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Macroeconomic Effects of Unconventional Monetary Policy in Japan: Analysis Using Narrative Sign Restrictions *

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Abstract

We evaluate the macroeconomic effects of unconventional monetary policy (UMP) in Japan, focusing in particular on the Quantitative and Qualitative Monetary Easing (QQE) implemented during Governor Haruhiko Kuroda's tenure. To identify UMP shocks, we impose narrative sign restrictions on structural shocks and on historical decompositions, exploiting three major policy episodes that generated significant surprises in financial markets. Our results indicate that expansionary UMP shocks increase both output and the inflation rate. The exchange rates, stock prices, and bank lending also respond to the UMP shock in a manner consistent with standard macroeconomic theory. Furthermore, narrative sign restrictions resolve some puzzling responses observed with Cholesky decomposition and tighten the wide credible intervals typical of standard sign restrictions.

Keywords: Monetary policy shock; narrative restrictions; structural vector autoregressive models
JEL Classification: E31, E32, E44, E52

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1 Introduction

Various unconventional monetary policies have been adopted in Japan, including the zero interest rate policy from February 1999 to August 2000, the quantitative easing (QE) policy from March 2001 to March 2006, and the quantitative and qualitative monetary easing (QQE) policy from April 2013 to March 2024. Among these policies, QQE was the largest monetary easing policy in Japan's history, which is why it is also referred to as "unprecedented monetary easing." It is important to note that QQE was characterized by the fact that the then-Bank of Japan (BOJ) Governor, Haruhiko Kuroda, placed particular emphasis on policy surprises rather than dialogue with financial markets.

What are the quantitative effects of QQE introduced during the Kuroda regime? In this study, we aim to answer this question using structural vector autoregressive (VAR) models. In general, however, identifying monetary policy shocks during the period of unconventional monetary policy is considered a difficult task. To address this issue, we employ the identification strategy based on narrative sign restrictions, which exploit narrative evidence of "policy surprise" that influenced financial markets. Specifically, we focus on the following three key events during the Kuroda regime: (i) the introduction of QQE on April 4, 2013; (ii) the expansion of QQE on October 31, 2014; and (iii) the introduction of the negative interest rate policy on January 29, 2016. Because of the significant surprises they generated in financial markets, these three events are widely referred to in the media as "Kuroda's bazooka." [1]

In this paper, we also argue that identification based on the narrative sign restrictions has several advantages over traditional methods such as Cholesky decomposition and standard sign restrictions. We compare our benchmark results obtained from narrative sign restrictions with those obtained from traditional methods. The sign restrictions have been often used to identify monetary policy shocks in the analysis of monetary policy in Japan.[2] To the best of our knowledge, however, this paper is the first work to employ narrative sign restrictions to identify the monetary policy shock

[1] See Gunji (2024) for a detailed explanation of the origin of the term "Kuroda's bazooka."

[2] For example, Braun and Shioji (2006) conducted such an analysis using data predating the QE and QQE policies.

of QQE.

The main findings of the paper are as follows. First, expansionary unconventional monetary policy (UMP) shocks significantly increase output and inflation rates. Using the historical decomposition, we find that UMP shocks have increased the level of GDP by 1.0% and the inflation rate by 0.2 percentage points on average over the QQE period. Second, exchange rates, stock prices, and bank lending respond as standard theory predicts, implying that the unconventional monetary policy transmits via exchange-rate, asset-price, and credit channels. Third, we confirm that the narrative sign restrictions are effective in identifying UMP shocks. The use of the narrative sign restrictions eliminates some puzzling responses observed in the case of Cholesky decomposition, and also provides tighter credible intervals than in the case of standard sign restrictions.

Overall, our results confirm some of the previous findings that support the effectiveness of unconventional monetary policy in Japan. There are a number of previous empirical studies on QE and QQE policies using the VAR models.[3] To investigate the macroeconomic effects of the QE policy prior to Governor Kuroda's tenure, Schenkelberg and Watzka (2013) conduct a VAR analysis with sign restrictions and find that monetary easing policies have a positive effect on output but only a limited effect on increasing prices. Similarly, Honda et al. (2013) also find a positive effect on output but a small effect on the price level based on Cholesky decomposition. Hayashi and Koeda (2019) employ Cholesky decomposition in the regime-switching VAR models and find that the positive response of output and inflation to a positive excess reserves shock under the effective lower bound regime.[4]

Regarding the effectiveness of QQE policy, many VAR studies employ sign restrictions and/or external instruments to identify monetary policy shocks. For example, Michaelis and Watzka (2017) employ a time-varying parameter VAR model combined with sign restrictions and find that the effects on output and prices differ between the QE and QQE periods. In particular, the responses of the price level tend to be stronger

[3]See also Aoki and Ueda (2025) for a comprehensive review of empirical works on the effect of unconventional monetary policy in Japan.

[4]Furthermore, De Michelis and Iacoviello (2016) employ long-run restrictions rather than short-run restrictions to identify the inflation target shock in Japan and find its effect on both GDP and inflation.

at the onset of the QQE period. On the other hand, by using high-frequency surprises in Euroyen futures rates within a thirty-minute window around each Monetary Policy Meeting (MPM) as external instruments, Kubota and Shintani (2025) claim that both output and prices respond to monetary policy shocks. It should be noted that such a high-frequency identification strategy has been widely used in the literature since the seminal work of Gertler and Karadi (2015) on the US. Accordingly, other studies on Japan, such as Nakamura et al. (2024) and Nakashima et al. (2024), use external instruments based on market surprises.[5]

Identification of unconventional monetary policy shocks in the nonlinear VAR framework has also been conducted in several studies. For example, Koeda (2019), Miyao and Okimoto (2020), and Ikeda et al. (2024), respectively, employ a regime-switching VAR model, a smooth transition VAR model, and a censored and kinked VAR model. The former two studies use Cholesky decomposition, while the latter uses sign restrictions in identifying the monetary policy shocks. Note that these studies focus more on the possibility of regime shift in identifying the monetary policy shocks because their sample period includes both QE and QQE periods. In contrast, our sample period starts after the end of QE and we evaluate the effectiveness of QQE policy in a simple linear VAR framework.

The remainder of the paper is organized as follows. Section 2 provides a literature review on topics related to narrative sign restrictions and discusses the advantages. Section 3 describes the narrative information about QQE events, the empirical model, data, identification strategy, and estimation algorithm. Section 4 presents the estimation results, and finally, Section 5 concludes the paper.

[5] Gertler and Karadi (2015)'s approach is further extended by Jarociński and Karadi (2020) who incorporate sign restrictions to distinguish monetary policy shocks from information shocks in the US. Tanahara et al. (2023) and Morita et al. (2025) apply this method of combining the external instruments from high-frequency data and sign restrictions to evaluate the effect of monetary policy in Japan.

2 Why narrative restrictions?

In this paper, we identify monetary policy shocks based on narrative sign restrictions. This section provides an overview of the literature underlying this identification strategy and discusses its advantages.

The identification strategy using sign restrictions on impulse response functions, originally proposed by Uhlig (2005), has been widely applied in VAR analyses of monetary policy. Another widely used identification strategy relies on external instruments, such as high-frequency monetary surprise series. Using artificial data generated from a medium-scale New Keynesian model, Wolf (2020) evaluates the performance of identification schemes commonly employed in macroeconomic analysis. He finds that identification based solely on sign restrictions often fails to recover the true structural shock, as it tends to mix multiple shocks. In contrast, identification methods using external instruments tend to perform considerably better.

The narrative approach, which utilizes central bank policy records (episodes) to construct monetary policy shock series, was pioneered by Romer and Romer (1989) and Romer and Romer (2004).[6] Inspired by the narrative approach, Antolín-Díaz and Rubio-Ramírez (2018) develop the narrative sign restriction method, which incorporates narrative information as sign restrictions on structural shocks during specific event periods. Applying this method to U.S. data, they demonstrate that even a single narrative sign restriction can substantially sharpen inference relative to conventional sign-restriction. Furthermore, Plagborg-Møller and Wolf (2021) suggest that the information underlying the narrative sign restrictions of Antolín-Díaz and Rubio-Ramírez (2018) can be used as an instrument to estimate the model. However, Giacomini et al. (2022) argue that when narrative proxies are used directly as instruments, inference may become invalid unless the proxy is constructed from narrative information covering a sufficiently large number of periods. In contrast, narrative sign restrictions provide a more robust basis for inference. Badinger and Schiman (2023) also point out that while using high-frequency data directly as instruments may suffer from contam-

[6] Nakamura and Steinsson (2018) view the narrative approach as a form of "natural experiments."

ination by central bank information effects, narrative sign restrictions can mitigate this problem when identifying monetary policy shocks.

In this paper, we follow Antolín-Díaz and Rubio-Ramírez (2018) and estimate a narrative sign restricted VAR model in a Bayesian framework. As in standard sign restricted VAR models, the Bayesian estimation of narrative sign restricted VAR models requires drawing an orthogonal matrix. Rubio-Ramírez et al. (2010) propose a method for estimating structural VARs under zero and sign restrictions using QR decomposition, employing a uniform prior (the Haar measure) over the space of orthogonal matrices. Although Baumeister and Hamilton (2015) raise concern about the use of the uniform prior in sign-restricted Bayesian inference, recent work by Inoue and Kilian (2025) shows that, under stronger narrative restrictions, sensitivity to the choice of such a prior becomes negligible.

