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Effects and Side Effects of Unconventional Monetary Policy: A Shadow Rate Approach*

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Abstract

Over the past 25 years, the Bank of Japan has conducted a variety of unconventional monetary policies. This paper empirically analyzes the impact of these unconventional monetary policies on Japan's economic activity, prices, and financial sector. First, we investigate the impact of the Bank of Japan's purchase of long-term JGBs on long-term interest rates and find that it lowered the rates by lowering the term premium. Its impact was particularly pronounced following the introduction of Quantitative and Qualitative Monetary Easing (QQE) in 2013. Second, we employ a factor-augmented vector autoregression (FAVAR) and the shadow rates as a proxy of a monetary policy stance reflecting information on the entire government bond yield, and investigate the counterfactual analyses. Our estimation result indicates that the series of unconventional monetary policies had a positive effect on output and prices, and the large-scale monetary easing after the introduction of QQE contributed to fostering a non-deflationary environment in Japan. The empirical analysis also indicates that the unconventional monetary policies may have had the side effect of reducing the profitability of banks by lowering lending rates.

JEL Classification: E43, E44, E52, E58

Keywords: Monetary policy, Term structure model, Shadow rate, FAVAR, Counterfactual analysis

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1. Introduction

In the late 1990s, Japan's nominal short-term interest rates hit their effective lower bound, making it challenging for traditional monetary policy to sufficiently stimulate the Japanese economy.[1] In response to these circumstances, the Bank of Japan (BOJ) implemented a series of unconventional monetary policies over the following two decades, including the massive purchase of long-term government bonds, the introduction of forward guidance, and the implementation of a negative interest rate policy. The BOJ was a pioneer in the introduction of unconventional monetary policy in the late 1990s and the 2000s. The global financial crisis of 2008 prompted major foreign central banks to use similar unconventional policy measures, leading to a significant accumulation of research on the effects and side effects of these policies to date. Existing studies have revealed a variety of implications, from the economically positive effects to potential negative consequences such as a deterioration in financial institutions' profitability.

This paper provides an empirical analysis of the effects and side effects of Japan's unconventional monetary policy as part of the Bank of Japan's analysis of the "Review of Monetary Policy from a Broad Perspective."[2] The analyses in this paper, which examine the propagation channels through which unconventional monetary policy affects the economy and prices, are two-fold. First, the analysis studies the impact of unconventional monetary policy on long-term interest rates. For this purpose, a shadow-rate term structure (SRTS) model of interest rates is employed to decompose the nominal long-term interest rate into the expected rates (calculated as the average of expected short-term interest rates up to a specific maturity) and the term premium. The effects of unconventional monetary policy on the expected rates and the term premium are then used for an event study. The SRTS model employed in this paper is based on the framework developed by Imakubo and Nakajima (2015) for Japan. Our empirical analysis indicates that while the quantitative easing policy implemented in the early 2000s appears to have lowered long-term interest rates mainly by pushing down the expected rates, the introduction of "Quantitative and Qualitative Monetary Easing" (QQE) in 2013 was

[1] Behind the nominal short-term interest rate hitting the effective lower bound constraint, previous studies discuss the weakening of funding needs due to a declining potential growth rate reflecting structural factors such as demographic changes and deepening of globalization, which led to a decline in the natural rate of interest, the level of real interest rates that is neutral to the economy and prices. For a discussion of recent developments in the measurement of the natural rate of interest, see Nakano et al. (2024).

[2] The scope of unconventional monetary policy addressed in this paper does not explicitly exclude purchases of risky assets and lending facility programs. However, as the analysis is based on the impact on the yield curve and its propagation, our focus is on policies that act directly on the yield curve, such as large-scale purchases of long-term government bonds and forward guidance.

followed by a significant decline in long-term interest rates by pushing down the term premium.

Second, a factor-augmented vector autoregression (FAVAR) comprising more than 200 economic variables is constructed in order to estimate the impact of unconventional monetary policy on a range of economic, price and financial variables. A comparable analysis is presented by Wu and Xia (2016) for the U.S. economy, and we use the framework of their empirical analysis as a reference while using data from Japan. Following Wu and Xia (2016), we use the "shadow rate," which reflects information on the entire yield curve of government bonds, as a proxy indicator of the monetary policy stance. The shadow rate is defined as the implicit nominal short-term interest rate that would have been realized in the absence of the effective lower bound constraint on the short-term interest rate. In recent years, various methods of estimating the shadow rate have been developed, and research has accumulated on the relationship between the shadow rate and macroeconomic variables. The empirical analysis conducted in this paper using the FAVAR indicates that Japan's unconventional monetary policy has had a certain degree of positive effect on output and prices. The quantitative impact on prices in our analysis is comparable with that in previous studies on Japan. The results remain almost unchanged when we use different methods of estimating the shadow rates. Our estimation result shows that while unconventional monetary policy exerted a positive influence on economic activity and prices, the policy might have had a side effect of contributing to the compression of financial institutions' profitability through a decline lending rates.

The magnitude of estimated policy effects in this paper is generally consistent with simulation results conducted using macroeconomic models with different analytical frameworks. Our results are robust with respect to the evidence that the unconventional monetary policy had a certain degree of positive effect in pushing up economic activity and prices. For example, the results of the magnitude of policy effects in this paper are comparable with those estimated using the large macroeconomic model, Quarterly Japanese Economic Model (Q-JEM), presented in Bank of Japan (2016, 2021), and most recently Haba et al. (2024a). In contrast to Q-JEM, which is based on assumptions of the theoretical economic structure, our analysis is distinctive in that it identifies policy effects based on the time-series relationships among economic variables. Consequently, the analysis in this paper can be seen as a complementary examination of the policy effects by Haba et al. (2024a). We consider it is essential to evaluate the effects of monetary policy from multiple perspectives using multiple methods.

The contribution of this paper is to estimate the FAVAR that incorporates the shadow rate as a proxy variable for monetary policy that reflects information on the entire yield curve.[3] This approach allows for a comprehensive assessment of the effects and side effects of the unconventional monetary policy in Japan. The use of the FAVAR, which incorporates over 200 economic and financial variables, has another advantage in that the impact of the unconventional monetary policy on various financial and economic variables can be analyzed within the same framework.

The rest of this paper is organized as follows. Section 2 provides an overview of related studies and their relationship to our analysis. Section 3 examines how the unconventional monetary policy has pushed down nominal long-term interest rates using the event study approach and the SRTS model. Section 4 uses the FAVAR to analyze the impact of unconventional monetary policy on economic activity and prices, and Section 5 concludes.

2. Literature review

This paper relates to three fields of research: (i) the impact of unconventional monetary policy on long-term interest rates as the initial point of the transmission mechanism, (ii) the impact on the real economy, including output and prices, and (iii) the unintended negative effects, or side effects. This section reviews findings in previous studies on these three areas and discusses the relationship between them and the current paper.[4]

First, the main channel through which unconventional monetary policy affects the economy when short-term interest rates are constrained by the effective lower bound is the impact on long-term interest rates. The purchase of long-term government bonds as part of quantitative easing, coupled with forward guidance on future short-term interest rates, is anticipated to exert both a direct and an indirect influence on long-term interest rates. A number of studies have reported that unconventional monetary policy has been found to result in a decline in long-term interest rates (Joyce et al. (2011); Hamilton and Wu (2012); Altavilla et al. (2015); Neely (2015); Greenlaw et al. (2018); De Santis (2020)). In their study, Borio and Zabai (2016) conduct a literature review on U.S. economy and monetary policy and find that the Federal Reserve's quantitative easing resulted in an approximately 76-basis point decline in the 10-year interest rate for QE1, a 28-basis point decline for QE2, and a 7-basis point decline for QE3.

Some previous studies decompose long-term interest rates into two components: the

[3] The transmission channel assumed in QQE to enhance medium- and long-term inflation expectations of private economic agents is discussed in Kaihatsu et al. (2024).

[4] A comprehensive survey on the effects of unconventional monetary policy is found in Borio and Zabai (2016), Dell'Ariccia et al. (2018), and Bhattarai and Neely (2022). A literature survey specifically on Japan is found, for example, in Ugai (2007), Ferreira-Lopes et al. (2022), and Aoki (2023).

expected rates, which reflect the expectations of future short-term interest rates, and the term premium,[5] and then analyze how unconventional monetary policy affects the factors (Gagnon et al. (2011); Rogers et al. (2014); Wu (2014); Bauer and Rudebusch (2016); Ihrig et al. (2018)). In this regard, Christensen and Rudebusch (2012) argue that the magnitude of the impact of unconventional monetary policy on the expected rates and the term premium differs across countries depending on market structure and the manner in which central banks communicate. With regard to Japan's quantitative easing, the study reports that until 2006, the effect was mainly through a reduction in the expected rates (Oda and Ueda (2007); Ugai (2007)). After 2008, the main effect was reported to be a reduction in long-term interest rates through the term premium, and its impact became particularly pronounced after the introduction of QQE (Fukunaga et al. (2015); Sudo and Tanaka (2021)). In addition, some studies note that the introduction of the negative interest rate policy in 2016 contributed to the decline in expected rates (Ueno (2017); Suganuma and Yamada (2017)).

Second, a growing body of research has investigated the impact of unconventional monetary policy on the real economy (Fuhrer and Olivei (2011); Kapetanios et al. (2012); Walentin (2014); Gambacorta et al. (2014); Weale and Wieladek (2016); Debortoli et al. (2019); Hohberger et al. (2019); Caldara et al. (2020); Ouerk et al. (2020); Altavilla et al. (2021)). In the case of U.S. monetary policy, Wu and Xia (2016) construct a FAVAR with the shadow rate estimated from yield curve data and used as a proxy for monetary policy under the effective lower bound constraint on the short-term interest rates. Their findings imply that the Federal Reserve's unconventional monetary policy since 2009 resulted in a reduction in the unemployment rate of approximately 1% by the end of 2013. Other studies, such as Sims and Wu (2021), employ a DSGE model to demonstrate that quantitative easing and forward guidance are as effective as traditional monetary policy. A review of studies on Japan reveals that the majority of those conducted after 2013 that include the QQE period highlight the positive effects of unconventional monetary policy on the economy and prices (Hayashi and Koeda (2019) ; Koeda (2019); Miyao and Okimoto (2020); Kubota and Shintani (2023)). More recently, Ikeda et al. (2024) examine the effects of conventional and unconventional monetary policies in Japan and report that unconventional monetary policies have smaller effects from a short-term perspective than conventional policies, but larger effects from a long-term perspective. However, some

[5] The term premium here refers to the additional premium that investors claim when investing in long-term bonds instead of short-term bonds, and is determined by a variety of factors, including expectations on future inflation and economic activities and monetary policy uncertainty, as well as the supply and demand for bonds, reflecting holdings for collateral purposes (Bernanke (2015a)). Since the term premium is not directly observable, the existing studies estimate it by computing a risk-neutral interest rate based on the term structure model of interest rates, as in this paper (see, for example, Kim and Wright (2005), and Adrian et al. (2013)).

studies, such as Michaelis and Watzka (2017), indicate that while the monetary easing policies after 2013 contributed to price increases, the empirical result does not show any significant effect on the real economy (GDP). Among studies before the introduction of QQE, Honda (2014) reports the accommodative impacts on the real economy. Other studies, such as Fujiwara (2006) and Kimura and Nakajima (2016), argue that the impact on the economy and prices is either limited or highly uncertain.[6]

Third, there have been various discussions on the possibility of unintended negative effects, or side effects, of unconventional monetary policy, which could undermine the efficiency of the economy or hinder the effectiveness of the policy. These discussions include (a) the impact on market functioning (e.g., increased asset purchases and holdings by the central bank could lead to reduced liquidity in government bond markets: Kandrac (2018); Schlepper et al. (2020)), and (b) the impact on central bank financing (e.g., the possibility that the expansion of the central bank balance sheet due to the purchase policy could lead to future losses: Del Negro and Sims (2015)).[7,8] In addition, other discussions focus on the financial system: (c) the impact on financial imbalances (e.g., financial imbalances accumulating as a result of a low interest rate environment and excessive risk-taking behavior; Hudepohl et al. (2021)), and (d) the impact on the profitability of financial institutions (e.g., due to the flattening of the yield curve; Borio et al. (2017); Brunnermeier and Koby (2018); Claessens et al. (2018)).[9] Others address the effects on real economic activity: (e) effects on the potential growth rate (e.g., prolonged monetary easing may hamper business dynamics and lower potential growth; Banerjee and Hofmann (2018); Acharya et al. (2019)), and (f) effects on inequality (e.g., increased asset dispersion due to higher asset prices; Domanski et al. (2016)).

It should be noted, however, that there is still no consensus on whether unconventional monetary policy has such side effects. The situation may differ depending on the economic background and phase of each country. In this regard, Haba et al. (2024b) conduct an empirical analysis of the medium- to long-term effects of monetary policy on supply-side factors such as potential growth and productivity. Their findings indicate that there is no clear evidence of either positive or negative effects. There is also a skeptical

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[6] With regard to economies outside Japan, Goodhart and Ashworth (2013), and Roubini (2013) highlight the potential limitations and uncertainty over the impact of unconventional monetary policies.

[7] The impact of monetary policy over the past 25 years on the functioning of the government bond and corporate bond markets is analyzed in Bank of Japan Financial Markets Department (2023), and Ochi and Osada (2024).

[8] The relationship between central bank financing and the conduct of monetary policy is discussed in Bank of Japan Monetary Affairs Department (2023).

[9] The impact of monetary easing on the financial system over the past 25 years is analyzed in Bank of Japan Financial System and Bank Examination Department (2023), and Abe et al. (2024).

view about the negative effects of monetary policy on inequality (Bernanke (2015b); Bivens (2015); Inui et al. (2017); Gornemann et al. (2021)). In its strategy review (Altavilla et al. (2021)), the European Central Bank (ECB) discusses the various possible side effects of monetary policy and notes that, while there is currently no evidence that they have impeded the effectiveness of monetary policy, we need to monitor the effectiveness carefully.

In light of the findings in the literature, this paper decomposes the long-term interest rate into its two factors: the expected rates, and the term premium based on the SRTS model. Then, we examine the impact of Japan's unconventional monetary policy on the long-term interest rate using an event study approach. Subsequently, following the analytical framework proposed by Wu and Xia (2016), we estimate the impact of unconventional monetary policy on a variety of economic variables using a FAVAR with the shadow rate. With regard to the shadow rate, a number of recent studies have proposed various estimation methods and examined the relationships between the shadow rate and macroeconomic variables (Lemke and Vladu (2016); Ichiue and Ueno (2018); Diegel and Nautz (2021); Jones et al. (2021); Koeda and Wei (2023)). In our paper, we regard the shadow rate as a useful indicator of monetary policy. Although it is challenging to conduct a comprehensive evaluation of economic welfare considering the side effects, we use the model to analyze the effects on various financial and economic variables, and discuss the possible side effects on financial institutions' profitability and other factors.

In order to identify monetary policy shocks during periods of unconventional monetary policy, prior studies have employed a variety of variables, including the central bank's balance sheet (Gambacorta et al. (2014); Haldane et al. (2016); Boeckx et al. (2017); Burriel and Galesi (2018)), the monetary base (Inoue and Okimoto (2008); Miyao and Okimoto (2020)), central bank asset purchases (Gertler and Karadi (2013); Weale and Wieladek (2016); Garcia Pascual and Wieladek (2016)), and long-term interest rates (Kapetanios et al. (2012); Baumeister and Benati (2013); Pesaran and Smith (2016)). The advantages of using the shadow rate have been highlighted in previous studies, which argue that it can reflect the impact of various unconventional monetary policy measures that influence the yield curve, including quantitative easing, forward guidance, and negative interest rate policies. Additionally, it can be employed consistently across conventional and unconventional policy regimes (Wu and Xia (2016); Krippner (2020)). Furthermore, the shadow rate is highlighted as being able to capture effects that cannot be identified by the central bank balance sheets and the monetary base alone, as the yield curve immediately reflects market expectations after the announcement of a policy change (Ouerk et al. (2020)).[10]

It should be noted, however, that the shadow rate may not be directly comparable to the nominal short-term interest rate for the period of conventional monetary policy. This is because the shadow rate is not the interest rate that is actually used or referred to in transactions in economic activities. In order to connect the shadow rate with the nominal short-term interest rate during conventional monetary policy period and to use the shadow rate as a proxy variable in monetary policy, it is essential to satisfy two key conditions: (i) it is necessary to assess whether the shadow rate accurately reflects the monetary policy stance and (ii) whether the relationship between the shadow rate and the economy remains consistent between the conventional and unconventional monetary policy periods, as highlighted by Krippner (2015b, 2020) and Wu and Xia (2016). Furthermore, since the shadow rate is not an observable variable, it is subject to estimation uncertainty due to the data and models employed (Bauer and Rudebusch (2016); Panizza and Wyplosz (2016)). For example, as Figure 1 shows, the estimated shadow rates for the U.S. reveal considerable variation depending on the model employed. Therefore, the estimated impact of the unconventional monetary policy on the economy and prices may differ depending on the shadow rate used. In light of this concern, this paper uses the shadow rates estimated by three different models (Imakubo and Nakajima (2015), Wu and Xia (2016), and Krippner (2015a)) and examines estimation uncertainty.[11]

3. Unconventional monetary policy and long-term interest rates

In this section, we use the SRTS model to decompose the nominal long-term interest rate into the expected rates and the term premium, and examine the channels through which unconventional monetary policy has affected the long-term interest rate. We also examine the shadow rates estimated in the SRTS model by checking a consistency of its time-series development with the BOJ's monetary policy stance. Various term structure models have been proposed in previous studies, and resulting estimates differ depending on the model assumption and data used. In this paper, we use the model of Imakubo and Nakajima (2015) (hereafter IN), which was constructed for the Japanese yield curve, as the baseline. In addition, we also employ the models of Wu and Xia (2016) (hereafter WX) and of Krippner (2015a) (hereafter Krippner), originally used to analyze the U.S. yield curves, to Japanese data to check the robustness of our baseline results.

[10] With regard to the impact on the yield curve, Koeda and Sekine (2022) and Shiratsuka (2024) use the Nelson-Siegel model to analyze the impact of monetary policy.

[11] Note that the analytical approach employed in this paper cannot specify which of the two components in the long-term interest rate (i.e. changes in the expected rates, and the term premium) directly moves the shadow rate.

