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Japan's Unconventional Monetary Policy and the Exchange Rate Dynamics

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Japan's Unconventional Monetary Policy and the Exchange Rate Dynamics*

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Abstract

This paper empirically examines the response of the nominal exchange rate (U.S. dollar-yen exchange rate) to the monetary policy changes, focusing on the effects of various unconventional monetary policy measures implemented by the Bank of Japan over the past 25 years. Specifically, applying the estimation method proposed by Inoue and Rossi (2019), we identify Japan's "monetary policy shocks" from changes in the entire yield curve and the exchange rate around policy announcements, and estimate the dynamic response of the exchange rate to them. The results show that the yen depreciated against the U.S. dollar in many cases in response to Japan's expansionary monetary policy shocks, and that non-interest rate differential channel – e.g., the shifts in future exchange rate expectations – accounts for the larger parts of such responses than conventional interest rate differential channel. Moreover, our findings suggest that the responses of the exchange rate to unconventional monetary policies have been state-dependent in the sense that they could vary significantly depending on global financial market conditions and investors' herding behavior at each point in time.

JEL classification: C32, E52, F31

Keywords: Unconventional monetary policy, Exchange rate, Functional local projection

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1. Introduction

Looking at the movements of the real effective exchange rate since the 1970s, when Japan shifted to a floating exchange rate system, we find the fluctuation of the Japanese yen much larger than that of other currencies of advanced economies (Chart 1). If the nominal exchange rate moves so that purchasing power parity (PPP) roughly holds, the real exchange rate should remain stable. In Japan, however, unstable movements in the exchange rate, i.e., misalignments that appear to be inconsistent with economic fundamentals[1], have often taken place, resulting in a significant impact on the economy and prices at each point in time (Chart 2). Looking back over the past 25 years, sharp appreciation of the yen which coincided with the extremely severe periods for the Japanese economy – namely, (i) the late 1990s after the financial crisis occurred in Japan, and (ii) the period from 2008 to mid-2012 when a series of negative shocks such as the collapse of Lehman Brothers, the Great East Japan Earthquake, and the European debt crisis arose – seems to have led to cautious corporate behavior including wage suppression, thereby making Japan's deflationary pressure prolonged. During this period, the Bank of Japan implemented various unconventional monetary policies, such as "Quantitative Easing," "Comprehensive Monetary Easing," and "Quantitative and Qualitative Monetary Easing," to support the economy and prevent deflation, even though there was limited room for reduction in the short-term policy rate due to the zero lower bound (effective lower bound) of the interest rate[2].

The purpose of this paper is to empirically examine how the nominal exchange rate of the yen has responded to monetary policy changes, focusing on the effects of unconventional monetary policies implemented by the Bank of Japan over the past 25 years, and thereby to derive important implications for its future conduct of monetary policy. It should be noted that

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[1] Rogoff (1996) uses the term "PPP puzzle" to refer to the fact that actual real exchange rate fluctuations are much larger than theoretical models predict and that it takes a long time – in fact with a half-life of three to five years – for the exchange rate to converge to the PPP.

[2] At the International Conference hosted by the Institute for Monetary and Economic Studies of the Bank of Japan in 2002, Yutaka Yamaguchi, who was the Deputy Governor of the Bank of Japan from 1998 to 2003, made the following candid comments: "Swings in the yen exchange rate cause headaches for the Bank of Japan from time to time. And the history since the collapse of the Bretton Woods system indicates that the yen has often fluctuated abruptly and often substantially, to levels that appear to many of us inconsistent with economic fundamentals. On some occasion in the past, the Bank of Japan's policymakers were said to be overly concerned or overly preoccupied with the impossible task of stabilizing the currency. … I will only say that the exchange rate movement has often been a puzzle and a concern as we endeavor to stabilize activity and prices." (Yamaguchi, 2002)

Similarly, Masaaki Shirakawa, who was the Governor of the Bank of Japan from 2008 to 2013, commented on the exchange rate as follows: "Looking back on monetary easing decisions during my tenure as governor, given that the yen was appreciating throughout the period (and significantly weighed on the outlook) the exchange rate was often at the center of our deliberations and one of the important factors in our decisions." (Shirakawa, 2021) the scope of this paper is limited to the empirical relationship between monetary policy and the exchange rate, and does not cover the impact of exchange rate fluctuations on the economy and prices.

The structure of this paper is as follows. In Section 2, we will conduct a survey of the previous related studies and clarify the contribution of this paper in the literature. Section 3 estimates the responses of the exchange rate to Japan's unconventional monetary policies using the functional local projection method, and Section 4 gives some discussion on the results. Section 5 concludes.

2. Previous Studies

Most previous empirical studies on the response of the exchange rate to monetary policy have examined how changes in U.S. interest rates (or interest rate differentials between the U.S. and other countries) affected exchange rates. One of the most important points in this literature is how to identify "monetary policy shocks." Since financial market participants are always expecting future monetary policies for their trading activities, we need to identify "unexpected monetary policy shocks (or surprises)" in order to accurately extract the effects of monetary policy from observed movements of financial variables. For example, consider the case of the rate cut decision by a central bank. If the rate cut is smaller than expected by market participants, it could be considered a "tightening surprise" in the market, putting appreciation pressure on the country's currency. Thus, the most standard approach in previous studies has been to regard "unexpected changes" in market interest rates as monetary policy shocks (Eichenbaum and Evans, 1995, etc.).

In recent years, following the pioneering work by Gürkaynak et al. (2005), high-frequency data have been widely used to measure changes in market interest rates over short time horizon before and after monetary policy decisions (releases of statements), and to consider these unexpected changes as monetary policy shocks. Specifically, some researchers measure interest rate changes over an extremely short time horizon, e.g., 30 to 90-minute window around the release of the policy statement. Other studies use changes over a slightly longer time horizon, e.g., one day after the announcement of the monetary policy change (i.e., daily change). The former has the advantage of eliminating noisy movements that are not directly related to monetary policy shocks (e.g., releases of economic indicators), while the latter has the advantage of taking into account cases where financial market participants need some time to fully "digest" the monetary policy surprise.

As the U.S. short-term interest rates fell to near zero following the global financial crisis and the Federal Reserve launched unconventional monetary policies aimed at lowering longer-term interest rates, a growing number of studies have used data on interest rates over a wider range of maturities, not just short-term rates in identifying monetary policy shocks (Glick and Leduc, 2018; Rogers et al., 2018; Ferrari et al., 2021; Swanson, 2021). In this literature, researchers measure changes in interest rates for multiple maturities (e.g., 3-month rates, 2-year rates, and 10-year rates) over a short time horizon around the FOMC announcements and explicitly decompose monetary policy effects as follows: (i) the effects of changes in the policy rate, (ii) forward guidance effects on the expectation for future policy rates (over two years or so), and (iii) the effects of term premium compression by purchasing long-term government bonds. Of these, (ii) and (iii) can be said to correspond to the effects of so-called unconventional monetary policies. These papers point out that U.S. unconventional monetary policies have had a significant impact on the exchange rate through forward guidance and/or the reduction in the term premium even when the short-term policy rate is constrained by the zero lower bound (Glick and Leduc, 2018; Rogers et al., 2018; Ferrari et al., 2021). Some papers report that the effect of unconventional monetary policies on the exchange rate tends to be more persistent than that of conventional monetary policies (Swanson, 2021).

There are also several previous studies on the response of the exchange rate to Japan's monetary policy. In Japan, as the short-term interest rate has been near zero percent for a long time since the late 1990s, how to identify monetary policy shocks in such a situation has become an important empirical challenge. For example, Iwasaki and Sudo (2017) rely on the concept of the shadow rate to analyze the impact of monetary policy on various economic variables and report that a 1 basis point decline in the shadow rate caused by unconventional monetary policies has had a greater effect on the exchange rate than conventional monetary policies. Using high-frequency data, Nakamura et al. (2021) analyze the impact of monetary policy shocks identified from changes in Euroyen futures rates up to one year ahead over the 30-minute window around the monetary policy announcements, and show that unconventional monetary policies, as well as conventional monetary policies, have a significant impact on the exchange rate. Ferrari et al. (2021) also identify monetary policy shocks from high-frequency data for six major central banks, including the Bank of Japan, and demonstrate that the sensitivity of exchange rates to monetary policy shocks (responses to a 1 basis point change in interest rates) has generally increased in recent years[3].

Inoue and Rossi (2019, 2021), the most relevant previous studies to this paper, take a different approach from the above-mentioned papers and propose a new method of considering the change in the entire term structure of interest rates (yield curve) as the monetary policy

[3] Kubota and Shintani (2022, 2023) and Nakashima et al. (2024) also identify monetary policy shocks in Japan and analyze their transmission effects. Kubota and Shintani (2022, 2023) identify monetary policy shocks using high-frequency data of 30-minute window around the monetary policy announcements. Nakashima et al. (2024) estimate the effects of monetary policy shocks which are extracted as the common factor (principal component) from the daily change of various financial variables. However, these papers do not analyze the effects on the exchange rates directly.

shock. More specifically, after treating the yield curve as a function of maturity, they identify the monetary policy shock as the change in that function before and after the announcement of monetary policy (functional shock) to analyze the monetary policy effects. They do not intend to distinguish between the effect of forward guidance and that of asset purchases, because the change in the entire yield curve is considered to reflect both effects. Rather, they aim to capture the overall effects of the unconventional monetary policy measures as a whole, since recent unconventional monetary policies are often conducted as a combination of changes in short-term interest rates (such as introduction of the negative interest rate policy), forward guidance that affects the expected path for the future policy rate, and asset purchases that affect risk premiums. Inoue and Rossi (2019) estimate the response of the exchange rate to U.S. monetary policy shocks and point out that the response of the dollar exchange rate differs significantly over time depending on how monetary policy shocks affect economic agents' expectations of the future interest rate path.

We follow Inoue and Rossi (2019)'s empirical strategy to analyze the response of the exchange rate to Japan's monetary policy changes. To the best of our knowledge, this paper is the first attempt that analyze the response of the exchange rate to Japan's monetary policy shocks using the information from the entire yield curve based on the idea of functional shocks[4]. Moreover, as for the transmission channel through which the exchange rate responds to the monetary policy surprise, this paper explicitly considers the "non-interest rate differential channel" in addition to the conventional "interest rate differential channel." Generally speaking, one of the most important factors that govern the exchange rate movements is the change in interest rate differentials between home and foreign countries. However, it is well known in the empirical literature that there are also important factors other than interest rate differentials that affect exchange rate dynamics, and thus various theoretical studies attempt to incorporate these factors into the exchange rate models (e.g., Itskhoki and Mukhin, 2021). In the actual financial markets, policymakers often observe that the responses to the monetary policy changes are different between interest rate market and foreign exchange market – that is, interest rate differentials and exchange rates do not always move consistently –, since the active players clearly differ among the money market, the bond market, and the FX market. Given these observations, this paper proposes an estimation method that allows the monetary policy shock to transmit the exchange rate not only through the standard interest rate differential channel but also through the non-interest rate differential channel, e.g., by altering expectations of the FX market players. As a related research, Boehm and Kroner (2024) have recently introduced the concept of "non-yield shocks," i.e., monetary policy shocks that affect stock prices and exchange rates without changing yield curve. Their idea is

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[4] Miyamoto (2023) also applies the method of Inoue and Rossi (2019) to the analysis on the dollar-yen exchange rate dynamics, but he focuses on the effects of the U.S. monetary policy shocks, not Japan's ones.

very similar to the concept we introduce in this paper, but their estimation method is different from ours.

3. Empirical Analysis using Functional Local Projection

In this section, we estimate the response of the exchange rate to Japan's monetary policy changes by applying the method proposed by Inoue and Rossi (2019) that identifies monetary policy shocks from changes in the entire yield curve including short-term policy rates. Our analysis focuses on dynamics of the U.S. dollar-yen exchange rate (hereafter, dollar-yen exchange rate), rather than the nominal effective exchange rate of the yen, because the dollar-yen market is highly liquid and the data on the dollar-yen rate at the specific time in each business day are readily available.

3-1. Exchange Rate Changes on the Monetary Policy Meeting Days

First, we provide simple observational evidence on the measured changes in the dollar-yen exchange rate on each Monetary Policy Meeting (policy announcement) day since the late 1990s (Chart 3)[5].

We can see that the dollar-yen rate reactions to Japan's major monetary easing decisions have differed significantly meeting by meeting. During the Quantitative Easing (QE) period in the early 2000s, the yen did not necessarily depreciate against the U.S. dollar on the days monetary easing was decided, and changes in the exchange rate were not quantitatively significant. During the Comprehensive Monetary Easing (CE) period in 2010-2012, the yen showed the tendency to depreciate against the U.S. dollar on the major policy change days, but the rates of change in the exchange rate were less than 1 per cent except for August 4, 2011 when the foreign exchange intervention was conducted on the same day monetary easing decision was decided. On the other hand, during the Quantitative and Qualitative Monetary Easing (QQE) period, Japanese yen depreciated against the U.S. dollar by more than 1 per cent on the policy announcement days of QQE introduction (April 4, 2013), QQE expansion (October 31, 2014), and introduction of negative interest rate policy (January 29, 2016), partly because these policy changes were generally viewed as surprises by the FX market participants.

