (Δ) symbol represent the number of days (30, 60 or 90), months (1m, 2m or 3m) or quarters (1q, 2q) for which the change in the variable is calculated. For example, SE – 10y Δ30, is the percentage change in 10 year Swedish government bond yield during the 30 days that proceed a monetary policy announcement.

APPENDIX D

The table shows some summary statistics of the calculated surprises, in total and separately for positive surprises and negative surprises. In some cases, the surprise is exactly zero, hence $N_{pos} + N_{neg} < N_{tot}$.

Table D.1 Descriptive statistics of calculated surprises (percentage points)

Positive surprises							
	1m	**3m**	**6m**	**1y**	**2y**	**5y**	**10y**
N	105	124	122	108	106	105	109
Mean	0.02	0.02	0.02	0.02	0.02	0.01	0.01
Std	0.03	0.03	0.03	0.03	0.02	0.02	0.01
Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Max	0.15	0.16	0.17	0.21	0.17	0.12	0.07
Negative surprises							
	1m	**3m**	**6m**	**1y**	**2y**	**5y**	**10y**
N	90	96	111	139	144	149	146
Mean	-0.03	-0.03	-0.02	-0.02	-0.02	-0.02	-0.01
Std	0.07	0.05	0.04	0.03	0.03	0.02	0.01
Min	-0.51	-0.29	-0.22	-0.19	-0.16	-0.14	-0.08
Max	0.00	0.00	0.00	0.00	0.00	0.00	0.00
All surprises (both negative and positive)							
	1m	**3m**	**6m**	**1y**	**2y**	**5y**	**10y**
N	265	265	265	265	265	265	265
Mean	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Std	0.05	0.04	0.04	0.03	0.03	0.03	0.02
Min	-0.51	-0.29	-0.22	-0.19	-0.16	-0.14	-0.08
Max	0.15	0.16	0.17	0.21	0.17	0.12	0.07

Note. Surprises are calculated as the difference between the median price 20 minutes exactly after the time of the monetary policy communication and the median price 10 minutes exactly before the same time.

APPENDIX E

We investigate the price movements of the krona exchange rate, an asset that can be expected to react in a predicable way to surprises in the Riksbank's actions and communication. Figure E.3a shows the reaction in our first factor, the target factor, and the SEK/USD and SEK/EUR exchange rates, respectively.

Figure E.3a: Full sample: Policy rate shocks and exchange rate

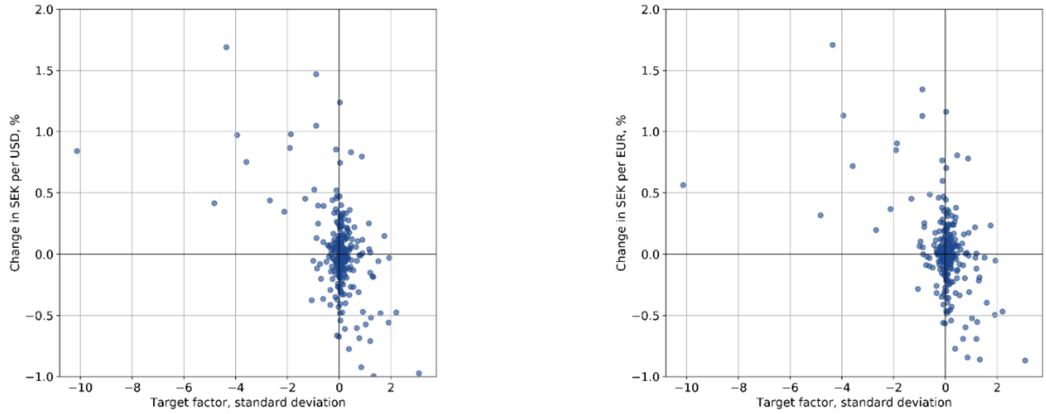


Figure E.3b: Sub-sample I: Policy rate shocks and exchange rates

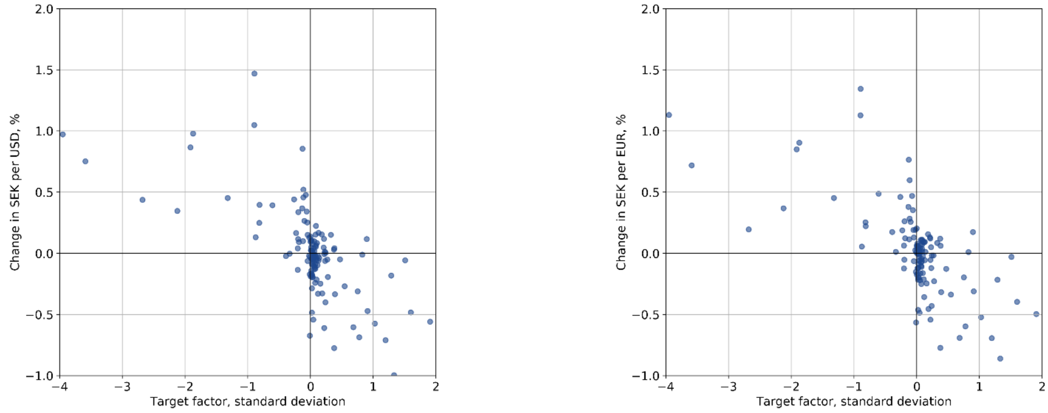
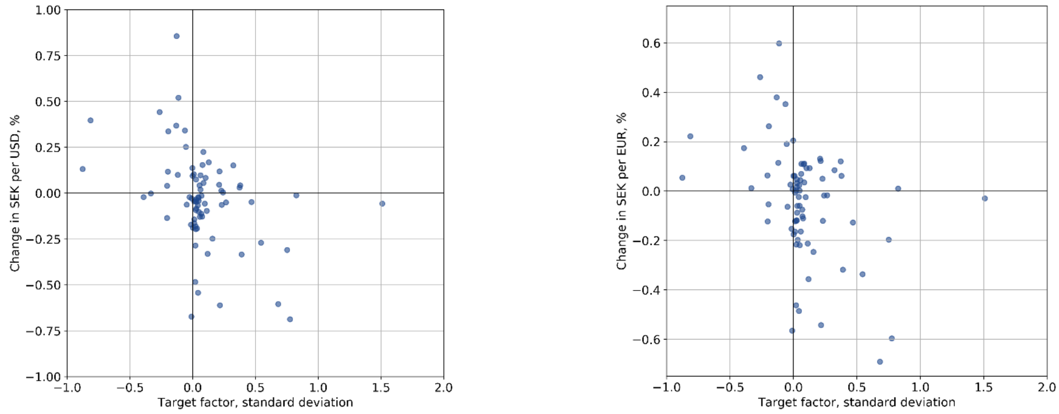


Figure E.3c: Sub-sample II: Policy rate shocks and exchange rate movement



Note: The figure plots exchange rate movements in a 30-minute window around the Riksbank's monetary policy communications and the target factor. The charts on the left plot changes in SEK/USD exchange rate and the charts on the right plot SEK/EUR. The full sample contains all 265 dates (Figure 3a). Sub-sample I (Figure 3b) only includes dates of the target factor where the target factor and path factor have the same sign (i.e. move in the same direction). Sub-sample II (Figure 3c) only includes dates of the target factor where the target factor and path factor have the same sign but the quantitative measures factor have the opposite sign.