3.1 Shadow-rate term structure model of interest rates

3.1.1 Shadow rate

We describe the SRTS model used in this paper, following IN.[12] Define X_t as the $(k \times 1)$ vector of latent factors governing the term structure and dynamics of bond yields. Let s_t^N denotes the instantaneous shadow rate, which is defined as an affine function of the factors. Then, the nominal instantaneous short rate, denoted by r_t^N, is defined as follows:

$$r_t^N = \max(s_t^N, \underline{r}_t^N),$$

where

$$s_t^N = \rho^N + \delta^N X_t,$$

and $\underline{r}_t^N$ is the lower bound of the nominal short rate. The model can avoid a negative nominal short rate in the following fashion: when s_t^N is above $\underline{r}_t^N$, r_t^N is equal to s_t^N; when s_t^N is below $\underline{r}_t^N$, r_t^N is equal to $\underline{r}_t^N$.

The model also specifies the real instantaneous short rate as an affine function of the factors.[13] The real short rate takes both positive and negative values and is free from the zero lower bound. Let r_t^R denote the real short rate, which is given by

$$r_t^R = \rho^R + \delta^R X_t.$$

Dynamics of the factors, which are common to nominal and real short rates, are specified as the following Gaussian process under the objective $\mathbb{P}$-measure:

$$dX_t = -K^P X_t dt + \Sigma dB_t^P,$$

where B_t^P is a standard k-dimension Brownian motion under the $\mathbb{P}$-measure.

3.1.2 Stochastic discount rate and market price of risk

With the stochastic discount factor M_t^i, $i \in \{N, R\}$, where N stands for "nominal" and R for "real," the bond price $P_{t,T}^i$ and the zero-coupon yield $y_{t,T}^i(X_t)$ of T-year maturity at

[12] For WX and Krippner, see their original papers (Wu and Xia (2016) and Krippner (2015a), respectively).

[13] WX and Krippner are the term structure models for only the nominal interest rates. In contrast IN incorporates both nominal and real interest rates.

time t are given by

$$P_{t,T}^{i} = \mathrm{E}_t^P\left[\frac{M_{t+T}^{i}}{M_t^{i}}\right], \quad i \in \{N, R\},$$

$$y_{t,T}^{i}(X_t) = -\frac{1}{T}\log P_{t,T}^{i} = -\frac{1}{T}\log\left(\mathrm{E}_t^P\left[\frac{M_{t+T}^{i}}{M_t^{i}}\right]\right), \quad i \in \{N, R\}.$$

We assume the following process of the stochastic discount factor:

$$\frac{dM_t^i}{M_t^i} = -r_t^i dt - \lambda_t^{i\prime} dB_t^P, \quad i \in \{N, R\},$$

where λ_t^i is the $(k \times 1)$ vector of the market prices of risk, specified by the affine function of the factors:

$$\lambda_t^i = \lambda^i + \Lambda^i X_t, \quad i \in \{N, R\}.$$

Given these settings, the arbitrage-free condition implies

$$y_{t,T}^{i}(X_t) = -\frac{1}{T}\log\left(\mathrm{E}_t^Q\left[\exp\left(-\int_0^T r_{t+\tau}^i d\tau\right)\right]\right), \quad i \in \{N, R\}, \tag{1}$$

where $\mathrm{E}_t^Q[\cdot]$ denotes the conditional expectation under the risk-neutral $\mathbb{Q}$-measure. Here we define the expected nominal/real rates, denoted by $y_{t,T}^{i,\exp} \equiv \frac{1}{T}\int_0^T \mathrm{E}_t^P\left[r_{t+\tau}^i\right] d\tau$, as the average of the expected nominal/real short rates from time t to $t+T$. Also, we define the nominal/real term premium, denoted by $y_{t,T}^{i,\mathrm{TP}}$, as the difference between the zero-coupon yield and the expected nominal/real rate. This means that the zero-coupon yield is decomposed as

$$y_{t,T}^{i} = y_{t,T}^{i,exp} + y_{t,T}^{i,TP}, \quad i \in \{N, R\}.$$

3.2 Estimation method

Following IN, we set the number of factors to $k = 4$. To make the model parsimonious, we restrict the parameters as follows:

$$\delta^N = [1, 1, 0, 0], \quad \delta^R = [\delta_1^R, \delta_2^R, 1, 1],$$
$$\lambda^N = [\lambda_1^N, \lambda_2^N, 0, 0]', \quad \lambda^R = [\lambda_1^R, \lambda_2^R, \lambda_3^R, \lambda_4^R]',$$
$$\Lambda^N = \begin{bmatrix} \Lambda_{11} & O_{2\times 2} \\ O_{2\times 2} & O_{2\times 2} \end{bmatrix}, \quad \Lambda^R = \begin{bmatrix} \Lambda_{11} & \Lambda_{21} \\ \Lambda_{12} & \Lambda_{22} \end{bmatrix},$$
$$\Sigma = \mathrm{diag}(\sigma_1, \dots, \sigma_4),$$

where Λ_{ij} is a (2×2) matrix $(i, j = 1, 2)$, and $\mathrm{diag}(\cdot)$ denotes a diagonal matrix.

The SRTS model can be estimated in the form of a state space model consisting of observation equations and state equations. To derive the form, the nominal yield in Equation (1) is rewritten as follows:

$$y_{t,T}^{N}(X_t) = \frac{1}{T}\int_0^T \mathrm{E}_t^{Q}[r_{t+\tau}^{N}]d\tau. \tag{2}$$

The zero lower bound constraint on the nominal yield makes it impossible to derive any analytical solution due to the existence of the integral in Equation (2). As suggested by Ichiue and Ueno (2013), the right-hand side of Equation (2) is conditionally linearized around the one-month-ahead linear-least-square forecast of the factors made in the previous month. Let $f_T^N(X_t, X_{t-1})$ denote the linearly approximated function of the right-hand side of Equation (2).

The real yield is free from the zero lower bound constraint. The observation equation of the real yield in Equation (1) is given in the form of an affine function:

$$y_{t,T}^{R}(X_t) = a_T^R + b_T^R X_t, \tag{3}$$

where a_T^R and b_T^R are the functions of the model parameters and the maturity T.

To sum up, the state space model to be estimated is as below.

Observation equation: $$\begin{bmatrix} Y_t^N \\ Y_t^R \end{bmatrix} = \begin{bmatrix} f_t^N \\ f_t^R \end{bmatrix} + e_t, \qquad e_t \sim N(0, V),$$

State equation: $$X_t = \Phi^P X_{t-1} + \Gamma^P \varepsilon_t^P, \qquad \varepsilon_t \sim N(0, I),$$

where Φ^P and Γ^P are matrices of functions of the model parameters; V is a diagonal matrix; Y_t^N and Y_t^R are vectors of nominal and real interest rates; f_t^N is a vector of the linear approximated function in Equation (2) (i.e., $f_{T_j}^N(X_t, X_{t-1})$); and f_t^R is a vector of affine functions in Equation (3) (i.e., $a_{T_j}^R + b_{T_j}^R X_t$). The observation equation of the nominal yield is nonlinear with respect to the factors. For the nonlinear estimation, the extended Kalman filter method is employed to obtain the maximum likelihood estimate.

3.3 Data

The nominal interest rates used for the observation equations are the uncollateralized overnight call rate and the 2-, 5-, 7-, 15-, and 20-year nominal zero-coupon rates (Figure 2). In line with IN, the 1-year ahead 2-year forward rate, calculated using the 1- and 3-year interest rates, is also used as an additional observation equation for the slope of the yield curve. The real zero-coupon rate is the difference in the nominal zero-coupon rate from the zero-coupon inflation swap rate (Table 1). The models are estimated on a monthly and daily basis, respectively. The estimation period is from January 1995 to June 2023. Note that it is not possible to calculate real interest rates prior to March 2007, due to data availability of inflation swap rates. For this period, the observation equations include only the nominal interest rates. In addition, we use the survey data on 10-year expected inflation from the Consensus Forecasts as a dependent variable, and the difference in the model-implied very long (50-year) expected nominal rate from the expected real rate as an independent variable.

The lower bound of the nominal interest rate, which must be set prior to the estimation, can have a significant impact on the estimated level of the shadow rate, as noted by Krippner (2015b). In our analysis, following survey data of market participants' expectations on short-term interest rates (as we will show later in Figure 3), we set the lower bound at 0% before the Complementary Deposit Facility applied an interest rate to the current account at the BOJ, at 0.1% thereafter, and at -0.1% after the introduction of the negative interest rate policy. In the estimation, following the idea proposed by Krippner (2020), the parameters that determine the variances of the shadow rate are calibrated so that the variance matches the one of the 3-month interest rate for the period when the short-term interest rate was not constrained by the effective lower bound.[14] Other parameters are obtained by the maximum likelihood estimation.

Table 1 summarizes the framework of the three models used in this paper. It is worth noting that, with respect to the number of factors, previous research argues that there is a trade-off (Krippner (2015b)). Specifically, although the larger number of factors leads to smaller observation error, the estimates are more likely to over-fit the data, and they are more sensitive to a slight change in data observations and the model settings.

[14] Specifically, the periods mentioned here are (i) from the start of the dataset up to the start of the zero interest rate policy (from January 1995 to January 1999), (ii) from the end of the zero interest rate policy up to the start of the quantitative easing policy (from August 2000 to February 2001), and (iii) from the end of the quantitative easing policy to the policy rate cut during the onset of the global financial crisis (March 2006 to November 2008).

Table 1: Summary of the Term Structure Models

Model		IN	WX	Krippner
Data	Interest rates	Nominal interest rate (O/N,1,2,3,5,7,15,20y) Inflation swap rate (2,5,7,15,20y)	Nominal interest rate (0.25,0.5,1,2,5,7,15,20y)	Nominal interest rate (0.25,0.5,1,2,3,5,7,15,20y)
	Economic variable	Long-term inflation forecast (Consensus Forecasts)	--	--
Lower bound of nominal interest rate		Before October 2008: 0%. November 2008 to January 2016: 0.1%. Since February 2016: -0.1%.		
Estimation period		January 1995 to June 2023		
Number of factors		2	3	2

Note: The number of factors for IN is that for nominal interest rates.

3.4 Estimation results

3.4.1 Decomposition of changes in long-term interest rates and event study analysis

We first compare the monthly forward 3-month interest rates estimated by IN with the results of a market survey to assess the validity of the estimates. Figure 3 compares the 3-month interest rates derived from IN with the market forecasts for 1-month, 3-month, and 6-month ahead.[15] The IN estimates are generally within the range of market expectations and our estimation framework is considered to provide reasonable estimates.

Figure 4 shows the decomposition of the 10-year nominal long-term interest rate into the expected rates and the term premium based on monthly estimates of IN. As can be seen, the term premium declined significantly after the introduction of QQE. As Sudo and Tanaka (2021) and Koeda and Sekine (2022) point out, the decline in the term premium seems to be attributable to the BOJ's large-scale purchases of long-term government bonds.

Next, an event study analysis is conducted to examine the impact of unconventional

[15] In IN, the 3-month interest rate for h months ahead, $y_{t,h,3}$, is obtained by the following equation:

$$y_{t,h,3} = \frac{1}{3}\{(h+3)y_{t,h+3}^{N,exp} - hy_{t,h}^{N,exp}\} = \frac{1}{3}\int_{h}^{h+3} \mathrm{E}_t^P[r_{t+\tau}^N]d\tau,$$

where, $y_{t,h}^{N,exp}$ is the expected rates at maturity h, r_t^N is the nominal short-term interest rate, and $\mathrm{E}_t^P[\cdot]$ denotes the conditional expectation under the $\mathbb{P}$-measure.

monetary policy on the nominal long-term interest rate based on daily estimates of IN. Figure 5 shows the change in the nominal long-term interest rate (10-year) before and after the monetary policy events, decomposed into the expected rates and the term premium. The horizontal axis represents the date of the monetary policy actions, and the vertical axis represents the change in the long-term interest rate. This figure shows that at the time of introducing the "Comprehensive Monetary Easing policy" in 2010 and QQE in 2013, long-term interest rates declined, mainly due to the decline in the term premium. As mentioned earlier, the BOJ's balance sheet expanded significantly after QQE, which may be the reason for the particularly large downward effect of the term premium during this period (Figure 6). In addition, when the negative interest rate is introduced, the expected rates declined significantly. The fact that negative interest rates contributed to the decline in expected rates has been pointed out by Ueno (2017) and Suganuma and Yamada (2017) for Japan, and by Altavilla et al. (2021) for the euro area.

3.4.2 Shadow rates and monetary policy stance

Figure 7 shows the estimates of shadow rates obtained from the three term structure models. It shows that all shadow rates declined significantly after the introduction of QQE, although there are large differences in the level depending on the model, as in the United States.

Following Krippner (2015b), we assess whether the change in the shadow rate is consistent with a change in the monetary policy stance. Specifically, we obtained Kendall's rank correlation coefficient between the data, where 1 (-1) denotes the month in which the Bank's monetary policy stance changed in a tightening (accommodative) direction, and the month-to-month difference in the shadow rate (Table 2).[16] As a reference, Kendall's rank correlation coefficient is also calculated for the uncollateralized overnight call rate. When Kendall's rank correlation coefficient is statistically significant and positive, it indicates that the uncollateralized overnight call rate and the shadow rate change in the same direction as the BOJ's policy stance.

The table shows that the uncollateralized call rate does not significantly relate to changes in the policy stance during the period of unconventional monetary policy, while the shadow rates have a statistically significant relationship not only during the period of

[16] Kendall's rank correlation coefficient τ is given by the following equation:

$$\tau = \frac{K - L}{N(N-1)/2},$$

where N is the number of items, K is the number of pairs for which the relationship between the two items matches, and L is the number of two items that do not match. The denominator is the total number of pair combinations. See Abdi (2007) for the asymptotic distribution of τ.

conventional monetary policy but also during the period of unconventional monetary policy. These results suggest some validity in using the shadow rate as a proxy variable for the monetary policy stance.

Table 2: Shadow Rate and Monetary Policy Stance
(Kendall's Rank Correlation Coefficients)

Monetary policy phase	Uncollateralized O/N call rate	IN	WX	Krippner
Conventional	0.68***	0.68***	0.68***	0.68***
Unconventional	0.09	0.21**	0.23**	0.24**

Note: ***, **, * denotes statistical significance at the 1, 5, and 10 percent level, respectively, for changes in monetary policy stance over 1995-2016 (Table A1).

4. Impact of unconventional monetary policy on the real economy

In this section, we estimate the impact of unconventional monetary policy on the economy and prices using a FAVAR with the shadow rate as a proxy of the monetary policy stance.

4.1 FAVAR

The FAVAR method is a time series analysis method proposed by Bernanke et al. (2005). It has the advantage of summarizing the time series variation of a large number of economic variables into a few factors, thereby eliminating omitted variable bias that emerges when using specific variables and identifying shocks. This is also a useful approach for identifying the impact of monetary policy on a wide range of economic variables and for a comprehensive examination of the effects and side effects.

The FAVAR is defined by the following equation:

$$\begin{bmatrix} x_t^m \\ s_t \end{bmatrix} = \begin{bmatrix} \mu^x \\ \mu^s \end{bmatrix} + \sum_{p=1}^{P} \rho^p \begin{bmatrix} x_{t-p}^m \\ s_{t-p} \end{bmatrix} + \Sigma^m \begin{bmatrix} \varepsilon_t^m \\ \varepsilon_t^{MP} \end{bmatrix}, \quad \begin{bmatrix} \varepsilon_t^m \\ \varepsilon_t^{MP} \end{bmatrix} \sim N(0, I),$$

where x_t^m is a $N \times 1$ vector of factors, s_t is the shadow rate, and P is the lag length of the VAR.[17] μ^x and μ^s are the intercepts, and ρ^p is a coefficient for the AR term estimated by the ordinary least squares. Σ^m is the Cholesky decomposition of the variance-covariance matrix of the residuals, and ε_t^{MP} represents the monetary policy shocks, which are identified by the recursive assumption as in Bernanke et al. (2005) and Wu and Xia (2016). Due to the uncertainty in estimating unobservable shadow rates, as their estimates depend substantially on the model, our analysis employs each of the three

[17] The lag length of the VAR is set to 3 based on the AIC.

shadow rates presented in Section 3. As discussed in previous studies, identifying monetary policy shocks from the shadow rates, which reflects information from the entire yield curve, allows us to estimate the impact of not only changes in short-term interest rates but also changes in long-term interest rates and in the shape of yield curve.

For the factor x_t^m, the shadow rates s_t and the economic variables $y_{t,k}$, the FAVAR assumes the following relationship holds:

$$\begin{bmatrix} y_{t,1} \\ \vdots \\ y_{t,K} \end{bmatrix} = \begin{bmatrix} a_1 \\ \vdots \\ a_K \end{bmatrix} + \begin{bmatrix} \Lambda_1 & \psi_1 \\ \vdots & \vdots \\ \Lambda_K & \psi_K \end{bmatrix} \begin{bmatrix} x_t^m \\ s_t \end{bmatrix} + \begin{bmatrix} \eta_{t,1} \\ \vdots \\ \eta_{K,1} \end{bmatrix}, \quad \begin{bmatrix} \eta_{t,1} \\ \vdots \\ \eta_{K,1} \end{bmatrix} \sim N(0, \Omega).$$

where a_k is the intercept, and Λ_k and ψ_k denote the factor loadings estimated by the ordinary least squares. Under the recursive assumption, for economic variables that are expected to change with a lag from the monetary policy shock (slow-moving variables), we set $\psi_k = 0$. For variables that change contemporaneously (fast-moving variables), we set $\psi_k \neq 0$.[18] Using these parameters, the impulse response of economic variables (y_k) to a monetary policy shock h months ahead can be derived as follows:

$$\Phi_h^{MP,k} = \frac{\partial y_{t+h,k}}{\partial \varepsilon_t^{MP}} = \Lambda_k \frac{\partial x_{t+h}^m}{\partial \varepsilon_t^{MP}} + \psi_k \frac{\partial s_{t+h}}{\partial \varepsilon_t^{MP}}. \tag{4}$$

4.2 Data

The dataset consists of 231 macroeconomic variables, including industrial production, the unemployment rate, and the consumer price index (CPI). These variables are used to extract the factors through the principal component analysis (see Table A2). This dataset was mainly constructed by combining 12 additional variables related to bank loans and the other 219 variables provided in Maehashi and Shintani (2020), originally used to compare the predictability of machine learning techniques for the Japanese macroeconomy.[19] Following previous studies, some variables, such as the CPI, are converted from year-on-year changes to seasonally adjusted month-on-month changes.

