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"Big in Japan: A Structural Scenario Analysis of Monetary Policy Dynamics "

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ABSTRACT IN ENGLISH (100 words)

Japan, a pioneer in unconventional monetary policy, recently brought an era of negative interest rates to an end with its first hike in 17 years. We use structural scenario analysis to assess the impact of Bank of Japan's (BoJ) policy rate hike and alternative paths on its economy, considering different scenario drivers. Across a baseline, contractionary, and expansionary scenario driven by either supply or demand shocks, our analysis clearly distinguishes the effectiveness of policy interventions on inflation and industrial production depending on the shock driving the scenario. Our findings suggest that the BoJ's monetary policy tools effectively combat supply shocks, while their demand-driven interventions have a limited impact on the economy.

ABSTRACT IN CATALAN/ SPANISH (100 words)

Japón, un pionero en política monetaria no convencional, terminó con las tasas negativas al subirlas por primera vez en 17 años. Usamos una análisis de escenarios estructurales para evaluar el impacto del aumento de la tasa del Banco de Japón (BoJ) y caminos alternativos, considerando diferentes impulsores. En un escenario de referencia, contractivo y expansivo impulsado por choques de oferta o demanda, nuestro análisis muestra la eficacia de las políticas sobre la inflación y la producción industrial según cada choque. Los hallazgos indican que las herramientas del BoJ combaten eficazmente choques de oferta, mientras que las intervenciones impulsadas por la demanda tienen un impacto limitado en la economia.

KEYWORDS IN ENGLISH (3)**:** MONETARY POLICY, STRUCTURAL SCNEARIO ANALYSIS, BANK OF JAPAN

KEYWORDS IN CATALAN/ SPANISH (3)**:** POLÍTICA MONETARIA, ANÁLISIS DE ESCENARIOS ESTRUCTURALES, BANCO DE JAPÓN

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Abstract

Japan, a pioneer in unconventional monetary policy, recently brought an era of negative interest rates to an end with its first hike in 17 years. We use structural scenario analysis to assess the impact of the Bank of Japan's (BoJ) policy rate hike and alternative paths on its economy, considering different scenario drivers. Across a baseline, contractionary, and expansionary scenario driven by either supply or demand shocks, our analysis clearly distinguishes the effectiveness of policy interventions on inflation and industrial production depending on the shock driving the scenario. Our findings suggest that the BoJ's monetary policy tools effectively combat supply shocks, while their demand-driven interventions have a limited impact on the economy.[1]

[1]We are grateful to our supervisor Professor Mishel Ghassibe and Robert Wojciechowski for their valuable guidance and helpful suggestions, and to Professor Luca Gambetti and Konstantin Boss for helping us get this paper off the ground. We would like to thank Juan Rubio-Ramirez (as referenced in Antolin-Diaz et al., 2021) and Martin Stuermer (as referenced in Boer et al., 2023) for sharing their codes, which assisted us in building our codes and model. Your contributions have significantly enhanced the quality and depth of our research.

Contents

1 Introduction

Since the burst of the asset price bubble in the late 1980s, Japan has faced persistent challenges in achieving sustainable economic growth and meeting its inflation target despite extensive monetary policy efforts. Constrained by the zero lower bound, these efforts have been characterized by unconventional methods such as quantitative and qualitative monetary easing (QQE) and yield curve control. However, prompted by the inflation that emerged during the pandemic, the Bank of Japan (BoJ) raised its policy rate in 2024 for the first time in nearly two decades. This development raises intriguing questions about the future of Japan's economy and its monetary policy stance. In fact, the low inflation that the BoJ attempted to stimulate before the pandemic was mainly driven by demand-pull factors, while the recent surge in prices seems to be driven by global supply disruptions (Fukunaga et al., 2024). Current governor Ueda (2024) also stated that the global supply shock that emerged during the pandemic was one crucial component for Japan to exit the low inflation era. This suggests that the underlying forces that drive Japan's economy will be of significant importance for the different paths that might be awaiting Japan and its monetary policymakers.

This paper aims to study future scenarios of BoJ monetary policy interventions, the implications of different underlying forces driving these scenarios and their impact on inflation and production. To address this, we apply structural scenario analysis following Antolin-Diaz et al. (2021), which relies on structural shocks identified through a structural vector autoregression (structural VAR or SVAR) analysis (Sims, 1980) with sign restrictions (Uhlig, 2005).[2] The analysis is conducted for three different scenarios: baseline, expansionary and contractionary monetary policy. In each scenario we condition on a policy interest rate path driven by either an aggregate supply (AS) or aggregate demand (AD) shock. We use quarterly data on industrial production (IP), core inflation and the shadow rate over the period from 1986 to 2023.

Structural scenario analysis helps to overcome limitations of reduced-form conditional forecasts from VAR models, specifically the issue of missing causal mechanisms that complicate interpretation. The key advantage of this method lies in its ability to differentiate between structural shocks, allowing us to determine whether the Japanese economy's response varies depending on the nature of the shock driving the policy rate. Furthermore, the approach integrates two widely used forecasting methods in economic analysis: forecasting conditional on observables as in Waggoner and Zha (1999) and forecasting conditional on shocks as in Baumeister and Kilian (2014), enabling a more efficient way to forecast within the

[2] We build on previous SVAR studies that have been conducted for Japan to identify structural shocks using sign restrictions see e.g. Fukunaga et al. (2024), Schenkelberg and Watzka (2013) and Nakahira (2009).

SVAR framework.[3]

Our results provide key insights into the effects of the BoJ's monetary policy on inflation and IP across different scenarios. In the baseline scenario, refraining from further monetary policy adjustments leads to lower inflation and a quicker improvement in IP when supply shocks, as opposed to demand shocks, are the primary driver. When the BoJ's contractionary policy is triggered by AS shocks, the effect on inflation is stronger than in the case of AD-driven interventions. Furthermore, IP exhibits a similar trend in these scenarios, which may be attributed to the different impacts of exchange rate fluctuations on imports and exports.[4] Under the expansionary scenario driven by supply factors, inflation rises at the end of the forecast horizon while it has negligible effects on inflation in the demand-driven scenario. This may be explained by the asymmetric effects of transmission channels (Lau and Yip, 2020). Overall, these results suggest that the BoJ's monetary policy tools more effectively manage the economy in a supply-driven scenario, while their demand-driven interventions have a limited impact. Results are also robust across various specifications of our model such as changes in lags, horizon and sample period.

Our findings contribute to the previous literature in several ways. To our knowledge, this is the first study to empirically demonstrate the differentiated impacts of BoJ monetary policy tightening on inflation and the real economy through a structural scenario approach. Unlike previous studies that primarily focus on technical model frameworks (e.g., Leeper and Zha (2002), Banbura et al. (2014) and Antolin-Diaz et al. (2021)), our research provides empirical insights into how varying drivers of policy intervention, whether cost-push or demand-pull, impact the economy. We offer empirical evidence on the different trajectories the BoJ might encounter depending on whether the scenarios are driven by supply or demand shocks. This distinction is crucial, as central banks traditionally respond more effectively to AD shocks (Firat and Hao, 2023). Our research thus offers novel insights into the implications of policy rate interventions for addressing supply driven inflation in the unique context of Japan. Additionally, this paper provides a timely analysis in light of the BoJ's recent policy adjustments.

The remainder of the paper is organized as follows. In the next section we discuss the empirical methodology, detailing the identification scheme and scenario analysis framework. Results from the SVAR analysis and conditional forecasting exercise follow in section 4. We interpret findings in section 5 and support results using robustness checks in section 6. Finally, section 7 concludes.

[3] The method has been used by e.g. Boer et al. (2023) that study the effects of climate policy mix on future oil prices and Breitenlechner et al. (2022) that look at spillovers of US monetary policy.

[4] As shown by previous studies (Amiti et al., 2014, Sasaki and Yoshida, 2018, Iwaisako and Ito, 1995).

2 Methodology and Data

2.1 Econometric Framework

We begin our analysis by estimating a SVAR model following the approach of Sims (1980). This methodology assumes that the economy is influenced by random economic disturbances, referred to as structural shocks, and that macroeconomic outcomes are the aggregate result of agents' responses to these disturbances.[5] To obtain the structural shocks of interest, we start by estimating a VAR model of order p, with a lag length of $p = 2$ quarters based on the Bayesian Information Criterion and Hannan-Quinn Criterion. We estimate,

$$\mathbf{y}_t = \mathbf{c} + \mathbf{A}_1\mathbf{y}_{t-1} + ... + \mathbf{A}_p\mathbf{y}_{t-p} + \epsilon_t \tag{1}$$

where $\mathbf{y}_t$ is a 3×1 vector of the endogenous variables IP, core inflation and the shadow rate, $\mathbf{c}$ is a 3×1 vector of constants, $\mathbf{A}_1\mathbf{y}_{t-1} + ... + \mathbf{A}_p\mathbf{y}_{t-p}$ are 3×3 matrices of the reduced form coefficients and $\epsilon_t \sim WN(\mathbf{0}, \mathbf{\Sigma})$ is a 3×1 vector of the innovations. The reduced form parameters lack economic interpretation due to correlation of $\epsilon_\mathbf{t}$. Therefore, to obtain economically meaningful insights, we estimate the VAR in its structural form

$$\mathbf{B}_0\mathbf{y}_t = \mathbf{c} + \mathbf{B}_1\mathbf{y}_{t-1} + ... + \mathbf{B}_p\mathbf{y}_{t-p} + \mathbf{u}_t \tag{2}$$

where $\mathbf{B}_0$ identifies the contemporaneous relationship between the endogenous variables, $\mathbf{B}_1, ..., \mathbf{B}_p$ are matrices of the structural coefficients called the impulse response functions (IRFs) and $\mathbf{u_t}$ is a vector of the uncorrelated shocks normalized to have a unit variance s.t. $\mathbf{u}_t \sim WN(\mathbf{0}, \mathbf{I})$. The VAR in structural form is an estimate of the structural representation under the assumptions that the innovations are a linear combination of the structural shocks and that the structural representation is invertible. The assumptions imply that the structural shocks and IRFs relate to the reduced form VAR in the following way,

$$\mathbf{y}_t = \mathbf{C}(\mathbf{L})\mathbf{u}_t \tag{3}$$

$$\epsilon_t = \mathbf{B}_0^{-1}\mathbf{u}_t \tag{4}$$

$$\mathbf{B}(\mathbf{L}) = \mathbf{B}_0\mathbf{C}(\mathbf{L}) \tag{5}$$

where (3) is the vector moving average underlying the model under stationarity.[6] Further, $\mathbf{B}_0$ has to satisfy $\mathbf{B}_0\mathbf{B}_0' = \mathbf{\Sigma}$. Identification of the model implies finding the $\mathbf{B}_0^{-1}$ that maps the innovations into the structural shocks.