In what follows, we select 14 events of monetary easing decision listed in Table 1 as major policy changes, and conduct a time series analysis of the exchange rate's reaction to

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[5] Here, we use the rate of change of the dollar-yen exchange rate from 9 a.m. to 5 p.m. Japan time for each business day. The sample period starts from 1999 when the data on the dollar-yen exchange rate of the specific time became available. The time window is chosen so that we can include the impacts of both monetary policy announcements (typically around noon) and press conferences (around 3:30 p.m. - 4:30 p.m.), and avoid possible contamination by the factors in the U.S. time such as releases of U.S. economic indicators and FOMC announcements.

them. Specifically, as monetary easing decisions during the QE period, we opt to choose the two meetings in April and May 2003, when the target balance of current accounts was significantly raised by the Bank of Japan[6]. As for the monetary easing decisions after the QE period, we pick up the two rate cuts implemented in 2008 (note that they could be seen as conventional monetary easing decisions), as well as the major monetary easing events after the collapse of Lehman Brothers, mainly consisting of the CE policies. For the QQE period, we analyze not only the introduction and the subsequent expansion of QQE, but also the decisions to introduce the negative interest rate policy and the yield curve control. As in the previous literature, the following analysis identifies only "unexpected changes on the Monetary Policy Meeting days" as shocks, and it is therefore important to pay attention that we do not consider policy changes that were already expected in the market as policy shocks. In that sense, it should be noted that surprise policy changes that were not priced in the market prices tend to be treated as large policy "shocks."

3-2. The Concept of Functional Shocks

The basic idea of functional shocks that Inoue and Rossi (2019, 2021) propose is to use the changes in the function as a "shock" (functional shock) in the VAR or the local projection model, instead of using the changes in a scalar number (e.g., short-term interest rate). More specifically, Inoue and Rossi (2021) define the yield curve as a function $f_t(\tau)$ of maturity (τ) and regard the changes in the multiple parameters in the function $f_t(\tau)$, i.e., intercept, slope and curvature, before and after an event (such as monetary policy announcement) as shocks. Meanwhile, Inoue and Rossi (2019) treat the specific set of interest rates at different maturities in the yield curve as a vector and consider the changes in that vector as shocks. We follow the latter approach.

Specifically, we can write the Japan's yield curve which consists of n maturities as follows.

$$Y_t^{JP} = \begin{pmatrix} i_{1,t}^{JP} \\ \vdots \\ i_{n,t}^{JP} \end{pmatrix}$$

The change in the yield curve before and after the monetary policy announcement (ΔY_t^{JP}) can be regarded as the "monetary policy shock" that mainly reflects the unexpected policy change. This method has two main advantages. First, we can use richer information to analyze the effects of monetary policy changes based on the data on the entire yield curve instead of solely relying on the data on the interest rate at a specific maturity. Second, we can analyze both

[6] The introduction of zero interest rate policy and QE are not covered in our analysis due to the limitation of data availability.

"conventional monetary policy" where the policy instrument is the short-term interest rate and "unconventional monetary policy" that aims to influence interest rates at various maturities, including longer-term rates, in the same unified framework. In this approach, we treat the changes in multi-dimensional variables as shocks, and we do not need to assume independence of the shocks to interest rates at different maturities. In other words, we allow for contemporaneous correlations between individual interest rate shocks that constitute the functional shock.

In estimating impulse response functions, Inoue and Rossi (2019, 2021) propose both functional VAR and functional local projection. In this paper, we adopt functional local projection which is relatively simple[7].

3-3. Specification of Functional Local Projection

Inoue and Rossi (2019) employ only U.S. interest rate data as interest rate information for the purpose of estimating the response of exchange rates to U.S. monetary policy shocks. Since this paper focuses on the transmission of Japan's monetary policy shocks, we need to utilize Japan's interest rate data as well. As the dollar-yen exchange rate is actually affected by interest rates in both Japan and the U.S., the U.S.-Japan interest rate differential $i_{k,t}$ (k is the maturity; $k = 1, \ldots, n$) is used in the following analysis[8]. Letting $i_{k,t}^{JP}$ and $i_{k,t}^{US}$ denote interest rates in Japan and the U.S., respectively, the interest rate differential is $i_{k,t} = i_{k,t}^{US} - i_{k,t}^{JP}$ and can be displayed as a vector as follows.

$$Y_t = \begin{pmatrix} i_{1,t} \\ \vdots \\ i_{n,t} \end{pmatrix} = \begin{pmatrix} i_{1,t}^{US} \\ \vdots \\ i_{n,t}^{US} \end{pmatrix} - \begin{pmatrix} i_{1,t}^{JP} \\ \vdots \\ i_{n,t}^{JP} \end{pmatrix} = Y_t^{US} - Y_t^{JP}$$

Following Inoue and Rossi (2019), we impose a short-run restriction such that "the U.S.-Japan interest rate differentials affect the exchange rate contemporaneously, but the exchange rate shock does not affect the interest rate differentials contemporaneously." Thus we can write an estimation model for the change in the dollar-yen exchange rate (s_t) as follows. Note that s_t is expressed in logarithm.

$$s_t - s_{t-1} = \alpha + \begin{pmatrix} \beta_1 \\ \vdots \\ \beta_n \end{pmatrix}' \begin{pmatrix} \Delta i_{1,t} \\ \vdots \\ \Delta i_{n,t} \end{pmatrix} + \sum_{j=1}^{p} \begin{pmatrix} \gamma_{1,j} \\ \vdots \\ \gamma_{n,j} \end{pmatrix}' \begin{pmatrix} \Delta i_{1,t-j} \\ \vdots \\ \Delta i_{n,t-j} \end{pmatrix} + \sum_{j=1}^{q} \gamma_{s,j} \Delta s_{t-j} + u_t$$

[7] It is pointed out that local projection is more robust to the possible model misspecifications than VAR. For the general explanation of local projection method, see Jordà (2005).

[8] In order to check robustness, we also analyze the case where Japan and U.S. interest rates are employed as the separate explanatory variables, instead of using the interest rate differentials between the U.S. and Japan. We find the conclusion broadly unchanged. See appendix.

$$= \alpha + B_0{}'\Delta Y_t + \sum_{j=1}^{p} \Gamma_{0,j}{}'\Delta Y_{t-j} + \sum_{j=1}^{q} \gamma_{s,j}\Delta s_{t-j} + u_t$$

Here, α is the intercept, $B_0 = (\beta_1, \cdots, \beta_n)'$, $\Gamma_{0,j} = (\gamma_{1,j}, \cdots, \gamma_{n,j})'$ and $\gamma_{s,j}$ are parameters, p and q are lag lengths[9], and u_t is the residual. The factors other than the interest rate differentials that affect the exchange rate at time t will be summarized in u_t; therefore, the estimated residuals $\hat{u}_t$ can be considered as "a factor specific to exchange rate changes" which is independent of the interest rate differentials, and we denote $x_t = \hat{u}_t$. This procedure is essentially the same as imposing a short-run (Cholesky) restriction on a VAR model consisting of the interest rate and the exchange rate equations to identify the structural shock to the exchange rate.

A local projection model to analyze the effects of ΔY_t (the daily change in the U.S.-Japan interest rate differentials) and x_t (the factor specific to exchange rate changes) on the exchange rate at period $t + h$ $(h \geq 1)$ can be written as follows, which is similar to the one at period t.

$$s_{t+h} - s_{t-1} = \alpha_h + \begin{pmatrix} \beta_{h,1} \\ \vdots \\ \beta_{h,n} \end{pmatrix}' \begin{pmatrix} \Delta i_{1,t} \\ \vdots \\ \Delta i_{n,t} \end{pmatrix} + \beta_{h,s} x_t + \sum_{j=1}^{p} \begin{pmatrix} \gamma_{h,1,j} \\ \vdots \\ \gamma_{h,n,j} \end{pmatrix}' \begin{pmatrix} \Delta i_{1,t-j} \\ \vdots \\ \Delta i_{n,t-j} \end{pmatrix} + \sum_{j=1}^{q} \gamma_{h,s,j}\Delta s_{t-j} + u_{h,t+h}$$

$$= \alpha_h + B_h{}'\Delta Y_t + \beta_{h,s} x_t + \sum_{j=1}^{p} \Gamma_{h,j}{}'\Delta Y_{t-j} + \sum_{j=1}^{q} \gamma_{h,s,j}\Delta s_{t-j} + u_{h,t+h}$$

Here, α_h is the intercept, $B_h = (\beta_{h,1}, \cdots, \beta_{h,n})'$, $\beta_{h,s}$, $\Gamma_{h,j} = (\gamma_{h,1,j}, \cdots, \gamma_{h,n,j})'$, and $\gamma_{h,s,j}$ are parameters, and $u_{h,t+h}$ is the residual.

Using the estimation results of this local projection model, we can obtain the dynamic responses of the dollar-yen exchange rate to the monetary policy shocks. We consider two different types of monetary policy shocks: (i) monetary policy shocks that affect the interest rate differentials ($\varepsilon_{y,t}^{mp}$) and (ii) monetary policy shocks that affect the exchange rate directly through "non-interest rate differential channel" ($\varepsilon_{s,t}^{mp}$). These two shocks are monetary policy driven components of ΔY_t (the change in the U.S.-Japan interest rate differentials) and x_t (the factor specific to exchange rate changes), respectively, and they are identified outside the model as explained later in detail.

Letting $\hat{B}_h$ denote the estimate of the parameter B_h, the response of the exchange rate from period 0 through h to $\varepsilon_{y,t}^{mp}$ (monetary policy shocks that affect the interest rate

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[9] In this paper, we set $p = q = 1$. The estimation results are generally robust to changes in the lag lengths.

differentials) can be expressed as follows.

$$\left[\hat{B}_0{}'\varepsilon_{y,t}^{mp} \quad \hat{B}_1{}'\varepsilon_{y,t}^{mp} \quad \dots \quad \hat{B}_h{}'\varepsilon_{y,t}^{mp}\right]$$

The response of the exchange rate to the monetary policy shocks as a whole including both $\varepsilon_{s,t}^{mp}$ (monetary policy shocks that affect the exchange rate directly through "non-interest rate differential channel") and $\varepsilon_{y,t}^{mp}$ can be written as follows.

$$\left[\begin{pmatrix}\hat{B}_0\\1\end{pmatrix}'\begin{pmatrix}\varepsilon_{y,t}^{mp}\\\varepsilon_{s,t}^{mp}\end{pmatrix} \quad \begin{pmatrix}\hat{B}_1\\\hat{\beta}_{1,s}\end{pmatrix}'\begin{pmatrix}\varepsilon_{y,t}^{mp}\\\varepsilon_{s,t}^{mp}\end{pmatrix} \quad \dots \quad \begin{pmatrix}\hat{B}_h\\\hat{\beta}_{h,s}\end{pmatrix}'\begin{pmatrix}\varepsilon_{y,t}^{mp}\\\varepsilon_{s,t}^{mp}\end{pmatrix}\right]$$

3-4. Data

As for the data on interest rates, in order to extract information from a wide range of maturities, we use the following four specific interest rates both for the U.S. and Japan: (i) 3-month OIS (Overnight Index Swap), (ii) 2-year government bonds, (iii) 10-year government bonds, and (iv) 30-year government bonds (Chart 4). We use daily data, and Japanese and U.S. interest rates are measured at the close of trading in each Japan and U.S. time. The estimation period ranges from April 2002 through December 2023 where the Japan's OIS data are available. As for the exchange rate, we use the dollar-yen exchange rate data at 5 p.m. New York time, downloaded from Bloomberg and the dollar-yen exchange rate data at 9 a.m. and 5 p.m. Japan time, published by the Bank of Japan.

3-5. Identification of Shocks

Identification of monetary policy shocks are conducted outside the model. One possible method would be to use ΔY_t (the daily change in the U.S.-Japan interest rate differentials) and x_t (the factor specific to exchange rate changes) on the Monetary Policy Meeting days. However, these variables are also affected by factors other than Japan's monetary policy changes, such as fluctuations in U.S. interest rates and exchange rates in response to the release of U.S. economic indicators. Therefore, in the following, we opt to employ a method of extracting only the portion of these variables that are attributable to Japan's monetary policy changes.

Interest Rate Shocks

To obtain $\varepsilon_{y,t}^{mp}$ (monetary policy shocks that affect the interest rate differentials), we follow Inoue and Rossi (2019) by using the change in the entire yield curve in Japan on the Monetary Policy Meeting days. Specifically, letting d_t be a dummy variable which equals 1 on the Monetary Policy Meeting days, $\varepsilon_{y,t}^{mp}$ can be written as an n-variable vector (functional shock) as follows. Each component in the vector takes a positive value when Japan's interest rate falls (or the interest rate differential widens).

$$\varepsilon_{y,t}^{mp} = -\begin{pmatrix} \Delta i_{1,t}^{JP} \\ \vdots \\ \Delta i_{n,t}^{JP} \end{pmatrix} d_t$$

The key point of our identification strategy is that only information on Japan's interest rates is used, not the U.S.-Japan interest rate differentials. This allows us to exclude the ramifications of variations in U.S. interest rates associated with U.S.-specific factors such as the release of U.S. economic indicators, and thus to accurately identify shocks caused by shifts in Japan's monetary policy[10].

As was discussed in Section 2, recent studies use the variations in market interest rates within a very short time window (such as 30 minutes) around the monetary policy announcements as the "monetary policy shocks" in order to eliminate noisy unrelated movements to the extent possible. However, in reality, the market participants understand the content and background of Japan's monetary policy decisions by listening to the Governor's remarks at the press conferences, in addition to reading monetary policy statements released immediately after the meetings. In particular, since the specific measures of unconventional policies tend to be more complex than those of conventional policies, it is likely that market players need more time to fully digest the content of unconventional policies. Therefore, we opt to use daily changes in the interest rates measured in Japan business time as the monetary policy shocks, which is similar to Inoue and Rossi (2019).

Next, we examine the actual variations in the yield curve on the selected Monetary Policy Meeting days (Chart 5). In the first half of the 2000s when the QE policy was adopted, changes in the interest rates of different maturities were not so large on the days when the decisions were made to raise the target balance of current accounts held at the Bank of Japan. Regarding the policy responses in the wake of the Lehman Brothers collapse, falls in interest rates were observed upon the two interest rate cuts in 2008, mainly in the short end where there still remained room for reductions. For the monetary policy changes from 2009 to 2012, the declines in the interest rates were larger in the medium- to long-term zones than in the short-term zone. Looking at the monetary easing decisions during the QQE period, the long-term interest rates dropped by a large extent with short-term interest rates almost unchanged when the QQE was introduced. When the introduction of the negative interest rate policy was announced, interest rates fell across the board, and it is noteworthy that the declines were larger

[10] If the U.S. interest rate varies in tandem with Japan's interest rate, the variation in U.S.-Japan interest rate differential caused by Japan's monetary policy decision may be smaller than the one in the Japan's interest rate itself, but we assume such effect is not significant.

in the long-term zone than in the short-term zone.