The factors are constructed following the methodology of Wu and Xia (2016). First, four principal components are extracted from the 231 economic variables. Second, factors are converted as the variation of the four principal components that are orthogonal to the

[18] See Table A2 for the list of fast- and slow-moving variables.

[19] The additional 12 variables are from "Deposits, Vault Cash, and Loans and Bills Discounted (Monthly data)" published by the BOJ, with respect to types of lenders (*shinkin* banks and other banks), type of borrowers (total, corporate, and households), and purpose of funds (total and for fixed investment).

shadow rate.[20] Figure 8 illustrates the factor loadings obtained by regressing the economic variables by each factor. It shows that the first principal component is highly correlated with production and shipments, the second with finance, the third with labor and lending, and the fourth with inventories and prices.

The estimation period for this paper is January 2000 to December 2019 to exclude the impact of COVID-19 in the following years. One reason for setting the start of the estimation period at 2000 is the availability of data.[21] In addition, the following two reasons are taken into account.

First, the transmission channels of monetary policy in the 1990s may have been different from those in the subsequent decade. Indeed, monetary policy in the mid-1990s was conducted through an officially determined interest rate, namely the Official Discount Rate and window guidance. These policy instruments are different from the market interest rates guided through open market operations today (Itoh et al. (2015); Sonoda and Sudo (2016); Iwasaki and Sudo (2017)). Furthermore, prior to the enhanced transparency of monetary policy conduct under the Bank of Japan Act in 1998, policy decisions may have been communicated in a different manner from the current standard. For instance, the dates of policy meetings were not published in advance and were held irregularly in the 1990s. Second, the relationship between the shadow rate, the economy, and prices may differ and be asymmetric when the shadow rate is positive or negative.[22] One example is the research by Fujiwara (2006) and Inoue and Okimoto (2008), who, using a Markov switching vector autoregression (MS-VAR), report that the economic structure of Japan may have changed around the mid-1990s.

4.3 Impulse response function

Figure 9 shows the impulse response functions to a 25bp decrease in the shadow rate. The solid line represents the median estimate calculated using bootstrapping, and the shadow area represents its 90% confidence interval. Panels (A)-(C) illustrate the results when IN, WX, and Krippner's estimates are used as the shadow rate, respectively. Figure 10 plots the monetary policy shocks identified using each shadow rate.

[20] Specifically, we first extract the principal components from all macroeconomic variables $\widehat{pc_t}$ and principal components $\widehat{pc_t^*}$ from all slow-moving variables, respectively. Next, we regress the equations $\widehat{pc_t} = b_1\widehat{pc_t^*} + b_2 s_t + e_t$ by the ordinary least squares. The factor $\hat{x}_t^m$ is then given by $\widehat{pc_t} - \hat{b}_2 s_t$.

[21] The data for "Deposits, Vault Cash, and Loans and Bills Discounted (Monthly data)" is available from April 1998.

[22] Section 4.5 shows the formal results of robustness checks to test whether the transmission of shocks in the shadow rate differ when the shadow rate is positive or negative.

The results for IN in panel (A) of Figure 9 show that an accommodative monetary policy shock has a statistically significant and expansionary impact on many variables. For example, industrial production, building starts, disposable income, and loans outstanding tend to increase in response to accommodative monetary policy shocks, and the lending and unemployment rates tend to decrease. However, the response of the real consumption activity index has wide confidence intervals, and there may be a high degree of uncertainty regarding the impact of the monetary policy shock on consumption. The results obtained when WX and Krippner's shadow rates are employed are comparable to those of IN, indicating increases in industrial production and prices. Conversely, for the impulse response functions of the building starts and the real consumption activity index, the confidence intervals are large, and the estimates are insignificant when WX and Krippner are used, suggesting that the impact of monetary policy is uncertain.

These results suggest that accommodative monetary policy shocks, measured by the shadow rate, have an expansionary effect on various economic variables, and that unconventional monetary policy in Japan since 2000 has supported economic activities and price increases. However, it should be noted that while the impact of monetary policy is significant for production, prices, and employment-related variables, the impact on some economic variables, such as those related to consumption, are highly uncertain.

4.4 Counterfactual analysis

4.4.1 Methodology

In this section, a counterfactual analysis is conducted to quantitatively assess the effects and side effects of unconventional monetary policy. This is achieved by estimating the counterfactual developments of economic variables in the absence of unconventional monetary policy and comparing the difference between the actual and counterfactual values.

The historical decomposition technique allows us to express the contribution of monetary policy shocks to the economic variable $y_{t,k}$ as the combination of impulse response functions in Equation (4):

$$\sum_{\tau=\infty}^{t} \Phi_{\tau-t}^{MP,k}\, \varepsilon_{t-\tau}^{MP}, \tag{5}$$

where $\varepsilon_{t-\tau}^{MP}$ denotes the monetary policy shock identified by the VAR. Similarly, in the absence of unconventional monetary policy, the contribution of counterfactual monetary policy shocks $\varepsilon_{t-\tau}^{MP,CF}$ to the economic variable $y_{t,k}$ is described as follows:

$$\sum_{\tau=\infty}^{t} \Phi_{\tau-t}^{MP,k}\, \varepsilon_{t-\tau}^{MP,CF}. \qquad (6)$$

The impact of unconventional monetary policy on economic variables is estimated as the difference between Equations (5) and (6). Although it is not possible to uniquely determine the monetary policy shock in the absence of unconventional monetary policy ($\varepsilon_{t-\tau}^{MP,CF}$), our analysis employs the monetary policy shocks that maintain the shadow rate larger than zero as in Wu and Xia (2016). In other words, we assume a counterfactual scenario in which there is no unconventional monetary policy action, which is a situation where the shadow rate does not fall below zero. We use point estimates for the impulse response functions, and the counterfactual analysis is made for each of the three shadow rates, given the uncertainty in the estimates. The counterfactual analysis was conducted for three monetary policy phases separately: (i) Phase I: from March 2001 to February 2006, (ii) Phase II: from December 2008 to March 2013, and (iii) post-QQE: from April 2013 to December 2019.

4.4.2 Estimation results

Figure 11 illustrates the estimated counterfactuals for each monetary policy phase. In Figures 11-(1) to (7), the dark blue solid lines represent the actual values of economic variables, while the other lines represent the counterfactual values estimated using the three shadow rates. First, comparing each monetary policy phase reveals that the deviation between the counterfactual and the actual is larger after QQE than in the other periods. This suggests that large-scale monetary easing in the period had a more relevant effect. The average of the three counterfactuals after the introduction of QQE indicates that, in the absence of unconventional monetary policy, industrial production could have been 2.1%pts lower per year, and the unemployment rate could have been 1.3%pts higher at the end of 2019. Figure 11-(6) illustrates that the average impact on the year-on-year changes in the CPI is approximately 0.3%pts in Phase I and Phase II, and an additional 0.7%pts for the post-QQE period. Using the same parameters and the developments of shadow rates after January 2020 to extrapolate the impact up to June 2023, we get the impact on the CPI of approximately 0.9%pts. The magnitudes of these estimates about the impact of monetary policy after the introduction of QQE are comparable to those in previous literature and other analyses conducted by the BOJ.[23,24] These results imply that

[23] We compare the cumulative impulse response function reported by Michaelis and Watzka (2017) and Miyao and Okimoto (2020) (the two-year cumulative) multiplied by the change in the monetary base divided by GDP from 2013 to 2019.

[24] For details of the analysis, see Bank of Japan (2016), Kan et al. (2016), Bank of Japan (2021),

the series of monetary policies after the introduction of QQE in 2013 contributed to fostering a non-deflationary economic environment.

It should be noted that the shadow rate is the indicator of information on the entire yield curve. It is considered to reflect various monetary policy actions, including the outlook for future short-term interest rates and changes in the central bank's asset purchase policy. In this regard, the counterfactual of long-term interest rates in Figure 11-(7) reveals that they are, on average, reduced by -0.3%pts in Phase I, -0.5%pts in Phase II, and -1.2%pts during the post-QQE period on average, suggesting that these declines in long-term interest rates had affected the economy.

Also note that although various unconventional monetary policy instruments have been introduced in Japan based on the economic, price, and financial conditions prevailing at the time, our analysis employs the same model and fixed parameters within the sample period to conduct counterfactual analysis. To illustrate, concerning Phase I, the quantitative easing policy implemented in 2001 seems to have supported the economy, relaxed banks' liquidity, and mitigated adverse effects by supplying substantial funds to the market, under an awareness of financial instability at the time. However, our analysis does not explicitly incorporate such spillover channels originating from liquidity provision.

4.4.3 Discussion on the side effects of unconventional monetary policy

In this section, among the issues related to the unintended negative effects, or side effects, of monetary policy, we turn to a discussion using the analytical framework of our paper of the impact on (i) the supply side of the economy, such as the potential growth rate, and (ii) the profitability of financial institutions.

First, with respect to supply-side effects, some previous studies suggest that a prolonged period of low interest rates may hamper business dynamics and result in a subsequent depression of the potential growth rate (Banerjee and Hofmann (2018); Acharya et al. (2019)). Conversely, the impact of negative shocks that depress the potential growth rate through hysteresis – the spillover of short-term shocks in the economy to medium- and long-term economic growth trends through various channels – may be offset by monetary easing (Summers and Fatas (2016); BIS (2019); Jordà et al. (2020)). While there is thus no consensus on the medium- to long-term effects of monetary policy on supply-side issues such as potential growth, the results of the counterfactual analysis in this paper appear to support the latter view, that the spillover of

Kawamoto et al. (2021), and Haba et al. (2024a).

short-term shocks may be offset by monetary easing. As illustrated in Figures 11-(1)-(3), the counterfactual analysis indicates that unconventional monetary policy had a positive impact on industrial production, building starts, and employment. This suggests that it may have contributed to supporting the potential growth rate by accumulating capital stock and human capital.[25] The reduction in unemployment resulting from monetary easing may have had a positive distributional impact, as it is pointed out that monetary easing reduced income dispersion (Gornemann et al. (2021)).

Second, many previous studies indicate that the implementation of accommodative monetary policy may have a negative impact on the profitability of financial institutions (Borio et al. (2017), Brunnermeier and Koby (2018), Claessens et al. (2018)). For instance, Borio et al. (2017) conducted panel data analysis for major countries, including Japan, and reported a decline in bank profitability due to a reduction in short-term interest rates and a flattening of the yield curve. The results of the counterfactual analysis in Figures 11-(4)-(5) indicate that while unconventional monetary policy has led to an increase in loans outstanding, it has also resulted in a greater reduction in lending rates. This suggests that the latter factor has, to some extent, negatively impacted the profits of financial institutions. While Japan's financial system appears to be maintaining stability overall, it is important to closely monitor the relationship between monetary policy and the stability of the financial system and any structural changes.[26]

4.5 Robustness check

4.5.1 Relationship between shadow rates and economic dynamics

As the baseline results are estimated using data from 2000 to 2019, the majority of the results are derived from periods when the short-term interest rate was constrained by the effective lower bound. However, they also include periods when the short-term interest rate was above the effective lower bound, including the lift-off from the "zero interest rate policy" in August 2000, and the "quantitative easing policy" in March 2006. Given that the shadow rate is an unobservable interest rate that aggregates information from the entire yield curve, its impact on the real economy may be asymmetric when it is positive or negative. This could potentially affect our estimation results.

Therefore, following Wu and Xia (2016), this section employs a model to test whether the relationship between the shadow rates and economic variables differs during

[25] For the empirical analysis on the impact of monetary policy on the supply side of the economy in Japan, see Haba et al. (2024b).

[26] For more information on the stability of financial system, see Bank of Japan (2024), and Bank of Japan Financial System and Bank Examination Department (2023).

periods when short-term interest rates are subject to an effective lower bound constraint (ELB period) and those when they are not (non-ELB period). The model we estimated is as follows:

$$X_t = \mu^x + \rho^{xx} X_{t-1} + \rho_1^{xs} D(ELB) S_{t-1} + \rho_2^{xs}\big(1 - D(ELB)\big) S_{t-1} + \Sigma^{xx} \varepsilon_t^s,$$

$$S_t = \mu^s + \rho^{ss} S_{t-1} + \rho_1^{sx} D(ELB) X_{t-1} + \rho_2^{sx}\big(1 - D(ELB)\big) X_{t-1} + \Sigma^{ss} \varepsilon_t^s,$$

where $D(ELB)$ is a dummy variable that takes 1 in the ELB periods and 0 otherwise. The non-ELB periods are defined as the period from August 2000 (lift-off from the "zero interest rate policy") to February 2001 (before the start of the "quantitative easing policy"), and from March 2006 (lift-off of the "quantitative easing policy") to November 2008 (before the policy rate cut to around 0.1%).

The null hypothesis is as follows: the parameters that capture the effect of the shadow rate on the economy in the ELB and non-ELB periods (ρ_1^{xs}, ρ_2^{xs}), and the parameters that capture the effect of the economy on the shadow rate (ρ_1^{sx}, ρ_2^{sx}) do not differ statistically between ELB and non-ELB periods, respectively.

$$H_0\colon\ \rho_1^{xs} = \rho_2^{xs},$$

$$H_0\colon\ \rho_1^{sx} = \rho_2^{sx}.$$

Table 3 shows p-values of the likelihood ratio test (Hamilton (1994)). The result shows that the null hypothesis that the parameters remain constant throughout both periods is rejected at the 10% level for any of the shadow rates.[27] This evidence suggests that the relationship between the shadow rate and economic variables such as prices does not differ between the ELB and non-ELB periods. This finding is consistent with previous studies that support the use of the shadow rate as a proxy variable for the monetary policy stance (Wu and Xia (2016); Ichiue and Ueno (2018); Krippner (2020)).

[27] Note that the baseline model in this paper cannot be estimated earlier than April 1998 due to the unavailability of part of the dataset. However, we removed these unavailable data and created an alternative dataset that runs from January 1975, and conducted the same likelihood ratio test. We find that it can also not reject the null hypothesis that the parameters are the same throughout both periods at the 10% level.

Table 3: Likelihood Ratio Test for the Structural Change of Parameters (p-values)

Shadow rate	H_0: $\rho_1^{xs} = \rho_2^{xs}$	H_0: $\rho_1^{sx} = \rho_2^{sx}$
IN	0.64	0.20
WX	0.48	0.89
Krippner	0.48	0.72

Note: Figures are the p-value of the likelihood ratio test for the null hypothesis.

As a further robustness test, the impulse response function is estimated by limiting the estimation period to the ELB period only. Figure 12 compares the impulse response function estimated for the ELB sample and the baseline model. The median value for industrial production and building starts in response to a monetary policy shock is consistent with the baseline. Yet, the confidence interval for the ELB period alone includes zero. Conversely, the impact on the unemployment rate, loans outstanding, and the CPI remain statistically significant.[28]

4.5.2 Estimation using long-term interest rates as a policy variable

This section presents an alternative estimation result obtained when the nominal long-term interest rate (10-year interest rate) is employed instead of the shadow rate. The long-term interest rate is expected to reflect various factors, including domestic and international financial and economic conditions, and it is also particularly influenced by the monetary policy.[29] Previous studies, such as Baumeister and Benati (2013), employ the long-term interest rate as a proxy variable for the unconventional monetary policy stance.

Figure 13 shows the impulse response function to the accommodative monetary shock identified by the long-term interest rate as the proxy variable for policy stance. The figure indicates that the impact on building starts is no longer statistically significant, and the significant period for industrial production has decreased. However, the impact on the unemployment rate, disposable income, loans outstanding, and the CPI remains

[28] While beyond the scope of our analysis, it is also useful to analyze structural changes in the effectiveness of monetary policy. For example, Fujiwara (2006) estimates a MS-VAR and reports that a structural change may have occurred in the mid-1990s, when the zero interest rate policy was implemented, and a subsequent decline in the efficacy of the monetary policy.

[29] Bank of Japan Financial Markets Department (2023) reports the survey results showing that, while participants in the bond market before the introduction of QQE focused primarily on bond supply, demand and the economic environment, monetary policy became the dominant factor in the market following the introduction of QQE. Additionally, Kendall's rank correlation coefficient between the long-term interest rate and the BOJ's policy stance, calculated as in Table 2, is significant at the 5% level for both the conventional and unconventional policy periods, indicating that the long-term interest rate reflects the monetary policy stance.

statistically significant, which is generally consistent with the baseline results.

4.5.3 Estimation with an increased number of factors

Finally, we examine the impulse response function estimates when the number of factors is increased from the baseline model. In the baseline model, the number of factors is set to 4. However, the R squared for the CPI in our baseline model is 0.37, which is less than 0.89 for the U.S. economy, as reported by Wu and Xia (2016). As the number of factors is increased, there is the trade-off between the higher explanatory power and lower degree of freedom. This can lead to unstable parameters being estimated. Therefore, we choose the number of factors when the R squared for the CPI exceeds 0.5. Consequently, the number of factors is set to be 8, which yielded the R squared of 0.61.

Figure 14 shows the estimates of the impulse response function when the number of factors is set to 8. The shadow rate for IN is employed. The figure indicates that the impact on the real consumption activity index remains insignificant. However, the effects on other variables, such as industrial production and the CPI, are significant and consistent with the baseline results.

5. Concluding remarks

This paper employs a term structure model of interest rates and a time series model to investigate the impact of Japan's unconventional monetary policy since 2000 on long-term interest rates and the real economy. The estimates of the term structure model of interest rates indicate that long-term interest rates were lowered primarily due to the downward pressure on the term premium resulting from the BOJ's large-scale asset purchases after the introduction of QQE. It is also suggested that implementing negative interest rates seems to result in declining expected rates. Additionally, the time-series analysis indicates that unconventional monetary policy had a certain degree of expansionary influence on the economy and prices.