[5]As formulated by Frisch (1933) and Slutzky (1937).

[6]We check for stationarity before estimation and all eigenvalues lie inside the unit circle.

2.2 Identification

Identification is achieved by means of conventional sign restrictions imposed on $\mathbf{B_0^{-1}}$ as introduced by Uhlig (2005) and Faust (1998). We identify three types of structural shocks: an aggregate supply shock, an aggregate demand shock, and a monetary policy shock. AS shocks can originate from shocks to technology, productivity or labor supply, while AD shocks may result from changes in consumer preferences and consumption patterns (Gambetti and Musso, 2017). MP shocks are defined as exogenous changes in the policy rate that are not due to the central bank‘s systematic response to the macroeconomic outlook (Miranda-Agrippino and Ricco, 2021).

In empirical literature such as Peersman and Smets (2001) and Wolf (2019), AS and AD shocks are mainly identified to control for other business cycle disturbances that might be confused with the monetary policy, as pointed out by Uhlig (2005). However, in the context of our study, these shocks are crucial for accurate identification. Given the BoJ's monetary policy stance, identifying these shocks helps better understand the historical developments and co-movements of IP, core inflation, and the shadow rate. This identification allows us to disentangle the driving forces behind the inflation that the BoJ needed to respond to.

As is commonly accepted in the literature, an AS shock moves production and inflation in opposite directions, whereas an AD shock moves them in the same direction. Monetary policy shocks are characterized by opposite movements in the shadow rate and inflation, with production following the direction of inflation. The sign restrictions, summarized in Table 1, are imposed both on impact and one period after the shock. They are consistent with conventional wisdom (and many DSGE models) and often employed in the SVAR literature.[7]

Table 1: Sign Restrictions

Variable / Shock	AS	AD	MP
Industrial production	+	+	−
Core inflation	−	+	−
Shadow rate	NA	NA	+

Using sign restrictions means that we do not obtain point estimates but rather a set of possible parameter intervals for the different elements in $\mathbf{B_0^{-1}}$. As proposed by Rubio-Ramirez et al. (2010), we generate 1000 draws of the matrix that satisfy the identifying restrictions. Following Fry and Pagan (2011), we impose a penalty function to select the

[7] Additional restrictions can be added on the shadow rate. However, imposing more restrictions can increase the likelihood that no draw of $\mathbf{B}_0$ satisfies all the constraints as Rubio-Ramirez et al. (2010) points out. Therefore, we choose to keep only the restrictions necessary that identify all three shocks.

matrix closest to the median by minimizing the sum of squared differences, as they note that the median itself might not necessarily correspond to any of the identified models. For inference we employ the frequentist approach as proposed by Granziera et al. (2018).

2.3 Data

The dataset includes three variables that reflect key aspects of the Japanese economy relevant to our study: core inflation, IP and the shadow rate ranging over the period from Q3 1986 to Q4 2023. Firstly, to gauge the underlying trend of consumer price changes, we use core inflation. The series is estimated as a weighted median of the consumer price index by the BoJ, with a year-on-year growth rate at a quarterly frequency (BoJ, 2024). In line with Venter (2020) and Schenkelberg and Watzka (2013), we employ IP as a proxy for output. The IP index is seasonally-adjusted, indexed at 100 in 2015, and transformed from a quarterly series to year-on-year growth rates (OECD, 2024b).

To effectively capture the impact of conventional and unconventional monetary policy interventions in Japan, we use a shadow short rate (SSR) estimate (Krippner, 2013) during periods when the short rate is limited by the zero lower bound (ZLB) and the overnight call rate (OECD, 2024a) during other periods. The use of an SSR estimate as a proxy for monetary policy has become increasingly common in studies of advanced economies experiencing extended ZLB periods (see e.g. Venter (2020) and Ouerk et al. (2020)). The SSR estimate is sourced at a monthly frequency and the overnight call rate at a quarterly frequency. The monthly data is converted to a quarterly frequency using a weighted average, and the final series is then constructed by replacing all positive values of the SSR with the overnight call rate.

2.4 Structural Scenario Framework

We employ structural scenario analysis to explore alternative paths of monetary policy in Japan, following the methodology presented by Antolin-Diaz et al. (2021). This approach enables the imposition of constraints on selected observable variables and a subset of future shocks, directly linking these variables' future paths to specific disturbances. Our primary objective is to forecast core inflation and IP over three years (h=12), based on varying paths of the shadow rate driven by different structural shocks. To illustrate this more precisely, consider an unconditional forecast with no restrictions imposed

$$\mathbf{y}_{T+1,T+h} = \mathbf{b}_{T+1,T+h} + \mathbf{M}'\epsilon_{T+1,T+h} \tag{6}$$

Here, $\mathbf{y}_{T+1,T+h}$ is a vector containing the estimated forecasts over the specified horizon. $\mathbf{b}_{t+1,t+h}$ and the matrix $\mathbf{M}$ depend on the parameters of the model. The first term in equation (6) is predetermined and reflects the dynamic part of the forecast without any future structural shocks. The second term captures the stochastic component, representing structural shocks over the forecast horizon. The distribution of the forecast is

$$\mathbf{y}_{T+1,T+h} \sim \mathcal{N}(\mathbf{b}_{T+1,T+h}, \mathbf{M}'\mathbf{M}) \tag{7}$$

as Antolin-Diaz et al. (2021) demonstrate, and $\mathbf{M}'\mathbf{M}$ depends only on reduced-form parameters, meaning identification is not required to produce an unconditional forecast. This implies that in unconditional forecasts, future shocks follow their unconditional distribution. To address the core focus of our study, we build on this and add restrictions to both observables and shocks using selection matrices formed by zeros and ones. Let $\bar{\mathbf{C}}$ be a $k_0 \times nh$ matrix imposed on the observables, where k_0 are the number of restrictions and $\boldsymbol{\Xi}$ is a matrix of size $k_s \times nh$, where k_s denotes the structural shocks that are restricted to retain their unconditional distribution. We then obtain the following distributions for future observables and shocks

$$\bar{\mathbf{C}}\mathbf{y}_{T+1,T+h} \sim \mathcal{N}(\mathbf{f}_{T+1,T+h}, \boldsymbol{\Omega}_f) \tag{8}$$

$$\boldsymbol{\Xi}\epsilon_{T+1,T+h} \sim \mathcal{N}(\mathbf{0}_{k_s\times 1}, \mathbf{I}_{k_s}) \tag{9}$$

The second condition implies $\underline{\mathbf{C}}\mathbf{y}_{T+1,T+h} \sim \mathcal{N}(\underline{\mathbf{C}}\mathbf{b}_{T+1,T+h}, \mathbf{I}_{k_k})$ where $\underline{\mathbf{C}} = \boldsymbol{\Xi}(\mathbf{M}')^{-1}$. Combining these restrictions, we obtain the distribution for the conditional forecast or structural scenario

$$\hat{\mathbf{C}}\mathbf{y}_{T+1,T+h} \sim \mathcal{N}\left(\underbrace{\begin{bmatrix}\mathbf{f}_{T+1,T+h}\\ \underline{\mathbf{C}}\mathbf{b}_{T+1,T+h}\end{bmatrix}}_{\hat{\mathbf{f}}_{T+1,T+h}}, \underbrace{\begin{bmatrix}\boldsymbol{\Omega}_f & \mathbf{0}_{k_0\times k_s}\\ \mathbf{0}_{k_s\times k_0} & \mathbf{I}_{k_s}\end{bmatrix}}_{\hat{\boldsymbol{\Omega}}_f}\right) \tag{10}$$

with $\hat{\mathbf{C}}' = [\bar{\mathbf{C}}', \underline{\mathbf{C}}']$. In equation (10), the conditions on observables have been stacked with the conditions on shocks. The upper block indicates that certain variables must follow the path of $\mathbf{f}_{T+1,T+h}$ in expectation, while the second block ensures that unconditional shocks retain their unconditional distribution. It is evident that identification is needed to retain the forecast distribution. In addition, we fix the future paths of the conditioned variables at specific values instead of allowing the future values to lie within a certain range. Essentially, we consider the uncertainty around the estimation but not the restrictions. This approach is referred to as hard conditioning and is the most commonly employed approach within the literature (see e.g. Giannone et al., 2012 and Lenza et al., 2010), in this case indicated by $\hat{\boldsymbol{\Omega}}_f = 0$. Then, to obtain a median forecast along with credible sets, we draw 1000 times from this distribution described in (10).

2.5 Forecasting Scenarios

We will explore three different paths of the shadow rate to understand how core inflation and IP might react to various actions made by the BoJ. Table 2 shows the specific paths, which we motivated using historic data, statements from the BoJ, policy documents and independent forecasters.