3 Empirical Analysis

3.1 Narrative information

In this section, we provide direct narrative evidence that the three monetary policy events, often referred to as "Kuroda's bazooka" during the QQE period, were perceived as surprises by financial markets. [7]

The first of Kuroda's bazookas took place on April 4, 2013, when the Bank of Japan introduced QQE under the leadership of then Governor Haruhiko Kuroda. Aiming for a steady year-on-year increase in the CPI above two percent, the BOJ announced that it would double the monetary base, double its holdings of long-term JGBs, double the average maturity of purchased long-term JGBs, and increase purchases of ETFs and J-REITs over an initial period of about two years. These monetary easing packages exceeded the expectations of financial market participants. On April 4, the Nikkei Stock Average closed at 12,634 yen, up 272 yen from the previous day's close of 12,362 yen.

[7] We focus here on narrative evidence from sources written in English. Additional narrative evidence based on materials written in Japanese is also provided in the online appendix.

The Japanese yen weakened by 2.2 yen against the US dollar, from 93.4 yen per dollar to 95.6 yen per dollar at 5 p.m. on the Tokyo interbank market. The yield on 10-year JGBs also declined, falling from 0.55 percent to 0.455 percent. In an article entitled "Kuroda takes markets by storm" (April 4, 2013), the *Financial Times* (Soble, 2013) cited an analyst at Credit Suisse, Hiromichi Shirakawa, who stated that "the timing was a surprise and the magnitude was more than expected."

The second of Kuroda's bazookas occurred on October 31, 2014, when the BOJ announced an expansion of QQE. In addition to raising the target annual increase in the monetary base, the BOJ announced that it would increase its purchases of long-term JGBs, ETFs, and J-REITs, and extend the average remaining maturity of purchased long-term JGBs by up to about three years over the past. Just as with the first of Kuroda's bazookas, the announcement of the expansion of QQE stimulated trading in financial markets. On October 31, the Nikkei Stock Average closed at 16,413 yen, up 755 yen from the previous day's close of 15,658 yen. The Japanese yen depreciated by 2 yen against the US dollar, weakening from 109.2 yen per dollar to 111.2 yen per dollar. The yield on 10-year JGBs also declined slightly, from 0.47 percent to 0.45 percent. *Bloomberg News* on October 31, 2014 (Scott and Fujioka, 2014), reported that "Kuroda led a divided board in Tokyo in a surprise decision to expand unprecedented monetary stimulus." The article also cited Masaki Kanno, chief economist at JPMorgan Chase & Co. in Tokyo, who remarked: "We have to admit that this is sort of a second shock after we had the first shock in April last year."

The third of Kuroda's bazookas occurred on January 29, 2016, when the BOJ introduced a negative interest rate policy. The BOJ divided its current account into three tiers – Basic Balance, Macro Add-on Balance, and Policy-Rate Balance – and announced that it would apply an interest rate of -0.1 percent to the Policy-Rate Balance. According to *The Nikkei* article, this came as a surprise not only to the financial markets but also to the members of the BOJ Policy Board, as then BOJ Governor Kuroda had previously expressed his opposition to the introduction of a negative interest rate policy (Nikkei, 2016). On January 29, the Nikkei Stock Average closed at 17,518 yen, up 477 yen from the previous day's close of 17,041 yen. The Japanese yen depreciated by 1.8 yen against the US dollar, weakening from 118.8 yen per dollar to 120.6 yen per dollar at 5 p.m. on the Tokyo interbank market. The yield on 10-year JGBs also declined, falling from 0.22 percent the previous day to 0.095 percent. The *Financial Times* (Davies, 2016) reported that "some analysts have described the latest surprise announcement as 'a very big regime change'."

To reinforce our narrative identification of the three Kuroda bazookas, let us cross-check these events against the monetary policy surprise series constructed by Kubota and Shintani (2022). They identified monetary policy shocks using high-frequency data on interest rate futures to capture the immediate changes in market expectations. Specifically, they measured the difference between futures rates 10 minutes before and 20 minutes after BOJ statements, utilizing Euroyen and 10-year JGB futures.

Figure 1 plots the surprise series derived from the 10-year JGB futures, confirming that the three events identified by our narrative analysis correspond to significant monetary easing shocks during the QQE period. Excluding the post-Lehman period, the largest negative shock occurred in February 2016, capturing the impact of the negative interest rate policy introduced on January 29 (the third bazooka). The next largest decline corresponds to April 2013, marking the introduction of QQE (the first bazooka). Finally, a negative shock was observed in November 2014, reflecting the market reaction to the expansion of QQE announced on October 31 (the second bazooka).

Based on the evidence provided, we identify UMP shocks within a structural VAR framework, treating the three rounds of Kuroda's bazookas as major exogenous monetary easing shocks during the QQE period. In what follows, we outline how these three major monetary easing events can be translated into narrative sign restrictions to identify structural shocks and evaluate the effects of QQE.

3.2 Specification of the VAR model

As in Antolín-Díaz and Rubio-Ramírez (2018) and Giacomini et al. (2023), we consider a structural VAR model of order p given by:

$$\mathbf{A}_0 \mathbf{y}_t = \mathbf{A}_+ \mathbf{x}_t + \boldsymbol{\varepsilon}_t, \tag{1}$$

for $1 \leq t \leq T$, where $\mathbf{A}_0$ is an invertible $n \times n$ matrix, $\mathbf{y}_t$ is an $n \times 1$ vector, and $\mathbf{x}_t = (\mathbf{y}'_{t-1}, ..., \mathbf{y}'_{t-p}, \mathbf{z}'_t)'$ is an $m \times 1$ vector, $\mathbf{z}_t$ is an exogenous variable including a vector of ones, $\mathbf{A}_+ = (\mathbf{A}_1, ..., \mathbf{A}_p, \mathbf{A}_z)$ is a $n \times m$ matrix of parameters, and $\boldsymbol{\varepsilon}_t$ is an $n \times 1$ vector of structural shocks which follows $N(\mathbf{0}_{n\times 1}, \mathbf{I}_n)$. By rewriting equation (1), we obtain the reduced form VAR model given by

$$\mathbf{y}_t = \mathbf{B}\mathbf{x}_t + \mathbf{u}_t, \tag{2}$$

for $1 \leq t \leq T$, where $\mathbf{B}$=$\mathbf{A}_0^{-1}\mathbf{A}_+$, $\mathbf{u}_t$=$\mathbf{A}_0^{-1}\boldsymbol{\varepsilon}_t$ follows $N(\mathbf{0}_{n\times 1}, \boldsymbol{\Sigma})$ and $\boldsymbol{\Sigma}$ = $\mathbf{A}_0^{-1}(\mathbf{A}_0^{-1})'$. By allowing identification of a wider range of structural parameters $\mathbf{A}_0$ from estimates of $\mathbf{B}$ and $\boldsymbol{\Sigma}$, equation (2) can be also written as

$$\mathbf{y}_t = \mathbf{B}\mathbf{x}_t + \mathbf{P}\mathbf{Q}\boldsymbol{\varepsilon}_t, \tag{3}$$

for $1 \leq t \leq T$, where $\mathbf{P}$ is the Cholesky factor of $\boldsymbol{\Sigma}$ satisfying $\mathbf{P}\mathbf{P}' = \boldsymbol{\Sigma}$, and $\mathbf{Q}$ is an $n \times n$ orthonormal matrix satisfying $\mathbf{P}\mathbf{Q} = \mathbf{A}_0^{-1}$. Given the parameters $(\mathbf{B}, \boldsymbol{\Sigma})$ and $\mathbf{Q}$, the structural shocks, given by $\boldsymbol{\varepsilon}_t = \mathbf{A}_0\mathbf{u}_t = \mathbf{Q}'\mathbf{P}^{-1}\mathbf{u}_t$, can be identified.

3.3 Data

In our benchmark estimation, we employ the following six key macroeconomic variables:

$$\mathbf{y}_t = (GDP_t, INF_t, LTR_t, EXR_t, STOCK_t, LENDING_t)'.$$

GDP_t denotes the seasonally adjusted monthly real GDP constructed by the Japan Center for Economic Research (JCER). INF_t represents the inflation rate, defined as the year-on-year change in the consumer price index (CPI), excluding food (less alcoholic beverages) and energy, adjusted for consumption tax changes.

LTR_t denotes the 10-year JGB yield, which serves as the policy variable for UMPs in our benchmark estimation. Various policy variables have been used in previous empirical studies on the macroeconomic effects of UMPs, including bank reserves held at the BOJ (Schenkelberg and Watzka, 2013), the monetary base (Miyao and Okimoto, 2020), shadow rates (Wu and Xia, 2016), and long-term interest rates (Baumeister and Benati, 2013). We here adopt the long-term interest rate as our policy variable following Hirata et al. (2024), who argue that the "long-term interest rate channel" appears to be the primary transmission mechanism through which UMP affects the economy when short-term interest rates are constrained by the effective lower bound.[8] We also consider using alternative policy variables for robustness checks later in this paper.

In addition, we include three financial variables to capture the transmission mechanisms of monetary policy. Based on previous studies such as Mishkin (1995), Kuttner and Mosser (2002), and Boivin et al. (2010), we consider the exchange rate, asset price, and credit channels. Accordingly, we employ the nominal effective exchange rate (EXR_t), the Nikkei 225 stock price index ($STOCK_t$), and bank lending growth ($LENDING_t$) to represent these respective channels.

We use monthly data spanning from January 2007 to December 2024. All variables are expressed in logs, except for the inflation rate, the long-term interest rate, and bank lending growth. The lag length of the VAR model is set to 2 based on the AIC. The sample starting point is chosen to exclude the QE policy implemented by the BOJ in the 2000s, while the end point captures the termination of QQE. Table 1 provides details of the data sources.

[8] Hirata et al. (2024) reported that Kendall's rank correlation coefficient between the 10-year JGB yield and the BOJ's policy stance is significant at the 5% level in both conventional and unconventional policy periods.