Roughly half of the observations fall into the two quadrants (the first and fourth) that theory would predict, given that this factor may indeed be interpreted as a monetary policy shock (see Figure E.3a and Table E.2). In the case of the SEK/USD exchange rate, 66 per cent of the observations exhibit the expected reaction, whereby a positive (negative) shock to the target factor would be associated with an appreciation (depreciation) of the krona.

Table E.1. The share of observations in the expected quadrants

	Full sample	Sub-Sample I	Sub-Sample II
SEK/USD	0.66	0.68	0.72
SEK/EUR	0.66	0.68	0.72

Note: The table presents the share of observations (dates) where we observe (i) a positive policy rate shock and an appreciation of the krona or (ii) a negative policy rate shock and a depreciation of the krona. The full sample contains all 265 dates. Sub-sample I only include dates where the target factor and path factor have the same sign (i.e. move in the same direction). Sub-sample II only include dates where the target factor and oath have the same sign but the quantitative measures factor have an opposite sign. The shares are in decimals.

However, before drawing any conclusions about the validity of the target factor as a monetary policy shock from these data visualisations, it is essential to recognize the multidimensional character of the Riksbank's communications. Given the assumptions that underpin the factor model, and the estimated factor loadings presented in Table 1, it is reasonable to interpret the financial market surprise in each of our 265 communication events as the consequence of three different shocks. For each communication event, there are three different shock realizations, corresponding to the three extracted factors. Foreign exchange market participants can be expected to react to and draw conclusions from all three of these realizations: the current level of the Riksbank policy rate (factor 1), any forward guidance, intentional or not, that is communicated concerning the future level of the policy rate (factor 2), as well as any news about current or future expected quantitative measures (factor 3).

Figure E.3b and E.3c show the reaction of the krona exchange rate in two subsamples of our 265 communication events. Figure E.3b shows how the krona exchange rate reacted in events where both factor 1 and factor 2 have realizations of the same sign, implying that the surprises to the current policy rate and to forward guidance were both either hawkish or dovish. As can be seen when comparing Figure E.3a and E.3b, a slightly higher share of observations fall into quadrants one and four in this subsample. The relevant shares are summarized in Table E.1: 68 per cent of observations fall in the two relevant quadrants. These shares increase further when looking at the subsample of events where factors 1 and 2 both have the same sign and where, in addition, factor 3 has a sign opposite to that of factors 1 and 2. Recall that a positive shock to factor 1 and 2 increases rates whereas a positive shock to factor 3 both increases but also decreases rates at longer maturities.

We interpret this evidence on the krona exchange rate as an indication that the three extracted factors do indeed capture relevant dimensions of Riksbank communication. The monotonically increasing shares shown in Table E.1 suggest that when additional dimensions of central bank communication are accounted for, over and above communication concerning the current level of the policy rate, we can make sense of greater shares of the foreign exchange market reactions.

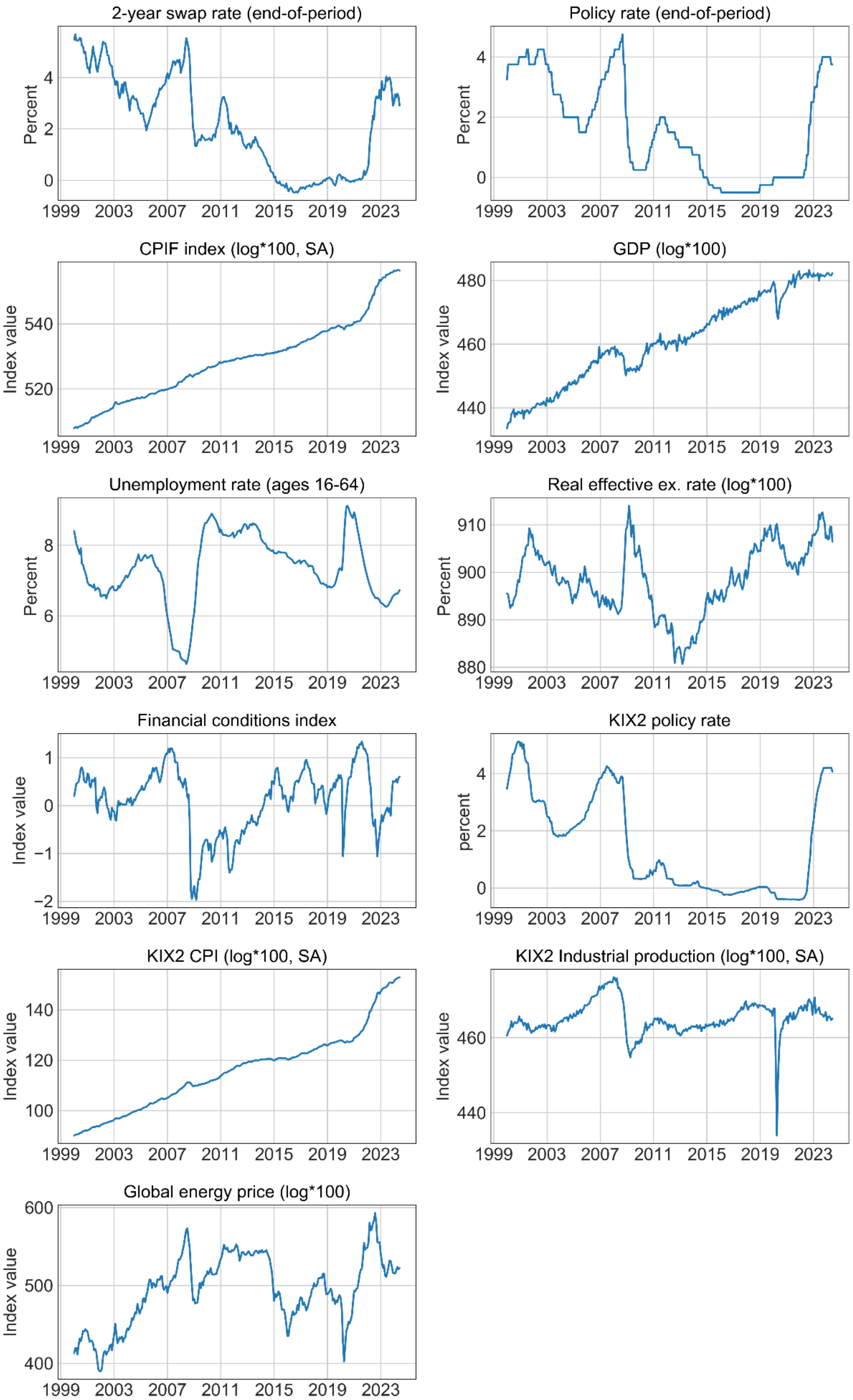
APPENDIX F

In this section, the data used in the macroeconomic model is described. The macroeconomic model contains six or seven endogenous variables and four exogenous variables, excluding intercept and dummies. Table F.1 reports sources and transformations of all variables that goes into the macroeconomic model. All variables are in log levels. The real interest rate is constructed by taking the log effective exchange rate plus the log CPI foreign price level, and subtracting the Swedish price level. The FCI consists of an unweighted average of three components of the FCI index described in Alsterlind et al. (2020): the housing market, the bond market and the stock market. The foreign variables are composed as a trade weighted average of the US and the euro area, so called KIX2. For the interest rate, it is composed by adding the rates in level, weighted with the KIX2 weights. For industrial production and CPI, the series are first normalizes so that the starting point takes value 100. The weighted index is then calculated using the per cent increase in the price level for each region, weighted with the KIX2-weights. The two series (CPI and industrial production) are then logged. Figure F.1 shows all the series that are used in the model estimation.