Direct Shocks to the Exchange Rate

To obtain $\varepsilon_{s,t}^{mp}$ (monetary policy shocks that affect the exchange rate directly through "non-interest rate differential channel"), we use the change of dollar-yen exchange rate from 9 a.m. to 5 p.m. Japan time ($\Delta s_{9\to17,t}$) on the Monetary Policy Meeting day. The change in the exchange rate until 5 p.m. Japan time is used to avoid the contamination by U.S. factors such as the release of U.S. economic indicators and the FOMC results and thus to accurately identify the impact of changes in Japan's monetary policy on exchange rates[11]. For example, looking at the intraday movements of the dollar-yen exchange rate on the days of introduction of QQE, expansion of QQE, and introduction of negative interest rate policy, the exchange rate showed significantly large variations, but the direct impacts of these policy shifts seemed to be almost priced in between 9 a.m. and 5 p.m. Japan time in all cases (Chart 6).

We should note that the change in the exchange rate caused by the fluctuations in interest rate differentials should be regarded as the impact of interest rate shock, and thus be excluded from the exchange rate shock. In doing so, we estimate a separate model in which the variation in the dollar-yen exchange rate from 9 a.m. to 5 p.m. Japan time is explained by the interest rate differentials, and we subtract the predicted value of the exchange rate change by the estimated model ($\widehat{\Delta s}_{9\to17,t}$) from the actual change ($\Delta s_{9\to17,t}$). Thus, the monetary policy shock that has a direct impact on the exchange rate ($\varepsilon_{s,t}^{mp}$) is calculated as follows.

$$\varepsilon_{s,t}^{mp} = \left(\Delta s_{9\to17,t} - \widehat{\Delta s}_{9\to17,t}\right) d_t$$

Here, $\widehat{\Delta s}_{9\to17,t}$ is the value predicted by the following estimation model.

$$\Delta s_{9\to17,t} = \alpha + B'\Delta Y_t + \sum_{j=1}^{p} \Gamma_j{}'\Delta Y_{t-j} + \sum_{j=1}^{q} \gamma_j \Delta s_{9\to17,t-j} + u_t$$

3-6. Results

In Chart 7, two types of estimated impulse responses are shown for each monetary easing decision. The graph (A) shows the response of the dollar-yen exchange rate to the interest rate shock $\varepsilon_{y,t}^{mp}$; i.e., the unexpected change in Japan's yield curve on the day of monetary policy

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[11] It is possible that the content of the Monetary Policy Meeting is digested over U.S. time, especially among foreign investors. In that case, it may be preferable to use the daily change of the exchange rate at 5 p.m. New York time, although it is more susceptible to possible noises arising from U.S. factors, e.g., the release of the U.S. economic indicators. Taking this possibility into account, we extend our analysis to allow for the case when we use daily changes of the dollar-yen exchange rate that cannot be explained by the interest rate differentials ($\varepsilon_{s,t}^{mp} = x_t d_t$), but we find the following results almost intact.

meetings. The graph (B) shows the response of the dollar-yen exchange rate to the monetary policy shock as a whole. This corresponds to the sum of the effects of $\varepsilon_{s,t}^{mp}$, which is the monetary policy shock that affects the exchange rate directly through "non-interest rate differential channel" – simply referred to as "exchange rate shock" in the chart – and the effects of the interest rate shock $\varepsilon_{y,t}^{mp}$.

First, on the two policy changes in April and May 2003 when the QE program was expanded, the responses of the dollar-yen exchange rate were very limited in both graphs (A) and (B) (Chart 7(1) (2)). Judging from these responses, the Bank of Japan's expansion in its current account target appears to have had little downward pressure on the interest rates and no significant direct impact on the foreign exchange market[12].

Next, looking at the estimated responses to the interest rate cuts immediately after the collapse of Lehman Brothers (October and December 2008), graph (A) shows that these rate cuts themselves had an effect of weakening the yen by widening domestic and foreign interest rate differentials. However, graph (B), which corresponds to the overall reaction of the exchange rate including the impact of a direct shock, shows that the yen appreciated against the U.S. dollar despite the Bank of Japan's monetary easing. This suggests that the interest rate declines caused by the Bank of Japan's monetary easing certainly exerted downward pressure on the yen at that time, but it may not necessarily have urged the FX market players to aggressively sell the yen. Meanwhile, the introduction of the fixed-rate funds-supplying operations against pooled collateral for the term of three months decided at the unscheduled meeting on December 1, 2009, gave rise to the persistent depreciation pressure of the yen not only via an interest rate shock but also via a direct shock to the exchange rate. Looking at the estimated responses to the clarification of the "understanding of medium- to long-term price stability" on December 18, 2009 and the announcement of the "price stability goal in the medium to long term" in February 2012, graph (A) indicates that the impact of the interest rate shock itself was quite small. Graph (B), however, shows that, taking direct shocks to the exchange rate into account as well, the yen depreciated against the U.S. dollar to some extent in response to these policy events (Chart 7(6) (8)). This implies that the monetary easing decisions accompanied with the changes in the Bank of Japan's views on the numerical price targets played a role in depreciating the yen in the FX market even though they did not lead to significant downward shift in Japan's yield curve.

Finally, when the Bank of Japan embarked on QQE in April 2013 and announced the introduction of negative interest rates in January 2016, interest rates dropped across a wide

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[12] Watanabe and Yabu (2013) provide interpretation for their time-series evidence that the Bank of Japan's expansions in the target balance of current accounts under its QE program helped strengthen the effects of foreign exchange intervention though leaving some of the concurrent large-scale foreign exchange intervention funds in the market (that is, de facto non-sterilization of FX intervention).

range of maturities including the longer end. Through the interest rate channel, the yen was estimated to depreciate against the U.S. dollar to a certain degree in these cases as shown in graph (A) (Chart 7(9) (11))[13]. However, as graph (B) shows, the depreciation effect of the policy shifts during the QQE period largely stemmed from direct shocks to the exchange rate. This was even more pronounced for the QQE expansion in October 2014: while the effect of interest rate shocks was almost negligible, direct shocks to the exchange rate had quite a large effect of yen depreciation (Chart 7(10)).

To sum up, our estimation results suggest that the yen depreciated against the U.S. dollar in many cases in response to Japan's unconventional monetary policies. Looking at the transmission mechanism, the orthodox channel of widening interest rate differentials certainly led to the yen's depreciation to some extent as these policies pushed down the entire yield curve, including long-term interest rates. However, the overall exchange rate responses appeared to be very different from what would be predicted by such an interest rate channel only: our findings indicate that while interest rate shocks could account for the relatively small part of the overall depreciation response, "direct shocks to the exchange rate" that were unrelated to interest rate differentials mattered more. At the same time, we find that the impact of such direct shocks to the exchange rate varied significantly over time.

4. Discussion on the Results

In this section, we discuss how to interpret the response of the exchange rate to unconventional monetary policies through the "non-interest rate differential channel." It is difficult to pin down a specific mechanism only from our empirical analysis, but one possible explanation is that the announcement of unconventional monetary policies may have altered foreign exchange market participants' expectations about future course of exchange rates. According to the Uncovered Interest rate Parity (UIP) condition, a representative theory of exchange rates, the current exchange rate s_t (in log form) can be expressed as follows, assuming risk neutrality of market participants[14].

[13] Contrary to the expectations, the yen actually appreciated significantly two business days after the introduction of negative interest rate policy was announced on January 29, 2016. In this regard, Ito (2016) offers the interpretation that the introduction of the negative interest rate policy itself certainly had the effect of yen depreciation, but that another new shock (instability in global financial markets) that occurred immediately after the announcement caused the yen to reverse its course and eventually appreciate.

[14] Many studies point out that UIP does not hold in a strict form because high-interest rate currencies actually tend to rise in the next period (UIP puzzle). This means that although the interest rate is higher in the U.S. than in Japan, we often see $s_{t+1} - s_t > 0$ in the exchange rate market. Given such a puzzle, some researchers argue that the UIP should be modified to take into account the risk premium of foreign currency investments and the differences in convenience yield between domestic and foreign assets. (Itskhoki and Mukhin, 2020; Obstfeld and Zhou, 2022; Boehm and Kroner, 2024, etc.). For example, if market participants are risk averse and the risk premium is denoted as ρ_{t+1}, the UIP would be modified as follows.

$$s_t = \left(i_t^{US} - i_t^{JP}\right) + E_t(s_{t+1}) - \rho_{t+1}$$

$$s_t = \left(i_t^{US} - i_t^{JP}\right) + E_t(s_{t+1})$$

$E_t(s_{t+1})$ is the expectation as of today for the exchange rate at the next period. This equation shows that the current exchange rate varies, driven not only by the domestic and foreign interest rate differentials, but also by expectations about the future exchange rate. Therefore, even if unconventional monetary policies do not lead to variations in the domestic and foreign interest rate differentials, the current exchange rate could move as long as they cause any shifts in the expected exchange rate. It is likely that such a transmission channel manifested itself as the direct shock to the exchange rate without affecting interest rate differentials in the estimation results in Section 3. For example, consider the case in which, other conditions being constant, the Japan's expected inflation rate among FX market participants rise significantly after the announcement of Japan's unconventional monetary policy. In this case, the expected path of the future price level in Japan would shift up in the FX market, raising the equilibrium dollar-yen rate determined by the "purchasing power parity," to which the exchange rate is expected to converge in the long run. If this mechanism works, unconventional monetary policy could cause yen's depreciation today even without altering interest rate differentials.

It is really debatable how plausible this expectation-based interpretation for our estimation results is, but the more important point is that the "expectations" in the FX market need not necessarily reflect "economic fundamentals" such as purchasing power parity. In fact, it appears to be quite difficult for participants in the FX market to find "appropriate level of the exchange rate," which is consistent with economic fundamentals, by relying on simple indicators. This is in contrast to the stock market, where corporate earnings (or PER) are generally used as benchmarks, or the bond market, where short-term policy rates will work as anchors. Therefore, once some narrative affecting the future exchange rate expectations becomes dominant among participants in the FX market, herding behavior strategy like "if everyone else believes it, I believe it" tend to be rational regardless of its consistency with economic fundamentals. Such "beauty contest" style herding behavior by noise traders might have manifested itself as "non-interest rate differential channel" in the estimated response of the exchange rate shown in Section 3. If this view is correct, the response of the exchange rate to unconventional monetary policies would be state-dependent, in the sense that it could vary widely depending on the market's narrative and investors' herding behavior at each occasion.

A rigorous examination of the relationship between monetary policies and expectations in the FX market is beyond the scope of this paper. In what follows, we provide anecdotal evidence on the FX market conditions and investors' behavior to explore why depreciation of

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However, this modification of UIP does not change our main argument that the current exchange rate can be affected by any change in the forecast of future exchange rates given the constant risk premium.

the yen did not tend to occur in response to Japan's unconventional policies during the global financial crisis and why the yen depreciated significantly after the introduction of QQE in 2013.

First, we could point out that heightened risk aversion among global investors contributed to the muted response of the dollar-yen exchange rate to Japan's unconventional policies implemented during the global financial crisis. Specifically, the collapse of Lehman Brothers in 2008 and the subsequent European debt crisis significantly increased uncertainty in international financial markets (Chart 8). Against this backdrop, the yen appreciated rapidly and significantly, driven by strong unwinding pressure on accumulated carry trade positions (Brunnermeier et al., 2009; Han and Westelius, 2019) and increasing demand for the Japanese yen, which had been considered as a "safe haven currency." In fact, De Bock and de Carvalho Filho (2015) show that currencies with features such as "current account surplus," "large external net assets," and "high liquidity" tend to appreciate during a risk-off phase, and the Japanese yen and Swiss franc fall into this category. It is thus likely that the story – "yen will appreciate during risk-off phases" – that had prevailed amid the global financial crisis played a key role in mitigating depreciation pressure of the yen in the face of Japan's unconventional monetary policies[15].

Second, it is also important to note that the central banks of major countries, including the U.S. which is the key currency country, embarked on large-scale monetary easing almost simultaneously in the wake of the global financial crisis. Since exchange rates are essentially relative prices among currencies, the number of independent exchange rates is N-1 in a world economy with N countries (This is known as the "N-1 problem"). Therefore, it is theoretically impossible for all the N countries to depreciate their own currencies using independent monetary policies. In other words, if almost all countries ease monetary policies, as they did during the global financial crisis period, some countries will be forced to accept the appreciation of their own currencies. In this regard, as Japan and Switzerland had extremely limited room for lowering their policy interest rates compared to other countries, their currencies, the yen and Swiss franc, may have come under appreciation pressures when many central banks strongly pushed forward with their monetary easing polices (Shirakawa, 2021). Such monetary policy developments in major foreign countries at the time may also have played a role in weakening the depreciation effect of Japan's unconventional policies on the yen exchange rate[16].

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[15] As a related story in the FX market (whether true or not), investors had been highly attentive to the possibility of repatriation: "When a negative shock occurs, Japanese financial institutions tend to sell overseas assets and repatriate funds to their home countries in order to secure the yen liquidity." In fact, the yen's appreciation that began immediately after the Great East Japan Earthquake in 2011 was driven by such a repatriation story.