The counterfactual analysis reveals the counterfactual paths in the absence of unconventional monetary policy. The result suggests that the large-scale monetary easing since the introduction of QQE in 2013, has contributed to fostering a non-deflationary environment. The magnitude of the impact on prices is found to be generally consistent with the findings of previous studies in Japan. While there are various arguments on the unintended negative consequences of monetary policy, or the side effects, our counterfactual analysis implies that the accumulation of capital stock and improvement in the labor market have had a positive impact on potential growth and wealth distribution. With regard to the stability of the financial system stability, however, our analysis indicates that while unconventional monetary policy led to an increase in loans outstanding, there may have been a negative effect on the profitability of financial institutions due to a lowering of lending margins.

Finally, it is important to acknowledge the uncertainty associated with the model and data constraints. In particular, the shadow rate employed as a proxy variable for monetary policy stance is a useful indicator that reflects information on the entire yield curve, including the outlook for future short-term interest rates and the central bank's asset purchases. However, the shadow rate is not an interest rate that is actually used in transactions or referenced in economic activities. It is, therefore, possible that the shadow rate may exhibit different characteristics from the nominal short-term interest rate used in the conventional monetary policy periods. Furthermore, estimating the shadow rate itself also entails uncertainty since it is not directly observable. In assessing the effect of monetary policy, it is essential to acknowledge these limitations, to avoid relying on a single method, and to employ a range of methodologies instead.

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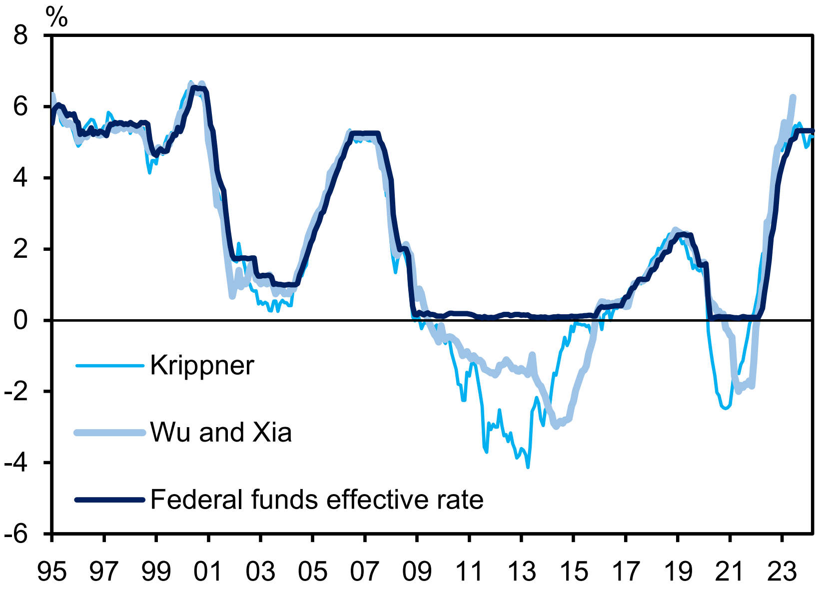
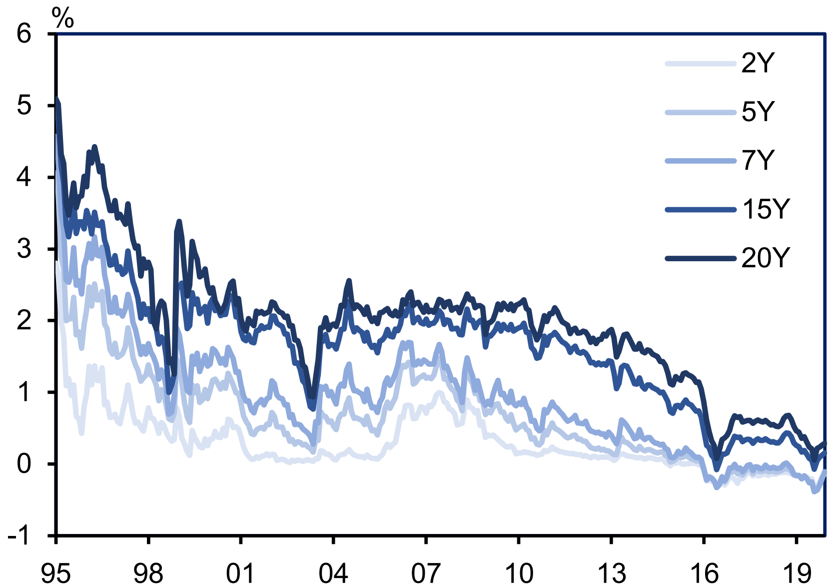
Figure 1: Estimates of Shadow Rates in the U.S.



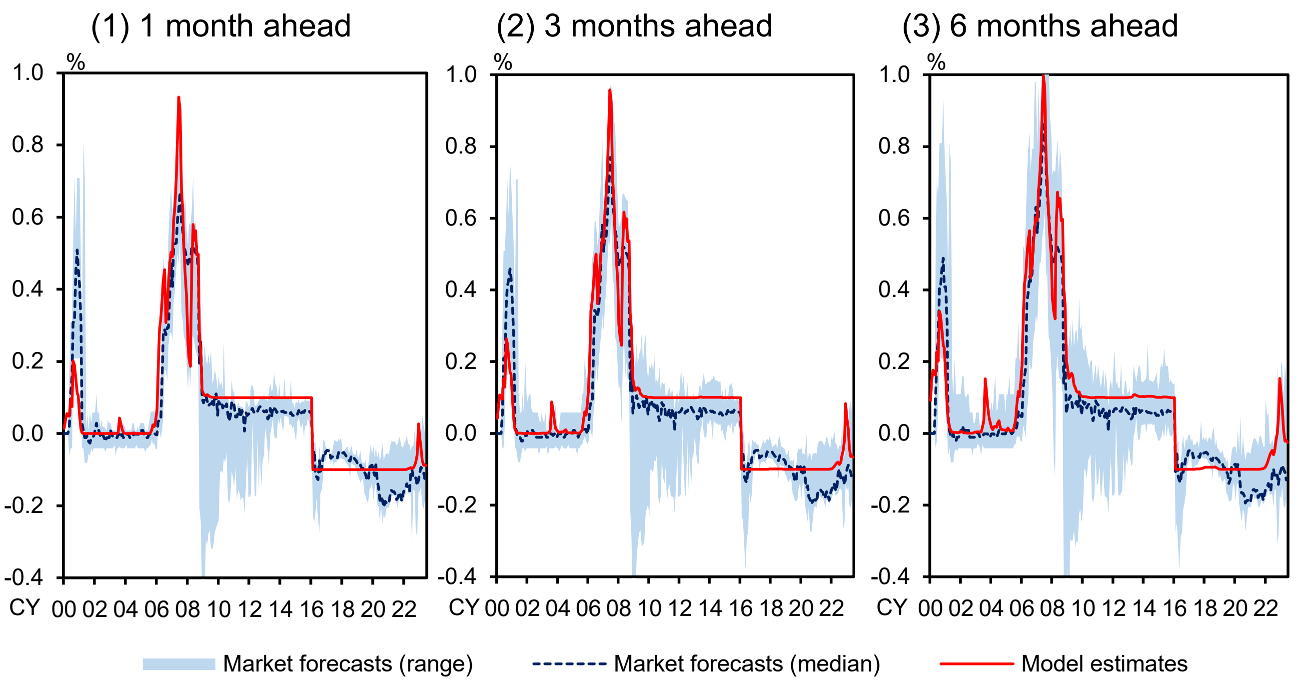
Sources: FRED, Jing Cynthia Wu's website, LJKmfa.

Figure 2: Nominal Zero Coupon Yield (Japan)



Source: Bloomberg.

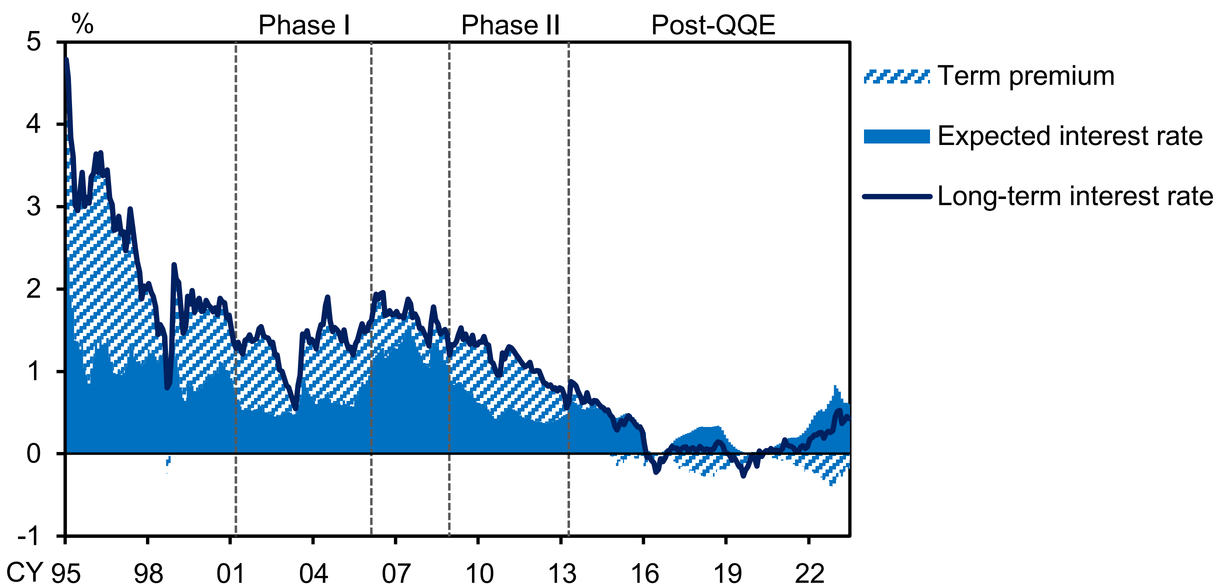
Figure 3: Estimates of 3-month Forward Nominal Interest Rates and Market Forecasts



Note: The market forecast is the TIBOR forecasts derived from the "QUICK Monthly Market Survey <Bonds>" and converted to OIS basis by adding spreads between TIBOR and OIS rates by authors. The range of market forecasts is the 1st and 99th percentile values.

Source: Bloomberg; Consensus Economics Inc., "Consensus Forecasts"; QUICK, "QUICK Monthly Market Survey <Bonds>"; Authors' estimates.

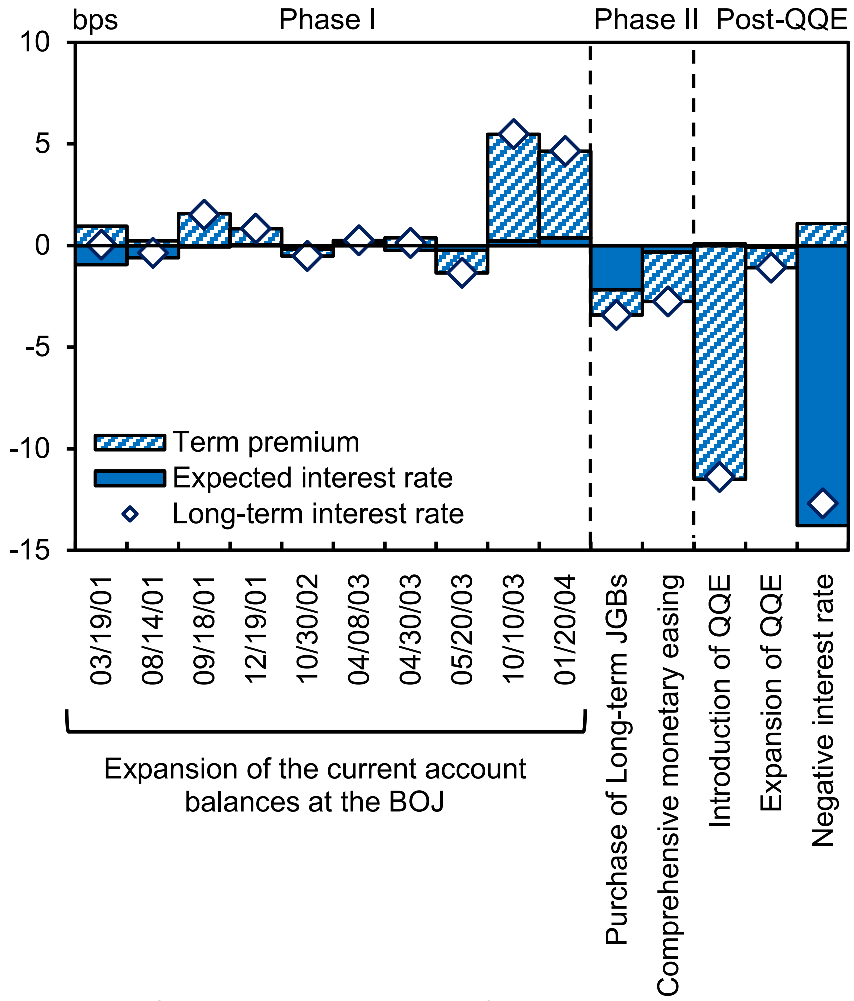
Figure 4: Decomposition of Nominal Long-Term Interest Rates (10-year)



Note: "Phase I" refers to the period from March 2001 to February 2006 (including the period of quantitative easing), "Phase II" refers to the period from December 2008 to March 2013 (including the period of expansion of long-term government bond purchase after the global financial crisis and the period of "comprehensive monetary easing policy"), and "post-QQE" refers to the period after April 2013. The same applies to the following figures.

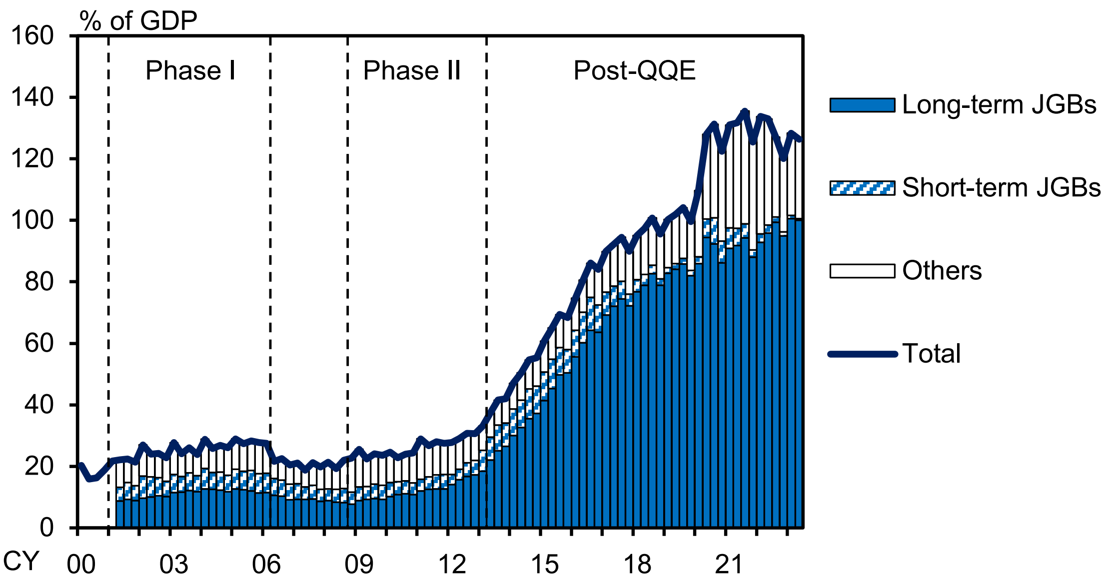
Source: Bloomberg; Consensus Economics Inc., "Consensus Forecasts"; Authors' estimates.

Figure 5: Daily Changes in Nominal Long-Term Interest Rate (10-year)



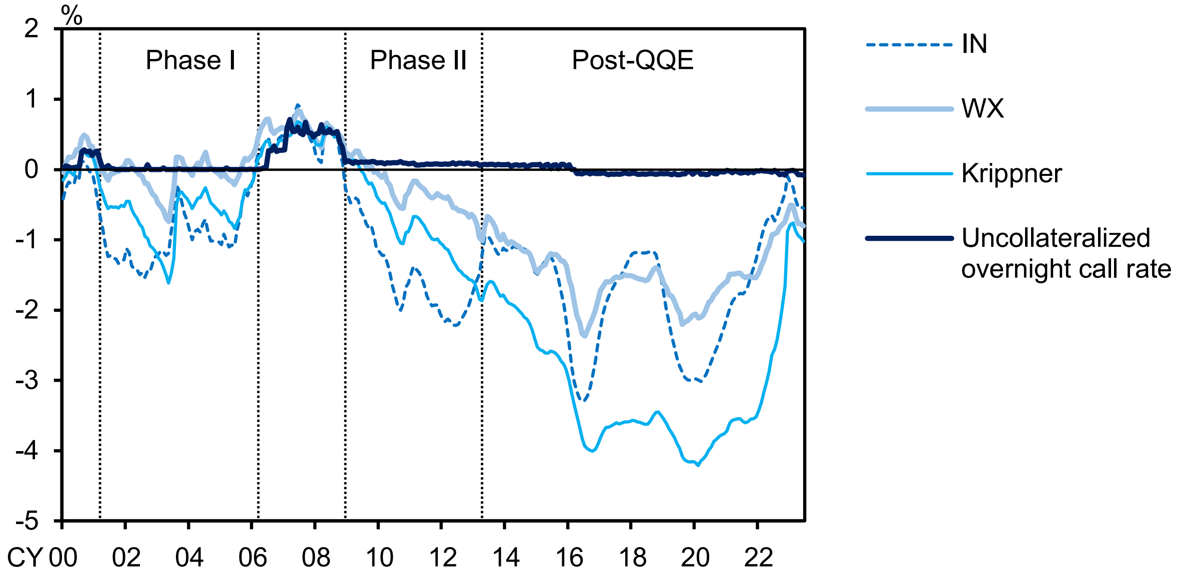
Source: Bloomberg; Consensus Economics Inc., "Consensus Forecasts"; Authors' estimates.