Table F.1: Data series used in the estimation of the macroeconomic model

Swedish data series	**Source**	**Transformation**
2-year swap rate	Bloomberg	end-of-month value
Policy rate	Sveriges Riksbank	end-of-month value
Price level (CPIF)	Statistics Sweden	Seasonal adjustment using X-11 starting from 1995. Nat log
GDP	Statistics Sweden	Nat log
Unemployment ages 16-64	Swedish employment agency	-
Exchange rate	Sveriges Riksbank	Nat log
Financial conditions index	Sveriges Riksbank	Sum of housing, stock market and bond components
Foreign data series	**Source**	**Transformation**
Federal funds rate	Federal reserve	-
EONIA rate **check**	European central bank	-
Euro area industrial production	Euro stat	Nat log
US industrial production	Federal reserve	Nat log
US CPI	U.S. Bureau of Labor Statistics	Seasonal adjustment using X-11 starting from 1995. Nat log
Euro area HICP	Eurostat	Seasonal adjustment using X-11 starting from 1995. Nat log
Euro area KIX weight	Sveriges Riksbank	-
US KIX weight	Sveriges Riksbank	-
Global energy price	IMF	Nat log

Figure F.1: Time series data used in the macroeconomic model



APPENDIX G

In this section, we report additional robustness exercises with a focus on changes in the macroeconomic model specification. First, however, we report a robustness exercise with a different cleaning methodology. In section 4, we showed that orthogonalizing the monetary policy surprises by cleaning them from ex ante correlated variables known to the public did not change the results in any economically meaningful way. It might however be the case that the correlations differ between minutes and monetary policy decisions. Therefore, we perform a second cleaning exercise in this section, where we clean the two types of announcements separately from each other.

Separate cleaning of minutes and rate announcements

Figure G.1 shows the resulting IRFs from the separate cleaning exercise. The results are qualitatively similar to the baseline case, but effects are stronger. The strength of the instrument for the target factor is however lower in this exercise, 8.5. For the second factor, F-statistics are instead higher, 10.6, implying a strong enough instrument for these shocks. Results are also qualitatively similar to the baseline case, but the effect on inflation and output are weaker.

Sample ending in 2019

Figure G.2 shows the resulting IRFs from stopping the sample in 2019 in the VAR model. The F-statistics for the target factor and the path factor are 34.1 and 8.5 respectively.

12 lags in the estimation

Figure G.3 shows the resulting IRFs from including 12 lags instead of 9 in the VAR model. The F-statistics for the target factor and the path factor are 19.5 and 5.7 respectively.

6 lags in the estimation

Figure G.4 shows the resulting IRFs from including 6 lags instead of 9 in the VAR model. The F-statistics for the target factor and the path factor are 30.6 and 6.9 respectively.

No pandemic dummies

Figure G.5 shows the resulting IRFs when removing the pandemic dummies that are included in the baseline specification on the model. The F-statistics for the target factor and the path factor are 30.4 and 9.7 respectively.

No Swedish financial conditions in estimation

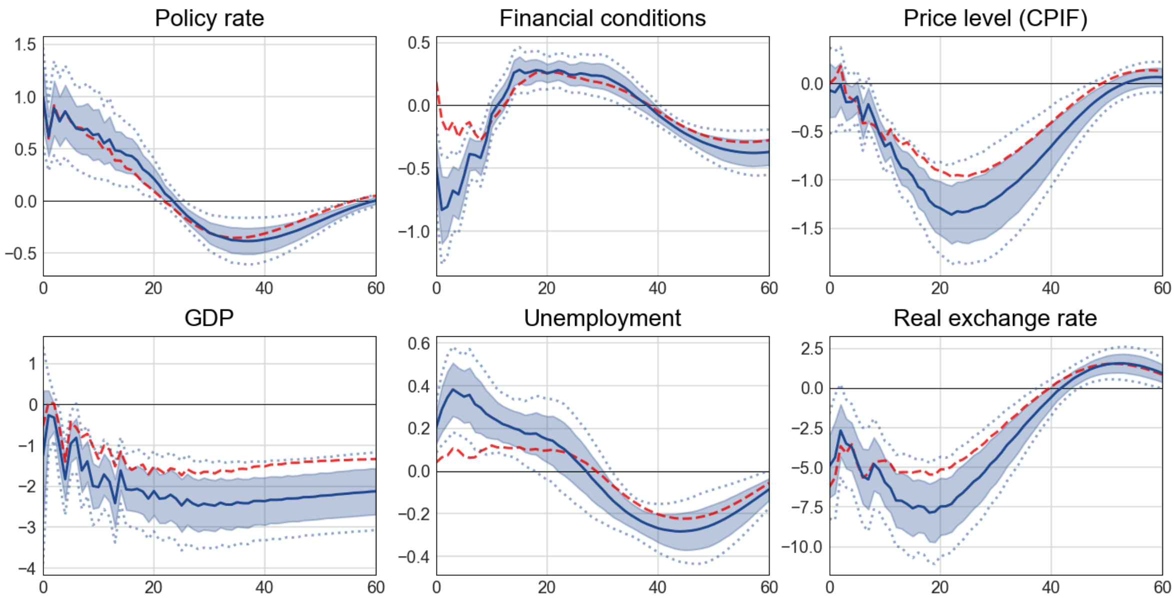
In this exercise, we remove the financial conditions index from the estimation, to see how it affects the results. The results are illustrated in Figure G.6, and the F-statistics for the target factor and the path factor are 15.0 and 8.4 respectively.