[16] In September 2011, the Swiss National Bank initiated exchange rate guidance to prevent its currency

On the other hand, we can point out the reversal of the above two factors as the reasons why the yen depreciated more than the interest rate differential channel suggested following the introduction and the subsequent expansion of the QQE. First, as the European debt crisis calmed down, market's risk-off sentiment had eased and demand for safe haven currencies had receded. Second, as the U.S. economy was recovering, the Fed had been shifting to a stance of reducing monetary accommodation, with indications of beginning tapering of its large-scale asset purchases (Kano and Wada, 2017). In addition to these circumstances, it is also important that the level of the yen exchange rate at that time did not seem to fully reflect the deterioration in Japan's economic fundamentals such as the widening trade balance deficits following the Great East Japan Earthquake (Chart 9). Therefore, it is likely that the Bank of Japan's introduction of QQE played a catalytic role in correcting the misalignment of excessively strong yen at that time (Ikeo, 2016).

In fact, looking at IMM net positions of non-commercial traders, which are said to be an indicator of the behavior of short-term investors such as foreign hedge funds that often exhibit herding behavior in the FX market, a long yen position had continued to be built almost all the time from 2008 to 2012. However, this trend clearly changed around the time of the introduction of QQE in 2013, and a relatively large short yen position was formed afterwards (Chart 10)[17]. Such herding behavior of short-term investors in the FX market may have played a role in dampening or amplifying the effects of Japan's unconventional monetary policies.

5. Conclusion

In this paper we examined the response of the nominal exchange rate (dollar-yen exchange rate) to the monetary policy changes, focusing on the effects of various unconventional monetary policy measures implemented by the Bank of Japan over the past 25 years. Specifically, we identified Japan's "unexpected monetary policy shocks" from changes in the entire yield curve and the exchange rate around the policy announcements, and estimated the dynamic response of the exchange rate to these shocks, using functional local projection method. The results show that while the yen depreciated against the U.S. dollar in many cases in response to Japan's expansionary monetary policy shocks, non-interest rate differential

from appreciating below 1.20 Swiss franc per euro in order to counter appreciation pressure. This policy can be interpreted as an actual implementation of "a foolproof way of escaping from a liquidity trap" that will not fail even under the zero lower bound of interest rate, proposed by Svensson (2001) at the International Conference hosted by the Institute for Monetary and Economic Studies of the Bank of Japan. It should be noted that this policy could be adopted because Switzerland is a "small open economy" and similar policy was unlikely to be a realistic option for the Bank of Japan (Yamaguchi, 2002).

[17] The "net position of non-commercial traders in the currency futures market at the Chicago Mercantile Exchange (IMM net position)" is often used as an indicator to capture the behavior of short-term investors such as hedge funds in the FX market. Although these data have the problem of insufficiency in their coverage, previous studies have indicated that they are useful as a proxy for trading activities by hedge funds (Brunnermeier et al., 2009; Galati et al., 2007; Klitgaard and Weir, 2004).

channel – e.g., the shifts in market participants' expectations of the future exchange rate – quantitatively matters more than the orthodox channel of interest rate differential. Furthermore, our findings suggest that the responses of the exchange rate to unconventional monetary policies have been state-dependent in the sense that they could vary significantly depending on global financial market conditions and investors' herding behavior.

Unconventional monetary policy is a policy that extends its target to other financial variables, i.e., longer-term interest rates and asset prices, when there is no room for lowering short-term interest rates due to the effective lower bound. In Japan, since the late 1990s, the margin for reduction has become smaller and smaller for long-term interest rates as well as for short-term interest rates. Consequently, the effectiveness of unconventional monetary policies has crucially depended on how asset prices, such as exchange rates and stock prices, would react to these policies. In this respect, the estimation results in this paper indicate that the Bank of Japan have faced the difficult challenge that the effects of its unconventional monetary policies have been largely affected by precarious perceptions and expectations of FX market participants, which are generally hard to calibrate. Further analysis of the unconventional policy effects on asset prices is strongly needed for the purpose of securing policy effectiveness while avoiding market instability, and thus achieving accountability to the public.

Appendix. Robustness Check

To check robustness of the estimation results in Section 3, we conducted the empirical analyses for the following two cases: (i) when the Japanese and U.S. interest rates are treated as separate explanatory variables, and (ii) when the sample periods are divided.

Japanese and U.S. Interest Rates as Separate Explanatory Variables

In Section 3, we estimated the local projection model using the U.S.-Japan interest rate differentials. However, the degree of impact on the dollar-yen exchange rate may differ between Japan's and U.S. interest rates. Therefore, in the following analysis, we estimate the local projection model by treating the Japan's and U.S. interest rate as separate explanatory variables to check the robustness of our results.

$$\begin{cases} s_t - s_{t-1} = \alpha + \begin{pmatrix} B_0^{JP} \\ B_0^{US} \end{pmatrix}' \begin{pmatrix} \Delta Y_t^{JP} \\ \Delta Y_t^{US} \end{pmatrix} + \sum_{j=1}^{p} \Gamma_{0,j}{}' \begin{pmatrix} \Delta Y_{t-j}^{JP} \\ \Delta Y_{t-j}^{US} \end{pmatrix} + \sum_{j=1}^{q} \gamma_{s,j} \Delta s_{t-j} + u_t \\ s_{t+h} - s_{t-1} = \alpha_h + \begin{pmatrix} B_h^{JP} \\ B_h^{US} \end{pmatrix}' \begin{pmatrix} \Delta Y_t^{JP} \\ \Delta Y_t^{US} \end{pmatrix} + \beta_{h,s} x_t + \sum_{j=1}^{p} \Gamma_{h,j}{}' \begin{pmatrix} \Delta Y_{t-j}^{JP} \\ \Delta Y_{t-j}^{US} \end{pmatrix} + \sum_{j=1}^{q} \gamma_{h,s,j} \Delta s_{t-j} + u_{h,t+h} \\ \qquad \cdots \quad \text{for } h \geq 1 \end{cases}$$

Here, the notation is the same as in Section 3, and $x_t = \hat{u}_t$.

After estimating the above model, we use variations in the Japan's interest rate on the policy announcements as the monetary policy shocks.

$$\varepsilon_{y,t}^{mp} = \begin{pmatrix} \Delta i_{1,t}^{JP} \\ \vdots \\ \Delta i_{n,t}^{JP} \\ 0 \\ \vdots \\ 0 \end{pmatrix} d_t$$

For $\varepsilon_{s,t}^{mp}$ (monetary policy shocks that directly affect the exchange rate), we follow the same procedures as shown in Section 3.

The estimation results show that the impact of interest rate shocks on the dollar-yen exchange rate is smaller than the results presented in Section 3 (Chart A-1). This may be because interest rate fluctuations in Japan during the sample period were generally small, making it difficult to detect the significant effects by a time series analysis. Meanwhile, it remains the case that most exchange rate fluctuations in response to policy changes are caused by "direct exchange rate shocks" that are unrelated to interest rate differentials.

Separating Sample Periods

One of the advantages of the functional local projection we employed is that by using interest rate information from a wide range of maturities, the effects of conventional and unconventional monetary policies can be analyzed in the same unified framework. Thus, we do not need to divide the sample period to make distinction between conventional and unconventional monetary policies.

However, it is possible that the degree of quantitative impact of the interest rate differentials on the exchange rate may be time-varying. In fact, some previous studies report that the impact of long-term interest rates on the exchange rate has been increasing in recent years (e.g., Ferrari et al., 2021). Therefore, we demonstrate the estimation results when the sample period is divided into the following two periods: before 2012 and after 2013. We choose this timing of sample split to allow for the possibility that the strength of interest rate channel may differ before and after introduction of the QQE. The results make sure that there is no significant change in the dollar-yen exchange rate response (Chart A-2). In particular, there is no significant change in the impact of interest rate shocks, and our main finding that "direct shocks to the exchange rate" matter more is robust even when the sample period is divided.

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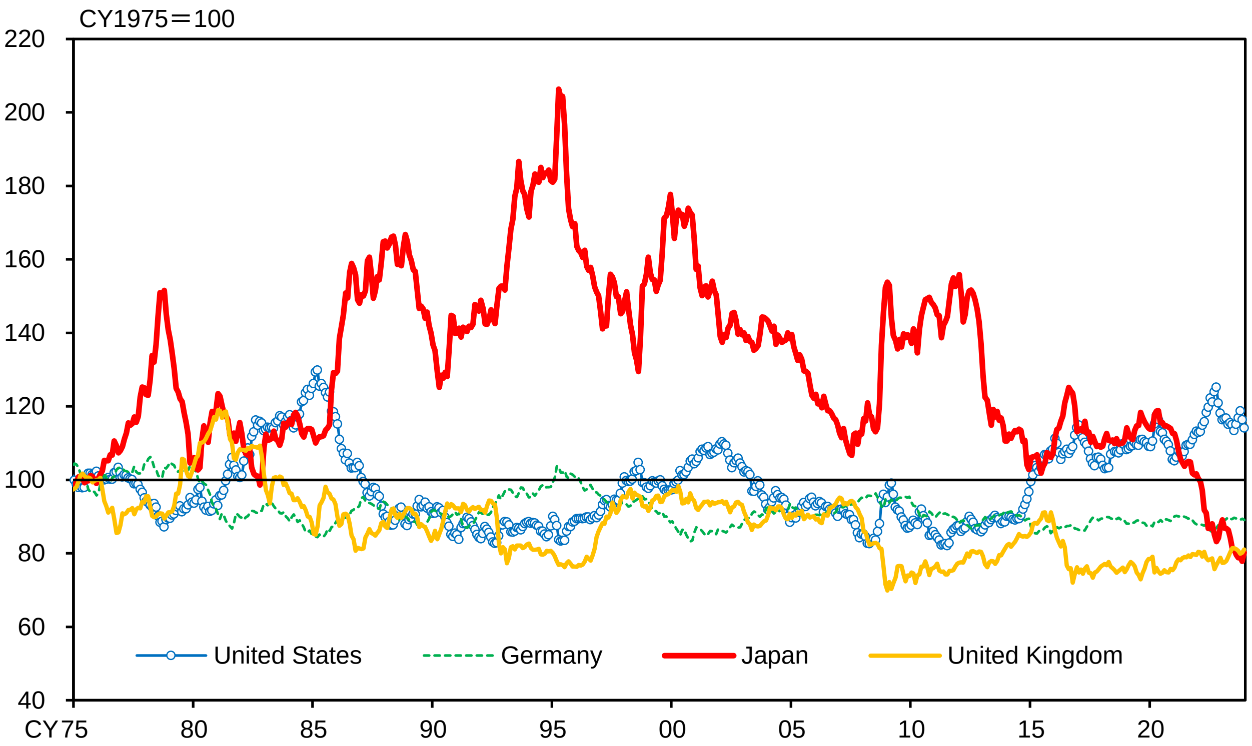
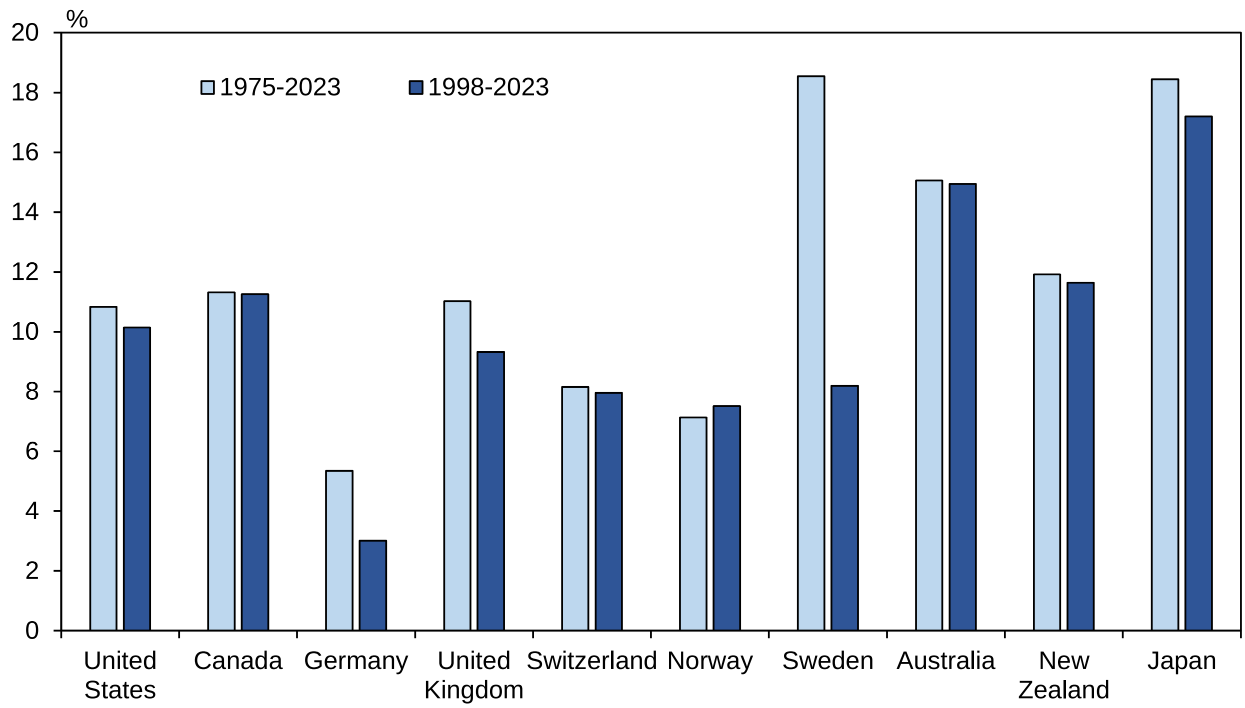
Chart 1: Real effective exchange rates