Table 2: Scenarios - Shadow Rate

	2024				2025				2026			
Scenario	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Baseline	-0.26	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Tightening	-0.26	0.05	0.05	0.18	0.18	0.30	0.30	0.43	0.43	0.55	0.55	0.55
Expansion	-0.26	0.05	0.05	0.00	-0.10	-0.20	-0.25	-0.50	-0.75	-1.00	-1.25	-1.50

The first scenario is the baseline, that will serve as our reference point for other scenarios. Since we are forecasting from the end of 2023 onward, we will incorporate the central bank‘s early 2024 announcement, where they state that the uncollateralized call rate should be within the range of 0 and 0.1. The BoJ expects to remain within the range if the current economic outlook, firms' long-term inflation expectations and observed wage-price cycle remains intact (Ueda, 2024). For simplicity, we take an average of this range (0.05) and assume the central bank maintains this average rate throughout the forecast horizon, implying the range itself will not change.

Next, we will consider a tightening scenario where we assume a modest rate hike every two quarters, with the policy interest rate reaching 0.55% at the end of the forecasting period. This scenario is based on a recent survey of economists predicting the BoJ's actions for the later quarters of 2024 (Fujioka and Li, 2024), as well as claims made by the BoJ governor (Ueda, 2024). According to Ueda (2024), an increase of the policy interest rate is plausible if the current economic outlook is revised upwards or if upward risk becomes high. Such a scenario might evolve if e.g. the wage-price cycle strengthens even further, causing upward pressure on prices relative to the baseline scenario. Our estimates also draw on the actions of other central banks that have been constrained by the ZLB and have recently hiked their policy rate. Given the state and history of the Japanese economy, the stated path follows what can be considered a dovish monetary policy. A dovish stance is typically used in economies that have been constrained by the ZLB for a long period needing to counteract deflationary pressures, stimulate borrowing and spending, and support economic expansion (Gorodnichenko et al., 2023).

Finally, we will look at a scenario where the BoJ returns to its unconventional monetary policy, reinstating a negative interest rate policy at the beginning of 2025. The projected sharp decline in the shadow rate is based on its historical patterns of volatile drops. Although the BoJ wants to move away from its previous stance with unconventional methods, governor Ueda (2024) states the bank will consider taking necessary action if prices and economic activity face a large downward shock. Although such a scenario is unpredictable, it's an important one since global external shocks have had large consequences for the Japanese economy. For instance, external shocks played a major role in bringing down inflation in the 90s, a catalyst of the low inflation era that characterized Japan's economy the following decades (Fukunaga et al., 2024).

3 Results

This section presents the empirical results of our model in two parts. First, we discuss the outcomes of the SVAR model through IRFs, forecast error variance decompositions (FEVDs), and historical decompositions (HDs). Second, building upon the SVAR results, we focus on the conditional forecasting to project the future economy in three different scenarios, which are driven by either aggregate demand or aggregate supply shocks.

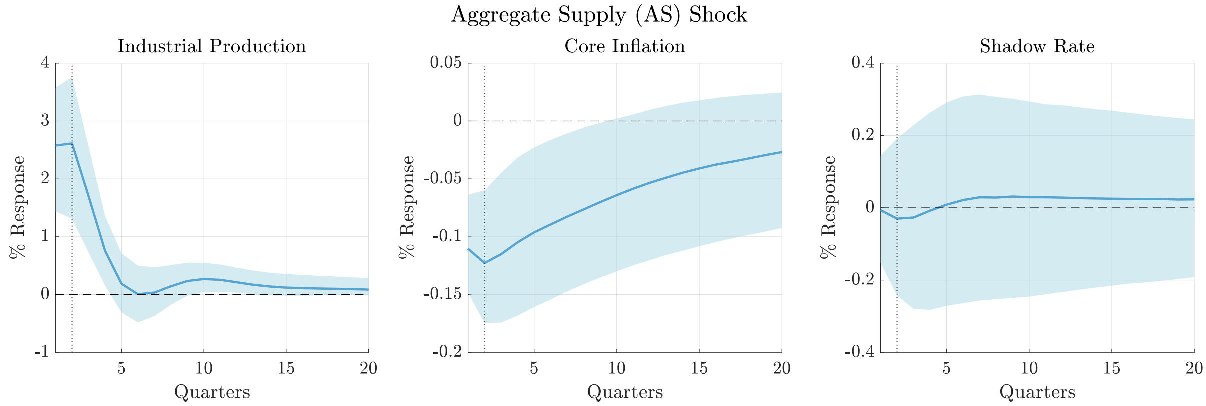
3.1 SVAR

3.1.1 Impulse response functions

The IRFs, illustrated in Figures 1, 2 and 3, show the dynamic effects of the three identified shocks on Japan's economy. The overall response signs are consistent with the imposed sign restrictions, and the confidence intervals are relatively narrow. However, the shadow rate exhibits wider confidence bands in response to AS and MP shocks. For the AS shock, this can be partly attributed to the absence of sign restrictions on the shadow rate. In the case of the MP shock, the wider bands, despite the imposed sign restriction, can reflect the nature of the shadow rate in capturing both the BoJ's call rate and unconventional monetary policy measures when nominal rates are at or near zero.

IRFs of the AS shock are reported in Figure 1. The immediate rise in growth of IP and decrease in core inflation is consistent with the imposed sign restrictions. IP peaks significantly in the first few quarters due to enhanced production capabilities, while core inflation falls sharply, indicating reduced price pressures from the increased supply of goods and services. Over time, both responses stabilize around zero, showing that the initial impacts are transitory and the economy adjusts to the new supply levels. These findings align with empirical research by Schenkelberg and Watzka (2013), which also identified similar short-term dynamics in response to supply shocks in Japan.

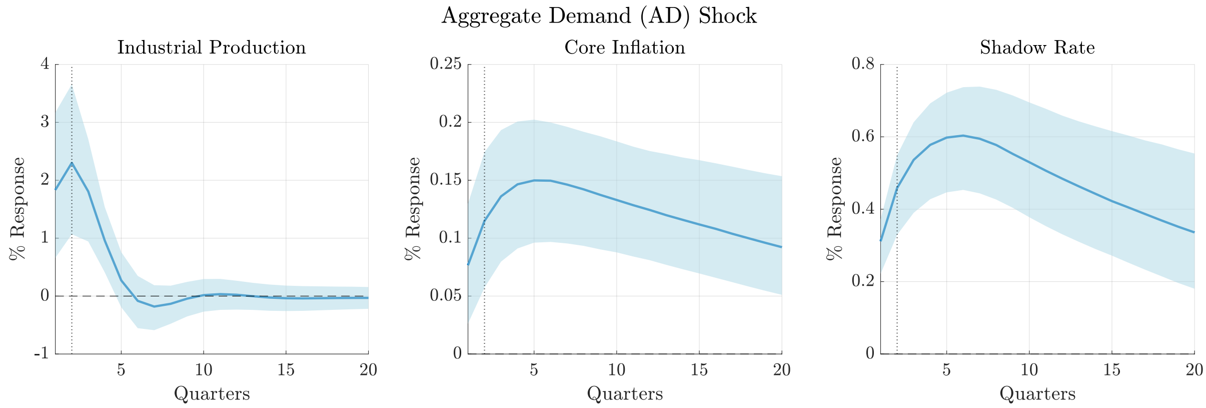
Figure 1: Impulse Response Functions to AS Shock



Note: The blue (lighter) shaded area represents the 68% (point-wise) confidence bands for the IRFs and the blue solid lines are the median IRFs to an aggregate supply shock of one standard deviation.

In the case of an AD shock (Figure 2), IP, core inflation and shadow rate all initially rise, as dictated by the sign restrictions. In the case of IP, the IRFs remains significantly positive beyond the restriction period, highlighting prolonged economic expansion, but reverts by the fifth quarter. Further, there is a substantial and persistent increase in inflation, signaling ongoing inflationary pressures following a demand surge. The shadow rate also rises significantly, reflecting a corresponding tightening of monetary policy in response to the increased demand and rising inflation. Similar patterns were observed by Christiano et al. (1999) in the U.S. economy, where demand shocks led to sustained increases in both output and prices, necessitating a monetary policy response. For Japan, Schenkelberg and Watzka (2013) and Fisher and Huh (2016) report similar findings.

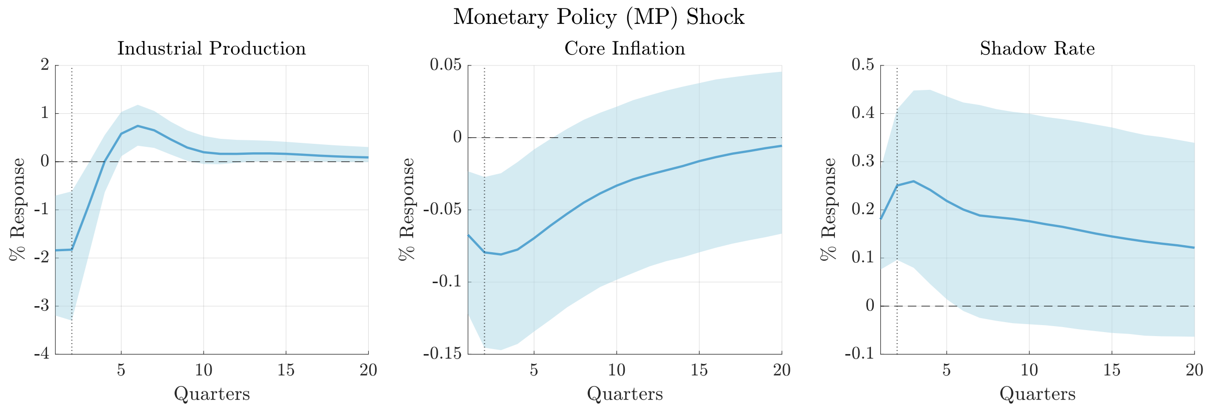
Figure 2: Impulse Response Functions to AD Shock



Note: The blue (lighter) shaded area represents the 68% (point-wise) confidence bands for the IRFs and the blue solid lines are the median IRFs to an aggregate demand shock of one standard deviation.