CPIFxe instead of CPIF in the estimation

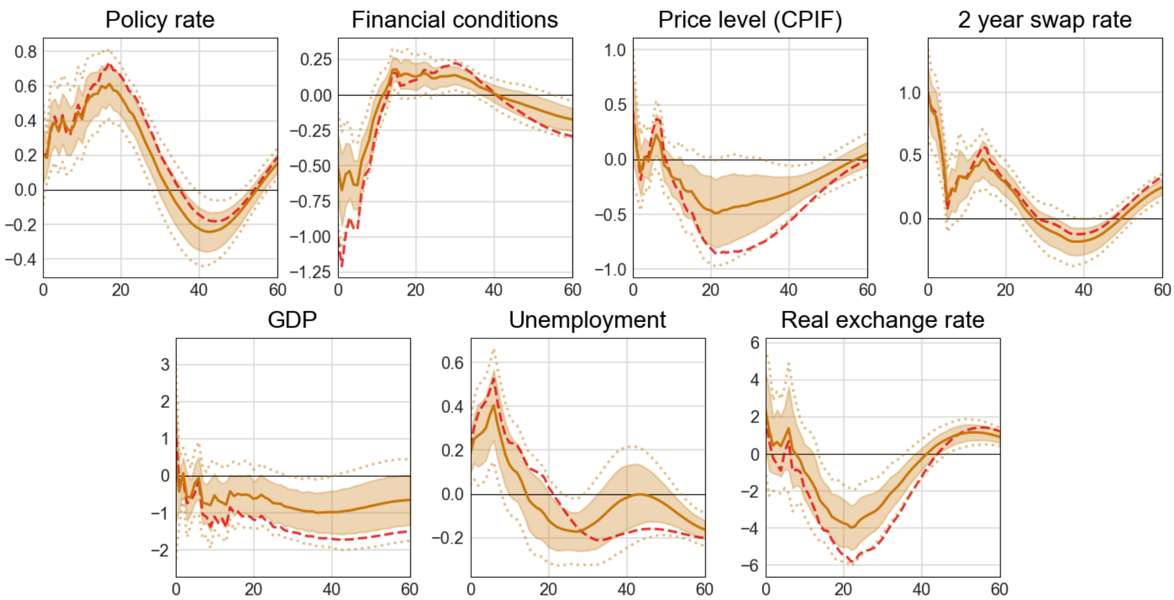
In the baseline estimation, we use the CPIF price level. In this robustness exercise, we exchange CPIF with CPIF excluding energy. The results are illustrated in Figure G.7, and the F-statistics for the target factor and the path factor are 23.7 and 6.1 respectively.

Figure G.1: Robustness – effect on macroeconomic variables when surprises are orthogonalized, separate cleaning for minutes and rate announcements

Panel A: Effect of target factor shock



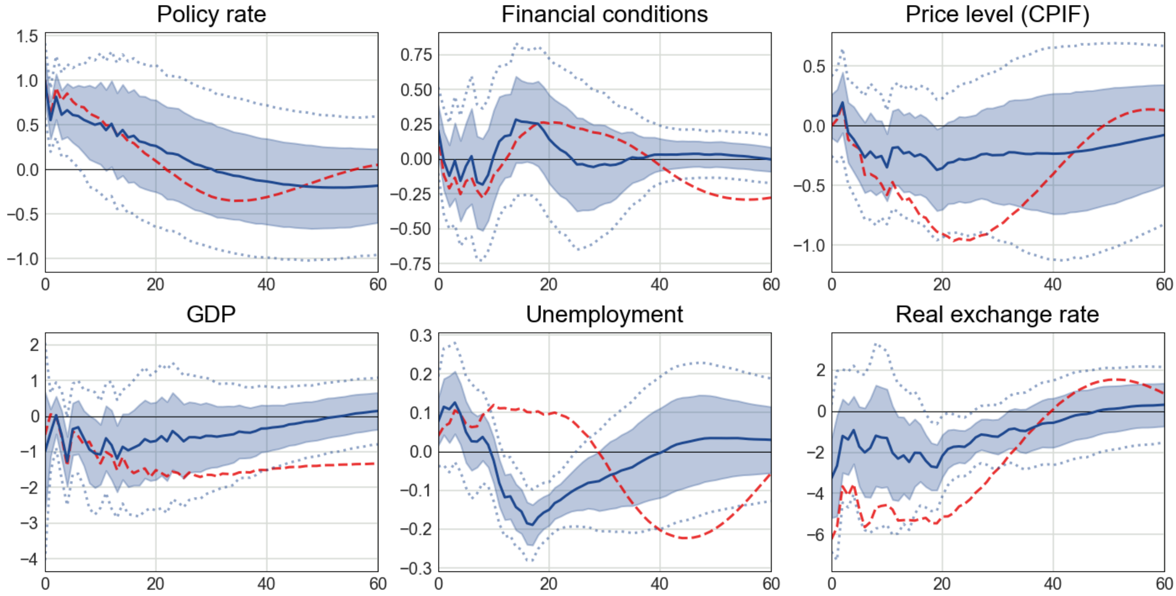
Panel B: Effect of path factor shock



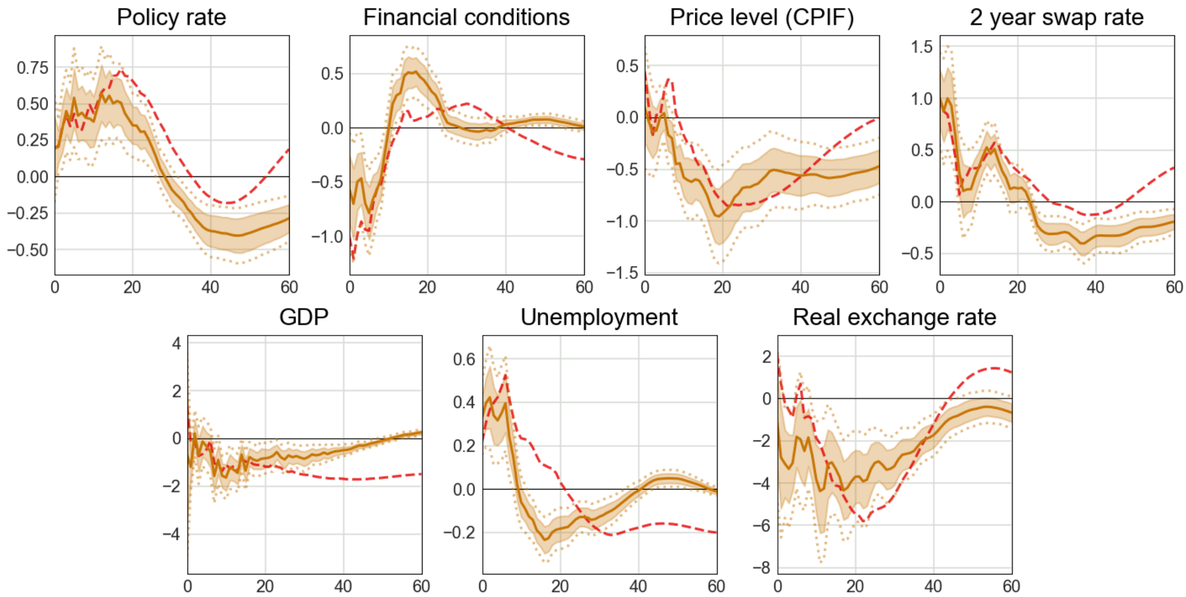
Note: The policy rate and the 2-year swap rate are measured at their end-of-period values. The dashed red lines show the point estimates in the baseline estimation. The solid lines show the point estimates of the impulse responses functions normalized to yield a 1 pp. higher policy rate on impact for the target factor shock, and 1 pp. higher 2-year swap rate on impact for the path factor shock. The shaded areas show 68 per cent bootstrapped confidence intervals around the point estimates and the dotted lines show the edges of the 90 per cent confidence intervals. The policy rate, 2-year swap rate, and unemployment rate are measured in percentage point deviations. Financial conditions are measured in index point deviations. The rest of the series are measured as per cent deviations.