3.4 Identification Strategy

We use the "narrative sign restrictions" to identify UMP shocks. The method imposes restrictions on the structural shocks by using external narrative information about historically important events.

We consider two types of narrative sign restrictions based on Antolín-Díaz and Rubio-Ramírez (2018) and Giacomini et al. (2023). One is called "shock sign restrictions," which impose restrictions on the sign of structural shocks (structural residuals) at specific periods. When the sign of the jth structural shock is negative, the restriction can be written as follows:

$$\varepsilon_{j,t_\nu} = \mathbf{e}'_{j,n}\varepsilon_{t_\nu}(\Theta) \ < \ 0, \tag{4}$$

where $\mathrm{e}_{j,n}$ represents the jth column of $\mathbf{I}_n$, and $\varepsilon_{t_\nu}(\Theta)$ represents the vector of structural shocks (structural residuals) at the specific event period $(t = t_\nu)$ based on the set of structural parameters (Θ).

The other restriction is called "historical decomposition restrictions," which imposes restrictions on the magnitude of the contribution of a particular structural shock in the historical decompositions of a certain variable in a certain period. The restriction is further classified into Type A or Type B based on the reference of the magnitude of the contribution.

The Type A restriction is that the contribution (absolute value) of a particular structural shock is the largest among all the contributions of the other structural shocks. In other words, the structural shock is regarded as the "most important contributor." The following expression of $H_{i,j,t_\nu,t_\nu+h_\nu}(\cdot)$ represents the contribution of the jth shock to the observed unexpected change in the ith variable between periods t_ν and $t_\nu + h_\nu$ by historical decomposition.

$$\begin{aligned} &\mid H_{i,j,t_\nu,t_\nu+h_\nu}(\Theta, \varepsilon_{t_\nu}(\Theta), ..., \varepsilon_{t_\nu+h_\nu}(\Theta)) \mid \\ &\qquad - \max_{j' \neq j} \mid H_{i,j',t_\nu,t_\nu+h_\nu}(\Theta, \varepsilon_{t_\nu}(\Theta), ..., \varepsilon_{t_\nu+h_\nu}(\Theta)) \mid > \ 0 \end{aligned} \tag{5}$$

On the other hand, the Type B restriction is that the contribution (absolute value) of a particular structural shock is greater than the sum of the contributions of all other structural shocks. In other words, the structural shock is regarded as the "overwhelming contributor."

$$\begin{aligned} &\mid H_{i,j,t_\nu,t_\nu+h_\nu}(\Theta,\varepsilon_{t_\nu}(\Theta),...,\varepsilon_{t_\nu+h_\nu}(\Theta)) \mid \\ &\qquad - \sum_{j'\neq j} \mid H_{i,j',t_\nu,t_\nu+h_\nu}(\Theta,\varepsilon_{t_\nu}(\Theta),...,\varepsilon_{t_\nu+h_\nu}(\Theta)) \mid > 0 \end{aligned} \tag{6}$$

The narrative sign restrictions explained above are also summarized in Table 2. In our benchmark case, our policy variable is the third variable and we refer to its innovation ($j = 3$) as the "UMP shock" and impose the following narrative sign restrictions.

$$\varepsilon_{3,2013m04} < 0 \tag{7}$$

$$\varepsilon_{3,2014m11} < 0 \tag{8}$$

$$\varepsilon_{3,2016m02} < 0 \tag{9}$$

$$\mid H_{3,3,2016m02}(\Theta,\varepsilon_{2016m02}(\Theta)) \mid - \sum_{j'\neq 3} \mid H_{3,j',2016m02}(\Theta,\varepsilon_{2016m02}(\Theta)) \mid > 0 \tag{10}$$

Equations (7)–(9) impose the "shock sign restrictions" so that the UMP shock is negative (expansionary) at the three Kuroda bazooka dates, April 2013, November 2014, and February 2016. Equation (10) imposes a Type B "historical decomposition restriction": in February 2016, the UMP shock's contribution to the long-term interest rate exceeds the sum of contributions from all other shocks.

These "shock sign restrictions" and "historical decomposition restrictions" have been motivated and rationalized by means of narrative analysis in Section 3.1. Furthermore, similar to Badinger and Schiman (2023), we note that our restrictions in the benchmark case differ from those of Antolín-Díaz and Rubio-Ramírez (2018) in their analysis of US monetary policy shocks because we do not combine our narrative restrictions with standard sign restrictions on impulse responses.

3.5 Estimation

In this study, we estimate the structural VAR in equation (3) using standard Bayesian methods with a Minnesota prior on the VAR coefficients. Giacomini et al. (2023) recommend replacing the conditional likelihood in the estimation algorithm of Antolín-Díaz and Rubio-Ramírez (2018) with the unconditional likelihood when constructing the posterior. Following this recommendation, Badinger and Schiman (2023) omit the importance sampling step of the algorithm in Antolín-Díaz and Rubio-Ramírez (2018). In our analysis, we evaluate the posterior based on both the conditional and unconditional likelihoods. Since the results were robust to this choice, we report only the results based on the latter.

In the estimation algorithm, we first draw a set of parameters $(\mathbf{B}, \mathbf{\Sigma})$ from the Normal-Inverse-Wishart posterior.[9] Simultaneously, for each posterior draw, an orthogonal matrix $\mathbf{Q}$ is drawn from the uniform distribution (Haar measure) using QR decomposition. We retain the tuple $(\mathbf{B}, \mathbf{\Sigma}, \mathbf{Q})$ if it satisfies the narrative sign restrictions; otherwise, the draw is discarded. This procedure is repeated until the number of valid draws reaches the required target.[10] Finally, the accepted draws are used to approximate the posterior distribution for analysis.

4 Results

4.1 Benchmark result

The estimation results for the benchmark case that imposes the three shock sign restrictions and a Type B historical decomposition restriction (overwhelming contributor) are reported in Figure 2, where the solid line and the shaded area show the posterior median and 68 percent highest posterior density (HPD) credible intervals for the impulse

[9]For $\mathbf{B}$, we set the Minnesota prior hyperparameters to $\lambda = 0.3$ (overall tightness) and $\alpha = 2$ (lag decay), incorporating dummy observations for initial conditions. Prior means are set to 1 for the first own lag and 0 otherwise. For $\mathbf{\Sigma}$, we use an Inverse-Wishart prior $\mathcal{IW}(S_0, v_0)$ with degrees of freedom $v_0 = n + 2$ and a diagonal scale matrix S_0 derived from univariate AR(1) residual variances.

[10]In this study, we repeat sampling until the number of draws satisfying the narrative sign restrictions exceeds 5,000.

responses of the six variables to an expansionary UMP shock over a 10-year period. The UMP shock has been normalized so that on impact the long-term interest rate (LTR_t) falls by 10 basis points (bps).

On the whole, the impulse responses to expansionary UMP shocks identified by using narrative sign restrictions are consistent with predictions from standard macroeconomic theory. First, both GDP and the inflation rate respond significantly in a positive direction. GDP increases within a few months of the shock, peaks at 0.4% after three years, and then gradually returns to its original level. The inflation rate also increases to 0.1% for about one year after the shock, and then gradually decreases. The result that the UMP shock has a positive effect on output and prices is consistent with the results of Miyao and Okimoto (2020) and Kubota and Shintani (2025).

Second, the three financial market variables also respond significantly. The stock prices and the growth rate of bank lending show a positive response, while the exchange rate shows a negative response, as it shows a response in the direction of a weaker yen. The stock prices increase by 4.8% after four years. The growth in bank lending also increases by 0.2% in one year. The exchange rate also shows a depreciation of the yen of 1.1% after four years. These responses imply that the exchange rate channel, asset price channel, and credit channel are all functioning as a transmission mechanism for unconventional monetary policy.

In Figure 3, we compare the actual series for each variable during the QQE period (April 2013–March 2024) with the counterfactual series obtained by shutting down the UMP shock, based on historical decompositions.[11] Focusing on GDP and the inflation rate, we can see that the counterfactual series without the UMP shock are lower than the actual series, and that the UMP shock had the effect of increasing GDP and the inflation rate. The maximum deviation is 11.1 trillion yen for GDP and 0.4 percentage points for the inflation rate. Figure 4 also shows the contribution of the UMP shock to the actual series of each variable. The historical decomposition confirms that the UMP

[11] Following the textbook treatment in Kilian and Lütkepohl (2017), we conduct a historical decomposition for April 2013–March 2024. We start at the beginning of the estimation sample, initialize lags at observed values, and implement the counterfactual by setting the UMP shock to zero over the QQE period while keeping all other realized shocks unchanged.

shock raised the level of GDP by 1.0% and the inflation rate by 0.2 percentage points on average over the period. With regard to financial variables, the UMP shock also affected the exchange rate by −2.5%, stock prices by 11.0%, and the growth rate of bank lending by 0.4 percentage points on average over the period. Our results imply that unconventional monetary policy is effective for the macroeconomy, and are broadly consistent with the results of Haba et al. (2025), who estimated the effects of UMP from the introduction of QQE in 2013 to the April-June quarter of 2023 using the Bank of Japan's large-scale macroeconomic model, Q-JEM (Quarterly Japanese Economic Model).[12]

4.2 Comparison with traditional identification methods

For comparison with the results of the benchmark case, we show the results of using other identification strategies that do not rely on the narrative information. Specifically, we show the results of using the recursive restrictions (Cholesky decomposition) and the standard sign restrictions.

Recursive restrictions are a traditional identification method in VAR analysis. In this specification, we assume the long-term interest rate is the policy variable. Following the conventional ordering, we place slow-moving variables (GDP, inflation rate) before the policy variable, and fast-moving variables (exchange rate, stock prices, bank lending) after it. Figure 5 reports the impulse responses to expansionary UMP shocks identified using recursive restrictions. Unlike the benchmark case based on narrative sign restrictions, this identification scheme produces several counterintuitive results. The inflation rate initially responds negatively, exhibiting the so-called "price puzzle." Furthermore, the exchange rate rises while stock prices and bank lending growth decline, which contradicts theoretical predictions.