Figure 6: Total Assets of the BOJ



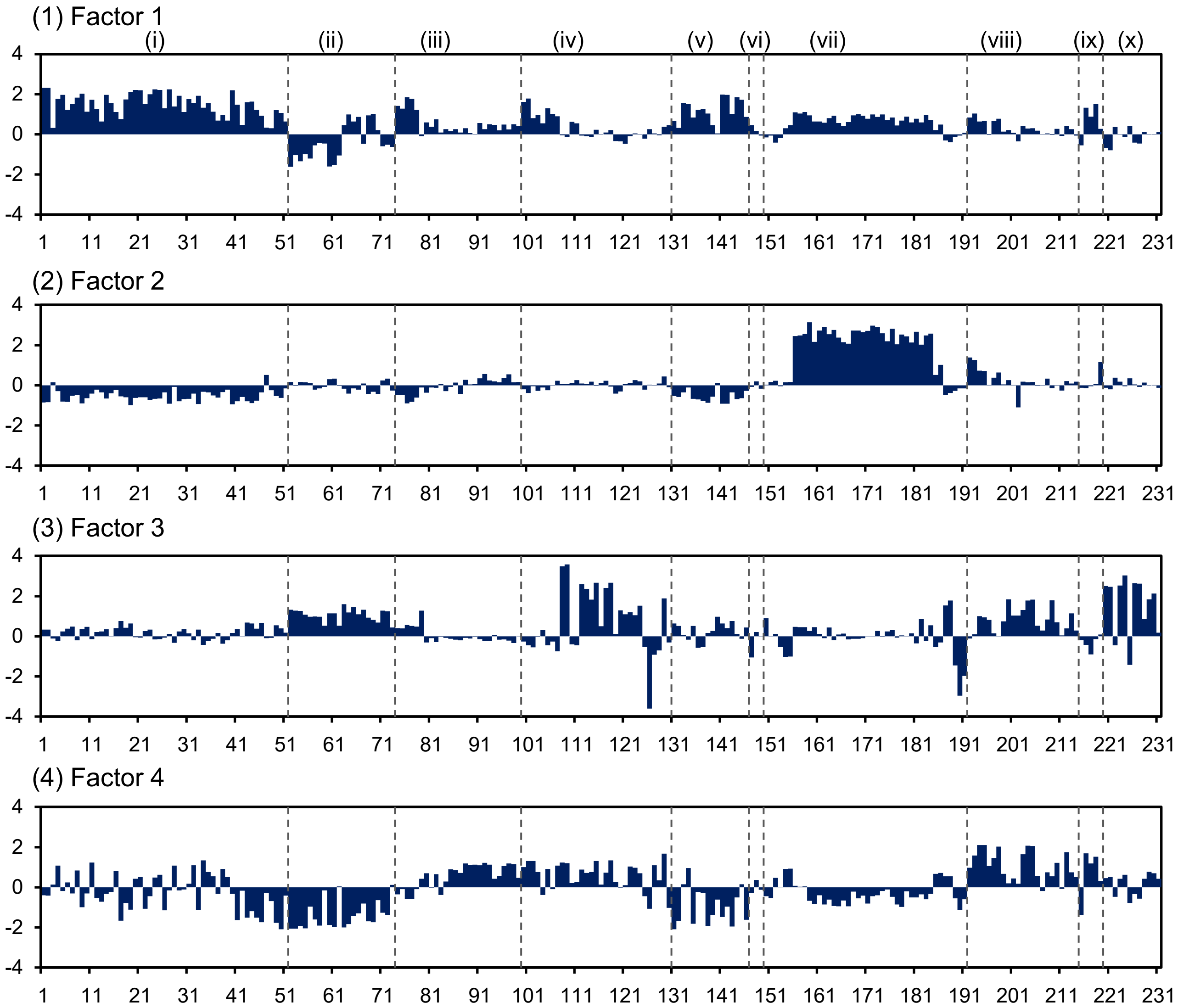
Note: Due to the data availability, only "Total" is shown for the period from March 2000 to March 2001.
Source: Cabinet Office, Bank of Japan.

Figure 7: Shadow Rates



Source: Bloomberg; Consensus Economics Inc., "Consensus Forecasts"; Bank of Japan; Authors' estimates.

Figure 8: Factor Loadings



Note: The figure shows the factor loadings estimated by regressing each economic variable shown on the horizontal axis on four factors extracted by principal component analysis from 231 economic variables. The period of data is from January 2000 to December 2019. The groups of economic variables are (i) production and shipments, (ii) inventories, (iii) investment, (iv) labor, (v) consumption, (vi) business environment, (vii) finance, (viii) prices, (ix) trade, and (x) lending. See Table A2 for details of the economic variables.

Figure 9: Impulse Response Function: Baseline Model <1/3>

(A) Shadow Rate: IN

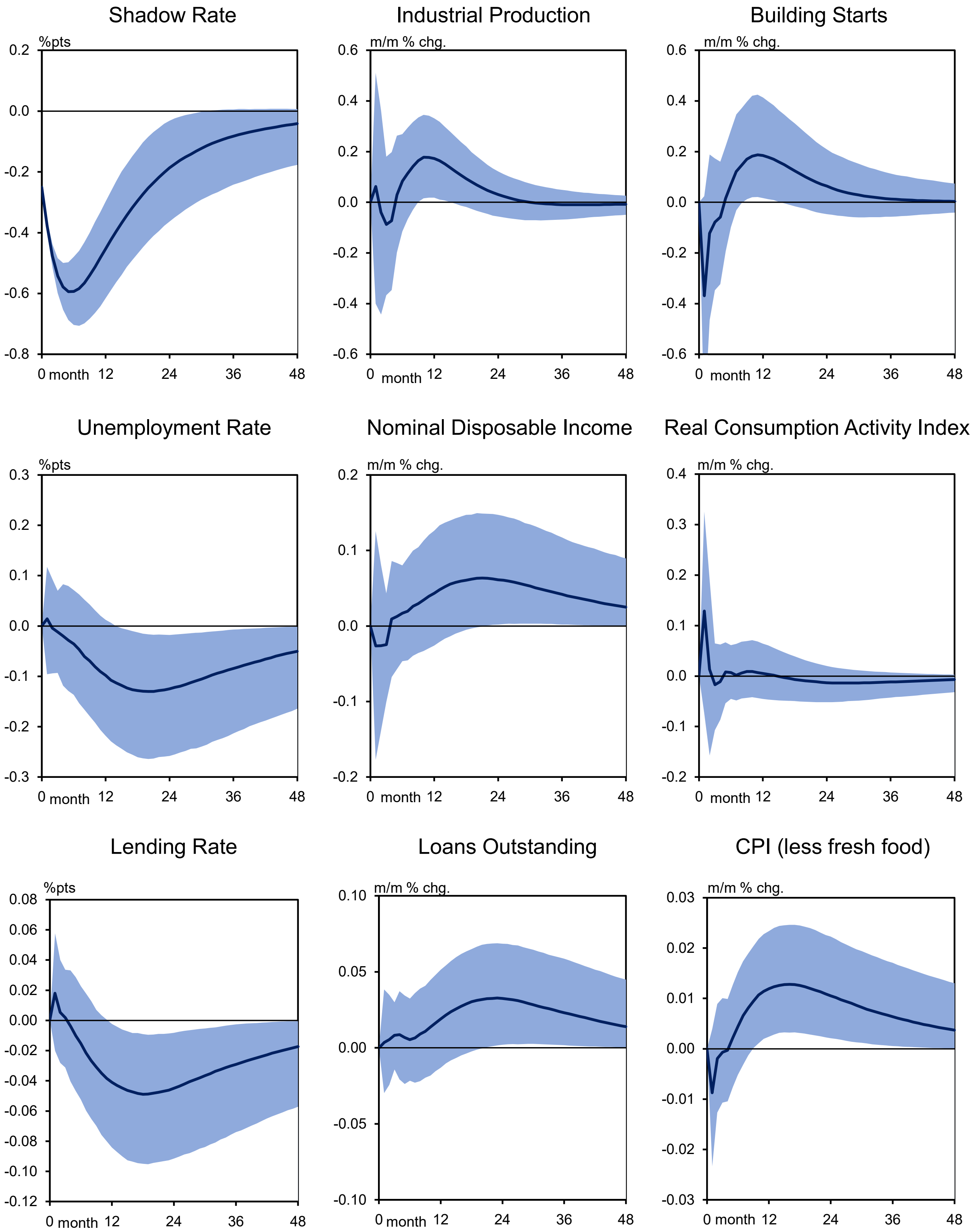


Figure 9: Impulse Response Function: Baseline Model <2/3>

(B) Shadow Rate: WX

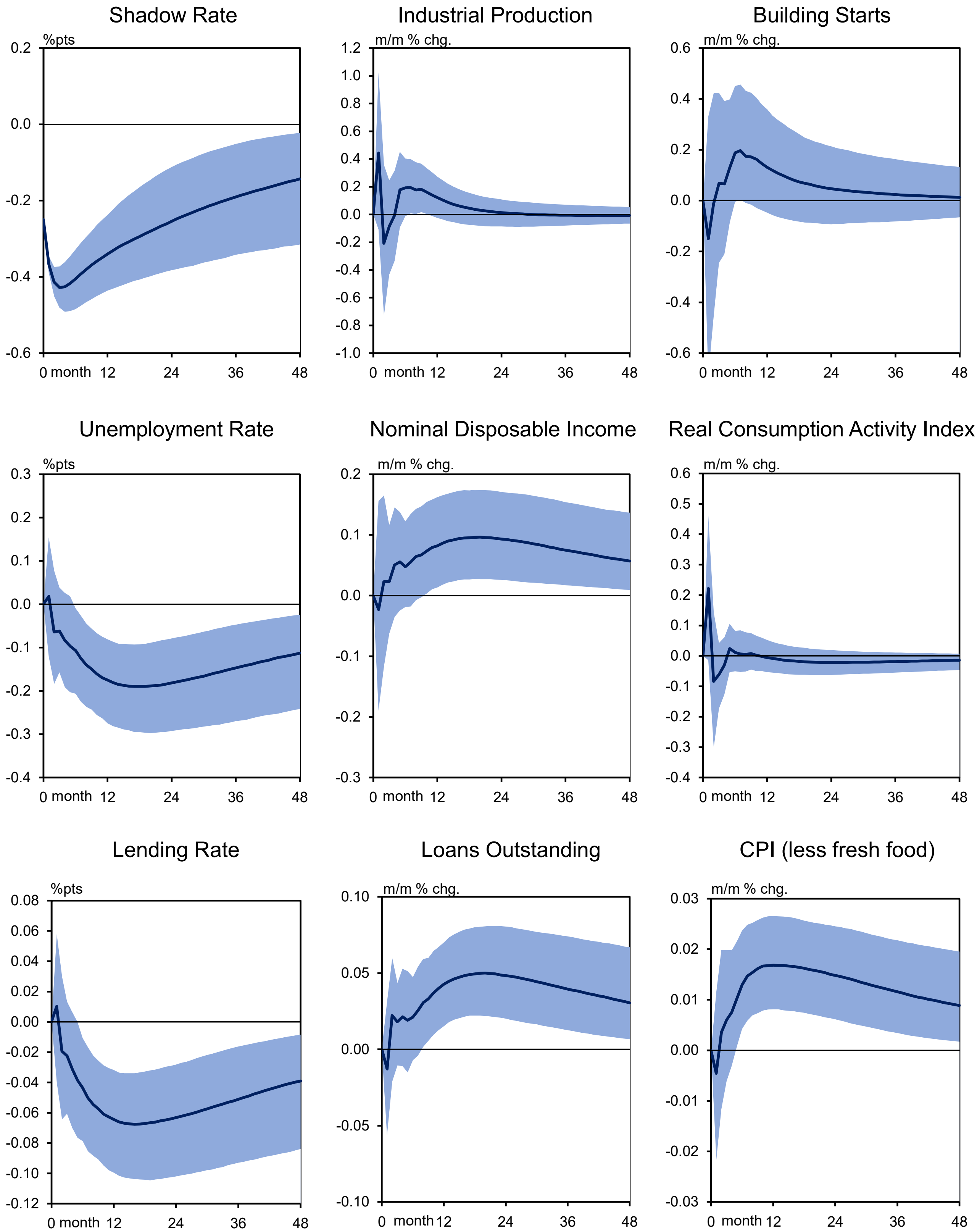
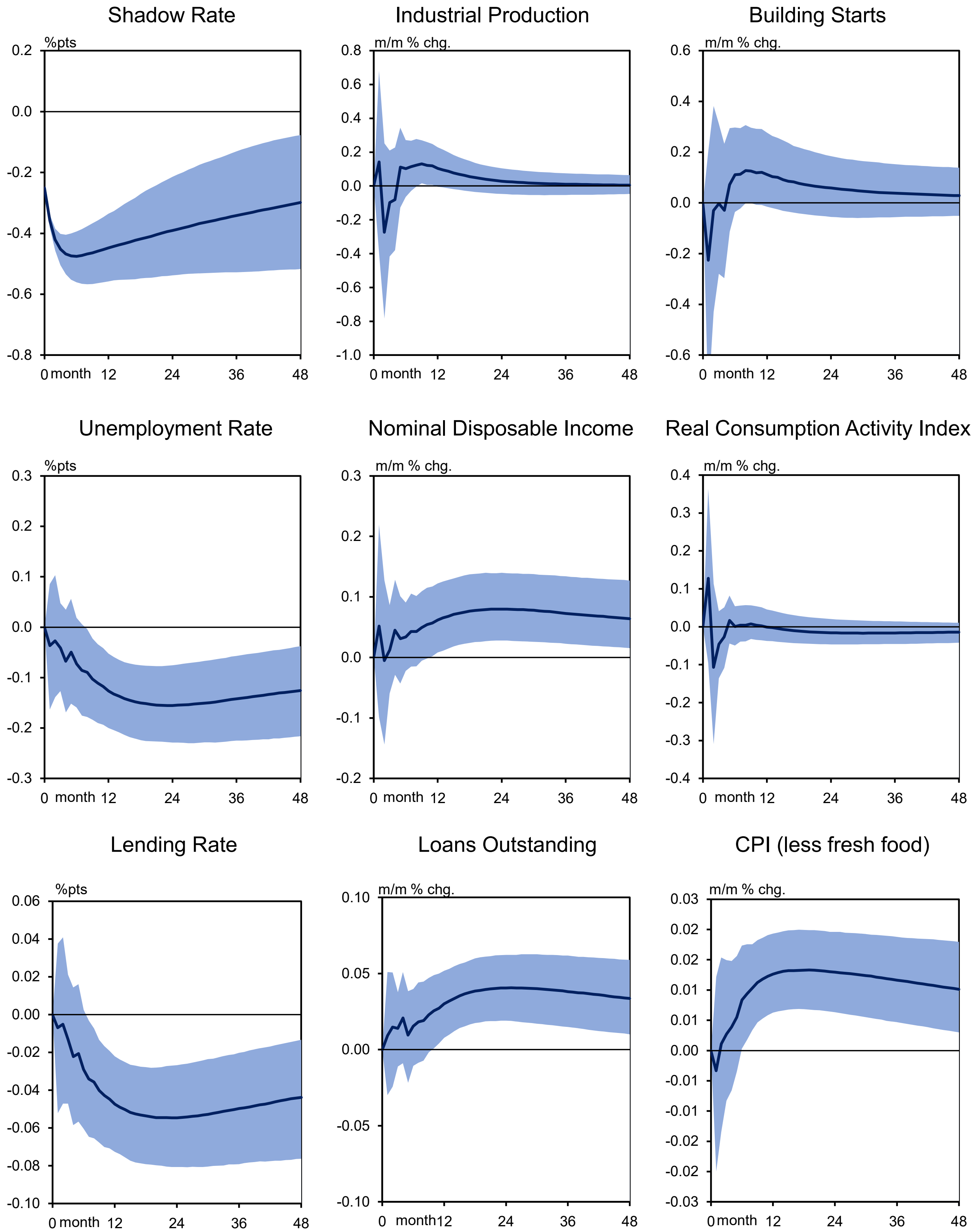


Figure 9: Impulse Response Function: Baseline Model <3/3>

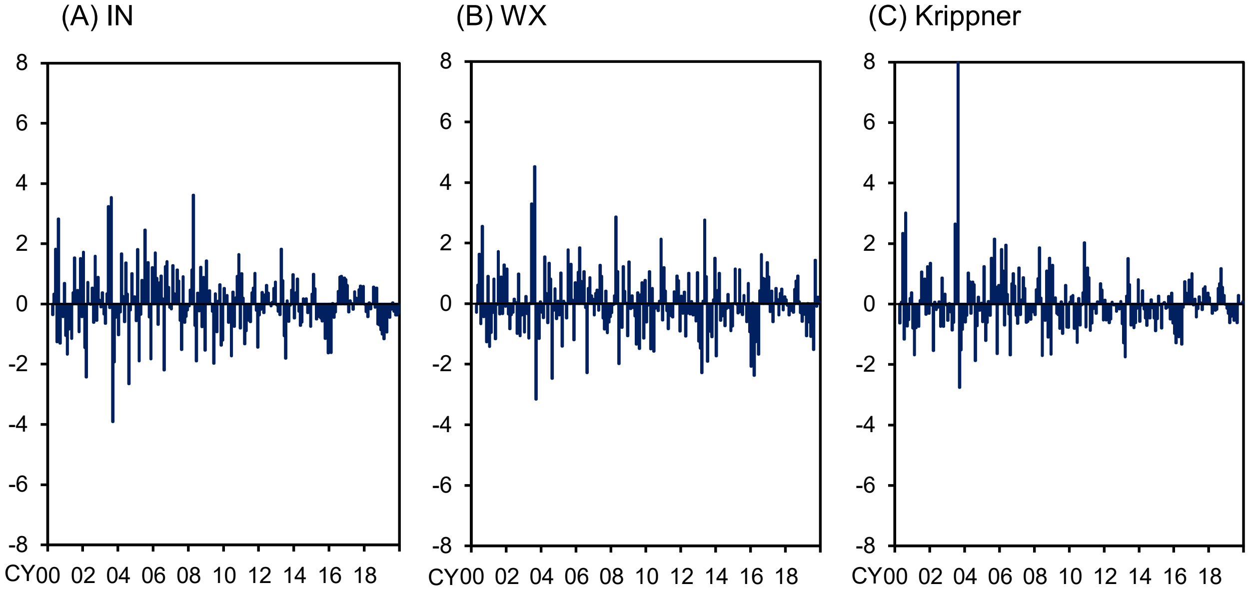
(C) Shadow Rate: Krippner



Note: The impulse response to an exogenous 25bps decline in the shadow rate. Shaded areas are 90% confidence intervals.