Figure G.2: Robustness - effect on macroeconomic variables when sample ends in 2019

Panel A: effect of target factor shock



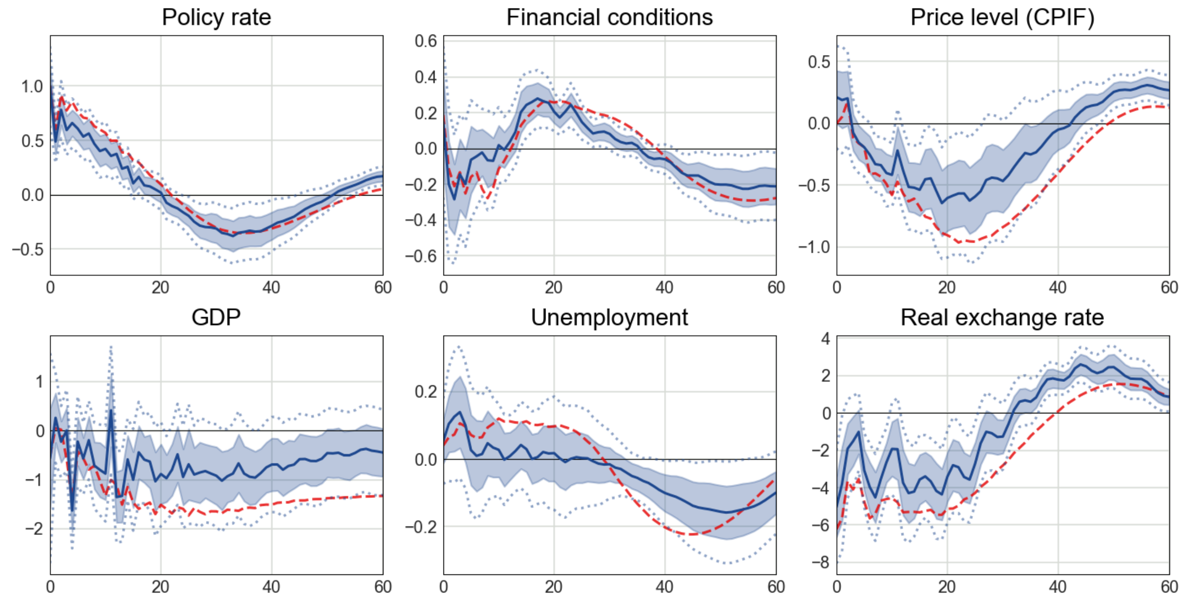
Panel B: effect of path factor shock



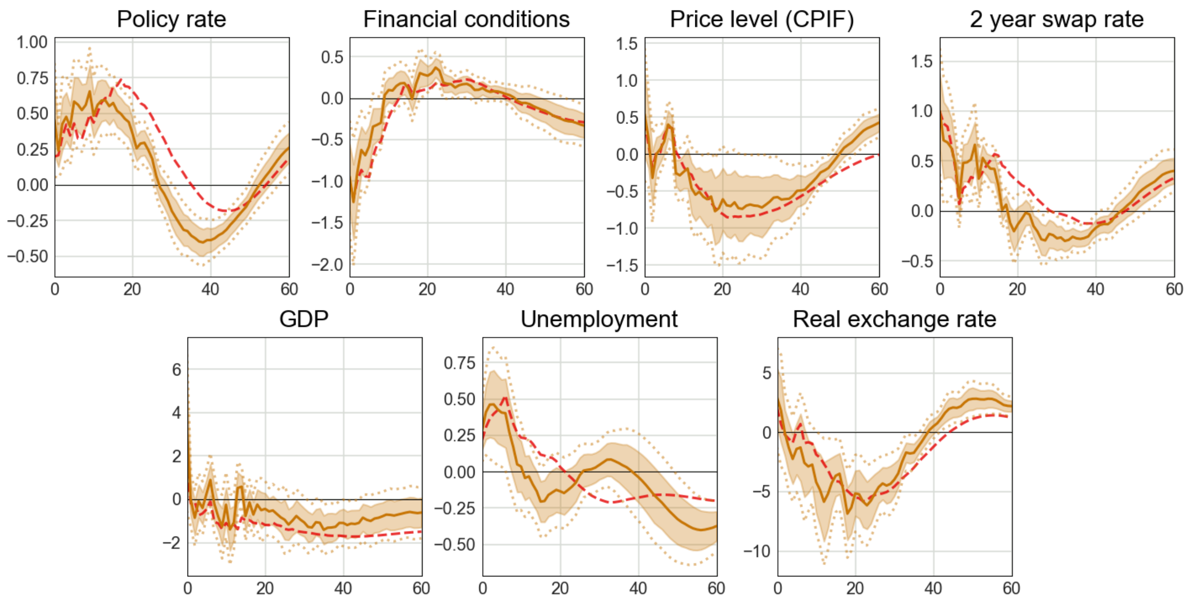
Note: The policy rate and the 2-year swap rate are measured at their end-of-period values. The dashed red lines show the point estimates in the baseline estimation. The solid lines show the point estimates of the impulse responses functions normalized to yield a 1 pp. higher policy rate on impact for the target factor shock, and 1 pp. higher 2-year swap rate on impact for the path factor shock. The shaded areas show 68 per cent bootstrapped confidence intervals around the point estimates and the dotted lines show the edges of the 90 per cent confidence intervals. The policy rate, 2-year swap rate, and unemployment rate are measured in percentage point deviations. Financial conditions are measured in index point deviations. The rest of the series are measured as per cent deviations.

Figure G.3: Robustness - effect on macroeconomic variables with 12 lags instead of 9