On the other hand, the standard sign restrictions developed by Uhlig (2005) rely on weaker assumptions than traditional identification schemes, such as recursive restrictions, and have therefore been widely used in the literature. To implement the standard

[12] They reported that QQE boosted the level of real GDP by an average of 1.3 to 1.8%, and the year-on-year change in CPI (excluding fresh food and energy) by an average of 0.5 to 0.7 percentage points.

sign restrictions, we follow Schenkelberg and Watzka (2013), who examines the effects of Japan's QE, and impose that the long-term interest rate responds negatively and inflation responds positively for twelve months following an expansionary UMP shock. Figure 6 reports the impulse responses to an expansionary UMP shock identified using these standard sign restrictions. The results indicate that all variables move in directions consistent with theoretical predictions. In particular, GDP and inflation increase in response to an expansionary UMP shock. Among the three financial variables, stock prices and bank lending growth rise, whereas the exchange rate depreciates.

However, we observe that the credible intervals are wider than those in the benchmark case using narrative sign restrictions. It is a widely recognized drawback that identification based solely on standard sign restrictions frequently results in wide credible intervals. To address this issue, Antolín-Díaz and Rubio-Ramírez (2018) demonstrate that additionally imposing narrative sign restrictions can significantly sharpen the inference of structural VAR models. Figure 7 reports the results of imposing the same narrative sign restrictions as in the benchmark case on top of the standard sign restrictions. As shown in the figure, the credible intervals for the impulse responses of all variables narrow effectively, becoming comparable to those in the benchmark case.

One reason why the impulse-response estimates are sharpened by additionally imposing narrative sign restrictions is that they allow for more precise identification of the structural shocks.[13] Figure 8 shows the posterior distribution of the UMP shocks in February 2016, corresponding to the third Kuroda bazooka. The lighter histogram represents the case imposing only standard sign restrictions, while the darker histogram represents the case with both standard and narrative sign restrictions. Under standard sign restrictions alone, a portion of the distribution falls into the positive region (contractionary shocks). In contrast, when narrative sign restrictions are added, the entire distribution is confined to the negative region (expansionary shocks) .

These comparisons highlight the advantages of employing narrative sign restric-

[13] Out of one million parameter sets (1,000 draws of B, Σ and, for each, 1,000 draws of Q), 91,337 satisfy the standard sign restrictions. Conditional on this, 55.1%, 60.1%, 88.8%, and 13.4% satisfy (7)–(10) individually, and 2.6% satisfy them jointly, implying a 0.2% overall acceptance rate (0.3% under narrative-only restrictions).

tions for identification. In particular, narrative information allows for a more reliable evaluation of UMP effects compared to traditional identification methods.

4.3 Robustness Check

4.3.1 Type A vs. Type B historical decomposition restrictions

In the benchmark specification, we impose the "shock sign restrictions" in equations (7)–(9) as well as the Type B "historical decomposition restriction" in equation (10). In this section, we examine whether using a weaker historical decomposition restriction affects the estimation results. Specifically, we replace the Type B restriction in (10) with the Type A "historical decomposition restriction" (most important contributor) in (11):

$$\mid H_{3,3,2016m02}(\Theta, \varepsilon_{2016m02}(\Theta)) \mid - \max_{j' \neq 3} \mid H_{3,j',2016m02}(\Theta, \varepsilon_{2016m02}(\Theta)) \mid > 0 \tag{11}$$

Figure 9 displays the impulse responses to expansionary UMP shocks. The results using the Type A restriction are depicted by dotted lines (with lightly shaded credible intervals), while the benchmark results using the Type B restriction are shown by solid lines (with darker shaded credible intervals). Compared to the benchmark, the credible intervals under the Type A restriction are slightly wider. However, the median responses of each variable are virtually identical in both cases. This result suggests that the findings derived from the benchmark estimation are robust to the specific strength of the historical decomposition restrictions.

4.3.2 Alternative policy variables

In the benchmark estimation, we used the long-term interest rate as the policy variable for UMPs. In this section, we substitute it with the short-term shadow rate (SSR_t) constructed by Krippner (2020). To identify the UMP shocks, as in the benchmark estimation, we use shock sign restrictions at three points based on Kuroda's bazookas and one Type B historical decomposition restriction. For the Type B restriction, we impose the condition that the contribution of the UMP shock to the change in the short-term shadow rate in February 2016 is greater than the sum of the contributions of the other shocks.

Figure 10 shows the estimated impulse responses to the expansionary UMP shock. The UMP shock has been normalized so that the short-term shadow rate (policy rate) falls by 10 bps on impact. Similar to the benchmark case, the impulse responses to UMP shocks identified using narrative sign restrictions are broadly consistent with predictions from standard macroeconomic theory, even when using the short-term shadow rate as the policy variable. First, both GDP and the inflation rate respond significantly in a positive direction. GDP increases to 0.1% after a half-year, and then gradually returns to its original level. The inflation rate also increases to 0.1% in the second month, and then gradually decreases. Second, the three financial variables also respond significantly. Stock prices and the growth rate of bank lending respond positively, while the exchange rate responds negatively. Stock prices increase by 1.7% after three and a half years. The growth rate of bank lending also increases by 0.1% after one and a half years. The exchange rate depreciates by 0.6% after two months.

Furthermore, Figure 11 compares the actual values of each variable during the QQE period (April 2013–March 2024) with the counterfactual series constructed by excluding the UMP shock in the historical decomposition. Focusing on GDP and the inflation rate, we observe that the counterfactual series without the UMP shock lie below the actual series. This indicates that the UMP shock resulted an upward pressure on both GDP and the inflation rate, consistent with the benchmark case. The maximum deviation is 14.6 trillion yen for GDP and 0.7 percentage points for the inflation rate. Figure 12 also shows the contribution of the UMP shock to the realized value of each variable. The historical decomposition confirms that the UMP shock raised the level of GDP by 1.2% and the inflation rate by 0.3 percentage points on average over the period. Regarding financial variables, the UMP shock also affected the exchange rate by -3.7%, stock prices by 12.6%, and bank lending growth by 0.4 percentage points on average over the period.

In addition, Figure 13 presents the impulse responses to an expansionary UMP shock identified with Cholesky decomposition, using the short-term shadow rate as the policy variable. Similar to the case using the long-term interest rate, several variables exhibit puzzling responses inconsistent with theoretical predictions. The expansionary UMP shock leads to yen appreciation, lower inflation, and reduced bank lending growth. Based on these results, we confirm that our benchmark findings are robust to the choice of the policy variable.

4.3.3 Subsample analysis

In the benchmark case, we use data from 2007 to 2024 for estimation. However, this period includes the introduction and termination of QQE, as well as the outbreak of the COVID-19 pandemic, which may affect the stability of the results. Therefore, in this section, we re-estimate the model using data restricted to 2007–2019 to evaluate the impact of excluding the COVID-19 period on our benchmark results.

Figure 14 shows the impulse responses to expansionary UMP shocks based on this subsample. Even when the data period is limited to the pre-COVID-19 period, all variables respond in directions broadly consistent with theoretical predictions. In particular, our finding that a UMP shock significantly raises macroeconomic variables, such as GDP and the inflation rate, remains unchanged. Compared with the benchmark case, although some differences in the median responses are observed, the credible intervals overlap substantially in many cases, suggesting that these differences are not statistically significant.

5 Conclusion

This study evaluates the macroeconomic effects of Japan's unconventional monetary policy during the QQE period, using a structural VAR model with narrative sign restrictions for shock identification. Specifically, we identify UMP shocks by imposing sign restrictions on structural shocks and on their contributions in historical decompositions, focusing on the three major monetary easing events known as Kuroda's bazookas.

The main findings are as follows. First, expansionary UMP shocks raise output and inflation rates. This result is consistent with the findings of Miyao and Okimoto (2020) and Kubota and Shintani (2025). Using the historical decomposition, we find that the UMP shock raised the level of GDP by 1.0% and the inflation rate by 0.2 percentage points on average over the QQE period. Second, the exchange rate, stock prices, and bank lending respond to UMP shocks in a manner consistent with the predictions of standard macroeconomic theory. This outcome implies that unconventional monetary policy operates through the exchange rate, asset-price, and credit channels. Third, we confirm that the narrative sign restriction is an effective tool for identifying UMP shocks. The use of narrative sign restrictions, either independently or in combination with standard sign restrictions, eliminates the puzzling responses of some variables observed under Cholesky decomposition, and also mitigate the wide credible intervals that often arise under standard sign restrictions.

This study can be extended in several directions. For instance, while we examined the macroeconomic effects of QQE as a single aggregate shock, QQE inherently comprises two major policy components: quantitative easing and qualitative easing. As Koeda (2019) and Nakashima et al. (2024) have pointed out, the macroeconomic impact of each component may differ. Incorporating narrative information may allow one to separately identify the macroeconomic effects of two components of QQE. We leave such an extension for future work.