(1) Real effective exchange rates of major countries



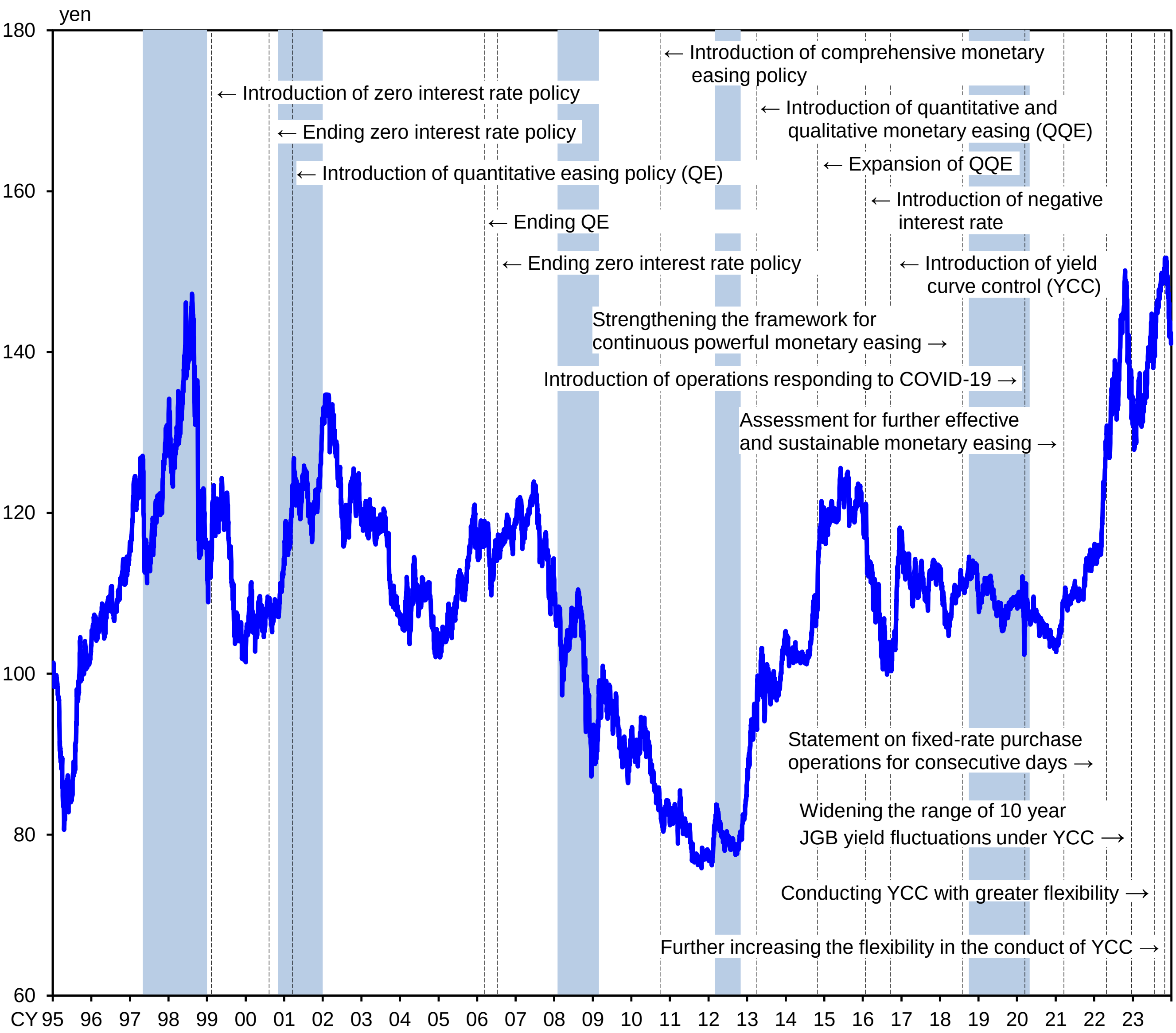
Note: Narrow indices.
Source: BIS.

(2) Standard deviation of real effective exchange rates



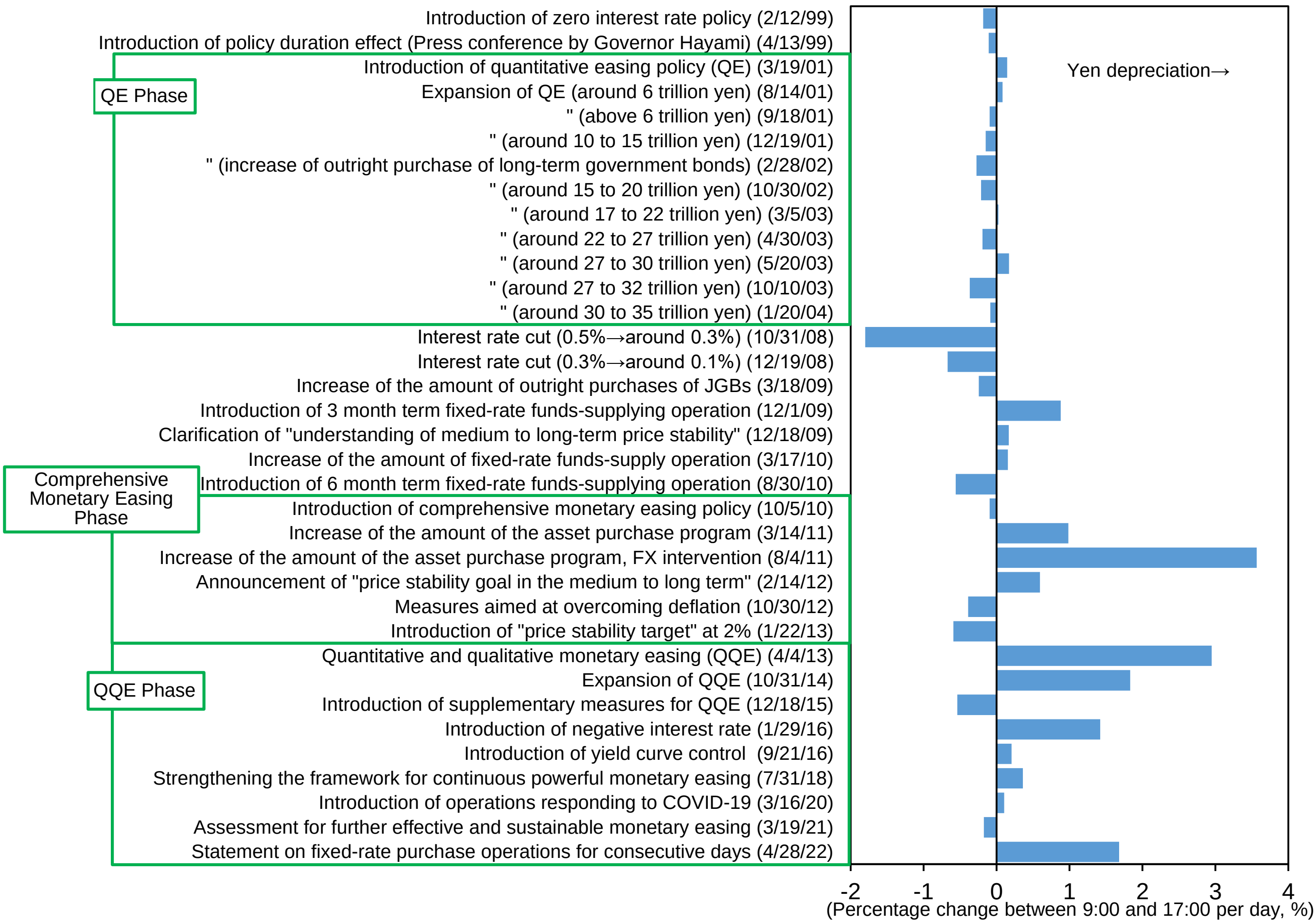
Note: Narrow indices. Standard deviation of the percentage deviation from the period average (1975-2023 or 1998-2023).
Source: BIS.

Chart 2: U.S. dollar-yen rates



Note: Shaded areas denote recession periods in Japan.
Source: Bloomberg; Cabinet office.

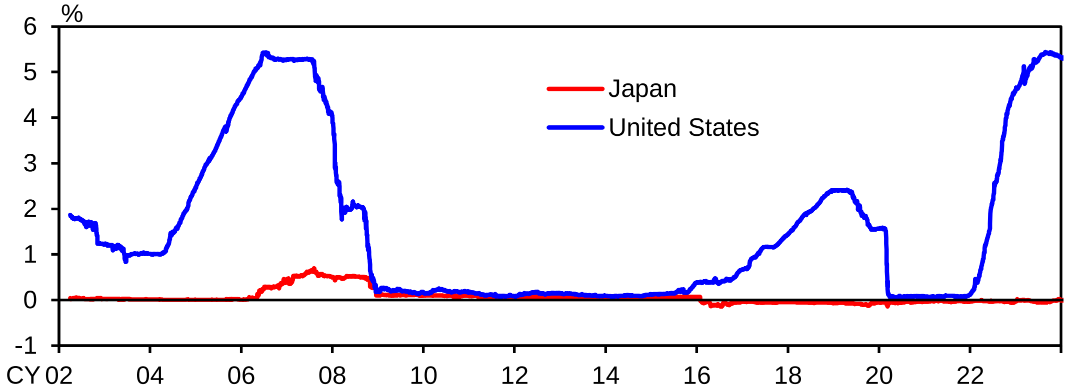
Chart 3: Changes in the dollar-yen rate on the Monetary Policy Meeting days



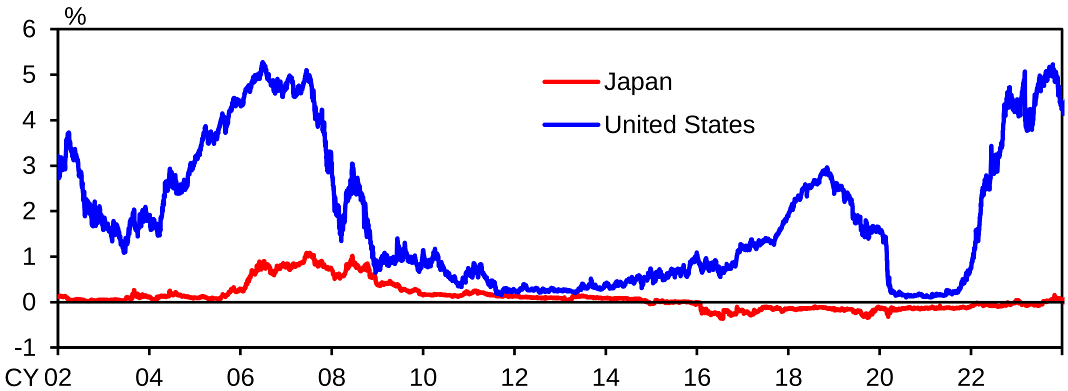
Source: Bank of Japan

Chart 4：Interest rate data used for the analysis

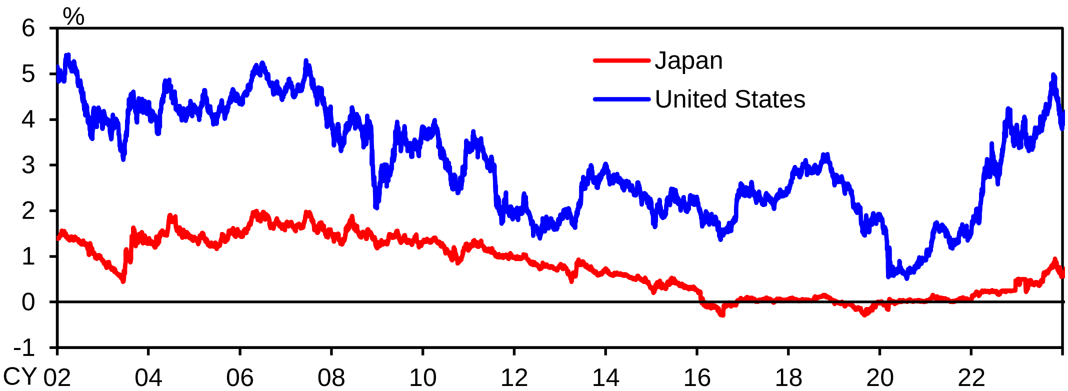
(1) 3-month OIS rates



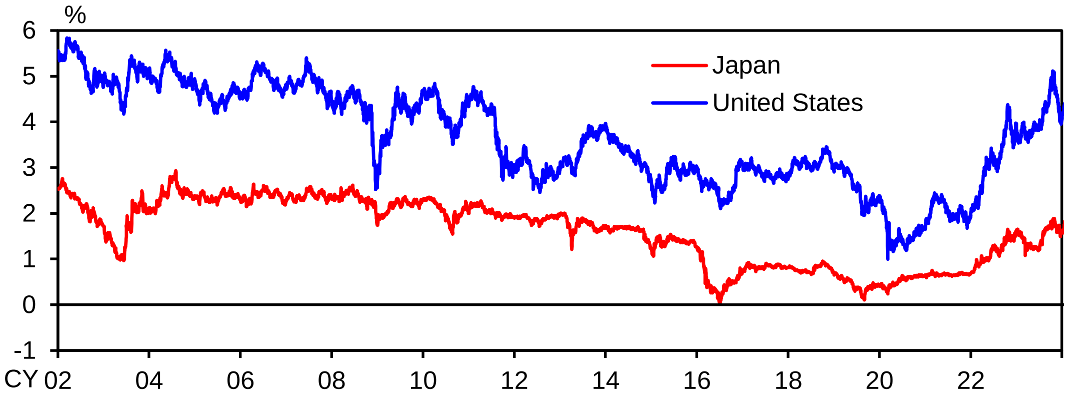
(2) 2-year government bond yields



(3) 10-year government bond yields



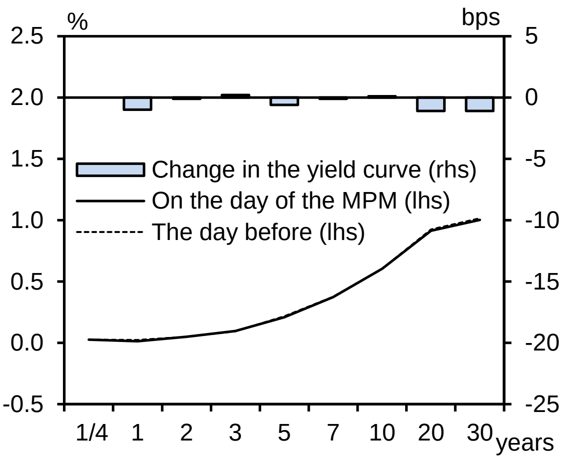
(4) 30-year government bond yields



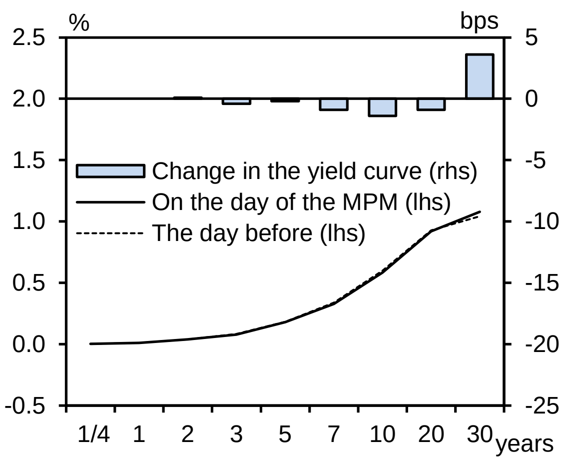
Source: Bloomberg.