Panel A: effect of target factor shock



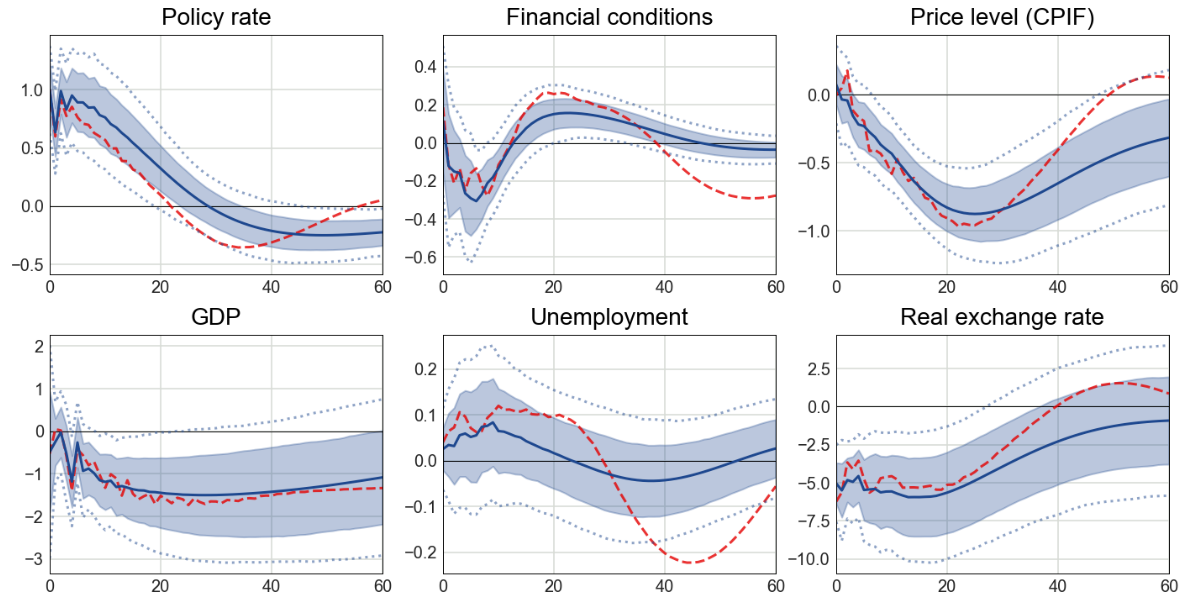
Panel B: effect of path factor shock



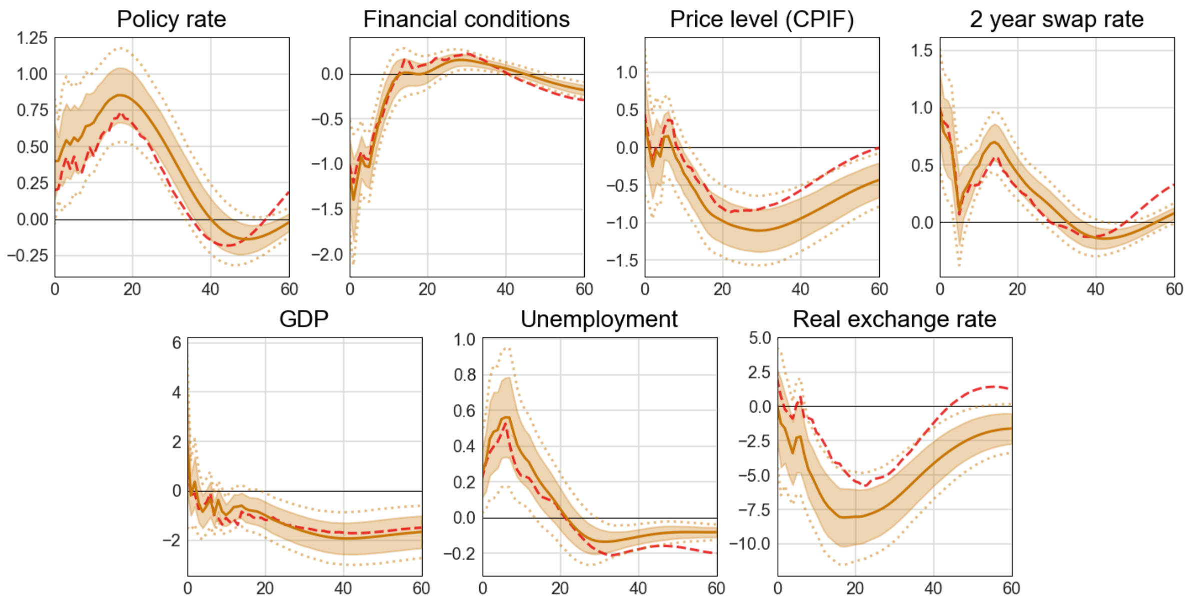
Note: The policy rate and the 2-year swap rate are measured at their end-of-period values. The dashed red lines show the point estimates in the baseline estimation. The solid lines show the point estimates of the impulse responses functions normalized to yield a 1 pp. higher policy rate on impact for the target factor shock, and 1 pp. higher 2-year swap rate on impact for the path factor shock. The shaded areas show 68 per cent bootstrapped confidence intervals around the point estimates and the dotted lines show the edges of the 90 per cent confidence intervals. The policy rate, 2-year swap rate, and unemployment rate are measured in percentage point deviations. Financial conditions are measured in index point deviations. The rest of the series are measured as per cent deviations.

Figure G.4: Robustness - effect on macroeconomic variables with 6 lags instead of 9