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Table 1. Data source

Variable	Definition	Source
GDP_t	Monthly Real GDP	Japan Center for Economic Research
INF_t	Year-on-year change in CPI excluding food (less alcoholic beverages) and energy with consumption tax adjusted	Ministry of Internal Affairs and Communications
LTR_t	Newly issued government bonds yield (10 years)	Cabinet Office
EXR_t	Nominal effective exchange rate	Bank of Japan
$STOCK_t$	Nikkei Stock Average index (Nikkei 225)	Nikkei Inc.
$LENDING_t$	Year-on-year change in domestic bank loans (Monthly average)	Bank of Japan

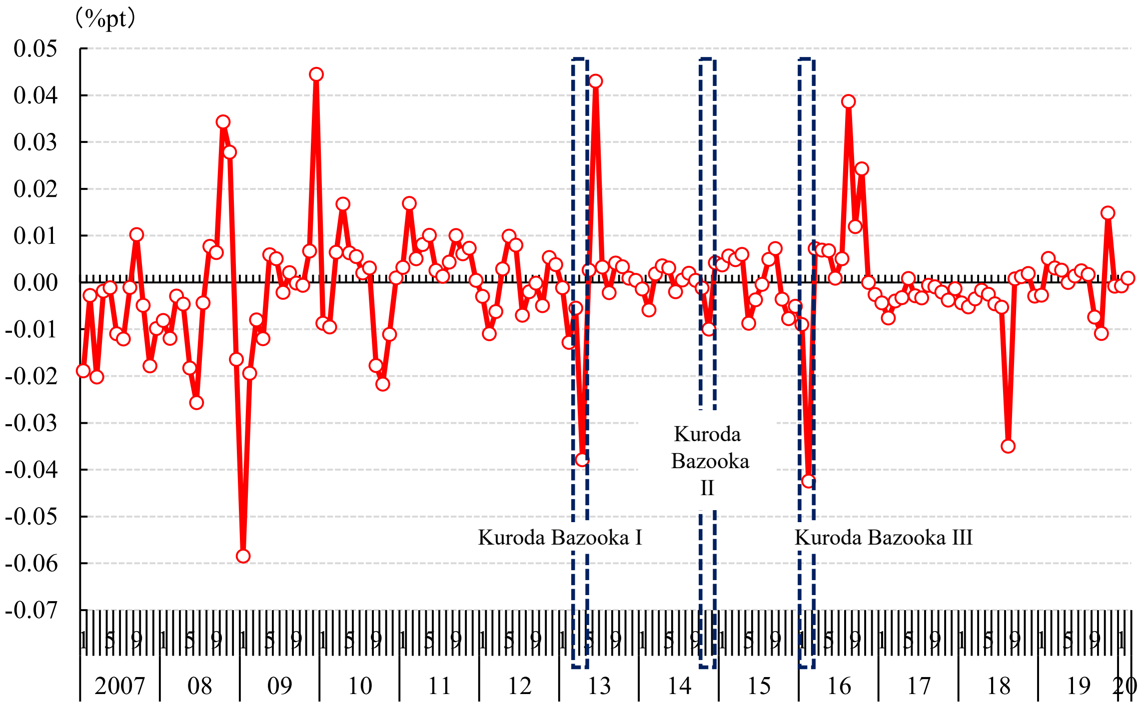
Notes: All variables are monthly series from January 2007 through December 2024. The GDP, exchange rate, and stock prices are in logarithmic form. The data series code for the domestic bank loan is BS02'FAABK_FAAB2DBHA37.

Table 2. Two types of narrative sign restrictions

(1)Shock sign restrictions
$\varepsilon_{j,t_\nu} = \mathbf{e}'_{j,n}\varepsilon_{t_\nu}(\Theta) < 0$
(2)Historical decomposition restrictions
(I)Type A restrictions (most important contributor)
$\mid H_{i,j,t_\nu,t_\nu+h_\nu}(\Theta, \varepsilon_{t_\nu}(\Theta), ..., \varepsilon_{t_\nu+h_\nu}(\Theta)) \mid - \max_{j'\neq j} \mid H_{i,j',t_\nu,t_\nu+h_\nu}(\Theta, \varepsilon_{t_\nu}(\Theta), ..., \varepsilon_{t_\nu+h_\nu}(\Theta)) \mid > 0$
(II)Type B restrictions (overwhelming contributor)
$\mid H_{i,j,t_\nu,t_\nu+h_\nu}(\Theta, \varepsilon_{t_\nu}(\Theta), ..., \varepsilon_{t_\nu+h_\nu}(\Theta)) \mid - \sum_{j'\neq j} \mid H_{i,j',t_\nu,t_\nu+h_\nu}(\Theta, \varepsilon_{t_\nu}(\Theta), ..., \varepsilon_{t_\nu+h_\nu}(\Theta)) \mid > 0$

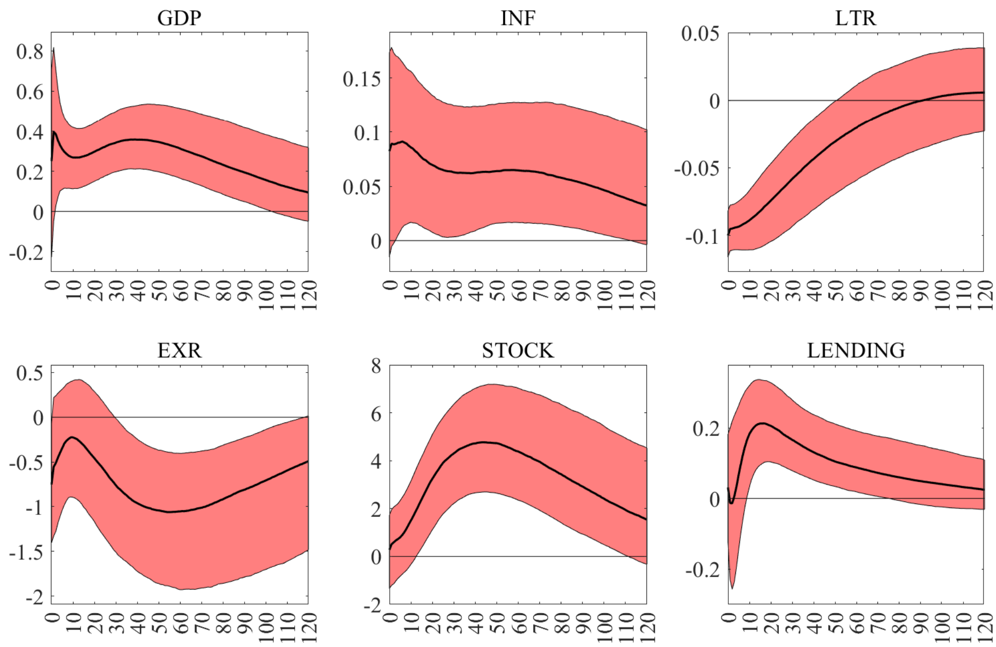
Notes: $\mathbf{e}_{j,n}$ is a selection vector defined as the jth column of $\mathbf{I}_n$. $H_{i,j,t_\nu,t_\nu+h_\nu}(\cdot)$ represents the contribution of the jth shock to the observed unexpected change in the ith variable between periods t_ν and $t_\nu + h_\nu$ by historical decomposition. Θ represents a set of parameters.

Figure 1. Monetary policy surprises in 10-year JGB futures



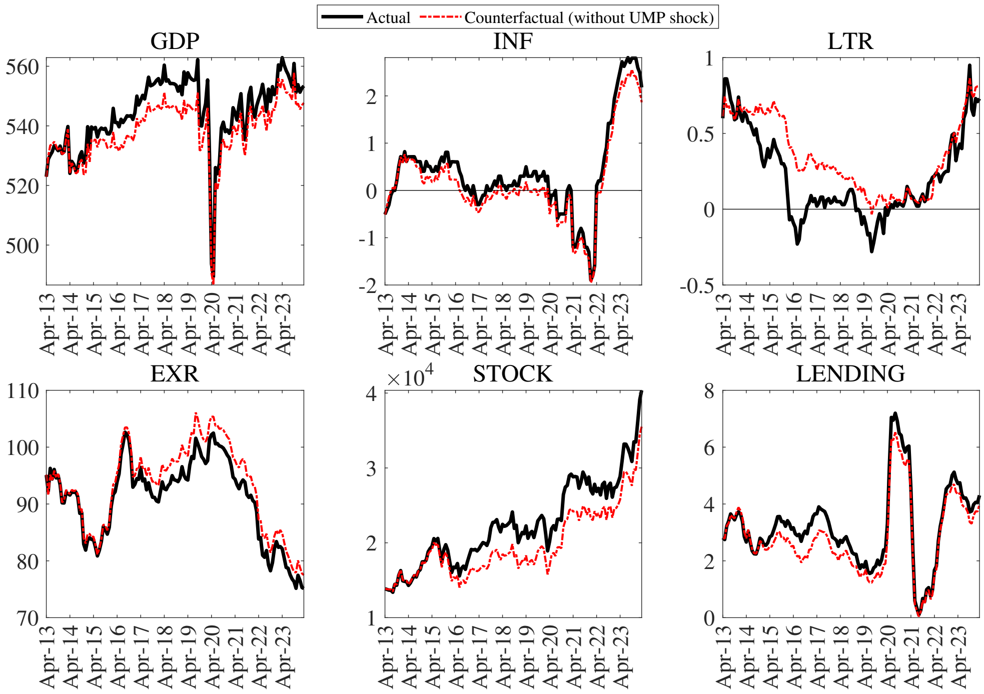
Notes: Monthly surprise series based on changes in 10-year JGB futures between 10 minutes before and 20 minutes after the release of BOJ statement (Kubota and Shintani, 2022).