Chart 5: Changes in the yield curve on the Monetary Policy Meeting days (1)

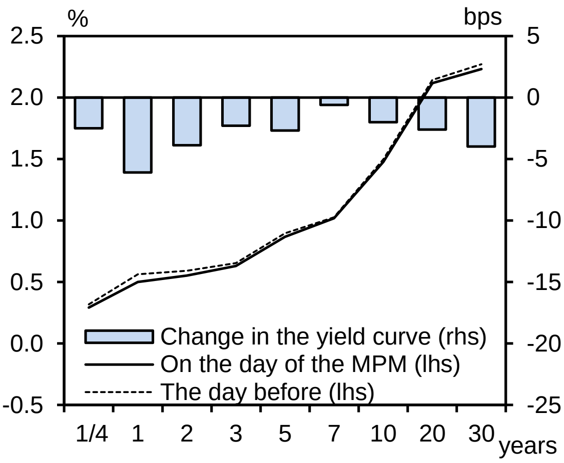
(1) April 30, 2003
Expansion of Quantitative Easing
(to around 22 to 27 trillion yen)



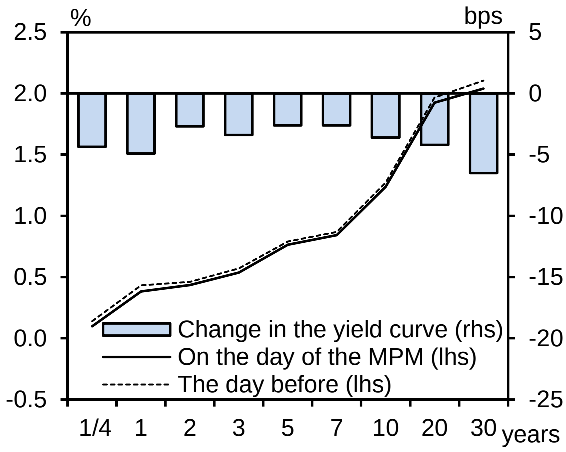
(2) May 20, 2003
Expansion of Quantitative Easing
(to around 27 to 30 trillion yen)



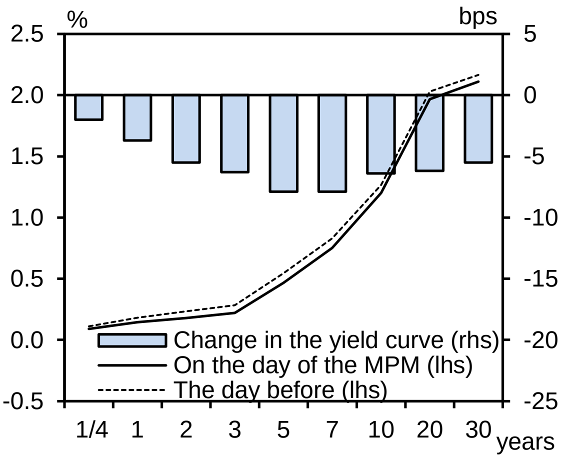
(3) October 31, 2008
Interest rate cut (0.5%→around 0.3%)



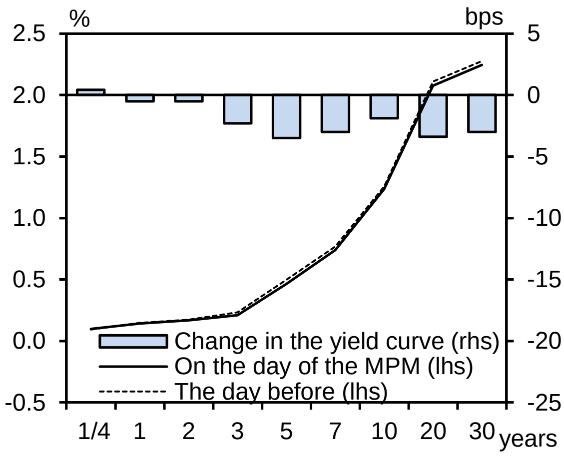
(4) December 19, 2008
Interest rate cut (0.3%→around 0.1%)



(5) December 1, 2009
Introduction of three-month term in the fixed-rate funds-supplying operation



(6) December 18, 2009
Clarification of the "understanding of medium- to long-term price stability"

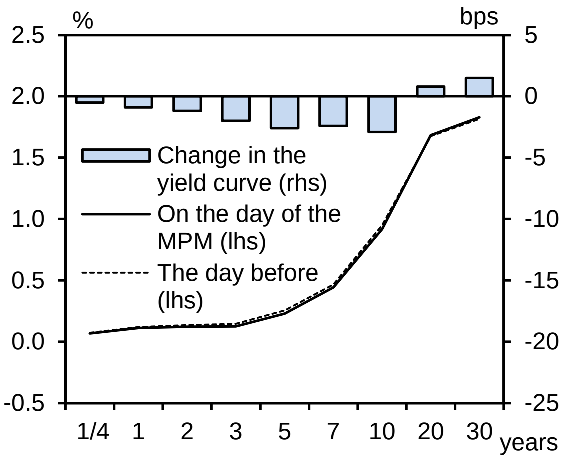


Source: Bloomberg.

Chart 5: Changes in the yield curve on the Monetary Policy Meeting days (2)

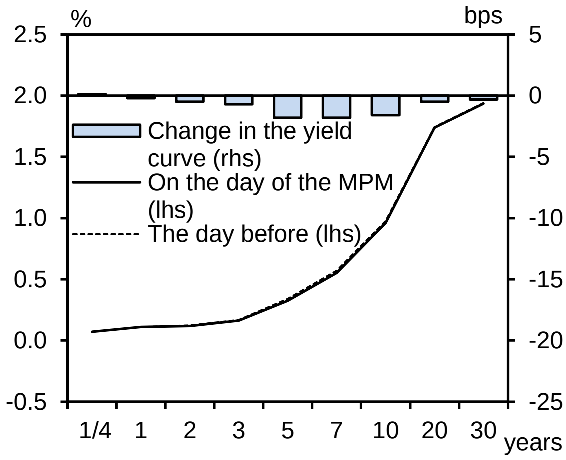
(7) October 5, 2010

Introduction of Comprehensive Monetary Easing



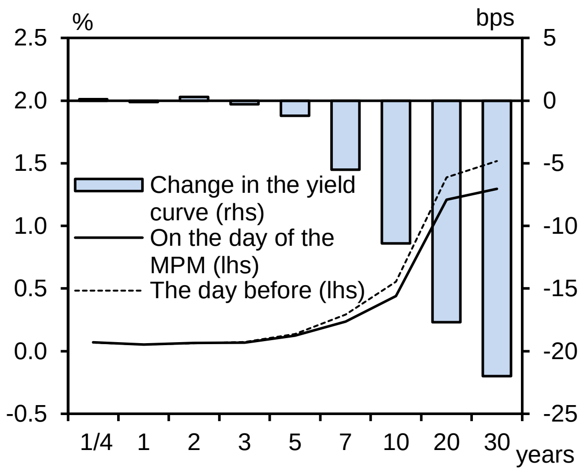
(8) February 14, 2012

Announcement of "price stability goal in the medium to long term"



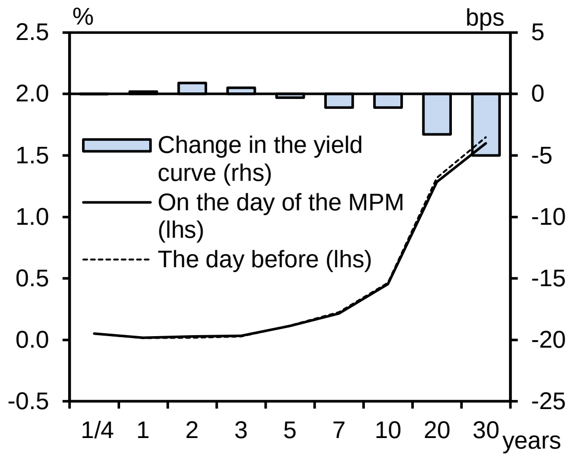
(9) April 4, 2013

Introduction of QQE



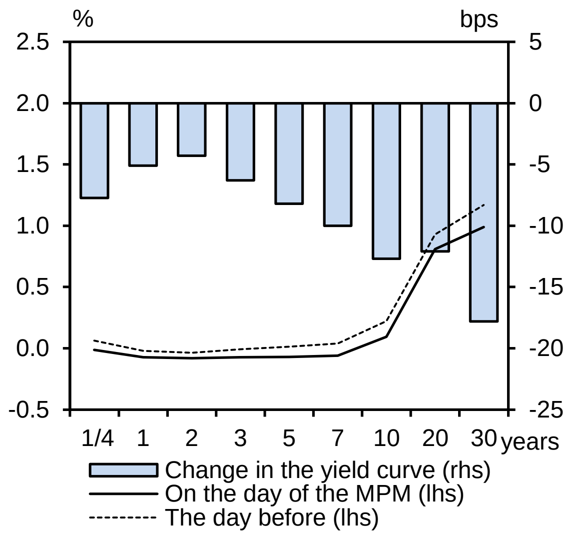
(10) October 31, 2014

Expansion of QQE



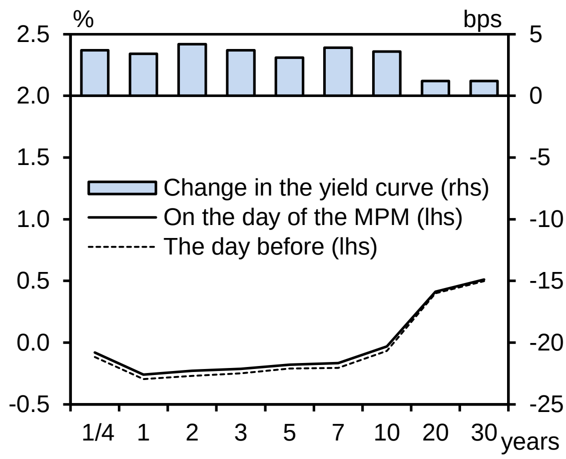
(11) January 29, 2016

Introduction of negative interest rate



(12) September 21, 2016

Introduction of yield curve control (YCC)

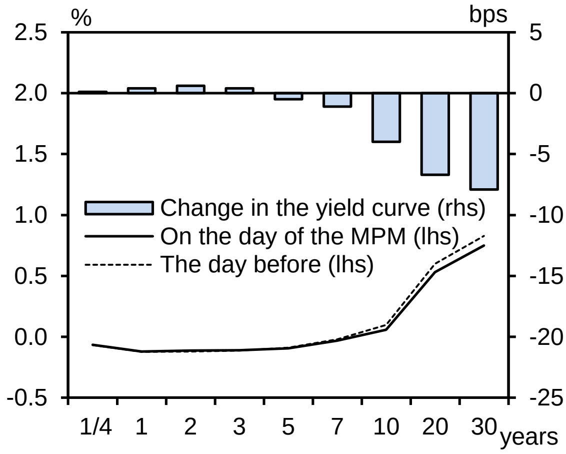


Source: Bloomberg.