IRFs for the MP shock are reported in Figure 3. The IRFs for IP decreasing sharply on impact reflect the contractionary effect of tighter monetary policy, aligning with previous findings by Honda et al. (2013). From the second period onward, IP begins to recover, peaking around the sixth quarter before stabilizing around zero. This suggests a temporary boost in production due to the exchange rate adjustments resulting in lower input prices. Further, core inflation exhibits a significant and immediate decrease, indicating reduced demand. This deflationary effect is consistent with New Keynesian models where reduced demand leads to lower expected marginal costs, affecting current pricing (Nishizaki et al., 2014).

Figure 3: Impulse Response Functions to MP Shock



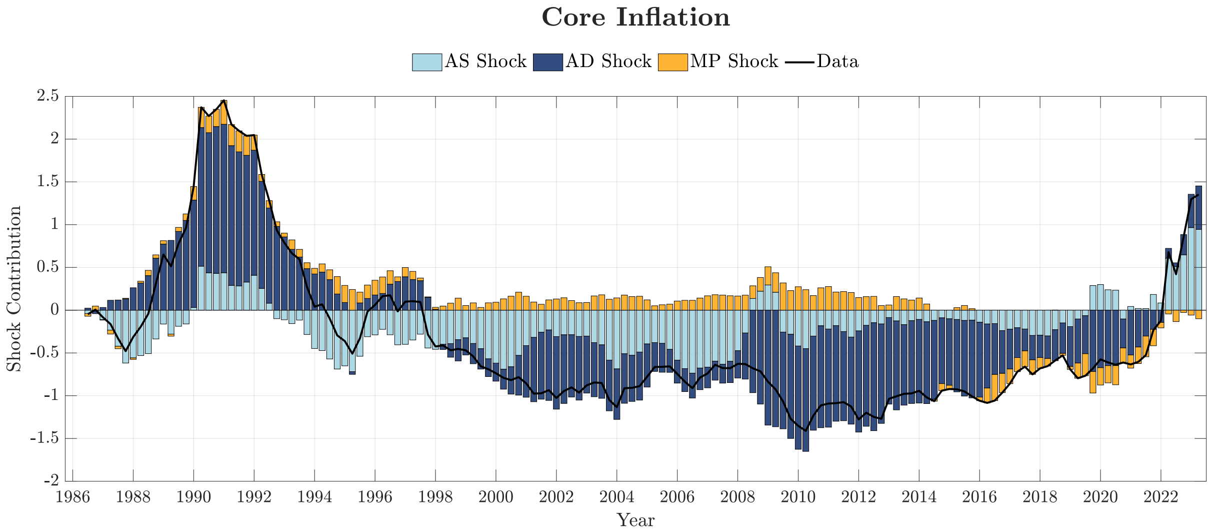
Note: The blue (lighter) shaded area represents the 68% (point-wise) confidence bands for the IRFs and the blue solid lines are the median IRFs to a tightening monetary policy shock of one standard deviation.

Over time, core inflation gradually converges towards zero, showing that the initial deflationary impact fades away. Lastly, after the initial peak, the shadow rate gradually declines until it begins to neutralize around the 6th quarter. This pattern suggests that while monetary tightening can curb inflation, it may also stimulate short-term economic activity. Findings by Fisher and Huh (2016) partially support this, confirming that tightening monetary policy shocks in Japan initially reduce demand, but subsequent economic adjustments can temporarily improve output.

3.1.2 Historical decomposition

In this section, we present the HDs of fluctuations in Japan's core inflation. For a brief HD analysis of IP and shadow rate, see appendix A. Figure 4 shows that core inflation was primarily driven by AD shocks during Japan's bubble economy in the early 1990s, as noted by Bayoumi and Collyns (2000). In the late 1990s to early 2000s, weak demand and deflationary pressures were evident, with MP shocks having a deflationary impact, consistent with Ueda (2000). During the global financial crisis, negative AD shocks reflected demand-side deflationary pressures, while MP shocks had a deflationary impact despite aggressive monetary easing efforts (Auerbach and Gorodnichenko, 2012).

Figure 4: Historical Decomposition of Core Inflation

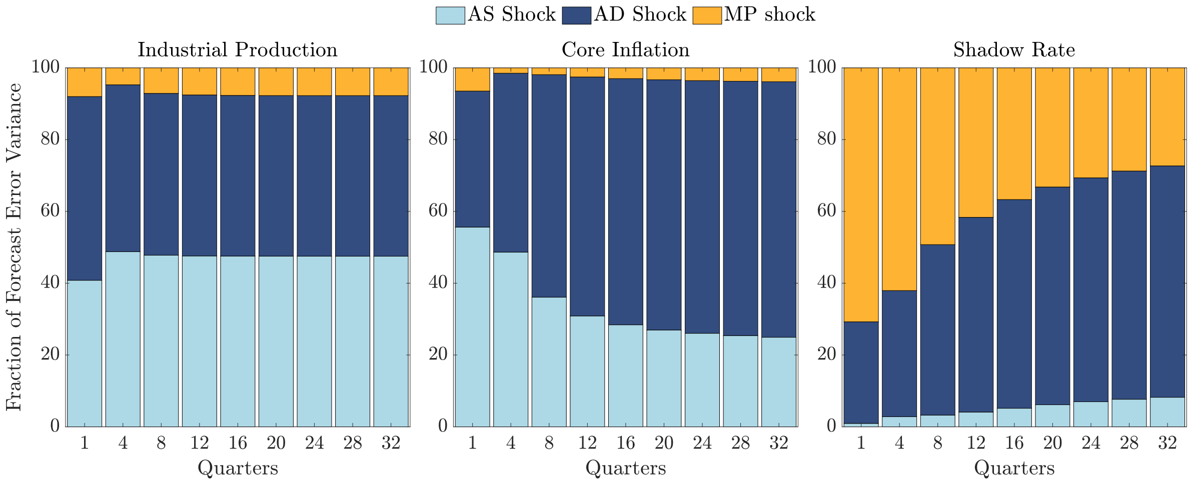


Post-2010, mixed contributions to core inflation were observed, with AD shocks turning positive and MP shocks reflecting sustained monetary easing (Hausman and Wieland, 2014). During the pandemic, AD shocks put downward pressure on core inflation. Recently, inflation has increased due to significant contributions from AS shocks, reflecting supply constraints and rising input costs (Goodhart and Pradhan, 2020). This is supported by Fukunaga et al. (2024), who noted the interplay of domestic and global supply shocks in rising consumer prices.

3.1.3 Forecast error variance decomposition

Figure 5 shows the FEVDs of IP growth, core inflation and the shadow rate. For IP, both AS and AD shocks play equally significant roles, indicating that its unexpected changes are driven by both supply-side factors and demand-side factors. For core inflation, AD shocks are the primary drivers of unexpected movements at horizons greater than one year, implying that persistent changes in AD heavily influence inflation. This result aligns with the findings of Fukunaga et al. (2024), who highlighted the significant role of demand shocks in driving inflation. Regarding the shadow rate, AD shocks are the main drivers over longer horizons. Initially, MP shocks significantly impact the shadow rate, underscoring the central bank's role in short-term adjustments. However, the influence of MP shocks diminishes over time, and AD shocks become more significant. This shift suggests that while monetary policy is crucial in the short term, long-term variations in the shadow rate are increasingly driven by economic demand conditions. These results are consistent with Antolin-Diaz et al. (2021), who found that the bulk of the unexpected variation in interest rates is due to the monetary authority's response to AD shocks.

Figure 5: Forecast Error Variance Decomposition (FEVD)



Note: For each panel, the coloured bars represent the fraction of the total variance of the respective endogenous variable attributable to a specific structural shock at the horizon given by the horizontal axis.

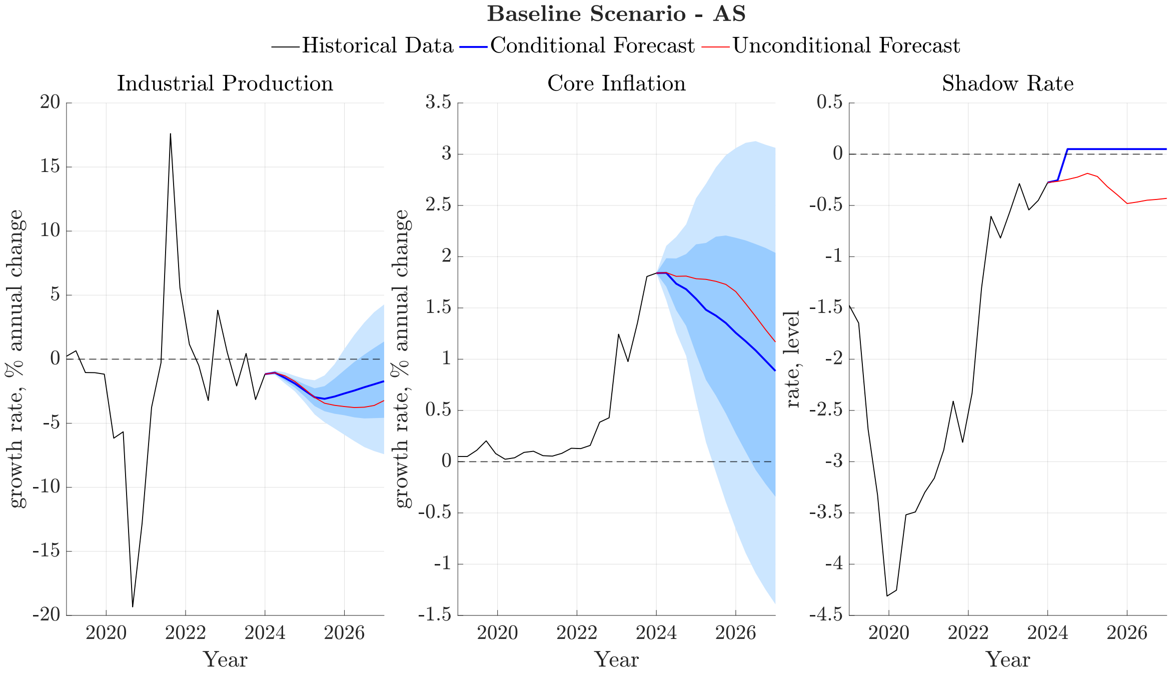
3.2 Structural Scenario Analysis

3.2.1 Conditional on policy rate driven by aggregate supply shock

Figures 6, 7 and 8 present conditional forecasts of Japan's IP and core inflation, along with the shadow rate. Each forecast is conditioned on the aforementioned scenarios of the shadow rate, where an aggregate supply shock is the main driver.