Source: Bloomberg; Consensus Economics Inc., "Consensus Forecasts"; Ministry of Economy, Trade and Industry; Ministry of Health, Labour and Welfare; Ministry of Land, Infrastructure, Transport and Tourism; Ministry of Internal Affairs and Communications; Cabinet Office; Bank of Japan; Authors' estimates.

Figure 10: Monetary Policy Shocks

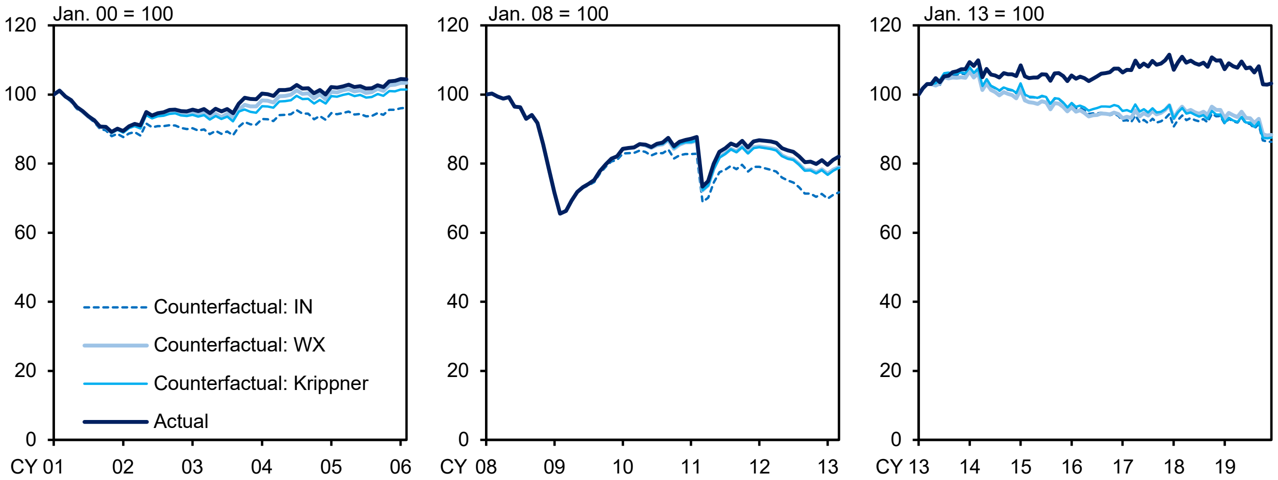


Note: The units of shocks are standardized.
Source: Bloomberg; Consensus Economics Inc., "Consensus Forecasts"; Authors' estimates.

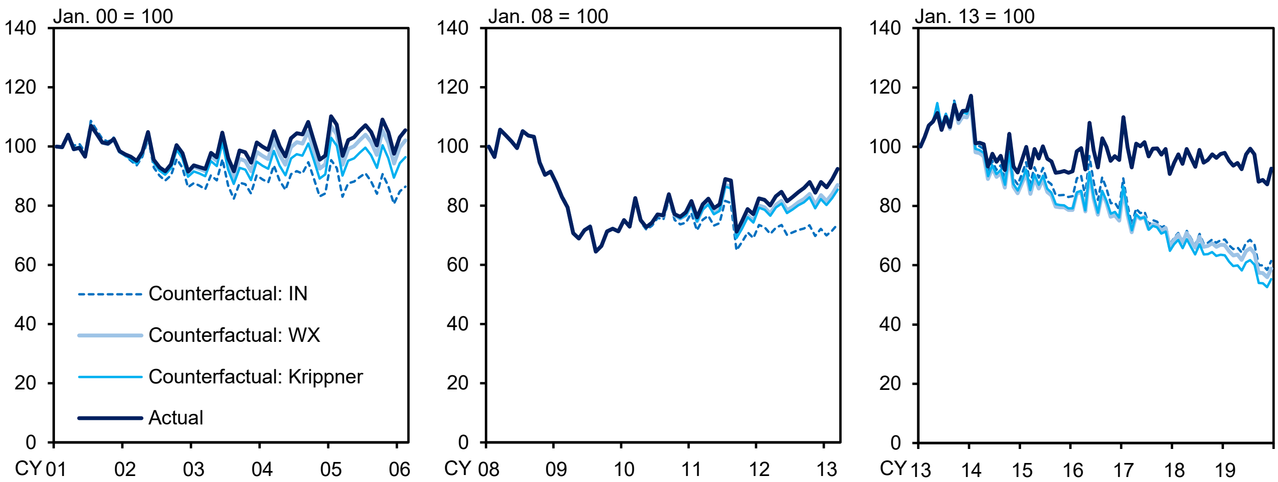
Figure 11: Counterfactual Analysis <1/3>

Phase I	Phase II	Post-QQE
March 2001 – February 2006	December 2008 – March 2013	April 2013 – December 2019

(1) Industrial Production



(2) Building Starts



(3) Unemployment Rate

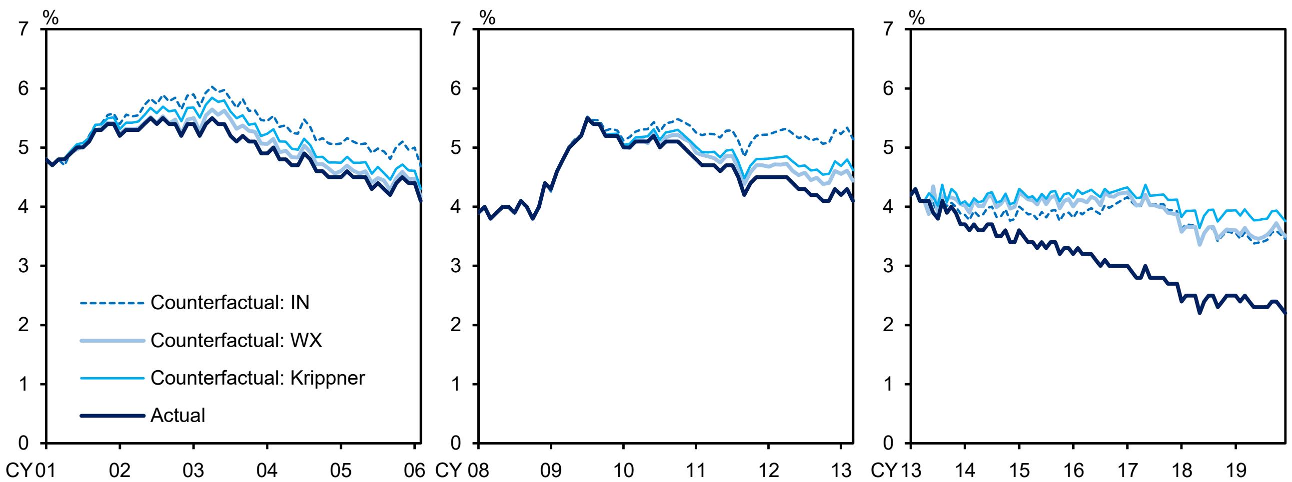


Figure 11: Counterfactual Analysis <2/3>

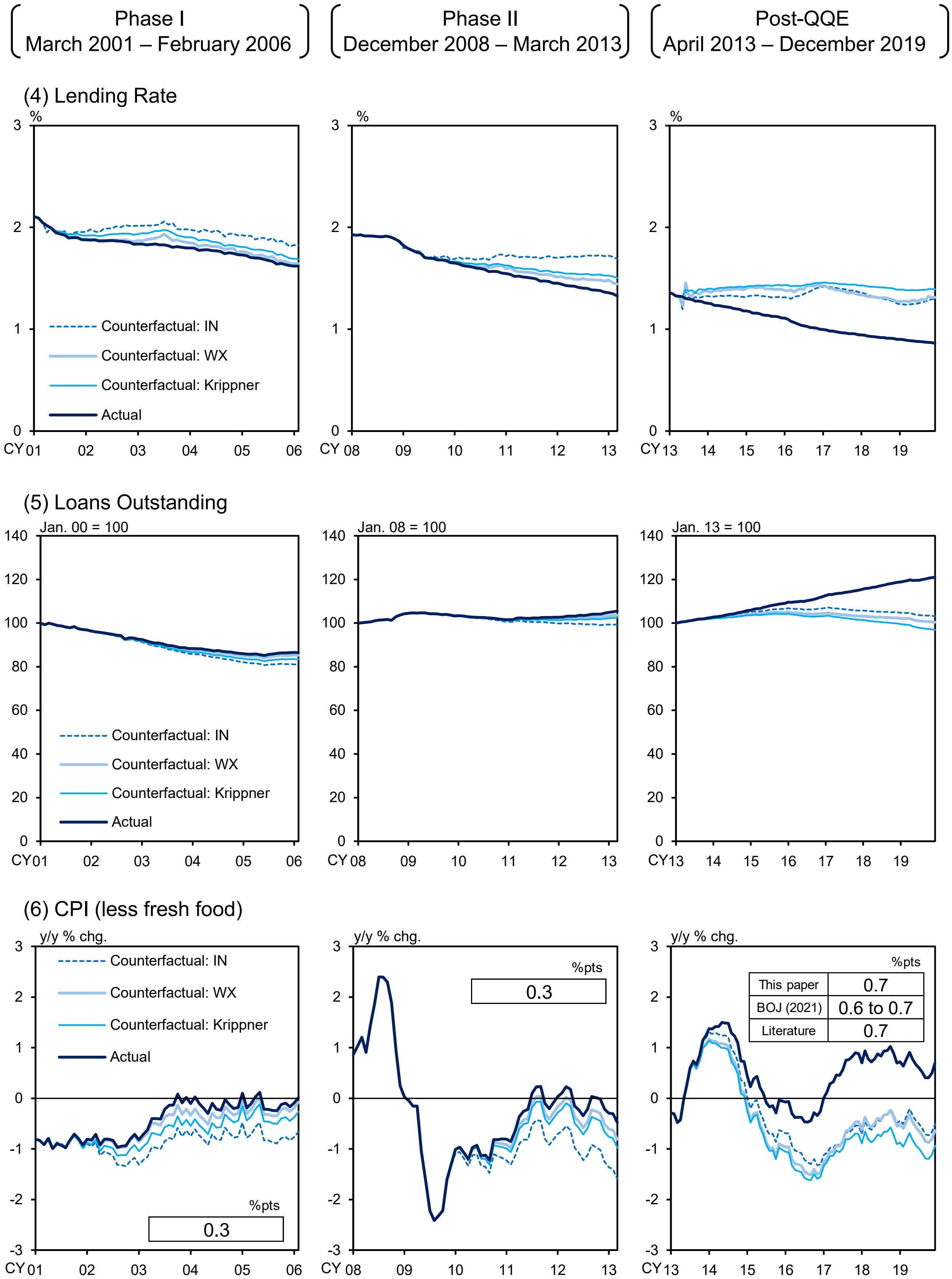
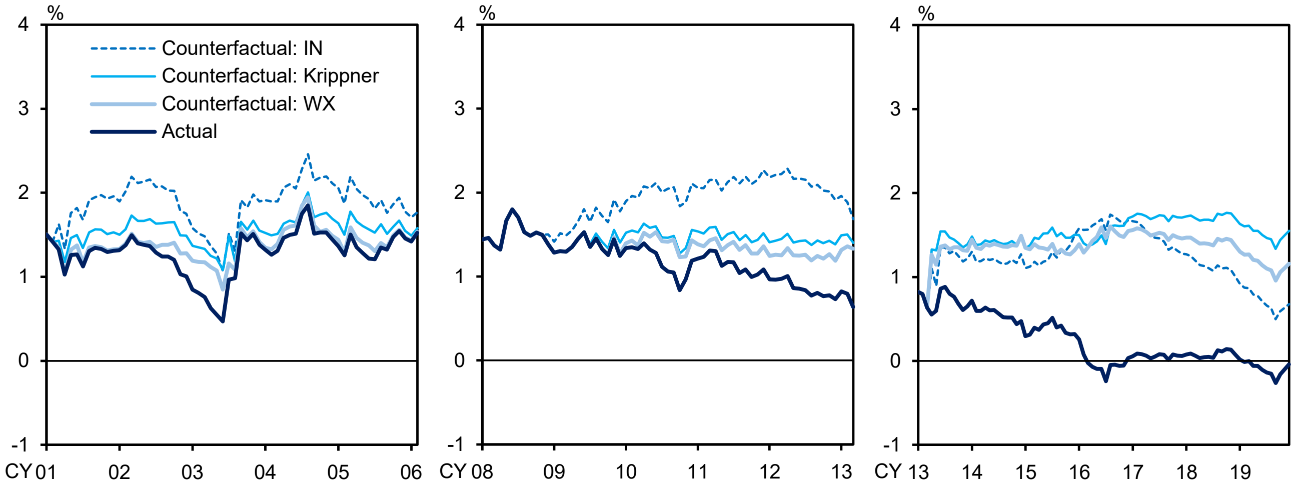


Figure 11: Counterfactual Analysis <3/3>

Phase I	Phase II	Post-QQE
March 2001 – February 2006	December 2008 – March 2013	April 2013 – December 2019

(7) 10-year Interest Rate



Note: 1. "Counterfactual" is estimated using point estimates of the impulse response function from each shadow rate.

2. CPI (less fresh food) is year-on-year change and excludes the impact of the consumption tax hike. Values in the tables represent the differences between the actual and the counterfactual. Values for post-QQE are additional impact from Phase II. The value for the literature is computed by the authors based on the cumulative impulse response functions reported by Michaelis and Watzka (2017) and Miyao and Okimoto (2020).

Source: Bloomberg; Consensus Economics Inc., "Consensus Forecasts"; Ministry of Economy, Trade and Industry; Ministry of Health, Labour and Welfare; Ministry of Land, Infrastructure, Transport and Tourism; Ministry of Internal Affairs and Communications; Cabinet Office; Bank of Japan; Authors' estimates.