Chart 5: Changes in the yield curve on the Monetary Policy Meeting days (3)

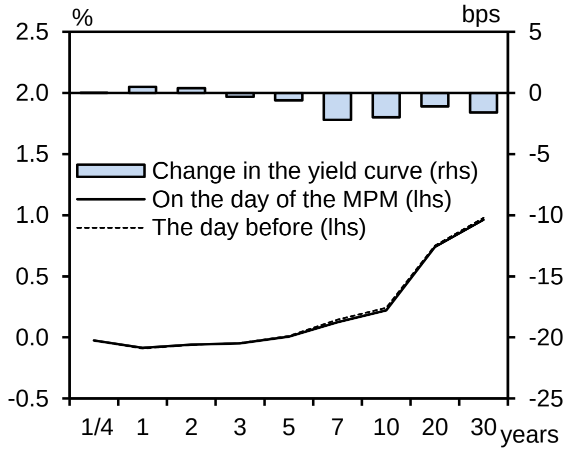
(13) July 31, 2018

Strengthening the framework
for continuous powerful monetary easing



(14) April 28, 2022

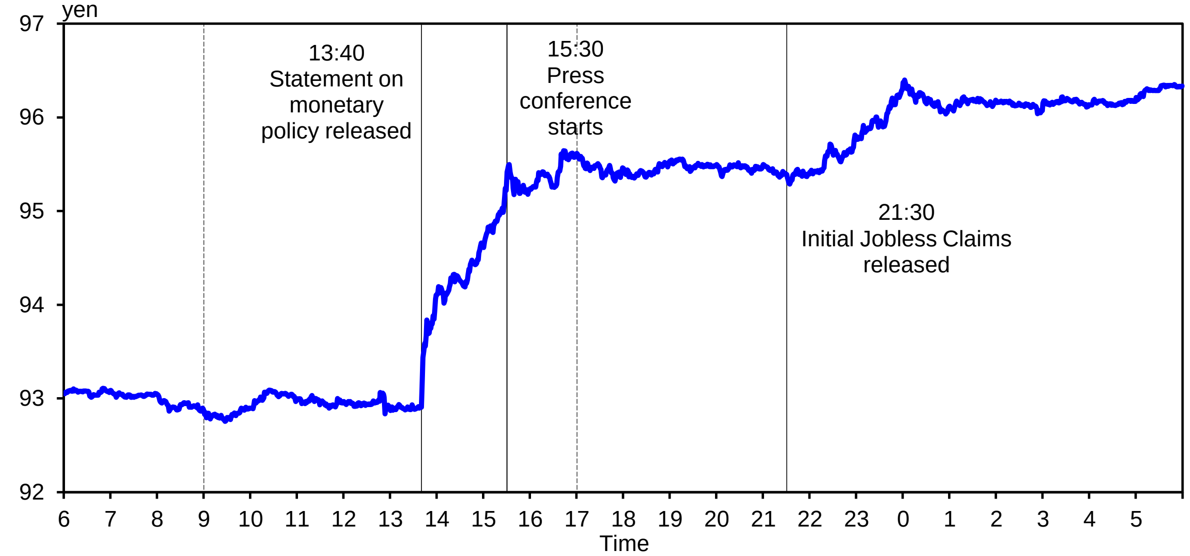
Statement on fixed-rate purchase
operations for consecutive days



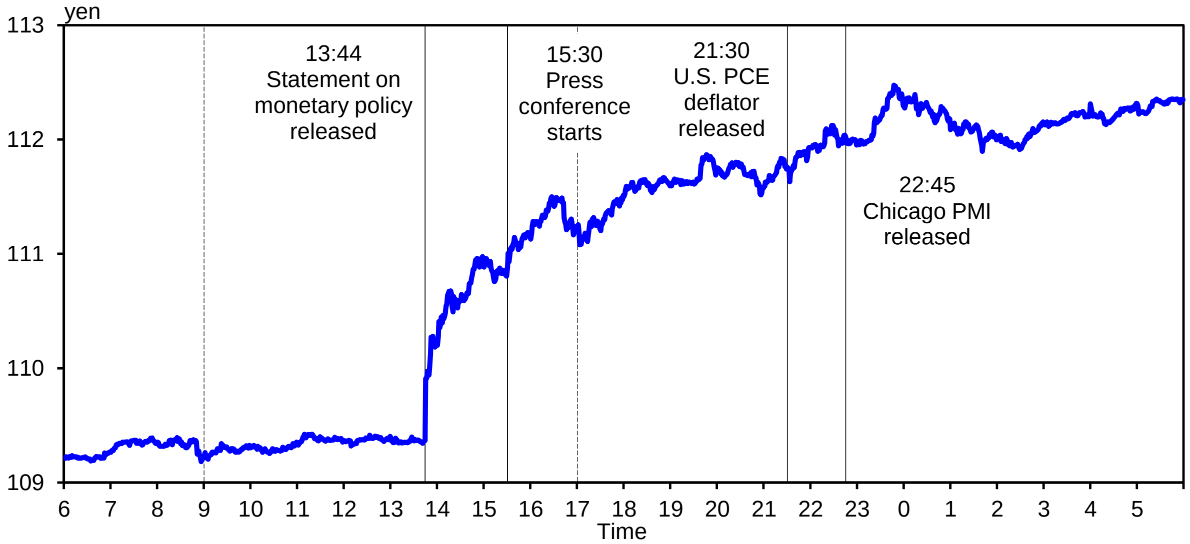
Source: Bloomberg.

Chart 6 : Intraday movements of the dollar-yen rate on the Monetary Policy Meeting days

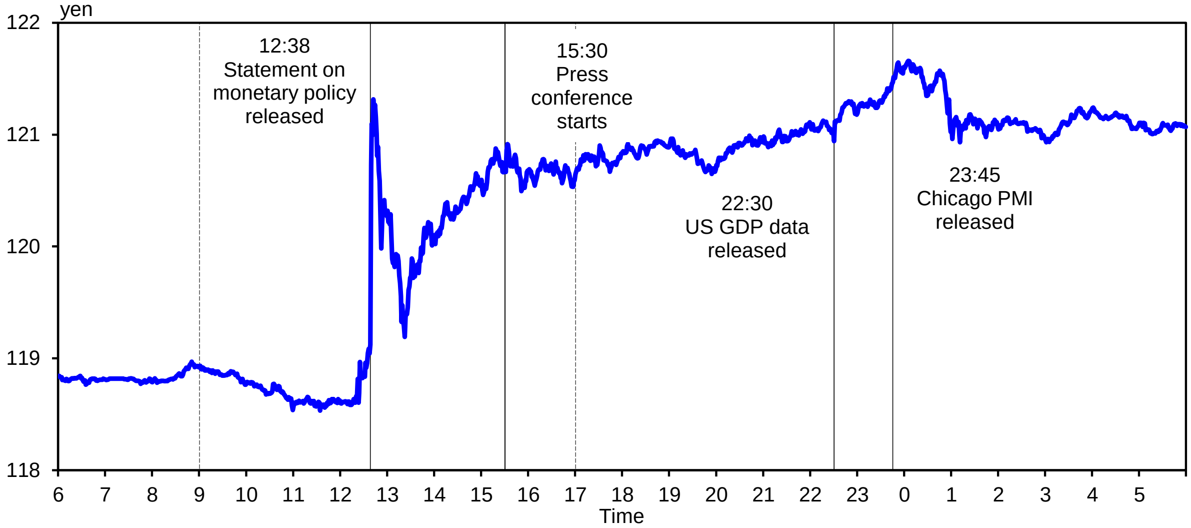
(1) Introduction of QQE (April 4, 2013)



(2) Expansion of QQE (October 31, 2014)



(3) Introduction of negative interest rate (January 29, 2016)

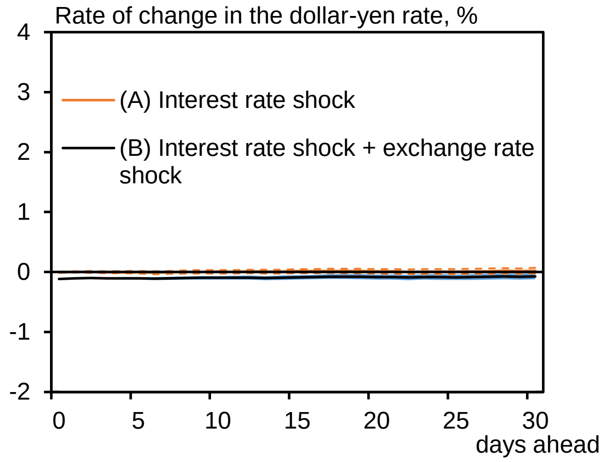


Source: EBS.

Chart 7: Impulse responses of the dollar-yen rate to monetary policy shocks (1)

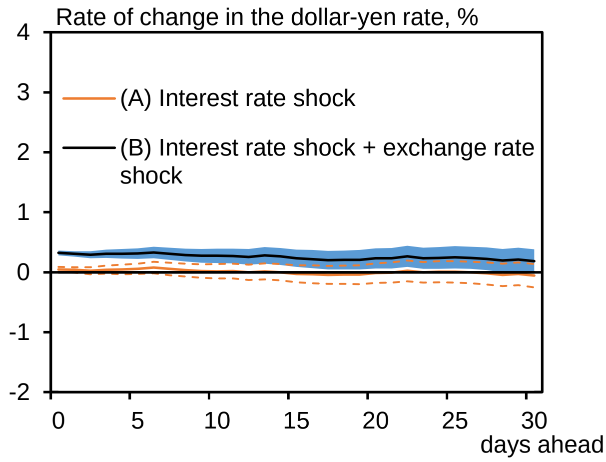
(1) April 30, 2003

Expansion of Quantitative Easing
(to around 22 to 27 trillion yen)



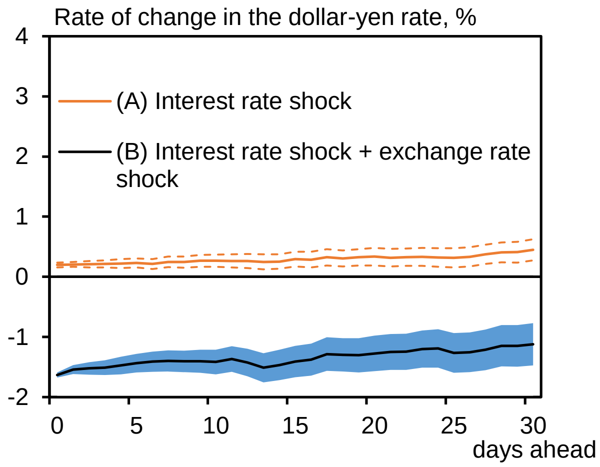
(2) May 20, 2003

Expansion of Quantitative Easing
(to around 27 to 30 trillion yen)



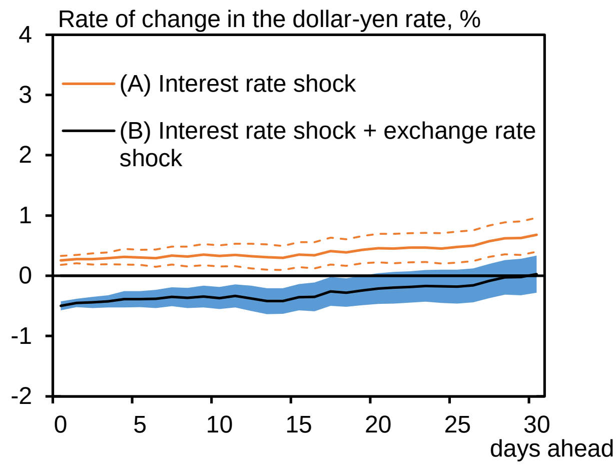
(3) October 31, 2008

Interest rate cut (0.5%→around 0.3%)



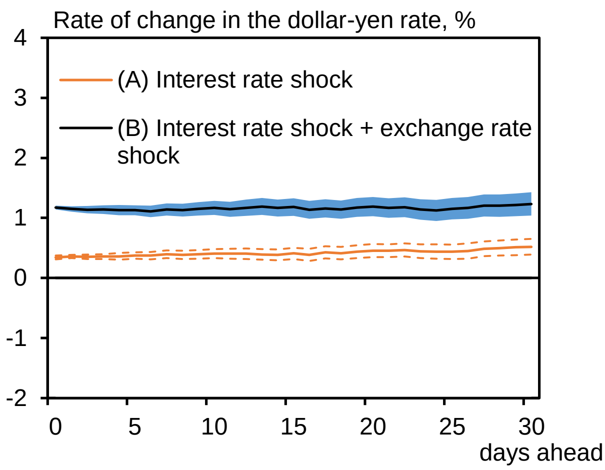
(4) December 19, 2008

Interest rate cut (0.3%→around 0.1%)



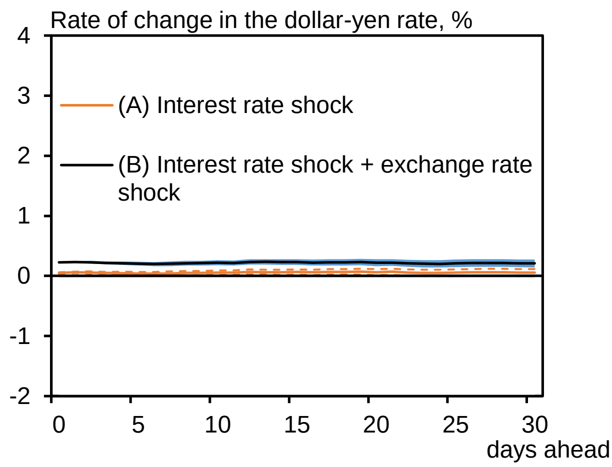
(5) December 1, 2009

Introduction of three-month term in the fixed-rate funds-supplying operation



(6) December 18, 2009

Clarification of the "understanding of medium- to long-term price stability"

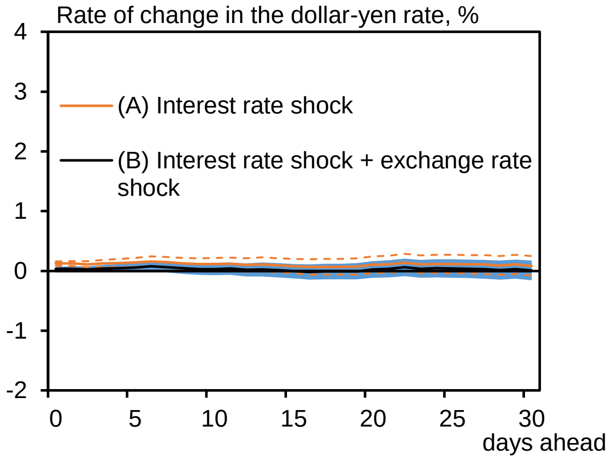


Note: Confidence intervals shown by shadows and dotted lines are 95% (calculated based on Newey-West standard errors).