In the baseline scenario (Figure 6), we assume that the rise in inflation will gradually dissipate, reducing the need for further policy intervention. Following the April 2024 announcement, the policy rate remains constant, reflecting the BoJ's decision to maintain its current policy stance throughout the forecast horizon. The model anticipates a steady decrease in inflation from 1.8% in 2023 to 0.9% by the end of 2026. This decline reflects both the initial monetary policy change and the fading cost-push drivers of inflation. Comparatively, the unconditional forecast, which does not account for the conditions on the shadow rate and all structural shocks follow their unconditional distribution, predicts a delayed fall in inflation. This prediction indicates the contribution of the recent hike in stabilizing prices. The real effects of the monetary policy change have a delayed impact on IP, aligning with the established lag in monetary policy transmission to the real economy (Havranek and Rusnak, 2012, Batini and Nelson, 2001, Friedman, 1972). IP initially follows the same trajectory as the unconditional forecast throughout 2024. However, from 2025 onwards, the conditional path projects an improvement, with the growth rate stabilizing at -1.7% by the end of the forecast period.

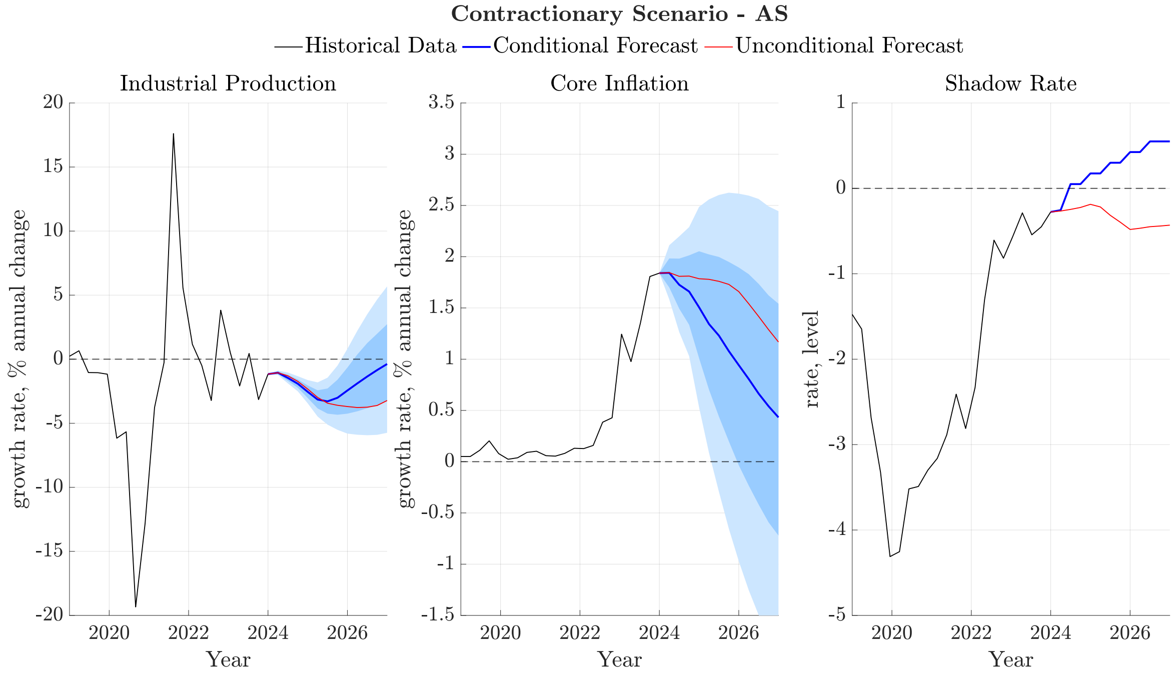
Figure 6: Baseline Scenario - Conditional on Shadow Rate driven by AS Shock



Note: Lighter and darker blue shaded areas denote the 40 and 68% pointwise credible sets around the conditional forecasts. Conditional and unconditional forecasts refer to the 4-quarter moving average.

In the contractionary scenario (Figure 7), the BoJ makes additional monetary policy adjustments due to the persistence of inflation. This scenario involves a gradual tightening of the monetary policy stance to mitigate the risks of e.g. wage-price spirals (see e.g. Bandera et al., 2023). Projections indicate that core inflation will reach 1.5% by the end of 2024, similar to the baseline scenario, suggesting minimal immediate impact from initial gradual rate hikes. By the end of 2026, core inflation is expected to decrease more significantly to 0.4%, demonstrating the effectiveness of the tightening measures, doubling the reduction compared to the baseline's 0.9%. IP shows improvement by the end of the forecast period, though it still falls short of entering positive growth territory, stabilizing just below 0%. This result may seem counterintuitive, as literature often suggests that tight monetary policy depresses productivity (Fornaro and Wolf, 2023, Jordà et al., 2020). However, this outcome might highlight the importance of the exchange rate channel for Japan where an interest rate hike leads to an appreciation of the yen. Currency appreciation makes imports cheaper, which has a positive impact on production (see e.g. Clarida and Gali, 1994, Faust and Rogers, 2003). Overall, in the contractionary scenario, the interest rate hike transmits to the economy as the projected change in IP, and core inflation is greater compared to the baseline scenario.

Figure 7: Contractionary Scenario - Conditional on Shadow Rate driven by AS Shock



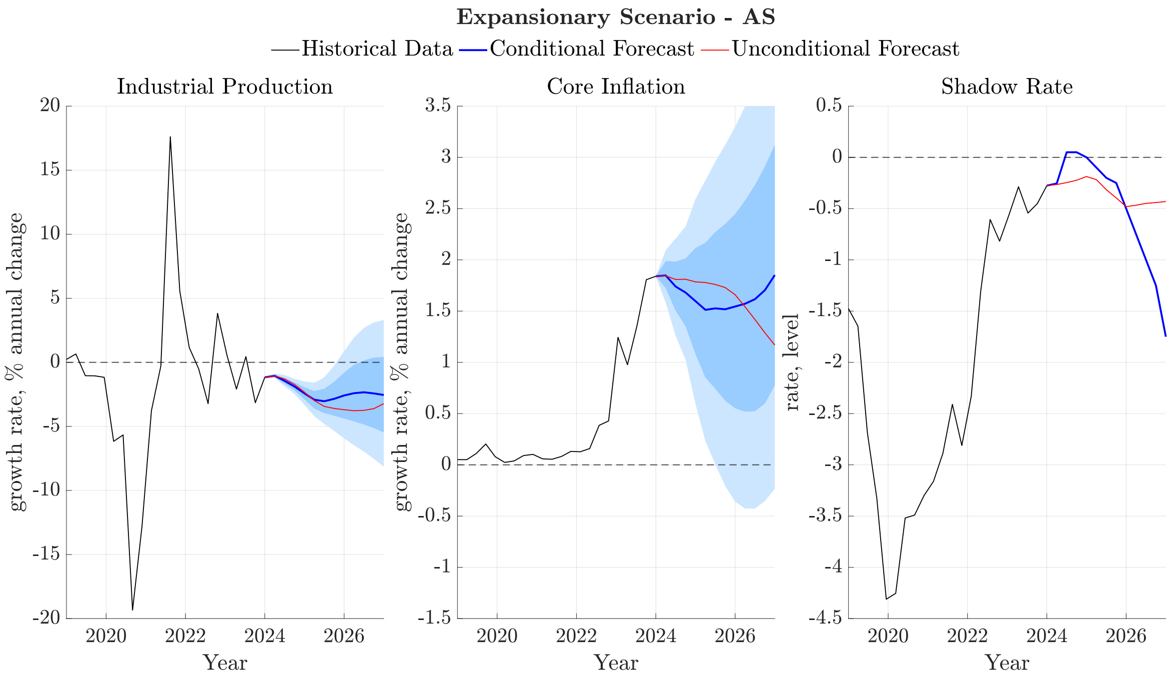
Note: Lighter and darker blue shaded areas denote the 40 and 68% pointwise credible sets around the conditional forecasts. Conditional and unconditional forecasts refer to the 4-quarter moving average.