Figure 2. Impulse responses to an expansionary UMP shock: Benchmark case



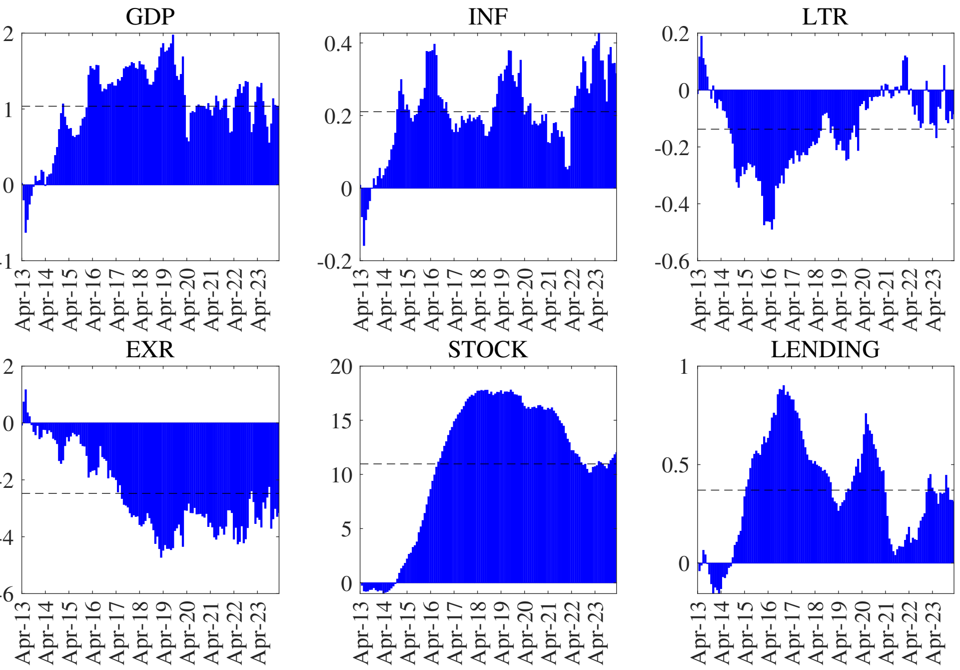
Notes: The impulse responses are obtained from our structural VAR model with shock sign restrictions and Type B historical decomposition restrictions (overwhelming contributor) based on narrative information on three events of Kuroda's bazooka. Based on 5000 draws that satisfy the restrictions. Solid line shows median estimates; shaded area corresponds to 68 percent credible intervals. The UMP shock has been normalized to have an impact of a 10-basis-point decline in LTR.

Figure 3. Historical counterfactuals during the QQE period



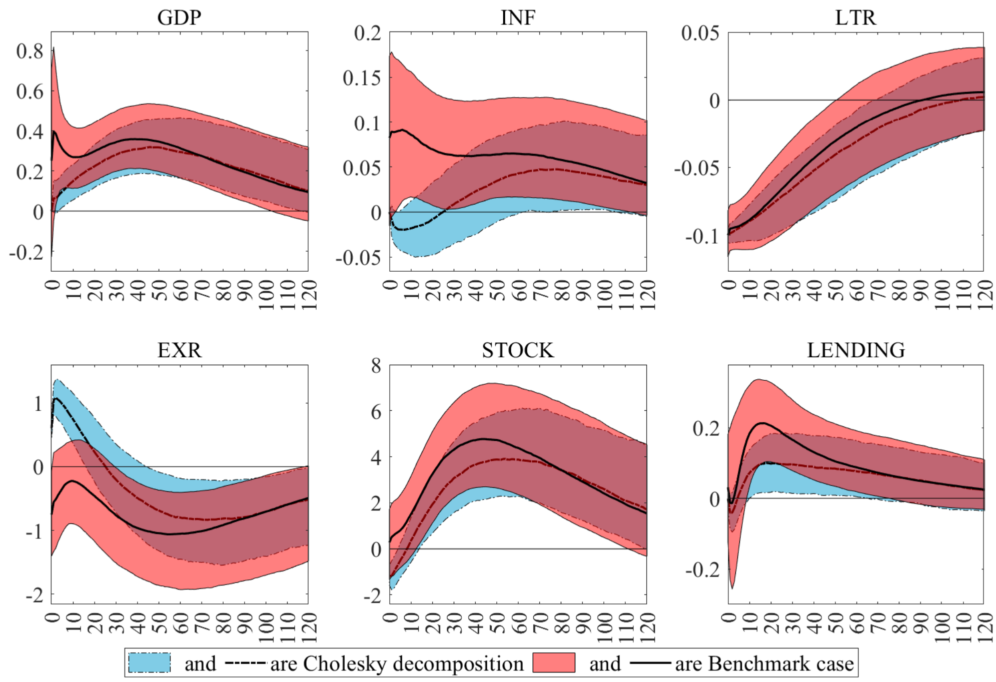
Notes: The bold line plots the actual series. The dashed line shows the counterfactual series with the UMP shock shut down in the historical decomposition.

Figure 4. Contribution of the UMP shock to the actual series during the QQE period



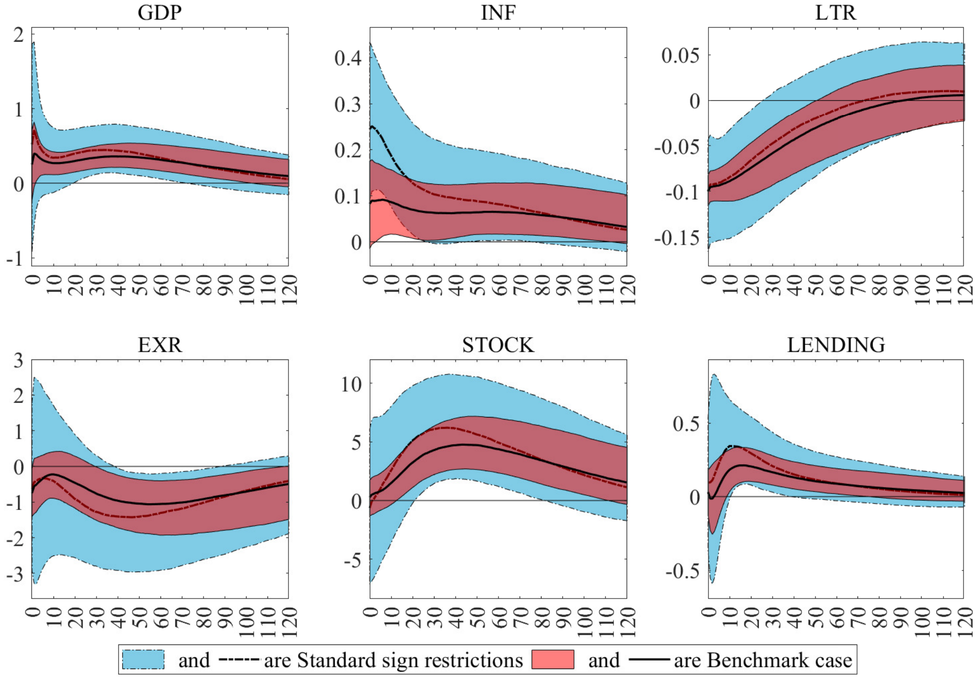
Notes: The bar chart depicts the contribution of the UMP shock to the actual series. The dashed line denotes the period average.

Figure 5. Impulse responses to an expansionary UMP shock: Cholesky decomposition



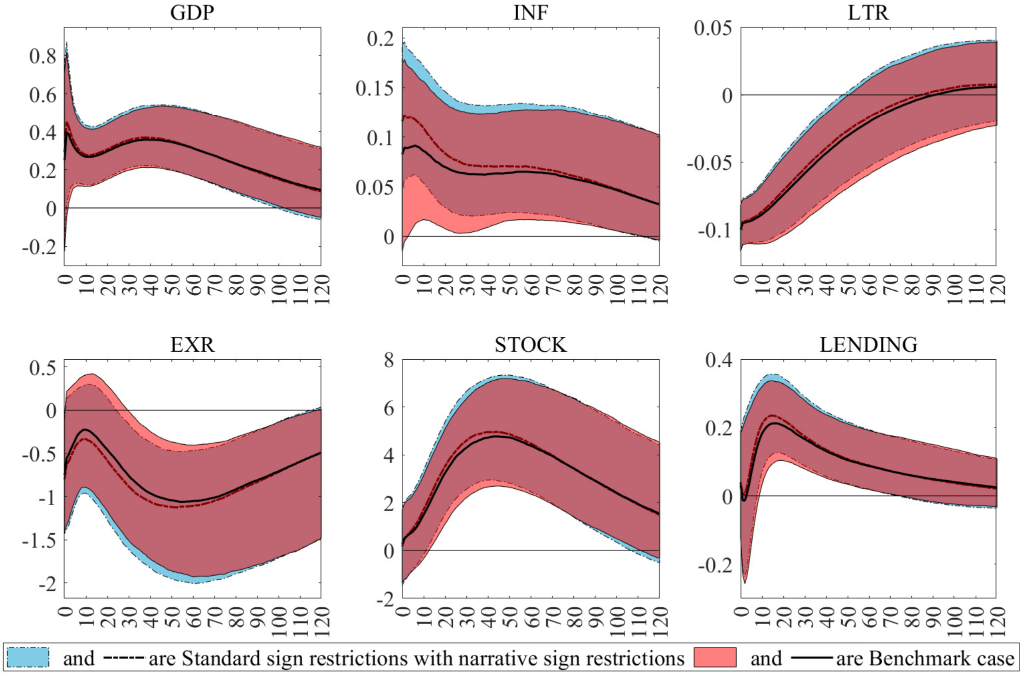
Notes: The impulse responses are obtained from our structural VAR model with Cholesky decomposition or narrative sign restrictions (Benchmark case). When using Cholesky decomposition, the variables are ordered as the slow variables (GDP_t, INF_t), the policy variable (LTR_t), the fast variables (EXR_t, $STOCK_t$, $LENDING_t$). Based on 5000 draws. The UMP shock has been normalized to have an impact of a 10-basis-point decline in LTR.