Figure 12: Impulse Response Function: Estimates for the ELB period <1/3>

(A) Shadow Rate: IN

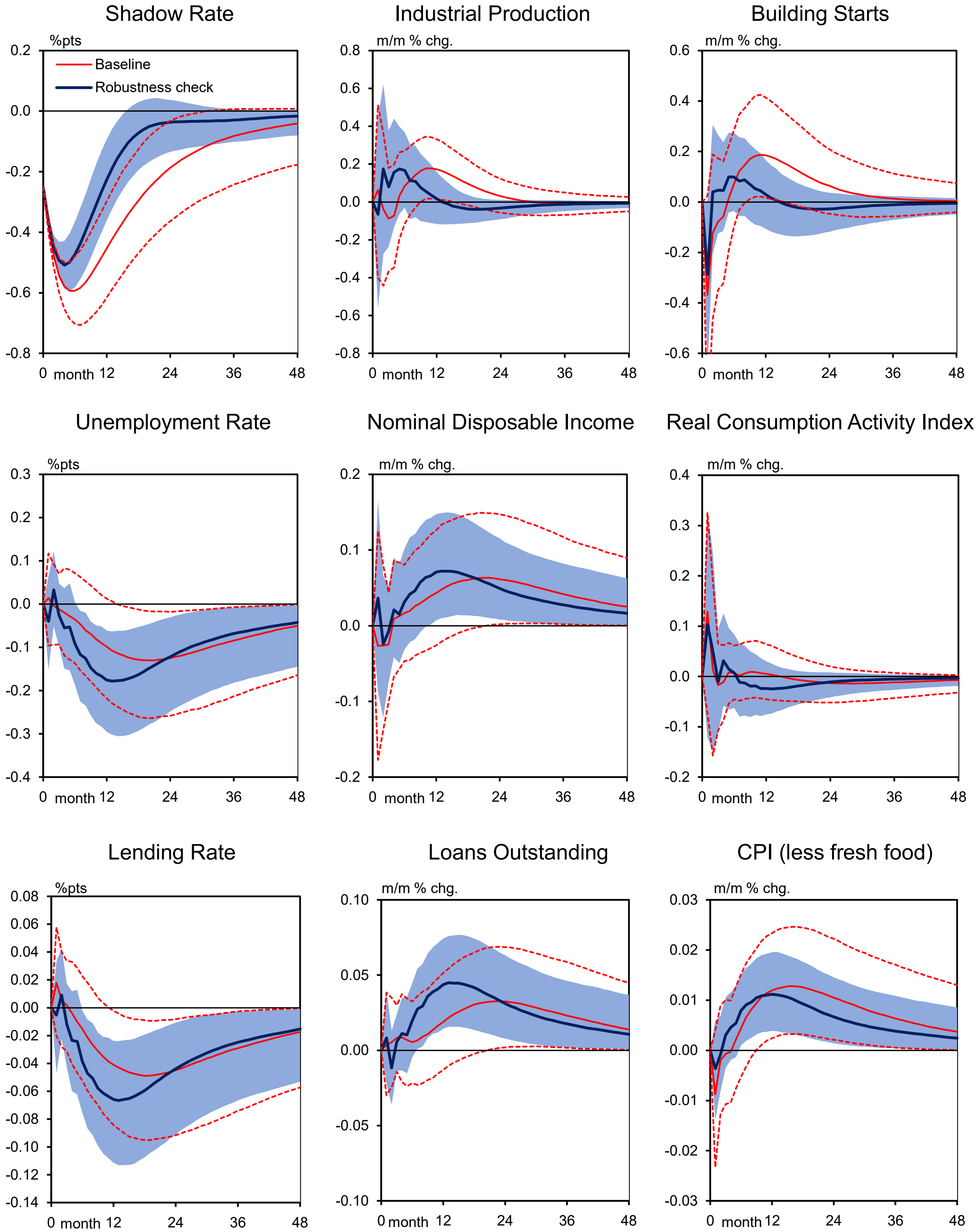


Figure 12: Impulse Response Function: Estimates for the ELB period <2/3>

(B) Shadow Rate: WX

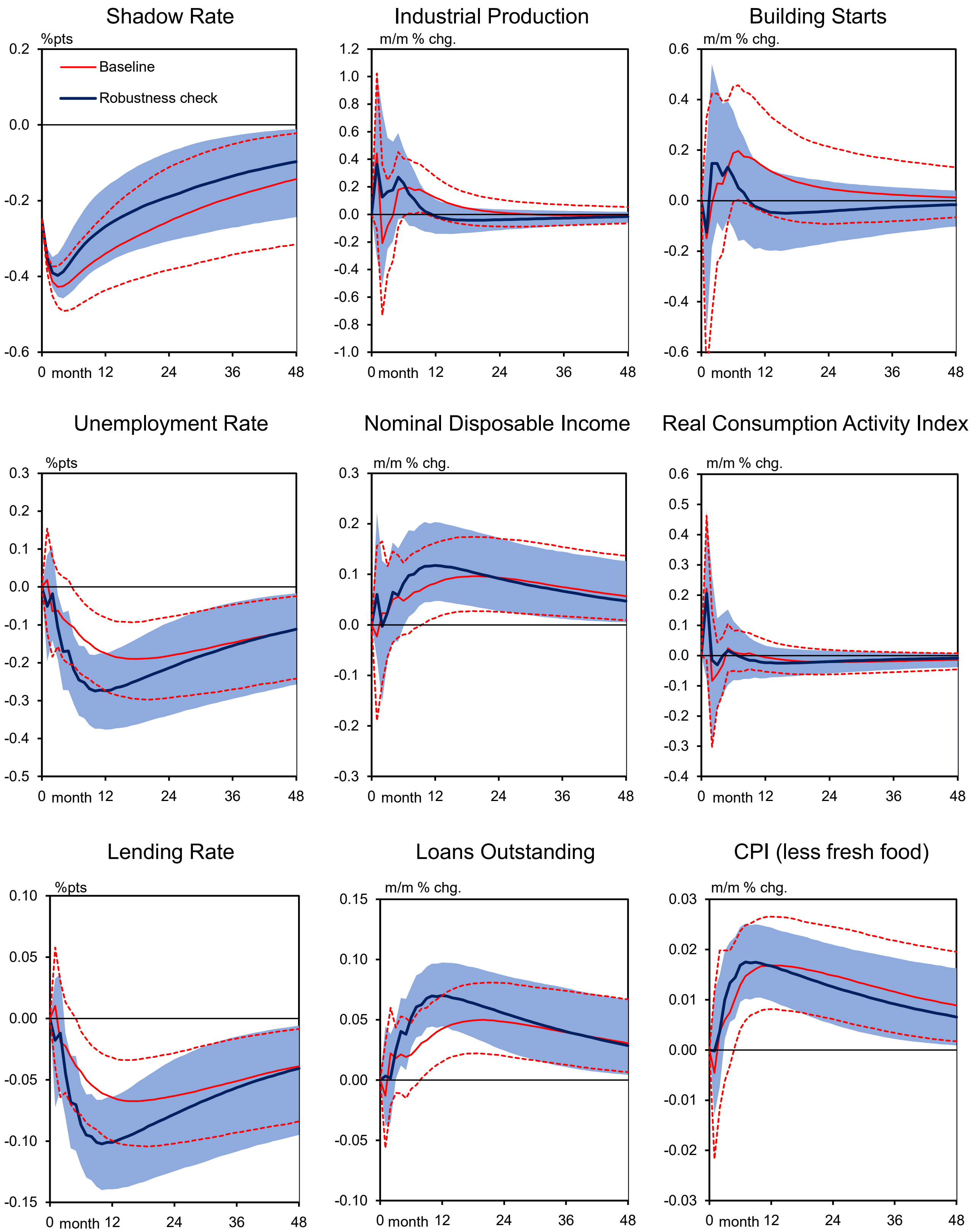
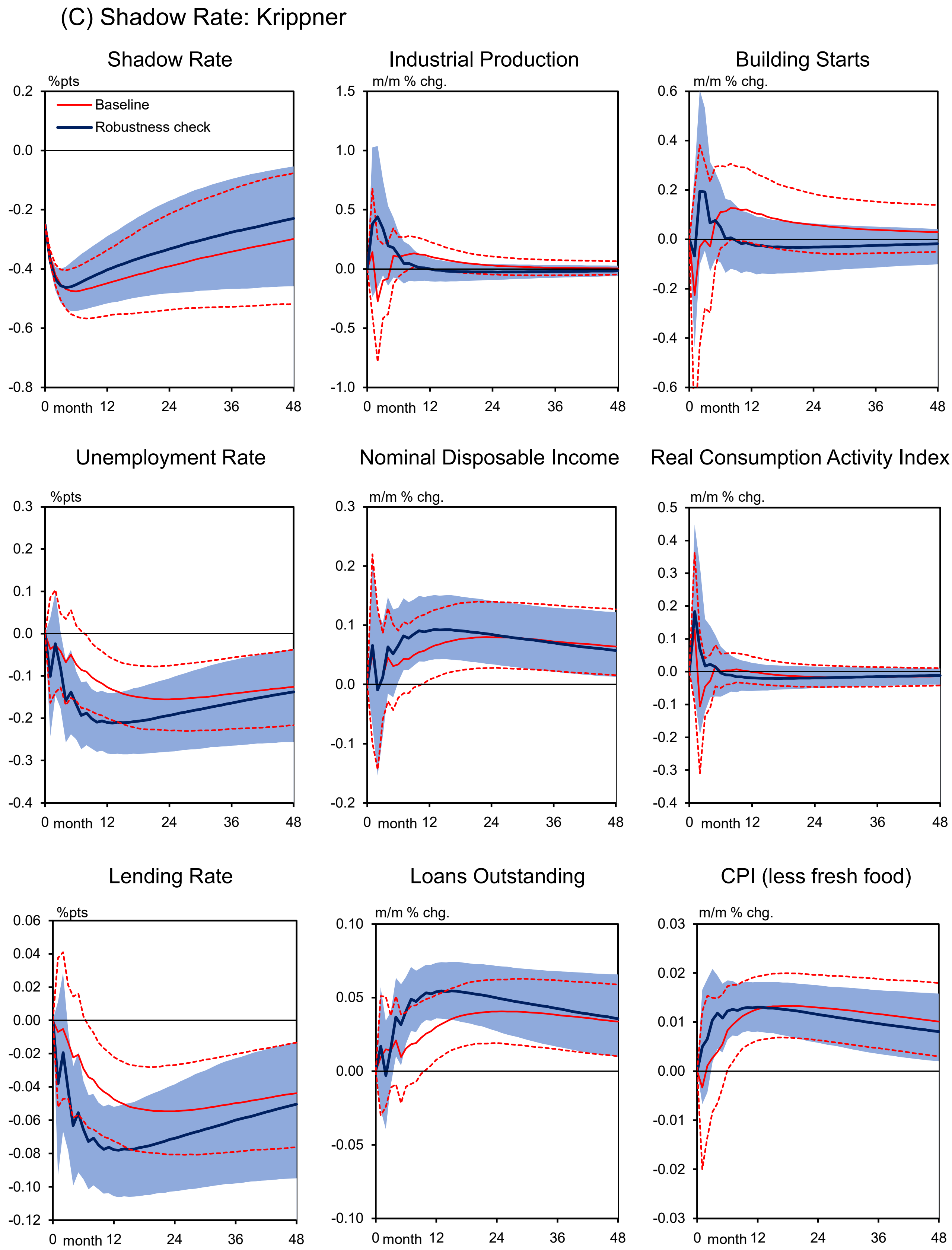


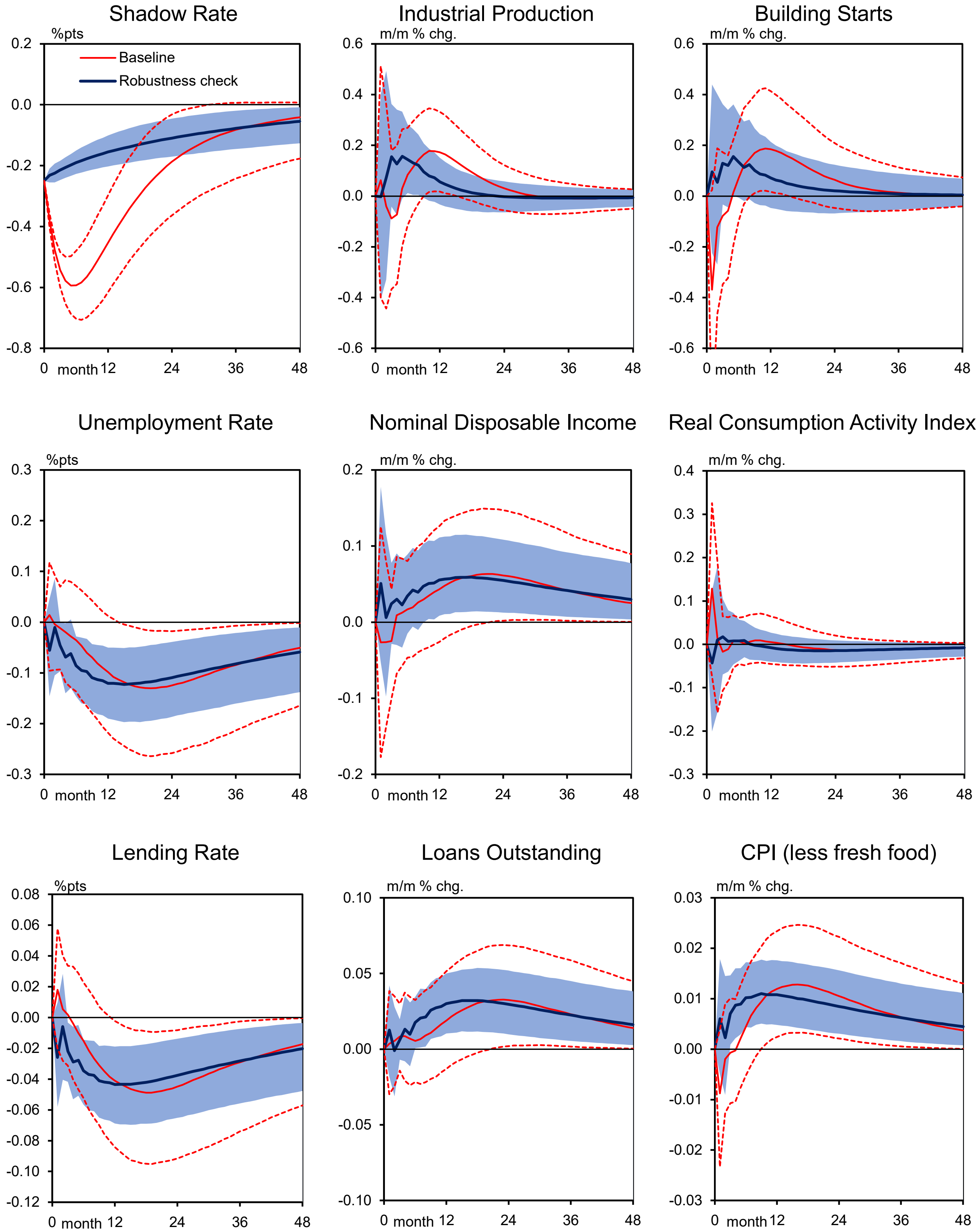
Figure 12: Impulse Response Function: Estimates for the ELB period <3/3>



Note: The impulse response to an exogenous 25bps decline in the shadow rate. Shaded areas and dotted lines are 90% confidence intervals.

Source: Bloomberg; Consensus Economics Inc., "Consensus Forecasts"; Ministry of Economy, Trade and Industry; Ministry of Health, Labour and Welfare; Ministry of Land, Infrastructure, Transport and Tourism; Ministry of Internal Affairs and Communications; Cabinet Office; Bank of Japan; Authors' estimates.

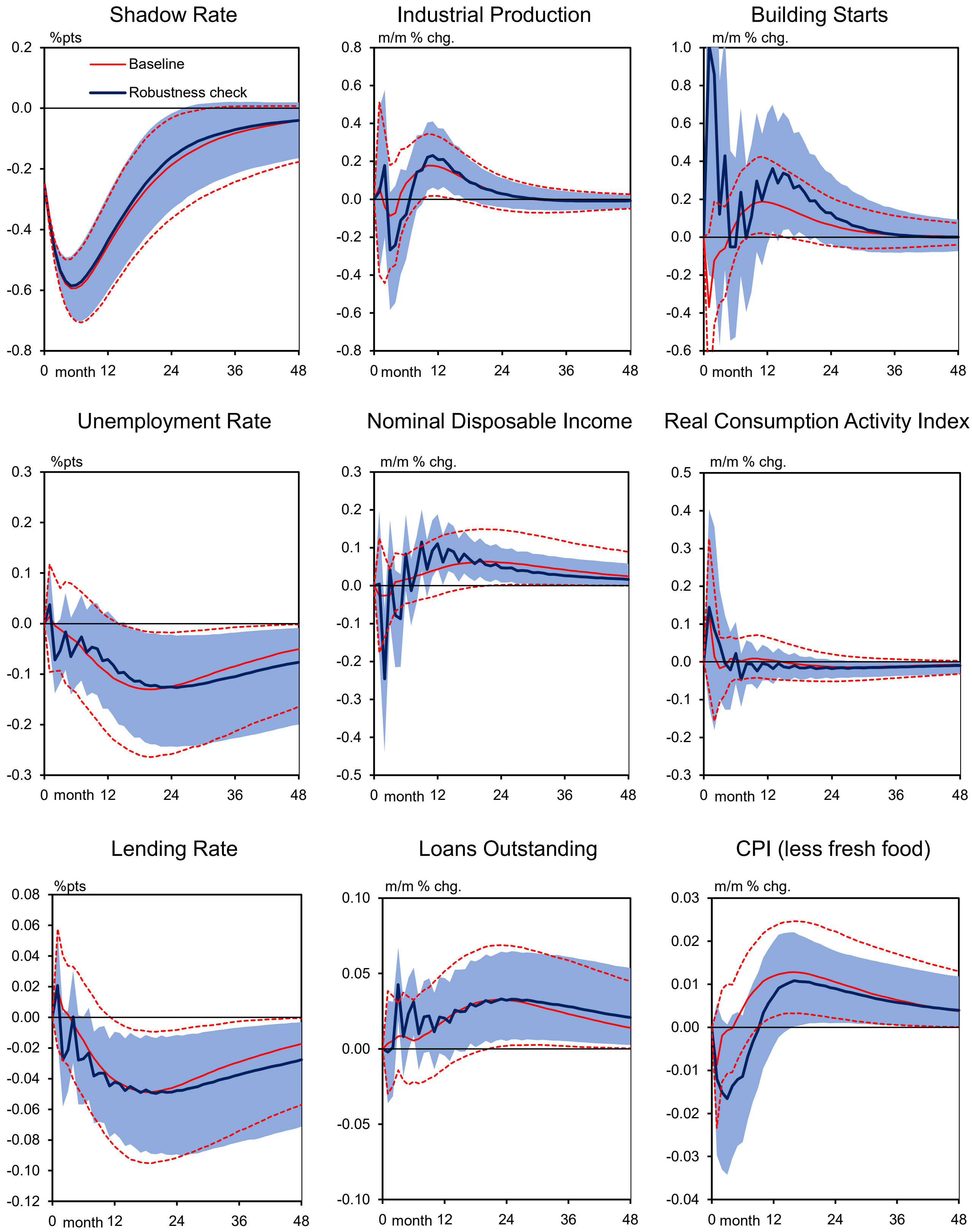
Figure 13: Impulse Response Function: Long-Term Interest Rates



Note: The impulse response to an exogenous 25bps decline in the 10-year interest rate. Shaded areas and dotted lines are 90% confidence intervals. "Baseline" is the estimate by the shadow rate of IN.

Source: Bloomberg; Consensus Economics Inc., "Consensus Forecasts"; Ministry of Economy, Trade and Industry; Ministry of Health, Labour and Welfare; Ministry of Land, Infrastructure, Transport and Tourism; Ministry of Internal Affairs and Communications; Cabinet Office; Bank of Japan; Authors' estimates.

Figure 14: Impulse Response Function: Increased Number of Factors



Note: The impulse response to an exogenous 25bps decline in the shadow rate. Shaded areas and dotted lines are 90% confidence intervals.

Source: Bloomberg; Consensus Economics Inc., "Consensus Forecasts"; Ministry of Economy, Trade and Industry; Ministry of Health, Labour and Welfare; Ministry of Land, Infrastructure, Transport and Tourism; Ministry of Internal Affairs and Communications; Cabinet Office; Bank of Japan; Authors' estimates.

Table A1: Changes in Monetary Policy Stance (1995-2019)

Date	Direction	Action
03/31/95	↓	Policy rate cut
07/07/95	↓	Policy rate cut
09/08/95	↓	Policy rate cut
09/09/98	↓	Policy rate cut
02/12/99	↓*	Policy rate cut (implementation of zero interest rate policy)
08/11/00	↑	Policy rate hike (end of zero interest rate policy)
02/28/01	↓	Policy rate cut
03/19/01	↓*	Introduction of QE
08/14/01	↓*	Expansion of QE
09/18/01	↓*	Expansion of QE
12/19/01	↓*	Expansion of QE
02/28/02	↓*	Expansion of QE
10/30/02	↓*	Expansion of QE
02/14/03	↓*	Expansion of QE stance
04/30/03	↓*	Expansion of QE
05/20/03	↓*	Expansion of QE
06/25/03	↓*	Purchase of risky assets
10/10/03	↓*	Expansion of QE
01/20/04	↓*	Expansion of QE
03/09/06	↑*	End of QE
07/14/06	↑	Policy rate hike
02/21/07	↑	Policy rate hike
10/31/08	↓	Policy rate cut
12/19/08	↓	Policy rate cut
01/22/09	↓*	Purchase of CPs
02/19/09	↓*	Purchase of CPs and corporate bonds
03/18/09	↓*	Purchase of JGBs
07/15/09	↓*	Extend the deadline of the purchase of CPs and corporate bonds
10/05/10	↓*	Introduction of comprehensive monetary easing policy
10/28/10	↓*	Purchase of JGBs, CPs, corporate bonds, ETFs, etc.
03/14/11	↓*	Expansion of asset purchase
08/04/11	↓*	Expansion of asset purchase
10/27/11	↓*	Expansion of asset purchase
02/14/12	↓*	Expansion of asset purchase Publication of "price stability goal in the medium to long term"
04/27/12	↓*	Expansion of asset purchase
07/12/12	↓*	Expansion of asset purchase
09/19/12	↓*	Expansion of asset purchase
10/30/12	↓*	Expansion of asset purchase Publication of "measures aimed at overcoming deflation"
12/20/12	↓*	Expansion of asset purchase
01/22/13	↓*	Introduction of "price stability target" at 2%
04/04/13	↓*	Introduction of QQE
10/31/14	↓*	Expansion of QQE
12/18/15	↓*	Introduction of supplementary measures for QQE
01/29/16	↓*	Introduction of negative interest rate
07/29/16	↓*	Expansion of purchase of ETFs

Note: "↑ (↓)" indicates a change in monetary policy stance in the direction of tightening (easing). "*" indicates a period of unconventional policies.