In the expansionary scenario (Figure 8), the BoJ loosens monetary policy and reverts to unconventional measures, leading to a negative shadow rate. The path of core inflation takes a U-shaped form as it decreases on impact and reverts back to previous levels at end of the forecast horizon. The decrease on impact may be attributed to the weak and highly uncertain impact of unconventional measures on inflation in line with previous research (see e.g. Ikeda et al., 2022, Koeda, 2019). The increase throughout 2025-2026 can be explained by the exchange rate channel, where a depreciation of the yen increases the importing costs, leading to an increase in inflation. This is in line with previous research showing that the exchange rate channel is significant for unconventional monetary policy in Japan (see e.g. Inoue and Rossi, 2019). This asymmetric effect of monetary policy on inflation relates to the study by Lau and Yip (2020), which finds that unconventional monetary policy interventions in Japan has asymmetric effects on inflation due to varying significance of the different channels in the short and long run. Lau and Yip (2020) show that the interest rate channel is particularly important in the short run while the exchange rate channel is important for the long run, relating to our findings of an immediate decrease in inflation reverting further into the forecasting horizon.

Regarding IP, the expansionary scenario suggests that the growth may be more negative than in baseline. The response to the expansionary policy is different from what might be expected for real GDP, which captures a broader, demand-driven side of the economy.

While expansionary measures generally stimulate economic demand, the resultant yen depreciation and higher price levels lead to increased input costs for IP (Kuroda, 2021, Shioji, 2015). These higher production costs can offset some of the stimulative effects of the policy, impeding the recovery of IP. Overall, the expansionary scenario illustrates the trade-offs inherent in the BoJ's policy choices. While loosening monetary policy can spur economic demand and increase trade competitiveness, it also brings the negative repercussions of rising inflation and yen depreciation, increasing production costs and potentially hindering industrial recovery.

Figure 8: Expansionary Scenario - Conditional on Shadow Rate driven by AS Shock



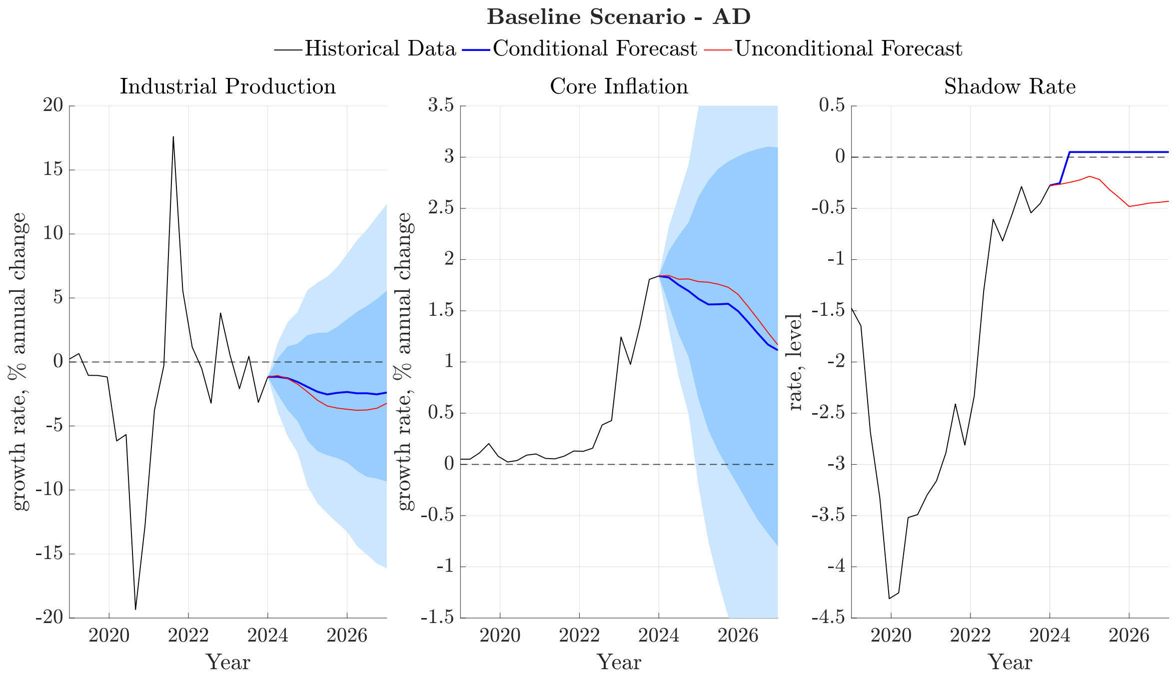
Note: Lighter and darker blue shaded areas denote the 40 and 68% pointwise credible sets around the conditional forecasts. Conditional and unconditional forecasts refer to the 4-quarter moving average.

3.2.2 Conditional on policy rate driven by aggregate demand shock

In the previous section, we considered scenarios that the BoJ might undertake in response to dominant AS shocks. Here, we imagine a scenario where the BoJ's policy rate is driven by demand shocks, maintaining the same scenario paths for baseline, contractionary, and expansionary monetary policies.

The baseline scenario (Figure 9) assumes a temporary need for monetary policy interventions. A gradual slowdown of core inflation, projected to reach 1.1% by the end of 2026, suggests that the initial hike driven by demand-pull factors contributes only marginally more to reducing price growth compared to the unconditional forecast. After an initial decrease, IP stabilizes after 2025, maintaining a relatively consistent negative growth rate across quarters. However, compared to the unconditional path, IP displays less negative developments, suggesting potential benefits from the recent monetary policy change and its moderate impact on inflation.

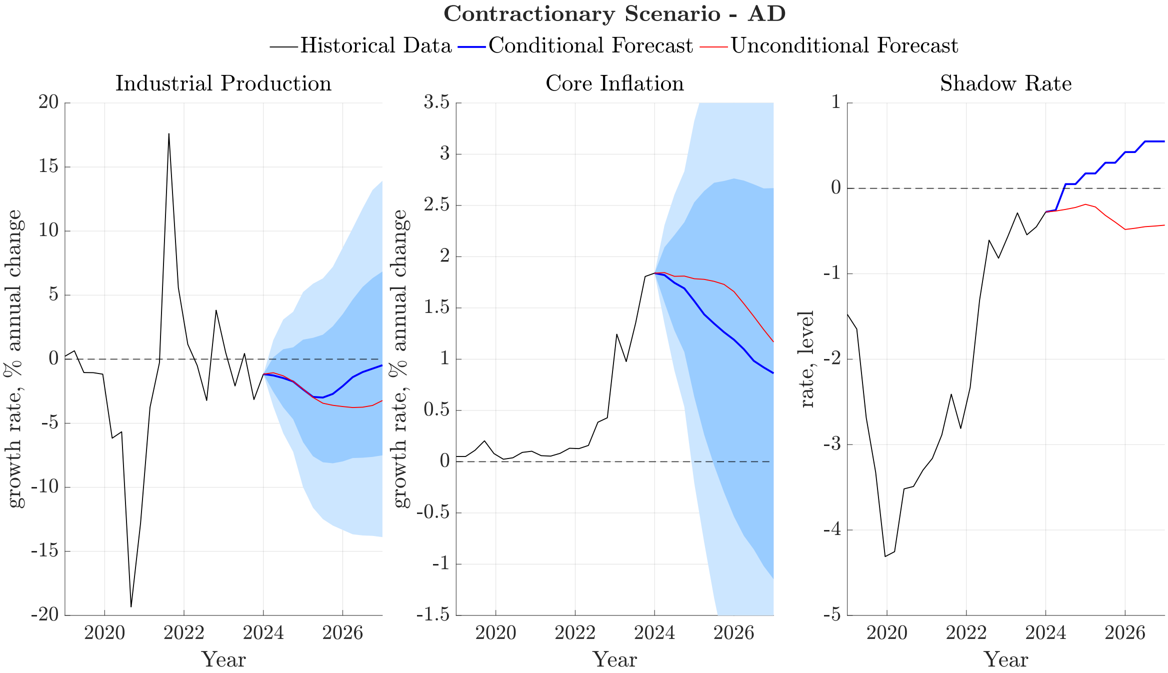
Figure 9: Baseline Scenario - Conditional on Shadow Rate and AD Shock



Note: Lighter and darker blue shaded areas denote the 40 and 68% pointwise credible sets around the conditional forecasts.

In the monetary policy tightening scenario (Figure 10), designed to address demand-pull inflationary pressures, the results indicate that with tightening measures the BoJ can quicker reduce inflation compared to the baseline. By the end of 2026, inflation is expected to halve, reaching 0.9%, down from the latest 2023 observation. This rapid containment of inflation translates into an earlier improvement in the overall real economy. In the case of IP, further monetary policy tightening yields better outcomes compared to the baseline. Assuming a global demand shock, this result is not surprising since it may result in higher demand for Japanese exports, leading to an improvement of IP. In other cases, the positive impact on IP might be offset by the exchange rate channel. However, Japanese exports are insensitive to exchange rate fluctuations due to the rise in value-added goods to exported products priced in local-currency (Kuroda, 2021). Additionally, previous studies have shown that large exporters are usually large importers which cancels out the effect of the exchange rate fluctuations (Amiti et al., 2014).