Figure 6. Impulse responses to an expansionary UMP shock: Standard sign restrictions



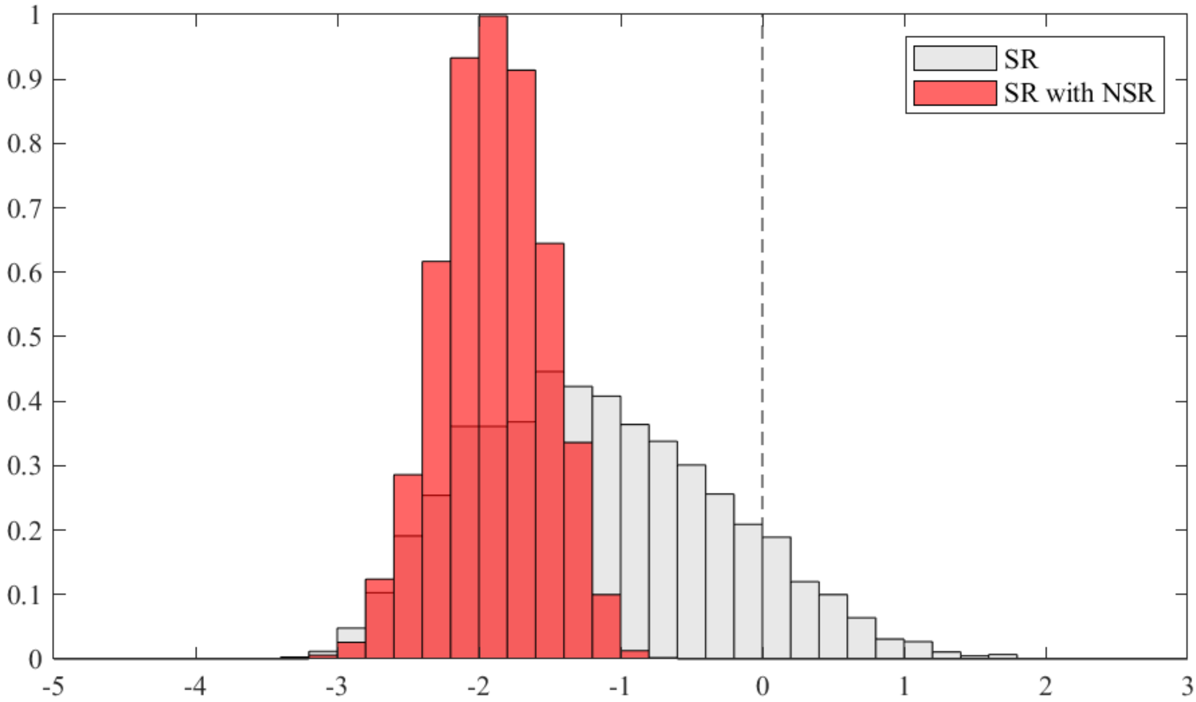
Notes: The impulse responses are obtained from our structural VAR model with standard sign restrictions or narrative sign restrictions (Benchmark case). Under standard sign restrictions, we impose that the long-term interest rate responds negatively and the inflation rate responds positively for twelve months after a UMP shock. Based on 5000 draws that satisfy the restrictions. The UMP shock has been normalized to have an impact of a 10-basis-point decline in LTR.

Figure 7. Impulse responses to an expansionary UMP shock: Standard sign restrictions and narrative sign restrictions combined



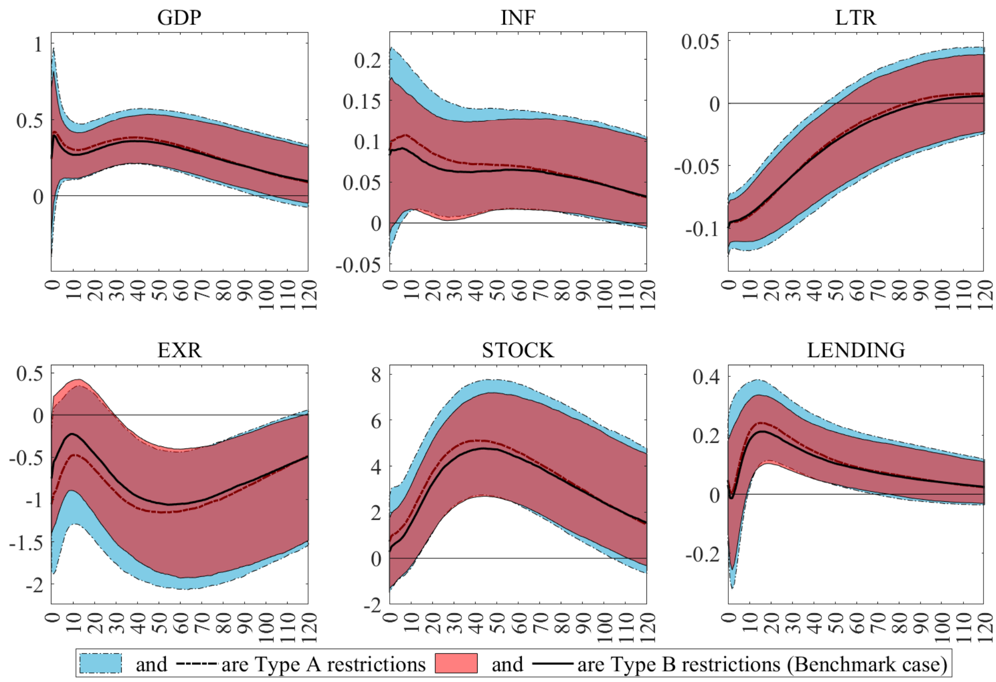
Notes: The impulse responses are obtained from our structural VAR model using standard sign restrictions with narrative sign restrictions or narrative sign restrictions (Benchmark case), solely. The settings for the standard sign restrictions are the same as the Figure 6. Based on 5000 draws that satisfy the restrictions. The UMP shock has been normalized to have an impact of a 10-basis-point decline in LTR.

Figure 8. Posterior distribution of the February 2016 UMP shock: With and without narrative sign restrictions



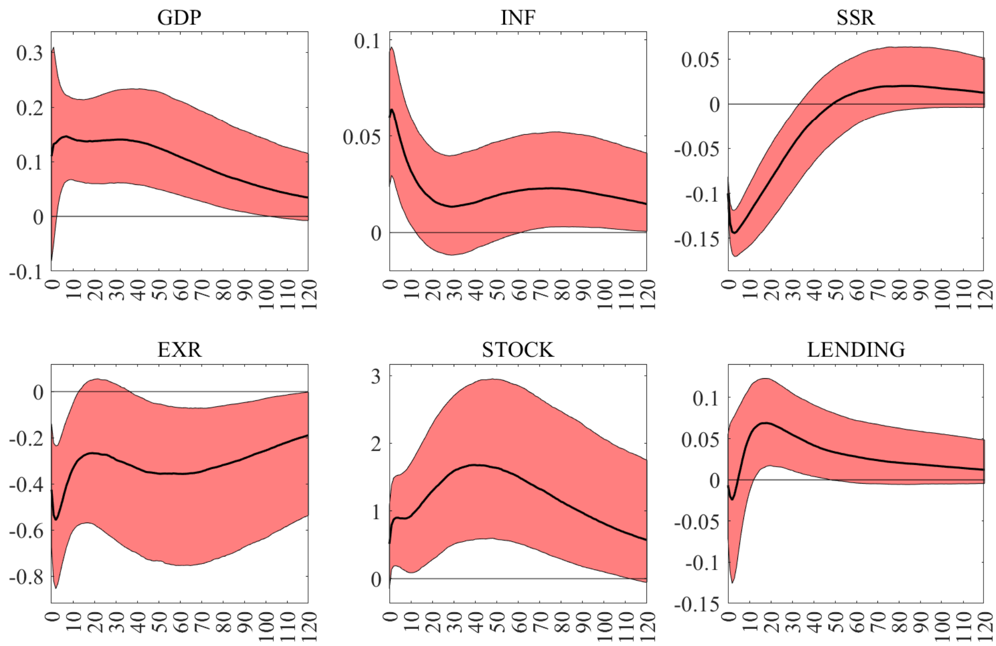
Notes: The histogram shows the posterior distribution of the February 2016 UMP shock under two specifications: one imposing only standard sign restrictions (lighter bars) and the other imposing both standard and narrative sign restrictions (darker bars). The horizontal axis shows values of the structural shock; and the vertical axis shows the corresponding posterior probability density. Based on 5000 draws that satisfy the restrictions.