Table A2: List of Economic Variables

No.	Variable	Transformation
Production and Shipments		
1	Index of Industrial Production (Mining and manufacturing)	S.A., Δln
2	Index of Industrial Production (Manufacturing)	S.A., Δln
3	Index of Industrial Production (Mining)	S.A., Δln
4	Index of Industrial Production (Iron and steel)	S.A., Δln
5	Index of Industrial Production (Non-ferrous metals)	S.A., Δln
6	Index of Industrial Production (Fabricated metals)	S.A., Δln
7	Index of Industrial Production (General machinery)	S.A., Δln
8	Index of Industrial Production (Electrical machinery)	S.A., Δln
9	Index of Industrial Production (Transport equipment)	S.A., Δln
10	Index of Industrial Production (Precision instruments)	S.A., Δln
11	Index of Industrial Production (Ceramics, clay and stone products)	S.A., Δln
12	Index of Industrial Production (Chemicals)	S.A., Δln
13	Index of Industrial Production (Petroleum and coal products)	S.A., Δln
14	Index of Industrial Production (Plastic products)	S.A., Δln
15	Index of Industrial Production (Pulp, paper and paper products)	S.A., Δln
16	Index of Industrial Production (Textiles)	S.A., Δln
17	Index of Industrial Production (Foods and tobacco)	S.A., Δln
18	Index of Industrial Production (Other manufacturing)	S.A., Δln
19	Index of Industrial Production (Final demand goods)	S.A., Δln
20	Index of Industrial Production (Producer goods)	S.A., Δln
21	Index of Industrial Production (Producer goods for mining and manufacturing)	S.A., Δln
22	Index of Industrial Production (Producer goods for others)	S.A., Δln
23	Index of Producer's Shipments (Final demand goods)	S.A., Δln
24	Index of Producer's Shipments (Producer goods)	S.A., Δln
25	Index of Producer's Shipments (Producer goods for mining and manufacturing)	S.A., Δln
26	Index of Producer's Shipments (Producer goods for others)	S.A., Δln
27	Index of Capacity Utilization Ratio (Manufacturing)	S.A., Δln
28	Index of Capacity Utilization Ratio (Iron and steel)	S.A., Δln
29	Index of Capacity Utilization Ratio (Non-ferrous metals)	S.A., Δln
30	Index of Capacity Utilization Ratio (Fabricated metals)	S.A., Δln
31	Index of Capacity Utilization Ratio (General machinery)	S.A., Δln
32	Index of Capacity Utilization Ratio (Electrical machinery)	S.A., Δln
33	Index of Capacity Utilization Ratio (Transport equipment)	S.A., Δln
34	Index of Capacity Utilization Ratio (Precision instruments)	S.A., Δln
35	Index of Capacity Utilization Ratio (Ceramics, clay and stone products)	S.A., Δln
36	Index of Capacity Utilization Ratio (Chemicals)	S.A., Δln
37	Index of Capacity Utilization Ratio (Petroleum and coal products)	S.A., Δln
38	Index of Capacity Utilization Ratio (Textiles)	S.A., Δln
39	Index of Capacity Utilization Ratio (Rubber products)	S.A., Δln
40	Index of Capacity Utilization Ratio (Machinery)	S.A., Δln
41	Index of Tertiary Industry Activity (Total)	S.A., Δln
42	Index of Tertiary Industry Activity (Electricity, gas, heat and water supply)	S.A., Δln
43	Index of Tertiary Industry Activity (Transport and Communication)	S.A., Δln
44	Index of Tertiary Industry Activity (Tranport)	S.A., Δln
45	Index of Tertiary Industry Activity (Wholesale, retail trade, eating and drinking places)	S.A., Δln
46	Index of Tertiary Industry Activity (Eating and drinking places)	S.A., Δln
47	Index of Tertiary Industry Activity (Finance and insurance)	S.A., Δln
48	Index of Tertiary Industry Activity (Real estate)	S.A., Δln
49	Index of Tertiary Industry Activity (Services)	S.A., Δln
50	Index of Tertiary Industry Activity (Personal services)	S.A., Δln
51	Index of Tertiary Industry Activity (Business services)	S.A., Δln
Inventories		
52	Index of Producer's Inventory Ratio of Finished Goods (Mining and manufacturing)	S.A., Δln
53	Index of Producer's Inventory Ratio of Finished Goods (Final demand goods)	S.A., Δln
54	Index of Producer's Inventory Ratio of Finished Goods (Investment goods)	S.A., Δln
55	Index of Producer's Inventory Ratio of Finished Goods (Capital goods)	S.A., Δln
56	Index of Producer's Inventory Ratio of Finished Goods (Construction goods)	S.A., Δln
57	Index of Producer's Inventory Ratio of Finished Goods (Consumer goods)	S.A., Δln
58	Index of Producer's Inventory Ratio of Finished Goods (Durable consumer goods)	S.A., Δln
59	Index of Producer's Inventory Ratio of Finished Goods (Non-durable consumer goods)	S.A., Δln
60	Index of Producer's Inventory Ratio of Finished Goods (Producer goods)	S.A., Δln

No.	Variable	Transformation
61	Index of Producer's Inventory Ratio of Finished Goods (Producer goods for mining and manufacturing)	S.A., Δln
62	Index of Producer's Inventory Ratio of Finished Goods (Producer goods for others)	S.A., Δln
63	Index of Producer's Inventory of Finished Goods (Mining and manufacturin)	S.A., Δln
64	Index of Producer's Inventory of Finished Goods (Final demand goods)	S.A., Δln
65	Index of Producer's Inventory of Finished Goods (Investment goods)	S.A., Δln
66	Index of Producer's Inventory of Finished Goods (Capital goods)	S.A., Δln
67	Index of Producer's Inventory of Finished Goods (Construction goods)	S.A., Δln
68	Index of Producer's Inventory of Finished Goods (Consumer goods)	S.A., Δln
69	Index of Producer's Inventory of Finished Goods (Durable consumer goods)	S.A., Δln
70	Index of Producer's Inventory of Finished Goods (Non-durable consumer goods)	S.A., Δln
71	Index of Producer's Inventory of Finished Goods (Producer goods)	S.A., Δln
72	Index of Producer's Inventory of Finished Goods (Producer goods for mining and manufacturing)	S.A., Δln
73	Index of Producer's Inventory of Finished Goods (Producer goods for others)	S.A., Δln
Investment		
74	Index of Producer's Shipments (Investment goods excluding transport equipments)	S.A., Δln
75	Index of Producer's Shipments (Construction goods)	S.A., Δln
76	Index of Industrial Production (Investment goods)	S.A., Δln
77	Index of Industrial Production (Capital goods)	S.A., Δln
78	Index of Industrial Production (Construction goods)	S.A., Δln
79	Index of Production Capacity (Manufacturing)	S.A., Δln
80	Machinery Orders (Total excluding ships)	S.A., Δln
81	Machinery Orders (Private sector excluding volatile orders)	S.A., Δln
82	Machinery Orders (Manufacturing)	S.A., Δln
83	Machinery Orders (Non-manufacturing excluding volatile orders)	S.A., Δln
84	Machinery Orders (Government)	S.A., Δln
85	Order Received for Construction (Grand total)	S.A., Δln
86	Order Received for Construction (Private)	S.A., Δln
87	Order Received for Construction (Public)	S.A., Δln
88	Total Floor Area of Building Starts (Grand total)	S.A., Δln
89	Total Floor Area of Building Starts (Mining, manufacturing and comercial use)	S.A., Δln
90	Total Floor Area of Building Starts (Mining)	S.A., Δln
91	Total Number of New Housing Construction Started (Total)	S.A., Δln
92	Total Number of New Housing Construction Started (Owned)	S.A., Δln
93	Total Number of New Housing Construction Started (Rented)	S.A., Δln
94	Total Number of New Housing Construction Started (Built for sale)	S.A., Δln
95	Total Number of New Housing Construction Started (Government housing loan corporation)	S.A., Δln
96	Total Floor Area of New Housing Construction Started (Total)	S.A., Δln
97	Total Floor Area of New Housing Construction Started (Owned)	S.A., Δln
98	Total Floor Area of New Housing Construction Started (Rented)	S.A., Δln
99	Total Floor Area of New Housing Construction Started (Built for sale)	S.A., Δln
Labor		
100	Index of Non-scheduled Worked Hours (All industries - 30 or more persons)	S.A., Δln
101	Index of Non-scheduled Worked Hours (Manufacturing)	S.A., Δln
102	Index of Total Worked Hours (All industries - 30 or more persons)	S.A., Δln
103	Index of Total Worked Hours (Manufacturing)	S.A., Δln
104	Ratio of Non-scheduled to Total Worked Hours (All industries - 30 or more persons)	S.A., Δln
105	Ratio of Non-scheduled to Total Worked Hours (Manufacturing)	S.A., Δln
106	New Job Offers	S.A., Δln
107	Effective Job Offers	S.A., Δln
108	New Job Offer Rate	S.A., Level
109	Effective Job Offer Rate	S.A., Level
110	New Job Offers (Parttime)	S.A., Δln
111	Effective Job Offers (Parttime)	S.A., Δln
112	New Job Offer Rate (Parttime)	S.A., Level
113	Effective Job Offer Rate (Parttime)	S.A., Level
114	Index of Regular Workers Employment (All industries - 30 or more persons)	S.A., Δln
115	Index of Regular Workers Employment (All industries excluding services)	S.A., Δln
116	Index of Regular Workers Employment (Mining)	S.A., Δln
117	Index of Regular Workers Employment (Construction)	S.A., Δln
118	Index of Regular Workers Employment (Manufacturing)	S.A., Δln
119	Index of Regular Workers Employment (Electricity, gas, heat supply)	S.A., Δln

No.	Variable	Transformation
120	Index of Regular Workers Employment (Transport and communication)	S.A., Δln
121	Index of Regular Workers Employment (Wholesale and retail trade)	S.A., Δln
122	Index of Regular Workers Employment (Finance and insurance)	S.A., Δln
123	Index of Regular Workers Employment (Real estate)	S.A., Δln
124	Index of Regular Workers Employment (Services)	S.A., Δln
125	Number of Unemployed	S.A., Δln
126	Unemployment Rate	S.A., Level
127	Number of Beneficiaries of Unemployment Insurance (Initial claimants)	S.A., Δln
128	Number of Beneficiaries of Unemployment Insurance (Total)	S.A., Δln
129	Number of Persons with Unemployment Insurance	S.A., Δln
130	Real Wage Index (Contractual cash earnings in all industries - 30 or more persons)	S.A., Δln
Consumption		
131	Sales at Department Stores (Total)	S.A., Δln
132	Sales at Department Stores (Per square meter floor space)	S.A., Δln
133	Index of Sales (Total)	S.A., Δln
134	Index of Sales (Wholesale)	S.A., Δln
135	Index of Sales (Retail)	S.A., Δln
136	Number of New Passenger Car Registrations and Reports (Total)	S.A., Δln
137	Number of New Passenger Car Registrations and Reports (excluding cars under 550cc)	S.A., Δln
138	Real Consumption Activity Index (data before 2002 is imputed by SNA)	S.A., Δln
139	Household Consumption Expenditure (Workers)	S.A., Δln
140	Household Disposable Income (Workers)	S.A., Δln
141	Index of Industrial Production (Consumer goods)	S.A., Δln
142	Index of Industrial Production (Durable consumer goods)	S.A., Δln
143	Index of Industrial Production (Non-durable consumer goods)	S.A., Δln
144	Index of Producer's Shipments (Consumer goods)	S.A., Δln
145	Index of Producer's Shipments (Durable consumer goods)	S.A., Δln
146	Index of Producer's Shipments (Non-durable consumer goods)	S.A., Δln
Business Environment		
147	Index of Investment Climate (Manufacturing)	S.A., Δln
148	Corporation Tax Revenue	S.A., Δln
149	Suspension of Business Transaction with Bank	S.A., Δln
Finance		
150	Money Supply (M2+CD, average outstanding)	S.A., Δln
151	Money Supply (M1, average outstanding)	S.A., Δln
152	Monetary Base (Average outstanding)	S.A., Δln
153	Bank Notes Issued (Average outstanding)	S.A., Δln
154	Bank Clearings (Number)	S.A., Δln
155	Bank Clearings (Value)	S.A., Δln
156	Nikkei Stock Average 225 Selected Stocks (Average of month)*	S.A., Δln
157	Nikkei Stock Average 500 Selected Stocks*	S.A., Δln
158	Stock Price Index (TOPIX)*	S.A., Δln
159	Stock Price Average (Tokyo stock market first section)*	S.A., Δln
160	Stock Price Index (Fisheries, agriculture and forestry)*	S.A., Δln
161	Stock Price Index (Mining)*	S.A., Δln
162	Stock Price Index (Construction)*	S.A., Δln
163	Stock Price Index (Foods)*	S.A., Δln
164	Stock Price Index (Textiles)*	S.A., Δln
165	Stock Price Index (Pulp and paper)*	S.A., Δln
166	Stock Price Index (Oil and coal products)*	S.A., Δln
167	Stock Price Index (Rubber products)*	S.A., Δln
168	Stock Price Index (Glass and ceramic products)*	S.A., Δln
169	Stock Price Index (Iron and steel)*	S.A., Δln
170	Stock Price Index (Non-ferro metals)*	S.A., Δln
171	Stock Price Index (Metal products)*	S.A., Δln
172	Stock Price Index (Machinery)*	S.A., Δln
173	Stock Price Index (Electrical machinery)*	S.A., Δln
174	Stock Price Index (Transportation equipment)*	S.A., Δln
175	Stock Price Index (Precision instruments)*	S.A., Δln
176	Stock Price Index (Other products)*	S.A., Δln
177	Stock Price Index (Electric and gas)*	S.A., Δln

No.	Variable	Transformation
178	Stock Price Index (Land transportation)*	S.A., Δln
179	Stock Price Index (Marine transportation)*	S.A., Δln
180	Stock Price Index (Air transportation)*	S.A., Δln
181	Stock Price Index (Warehouse and tranport related)*	S.A., Δln
182	Stock Price Index (Communication)*	S.A., Δln
183	Stock Price Index (Real estate)*	S.A., Δln
184	Stock Price Index (Service)*	S.A., Δln
185	Sales Volume (Daily Average, Tokyo stock market first section)*	S.A., Δln
186	Sales Value (Daily Average, Tokyo stock market first section)*	S.A., Δln
187	Official Discount Rates*	Level
188	Short-term Prime Lending Rates*	Level
189	Long-term Prime Lending Rates*	Level
190	Average Contracted Interest Rate on Loans and Discounts (Domestically-licensed banks)	Level
191	Yields of Interest-Bearing Government Bonds (10 years)*	Level
Prices		
192	Nikkei Commodity Price Index (17items)*	S.A., Δln
193	Nikkei Commodity Price Index (42items)*	S.A., Δln
194	Corporate Goods Price Index (All commodities)	S.A., Δln
195	Corporate Goods Price Index (Manufacturing industry products)	S.A., Δln
196	Corporate Goods Price Index (Beverages and foods)	S.A., Δln
197	Corporate Goods Price Index (Chemicals and related products)	S.A., Δln
198	Corporate Goods Price Index (Petroleum and coal products)	S.A., Δln
199	Corporate Goods Price Index (Iron and steel)	S.A., Δln
200	Corporate Goods Price Index (Electronic components and devices)	S.A., Δln
201	Corporate Goods Price Index (Electrical machinery and equipment)	S.A., Δln
202	Corporate Goods Price Index (Transportation equipment)	S.A., Δln
203	Consumer Price Index (General)	S.A., Δln
204	Consumer Price Index (General excluding fresh food)	S.A., Δln
205	Consumer Price Index (General excluding fresh food and imputed rent)	S.A., Δln
206	Consumer Price Index (Food)	S.A., Δln
207	Consumer Price Index (Housing)	S.A., Δln
208	Consumer Price Index (Fuel, light, and water charges)	S.A., Δln
209	Consumer Price Index (Furniture and household utensils)	S.A., Δln
210	Consumer Price Index (Clothes and footwear)	S.A., Δln
211	Consumer Price Index (Medical care)	S.A., Δln
212	Consumer Price Index (Transportation and communication)	S.A., Δln
213	Consumer Price Index (Reading and recreation)	S.A., Δln
214	Consumer Price Index (Miscellaneous)	S.A., Δln
Trade		
215	Terms of Trade Index (All commodities)	S.A., Δln
216	Quantum Index of Exports (Total)	S.A., Δln
217	Quantum Index of Imports (Total)	S.A., Δln
218	Customs Clearance (Value of exports, grand total)	S.A., Δln
219	Foreign Exchange Rate (Yen per US dollar, Spot)*	S.A., Δln
Lending		
220	Loans Outstanding (Banks excl. shinkin, total)	S.A., Δln
221	Loans Outstanding (Banks excl. shinkin, corporate)	S.A., Δln
222	Loans Outstanding (Banks excl. shinkin, households)	S.A., Δln
223	Loans Outstanding for Fixed Investment (Banks excl. shinkin, total)	S.A., Δln
224	Loans Outstanding for Fixed Investment (Banks excl. shinkin, corporate)	S.A., Δln
225	Loans Outstanding for Fixed Investment (Banks excl. shinkin, households)	S.A., Δln
226	Loans Outstanding (Shinkin banks, total)	S.A., Δln
227	Loans Outstanding (Shinkin banks, corporate)	S.A., Δln
228	Loans Outstanding (Shinkin banks, households)	S.A., Δln
229	Loans Outstanding for Fixed Investment (Shinkin banks, total)	S.A., Δln
230	Loans Outstanding for Fixed Investment (Shinkin banks, corporate)	S.A., Δln
231	Loans Outstanding for Fixed Investment (Shinkin banks, households)	S.A., Δln

Note: "S.A." denotes seasonally adjusted. "*" indicates that the variable is a fast-moving variable.