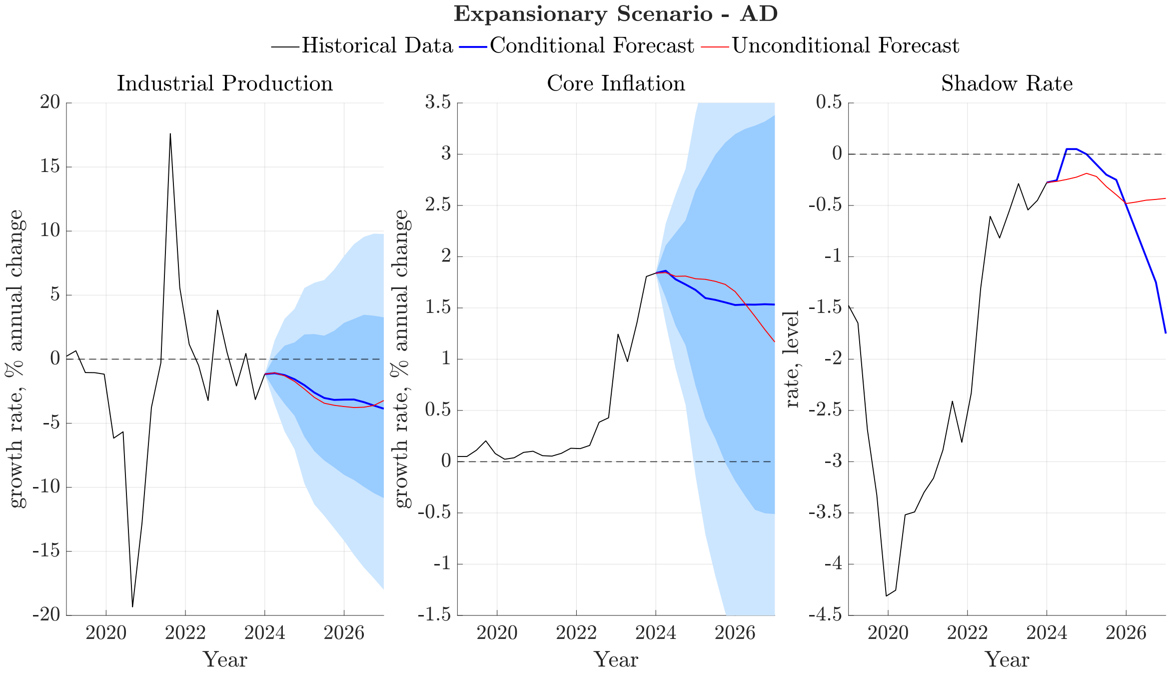
Figure 10: Contractionary Scenario - Conditional on Shadow Rate and AD Shock



Note: Lighter and darker blue shaded areas denote the 40 and 68% pointwise credible sets around the conditional forecasts. Conditional and unconditional forecasts refer to the 4-quarter moving average.

In the expansionary scenario (Figure 8), the BoJ reverts to unconventional measures, thus the shadow rate becomes negative. Despite stimulating interventions, core inflation is projected to be only 0.4 percentage points higher compared to the baseline scenario. Once again, this may be attributed to the weak impact of unconventional measures on inflation (see e.g. Ikeda et al., 2022, Koeda, 2019). For IP, the paths of both the unconditional and conditional forecasts are relatively overlapping, indicating a marginal impact of the demand-driven adjustments in the shadow rate on the real economy. However, IP is expected to show more negative developments compared to the baseline scenario. These results suggest a constrained monetary policy transmission mechanism, where the expected stimulus does not necessarily translate into increased demand.

Figure 11: Expansionary Scenario - Conditional on Shadow Rate and AD Shock



Note: Lighter and darker blue shaded areas denote the 40 and 68% pointwise credible sets around the conditional forecasts. Conditional and unconditional forecasts refer to the 4-quarter moving average.

4 The Balancing Act: BoJ's response to supply and demand shocks

Central banks respond differently to supply and demand shocks, each requiring distinct policies (Hetzel, 2004; Tenreyro, 2023; Bandera et al., 2023). Typically, monetary authorities focus on demand-pull shocks, as these are more effectively managed through policy interventions (Firat and Hao, 2023). Raising interest rates in response to supply shocks can worsen their impact on demand, risking lower economic growth or recession (Fornaro and Wolf, 2023). Addressing temporary price increases from supply shocks with rate hikes is often counterproductive, as these increases typically subside by the time monetary policy takes effect (Bandera et al., 2023). However, persistent inflation can trigger "second-round effects", where initial price hikes lead to higher wages and further price increases, potentially causing a wage-price spiral necessitating monetary policy tightening (Cos, 2022).

Japan's recent inflation experience illustrates these challenges. For twenty years, Japan faced near-zero inflation, battling deflation and trying to stimulate the economy with low rates and QQE. Recently, Japan experienced inflation from cost-push factors (see Figure 4), starting with transitory effects from global supply shocks evolving into more enduring effects due to changes in inflation expectations and tighter labor-market conditions (Ueda, 2024, Fukunaga et al., 2024).

Contrary to conventional wisdom, which posits that central banks exert more control over demand-pull inflation, our results suggest that, for the BoJ, the opposite may hold true. Our findings across various scenarios indicate that the BoJ demonstrates greater efficiency in managing inflation when reacting to supply shocks rather than demand shocks. In the baseline scenario, our analysis suggests that if the BoJ refrains from further monetary policy adjustments, it can achieve lower inflation levels when changes in the policy rate are driven by cost-push factors compared to demand-pull factors (0.9% versus 1.1%). Additionally, although IP may experience slightly more negative growth rates shortly after the initial hike in the case of an AS driven scenario, it signals a quicker improvement and less negative growth compared to the AD case (-1.7% versus -2.4%).

If the BoJ decides to implement additional policy tightening based on incoming economic data, the outcomes will significantly depend on the underlying drivers of core inflation. In case the BoJ responds to cost-push factors, further tightening could reduce inflation by an additional 0.4% by the end of the forecast horizon compared to when they react to demand-pull factors. IP exhibits similar trends in both cases due to the exchange rate channel in the supply shock case, and the increasing exports insensitive to exchange rate fluctuations in the demand shock case.

In an expansionary scenario, significant differences in core inflation trajectories emerge based on the underlying shock driving the scenario. Despite the fact that the impact is rather modest when supply shock drives the policy path, the impact on core inflation becomes negligible in the scenario driven by demand factors. The same distinction can be observed for IP. In the case of a supply shock, IP achieves lower negative growth rates. However, in the demand driven scenario, the potential path of IP closely overlaps with its unconditional path, suggesting a limited monetary policy transmission to the real economy.

Japan's limited transmission mechanism for demand shocks, as supported by our findings, can stem from several structural and economic factors. For instance, demographic challenges, such as a shrinking and aging population, result in a higher savings rate and lower consumption propensity, limiting the effectiveness of monetary policy adjustments (Katagiri (2021)). Additionally, low inflation expectations, rooted in Japan's prolonged deflationary period, weaken the responsiveness to monetary policy. Unless the BoJ manages to influence inflation expectations of Japanese households and firms, their attempt to stimulate demand may not be successful. This relates to the recent development in the Japanese economy where an external shock in combination with a tighter labor market prompted inflation expectations to change (Ueda, 2024, Fukunaga et al., 2024). These explanations, combined with our findings, suggest that the BoJ might be more effective in addressing cost-push inflation. Thus, while the BoJ's monetary policy tools effectively combat cost-push shocks, their demand-driven interventions has a limited impact on the economy.

5 Robustness

To validate our main findings, we conduct a number of robustness checks. Following previous literature, we evaluate our main findings by slightly altering model specifications and choice of variables. Due to space constraints, we only include one result per robustness check (see Appendix B), but all results are available upon request.

First, we estimate the SVAR with different model specifications by altering the number of restricted horizons and lags. As Uhlig (2005) emphasizes, the restricted horizon is usually arbitrarily determined, so it is useful to estimate the model with different restrictions. We change the horizon from two to four quarters, observing minor changes in the magnitude of the IRFs on impact while sign and direction remain consistent with our baseline results. Using three lags, recommended by the AIC criterion, instead of two produces similar IRFs on impact but results in stronger and more volatile IRFs beyond five horizons.

The use of SSR series in models increases parameter uncertainty due to the series' underlying model. Krippner (2019) emphasizes the need to scrutinize any SSR series before including it as a reliable proxy for the policy rate during ZLB periods. We control for this by comparing our results with a different SSR series (Wu and Xia, 2016) and find no major differences, concluding that our baseline model is not sensitive to changes in the SSR series. Additionally, changing our core inflation estimate from weighted to mode CPI[8] generates similar results as in our baseline model.

Finally, we ensure the model's consistency across different time periods by altering our sample into three shorter versions: 1986Q3-2019Q4 (excluding the pandemic), 1995Q1-2023Q3 (excluding the pre-ZLB period) and 1995Q1-2019Q4 (excluding both the pre-ZLB and pandemic). Overall, shortening the sample period shows no major differences for IP or the shadow rate, while magnitude and uncertainty changes for core inflation. We attribute changes in core inflation to changes in the characteristics of the series rather than model specifications, concluding that our model is robust to changes in the sample period.

[8]Mode CPI is the inflation rate with the highest density in the price change distribution. An estimate provided by the Research and Statistics Department at the BoJ.

6 Conclusion

This paper emphasizes the importance of understanding the underlying drivers of inflation and their influence on the scope and effectiveness of the BoJ's policy responses. By employing a structural identification approach on a quarterly dataset from 1986 to 2023, we assess potential future developments in inflation and industrial production through three policy scenarios driven by either aggregate demand or aggregate supply shocks.

Our study suggests that while the BoJ has limited tools for demand-driven inflation, it has greater scope to manage cost-push inflation, providing more effective means to stabilize the real economy. These findings are supported by previous literature on the structure of Japan's economy and monetary policy transmission mechanisms. In the baseline scenario, the initial policy intervention leads to lower inflation and a faster improvement in industrial production when supply shocks, rather than demand-driven factors, are the primary driver. With additional tightening measures, we observe similar effects as in baseline, underscoring the BoJ's ability to control cost-push inflation. While the two paths of industrial production follow a similar trend, they are attributed to asymmetric effects of the exchange rate channel. Under the expansionary scenario driven by supply factors, inflation rises at the end of the forecast horizon while it has negligible effects on inflation in the demand driven scenario. Results are also robust across various specifications of our model.