Panel A: effect of target factor shock



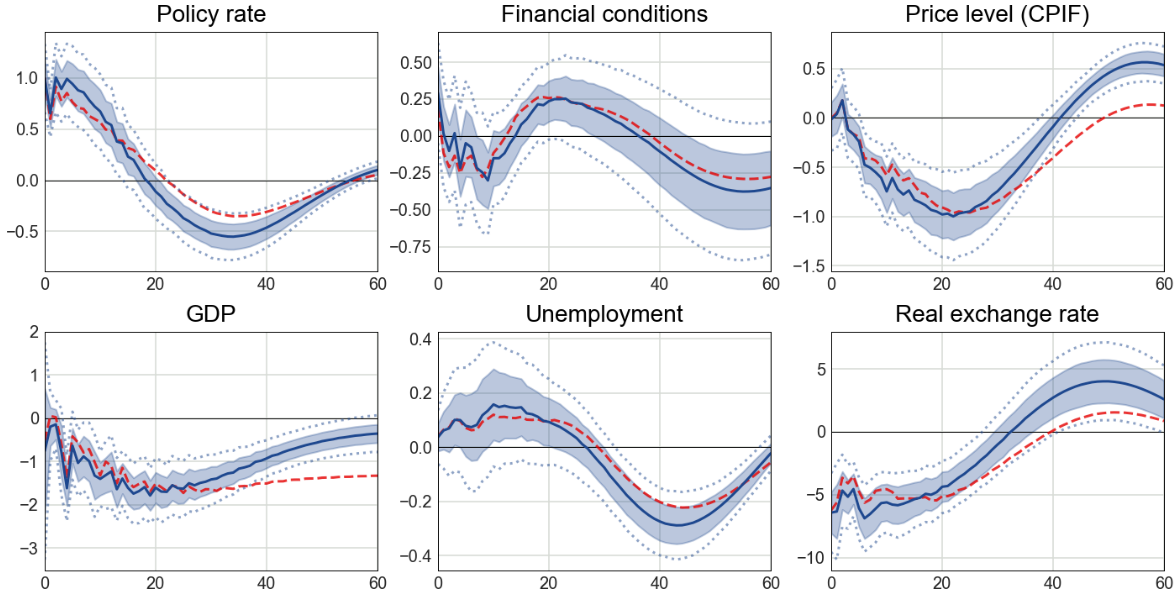
Panel B: effect of path factor shock



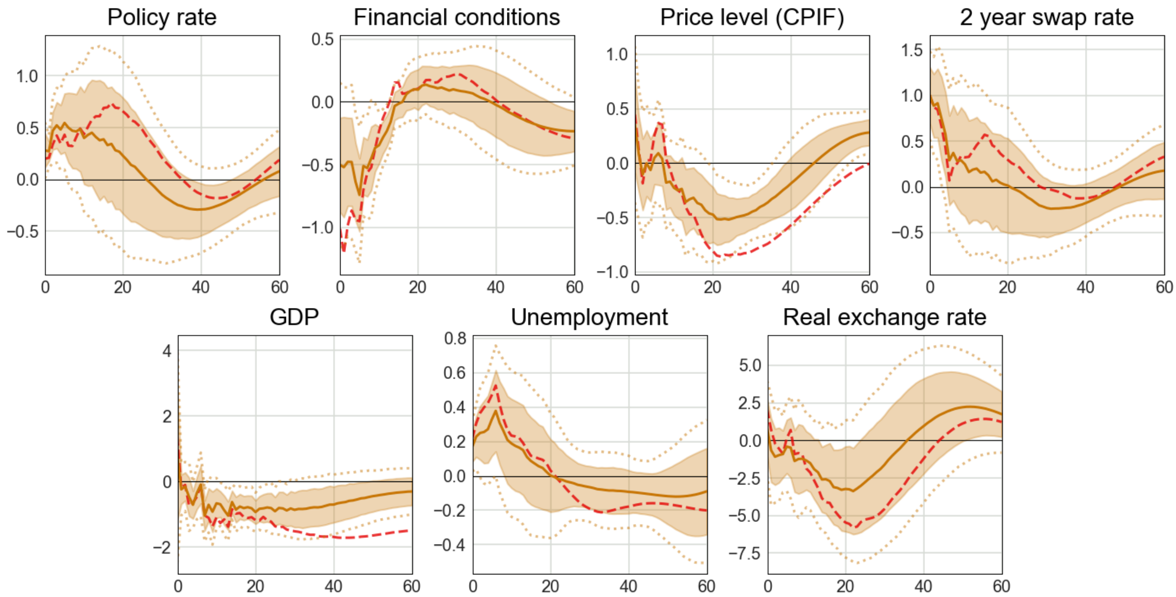
Note: The policy rate and the 2-year swap rate are measured at their end-of-period values. The dashed red lines show the point estimates in the baseline estimation. The solid lines show the point estimates of the impulse responses functions normalized to yield a 1 pp. higher policy rate on impact for the target factor shock, and 1 pp. higher 2-year swap rate on impact for the path factor shock. The shaded areas show 68 per cent bootstrapped confidence intervals around the point estimates and the dotted lines show the edges of the 90 per cent confidence intervals. The policy rate, 2-year swap rate, and unemployment rate are measured in percentage point deviations. Financial conditions are measured in index point deviations. The rest of the series are measured as per cent deviations.

Figure G.5: Robustness – no pandemic dummies included in the estimation

Panel A: effect of target factor shock



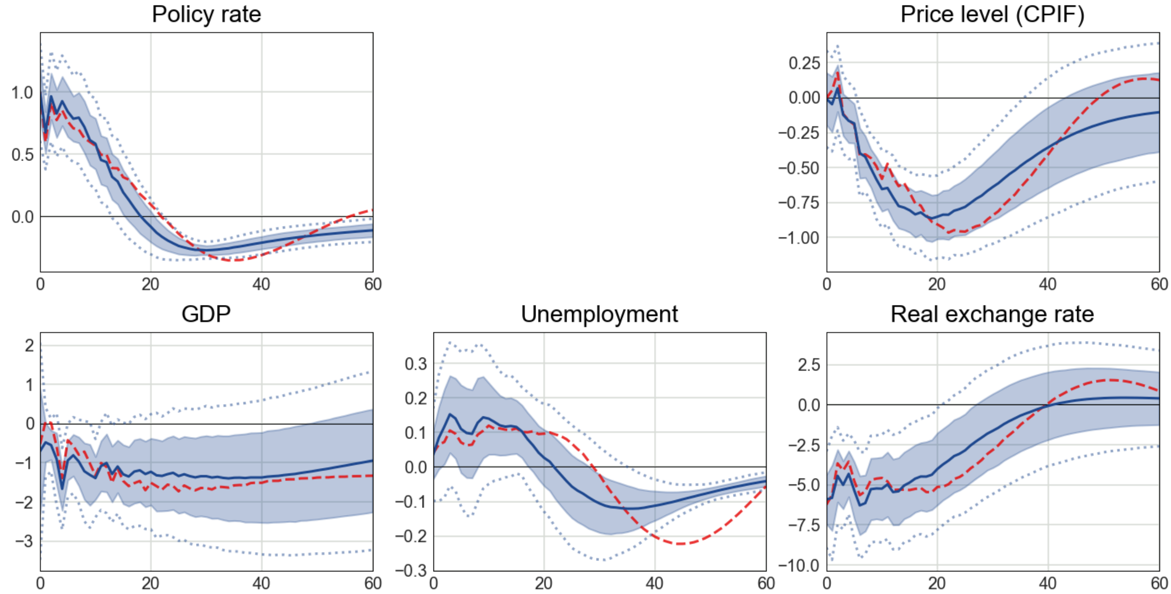
Panel B: effect of path factor shock



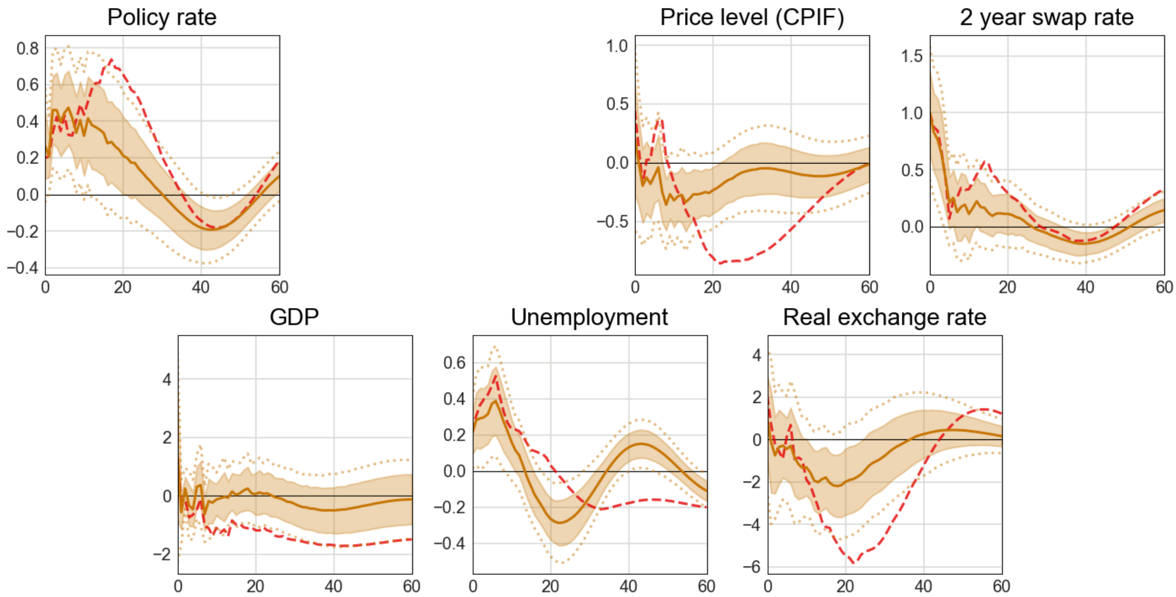
Note: The policy rate and the 2-year swap rate are measured at their end-of-period values. The dashed red lines show the point estimates in the baseline estimation. The solid lines show the point estimates of the impulse responses functions normalized to yield a 1 pp. higher policy rate on impact for the target factor shock, and 1 pp. higher 2-year swap rate on impact for the path factor shock. The shaded areas show 68 per cent bootstrapped confidence intervals around the point estimates and the dotted lines show the edges of the 90 per cent confidence intervals. The policy rate, 2-year swap rate, and unemployment rate are measured in percentage point deviations. Financial conditions are measured in index point deviations. The rest of the series are measured as per cent deviations.