Figure 9. Impulse responses to an expansionary UMP shock: Type A vs. Type B historical decomposition restrictions



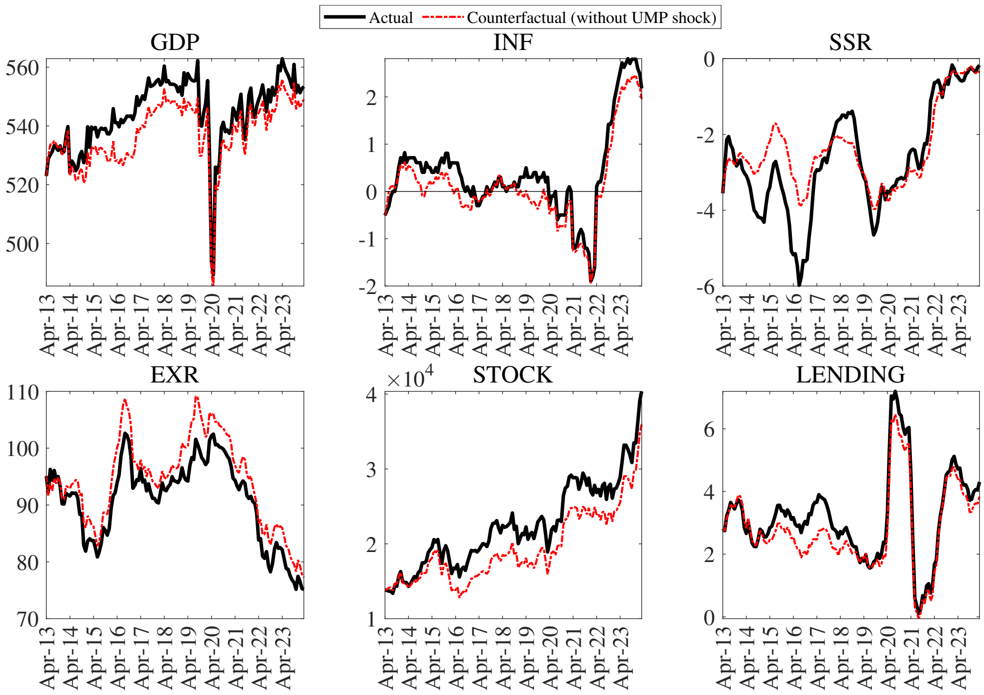
Notes: The lighter shaded area and dotted line represent the IRFs in the case where Type A (most important contributor) historical decomposition restrictions are imposed. The darker shaded area and solid line represent the IRFs of the case where Type B (overwhelming contributor) historical decomposition restrictions are imposed.

Figure 10. Impulse responses to an expansionary UMP shock using the short-term shadow rate as a policy variable : Narrative sign restrictions



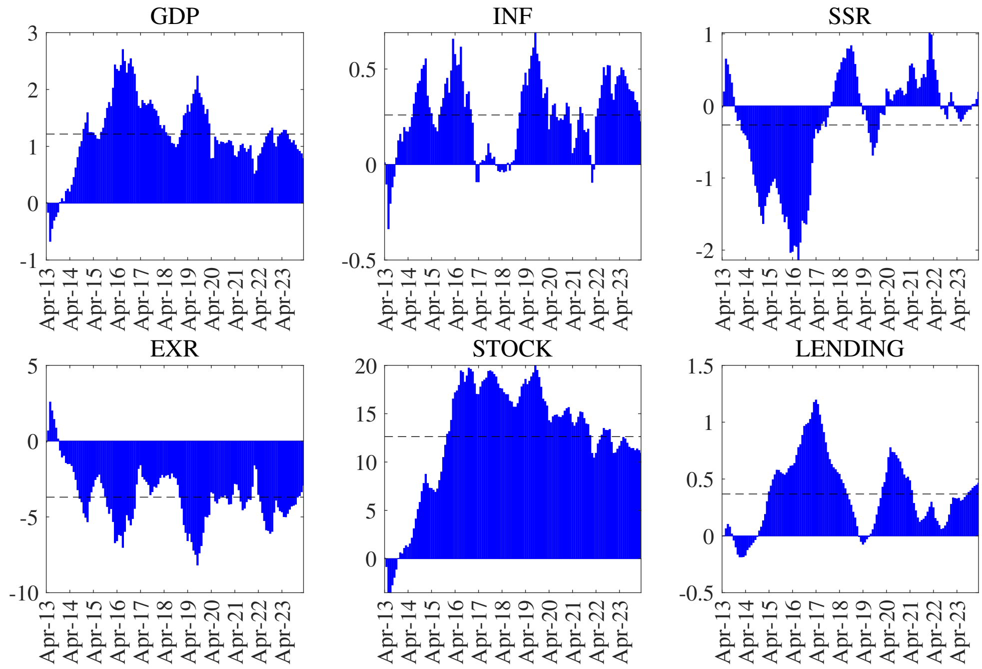
Notes: The impulse responses are obtained from our structural VAR model with shock sign restrictions and Type B historical decomposition restrictions (overwhelming contributor) based on narrative information on three events of Kuroda's bazooka. Based on 5000 draws that satisfy the restrictions. Solid line shows median estimates; shaded area corresponds to 68 percent credible intervals. The UMP shock has been normalized to have an impact of a 10-basis-point decline in SSR.

Figure 11. Historical counterfactuals during the QQE period using the short-term shadow rate as a policy variable



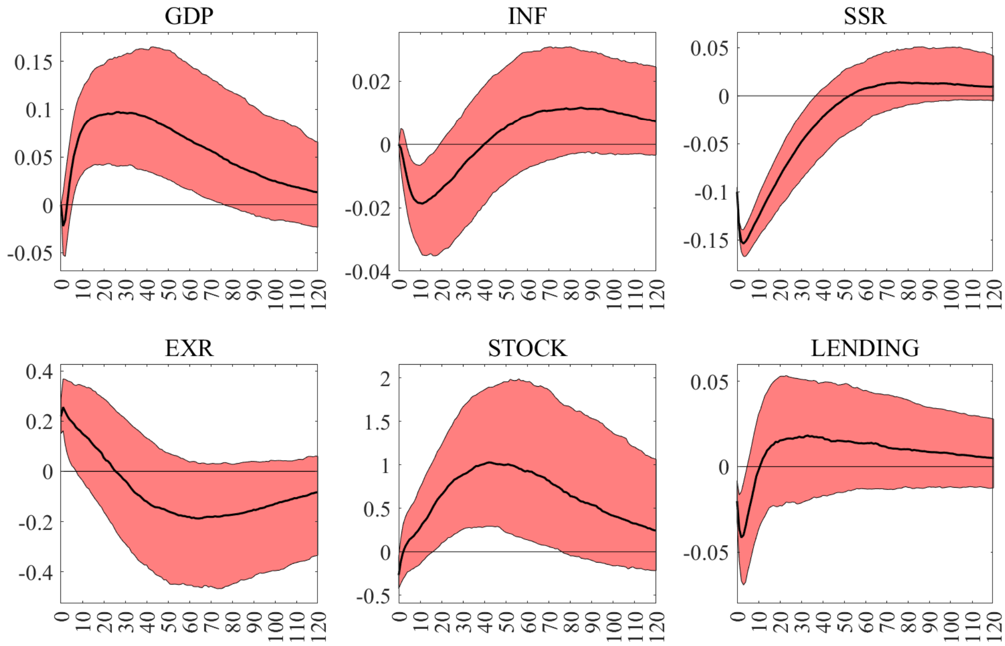
Notes: The bold line plots the actual series. The dashed line shows the counterfactual series with the UMP shock shut down in the historical decomposition.

Figure 12. Contribution of UMP shock to the actual value during the QQE period using the short-term shadow rate as a policy variable



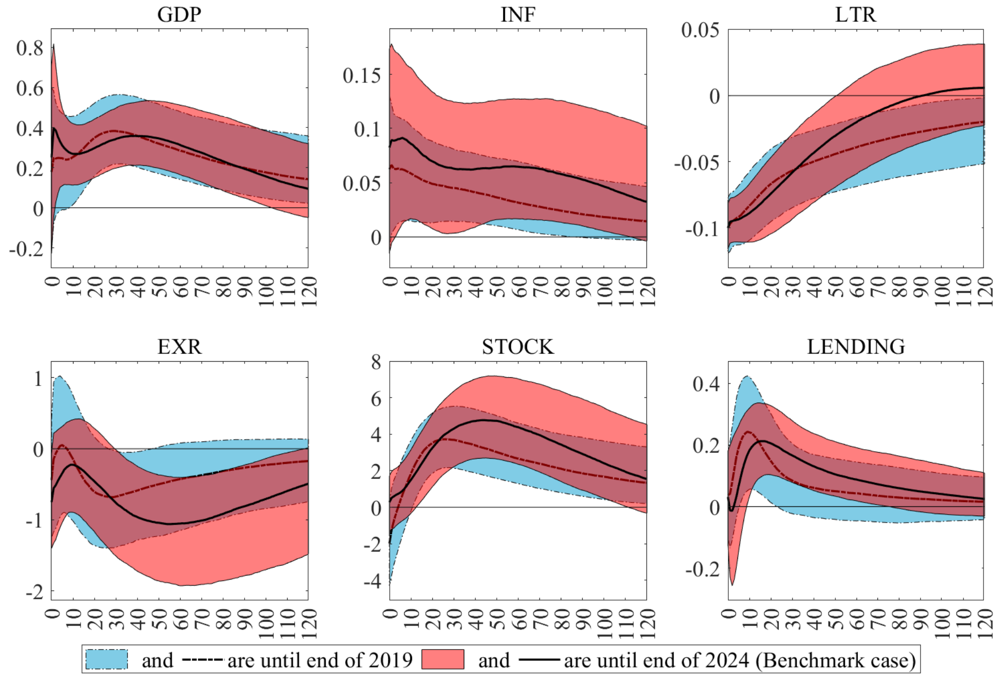
Notes: The bar chart depicts the contribution of the UMP shock to the actual series. The dashed line denotes the period average.

Figure 13. Impulse responses to an expansionary UMP shock using the short-term shadow rate as a policy variable: Cholesky decomposition



Notes: The impulse responses are obtained from our structural VAR model with Cholesky decomposition. The variables are ordered as the slow variables (GDP_t, INF_t), the policy variable (SSR_t), the fast variables (EXR_t, $STOCK_t$, $LENDING_t$). Based on 5000 draws. Solid line shows median estimates; the shaded area corresponds to 68 percent credible intervals. The UMP shock has been normalized to have an impact of a 10-basis-point decline in SSR.

Figure 14. Impulse responses to an expansionary UMP shock: Pre-COVID-19 subsample



Notes: The impulse responses are obtained using a subsample that divides the original data period from 2007 to the end of 2019. The restrictions used to identify the shocks are the same as in the benchmark case. The UMP shock has been normalized to have an impact of a 10-basis-point decline in LTR.