Future work can build on our analysis in several ways. One extension could consider a longer horizon path that allows for a significant departure from the ZLB thresholds, enabling the exploration of expansionary scenarios within conventional terms. Another extension would be to conduct the analysis in a Bayesian setting, which could reduce model uncertainty. Further, one could decompose the aggregate shocks into their domestic and global components and investigate scenarios conditioned separately on globally as well as domestically induced shocks. Lastly, researchers could explore the impact of fiscal policy measures in conjunction with monetary policy, examining how coordinated policy efforts could more effectively address both demand-pull and cost-push inflation.

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A Appendix: Additional Results

Figure 13 and 14 depict the historical decomposition of IP and shadow rate from 1986 until 2023. During the recent period marked by the COVID-19 pandemic and subsequent developments, the decline in industrial production (IP) was driven by a combination of AD shocks, reflecting demand disruptions, and AS shocks, indicating supply chain issues. The subsequent recovery was influenced by strong AD responses due to fiscal and monetary stimuli, consistent with the findings of Guerrieri et al. (2020). As for the shadow rate, MP shocks caused further declines, reflecting continued accommodative monetary policy.

Figure 13: Historical Decomposition of Industrial Production

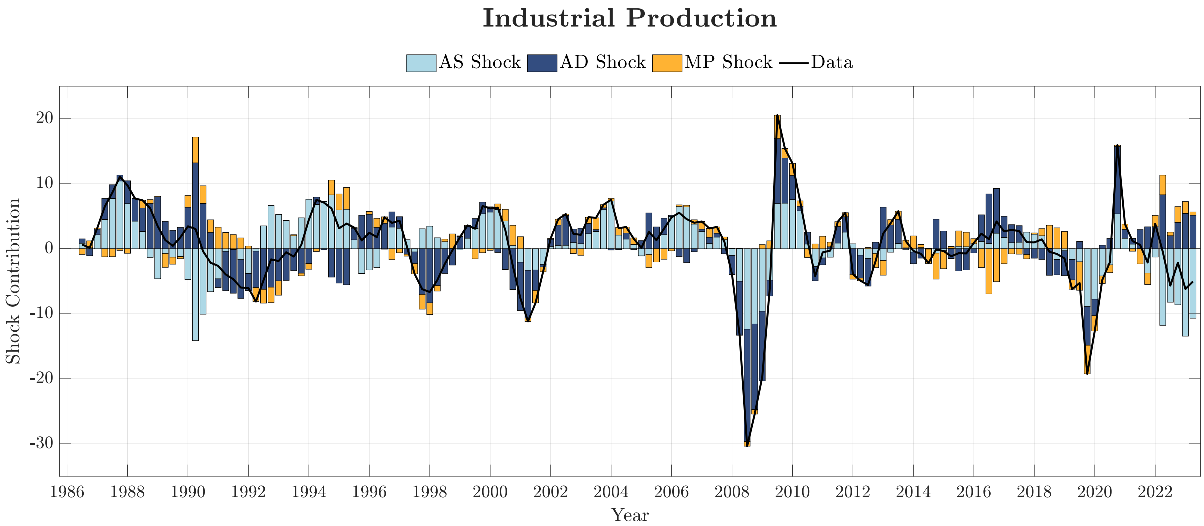
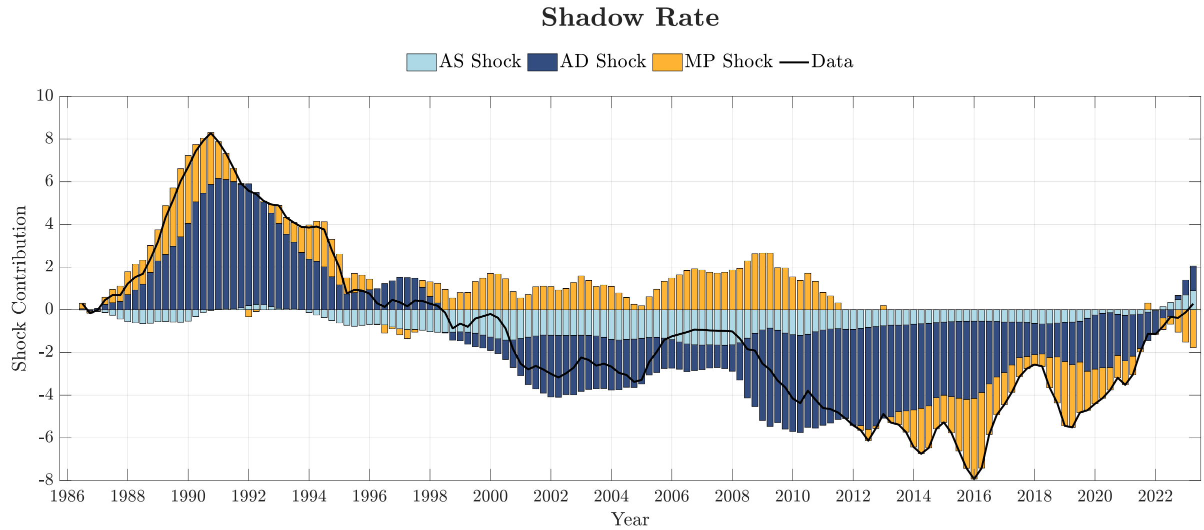


Figure 14: Historical Decomposition of Shadow Rate



B Appendix: Robustness Checks

Figure 15: Robustness check - 1995-2019

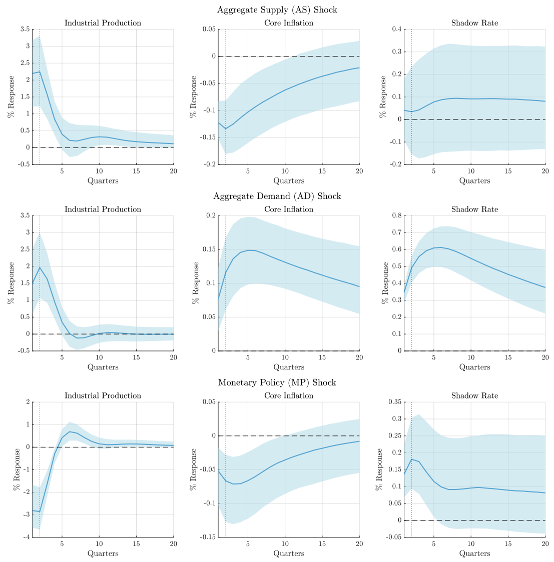


Figure 16: Robustness check - 4 horizons

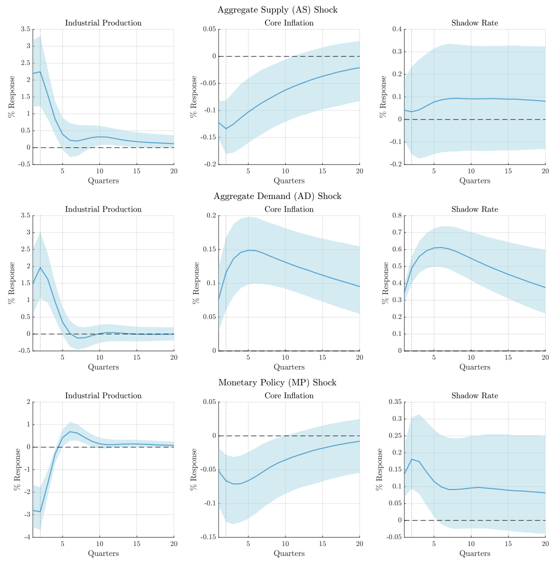


Figure 17: Robustness check - 3 lags

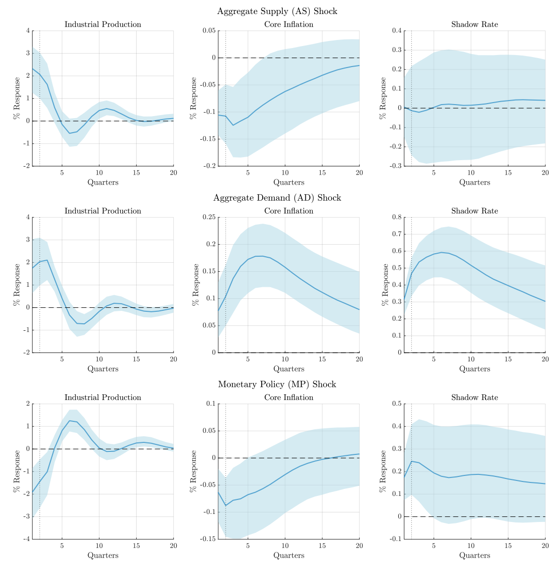
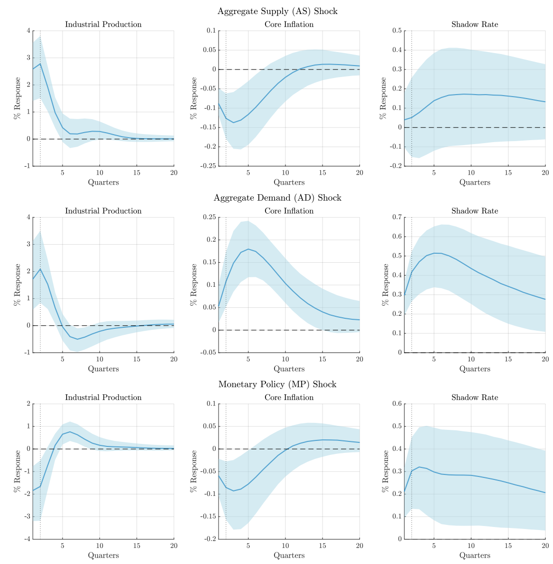


Figure 18: Robustness check - mode CPI



Note: The blue (lighter) shaded area represents the 68% (point-wise) confidence bands for the IRFs and the blue solid lines are the median IRFs to the respective shocks.