Figure G.6: Robustness – No Financial Conditions Index included in estimation

Panel A: effect of target factor shock



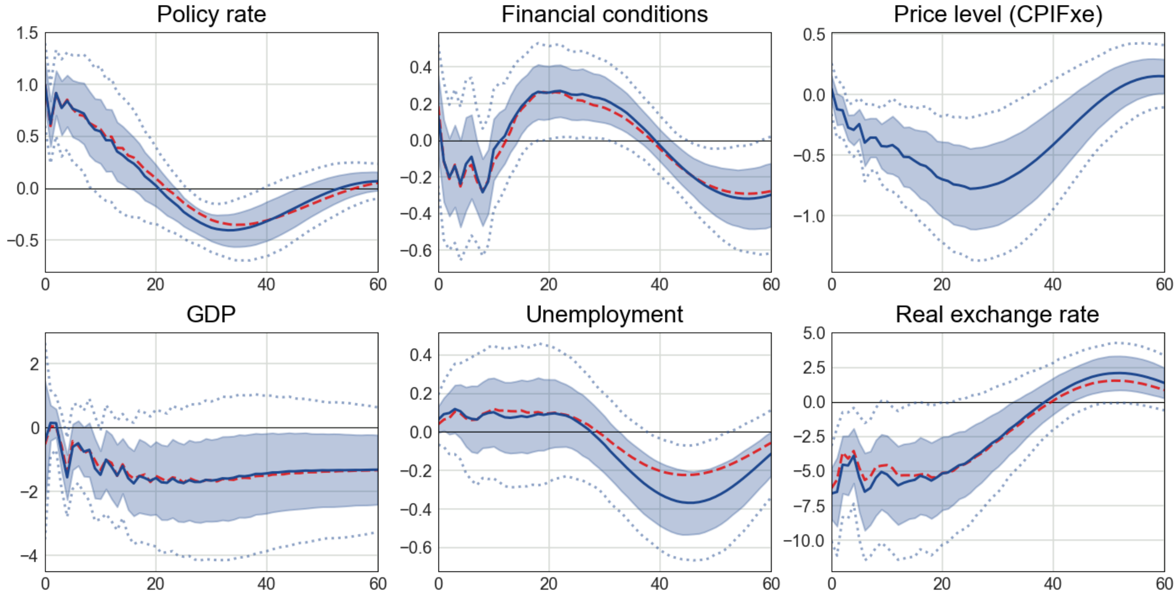
Panel B: effect of path factor shock



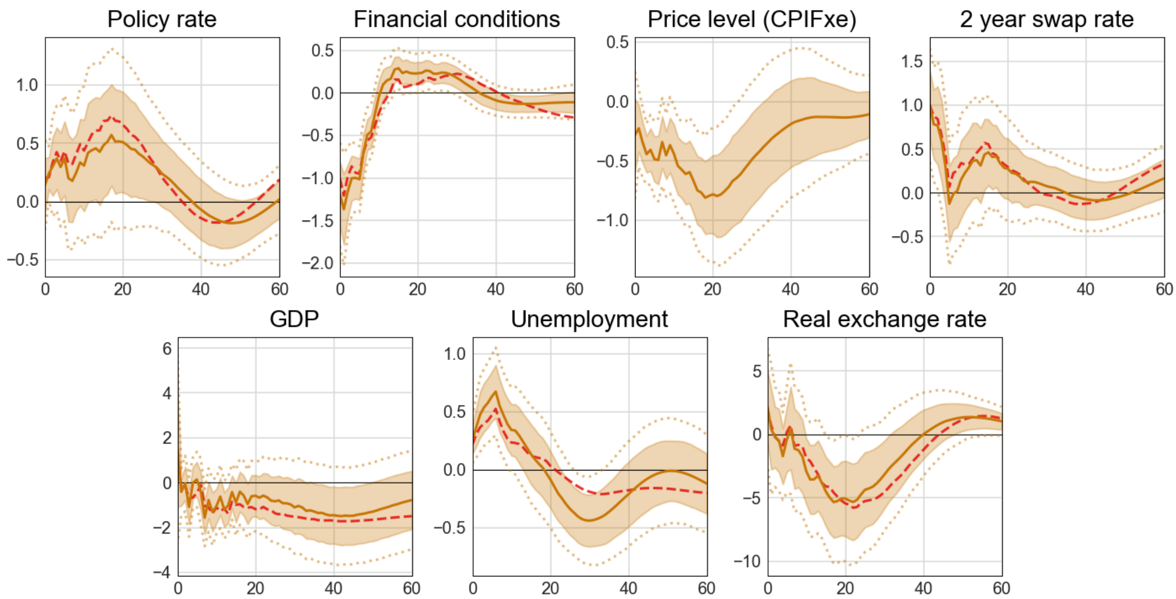
Note: The policy rate and the 2-year swap rate are measured at their end-of-period values. The dashed red lines show the point estimates in the baseline estimation. The solid lines show the point estimates of the impulse responses functions normalized to yield a 1 pp. higher policy rate on impact for the target factor shock, and 1 pp. higher 2-year swap rate on impact for the path factor shock. The shaded areas show 68 per cent bootstrapped confidence intervals around the point estimates and the dotted lines show the edges of the 90 per cent confidence intervals. The policy rate, 2-year swap rate, and unemployment rate are measured in percentage point deviations. Financial conditions are measured in index point deviations. The rest of the series are measured as per cent deviations.

Figure G.7: Robustness – CPIF excluding energy in estimation instead of CPIF

Panel A: effect of target factor shock



Panel B: effect of path factor shock



Note: The policy rate and the 2-year swap rate are measured at their end-of-period values. The dashed red lines show the point estimates in the baseline estimation. The solid lines show the point estimates of the impulse responses functions normalized to yield a 1 pp. higher policy rate on impact for the target factor shock, and 1 pp. higher 2-year swap rate on impact for the path factor shock. The shaded areas show 68 per cent bootstrapped confidence intervals around the point estimates and the dotted lines show the edges of the 90 per cent confidence intervals. The policy rate, 2-year swap rate, and unemployment rate are measured in percentage point deviations. Financial conditions are measured in index point deviations. The rest of the series are measured as per cent deviations.

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