Chart 7: Impulse responses of the dollar-yen rate to monetary policy shocks (2)

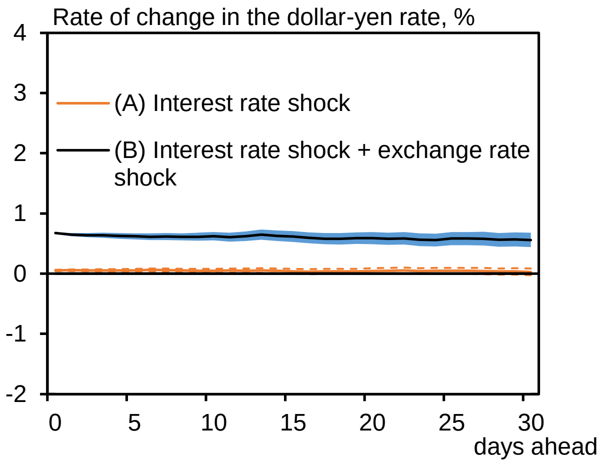
(7) October 5, 2010

Introduction of Comprehensive Monetary Easing



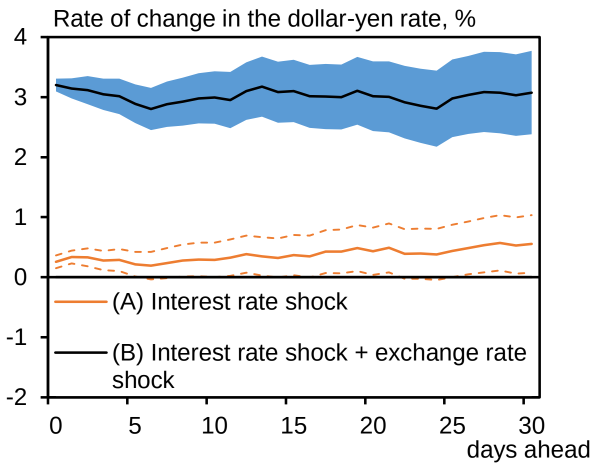
(8) February 14, 2012

Announcement of "price stability goal in the medium to long term"



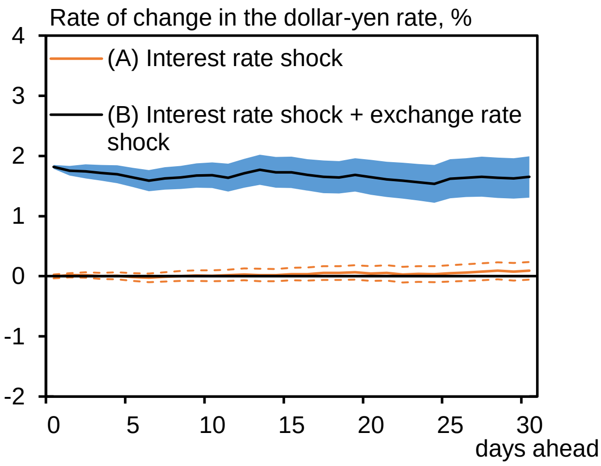
(9) April 4, 2013

Introduction of QQE



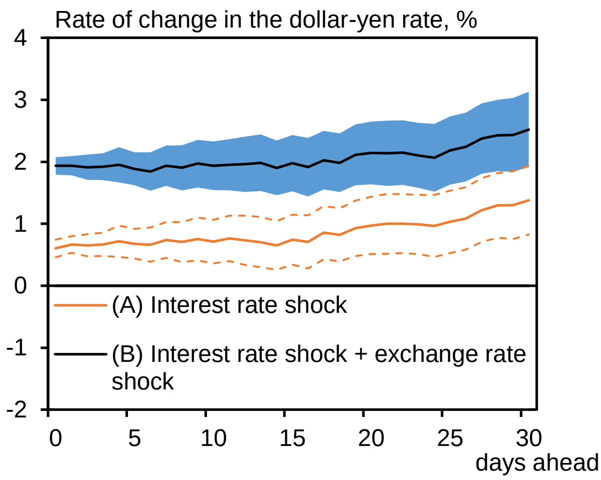
(10) October 31, 2014

Expansion of QQE



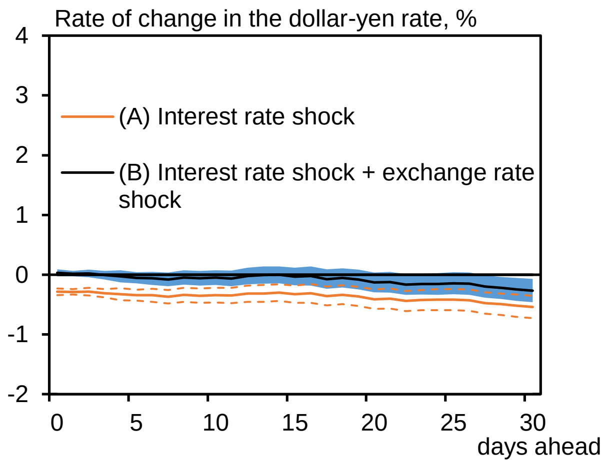
(11) January 29, 2016

Introduction of negative interest rate



(12) September 21, 2016

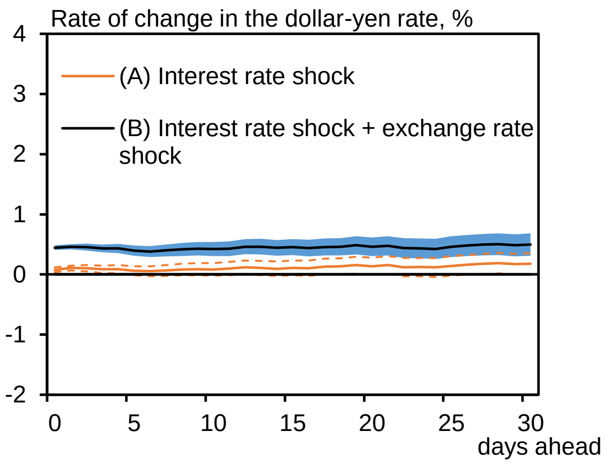
Introduction of yield curve control (YCC)



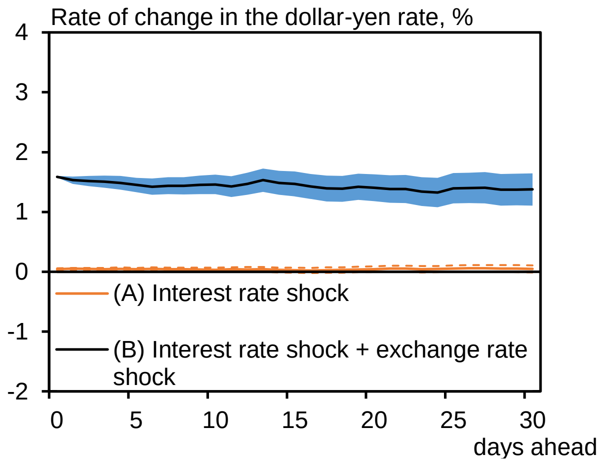
Note: Confidence intervals shown by shadows and dotted lines are 95% (calculated based on Newey-West standard errors).

Chart 7: Impulse responses of the dollar-yen rate to monetary policy shocks (3)

(13) July 31, 2018
Strengthening the framework
for continuous powerful monetary easing

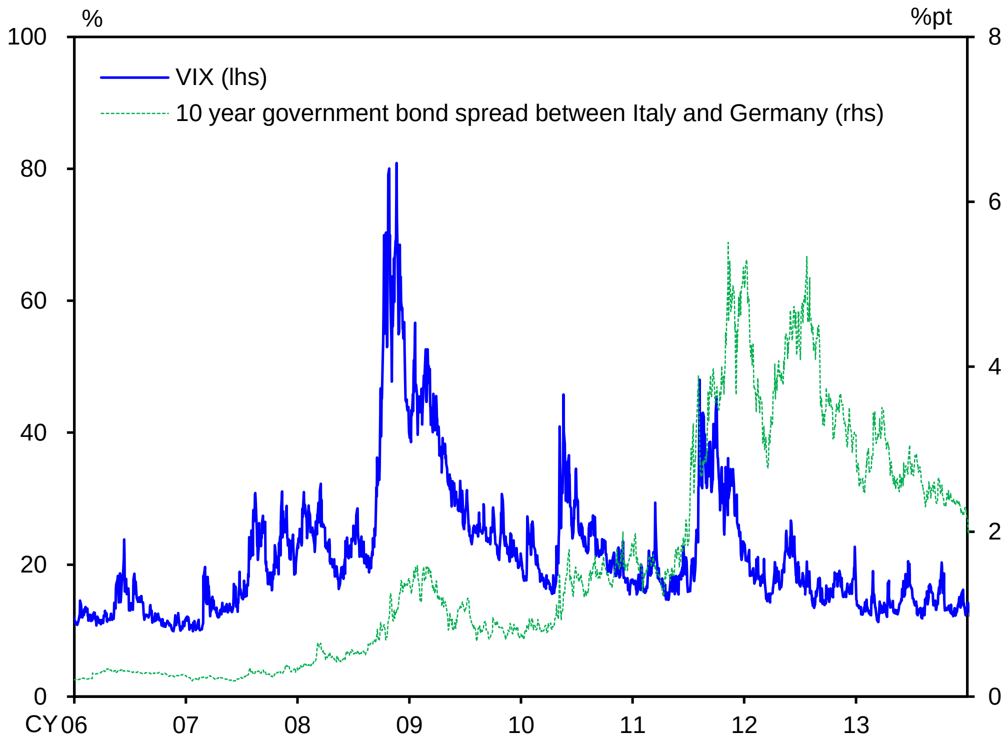


(14) April 28, 2022
Statement on fixed-rate purchase
operations for consecutive days



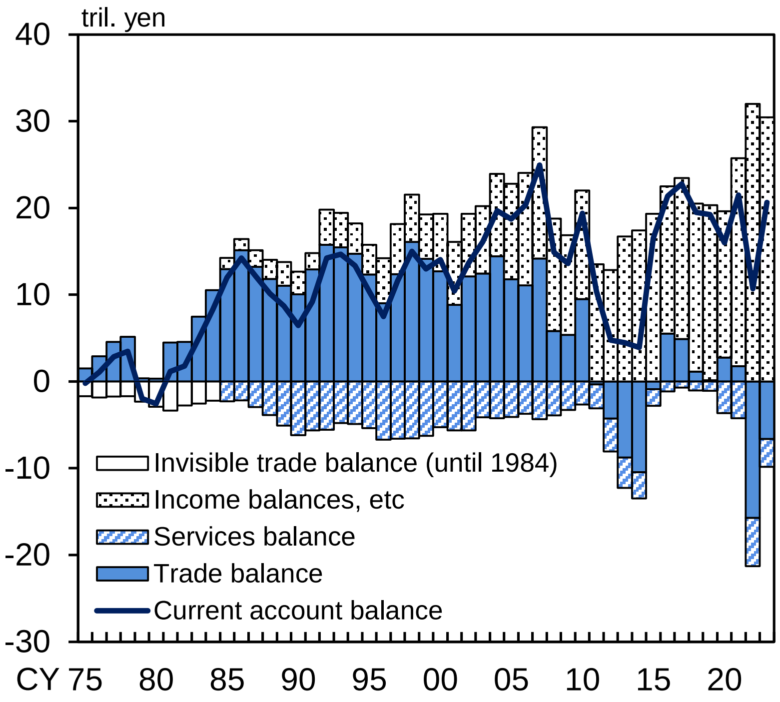
Note: Confidence intervals shown by shadows and dotted lines are 95% (calculated based on Newey-West standard errors).

Chart 8：Indicators of financial market sentiment



Source: Bloomberg.

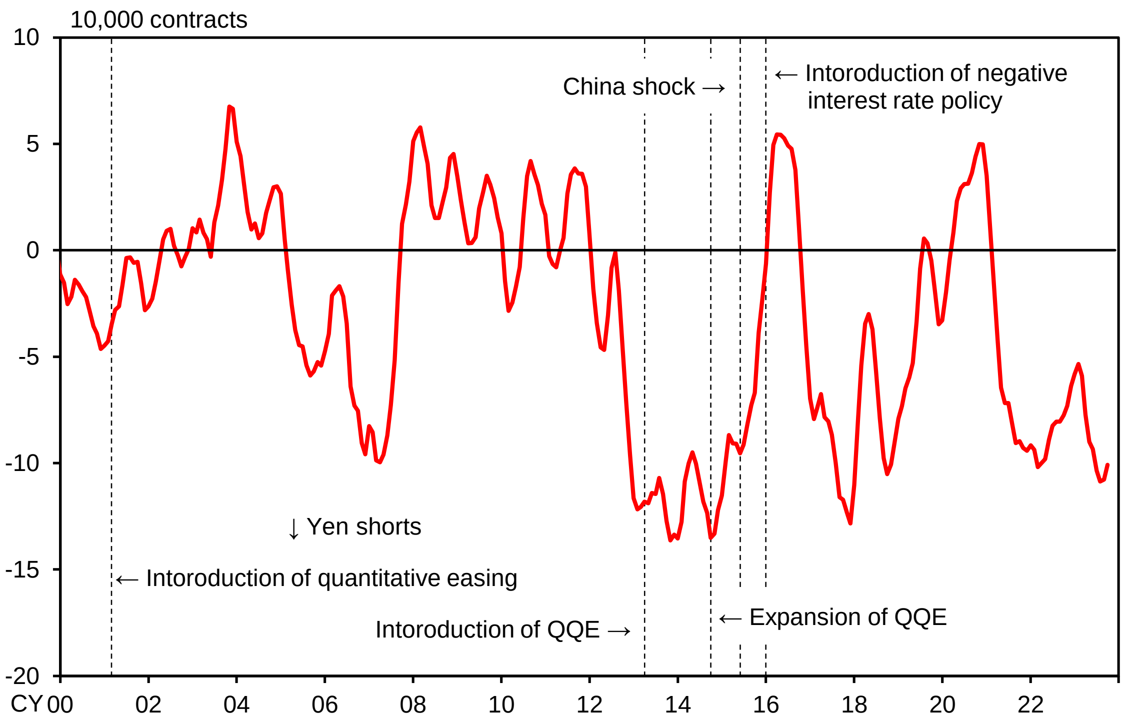
Chart 9: Japan's current account



Notes: For 1984 and earlier, the figures are classified as trade balance and others, and the original dollar figures of balance of payments are converted into yen using the U.S. dollar/yen exchange rate.

Sources: Ministry of Finance and Bank of Japan; Cabinet Office.

Chart 10：IMM net positions



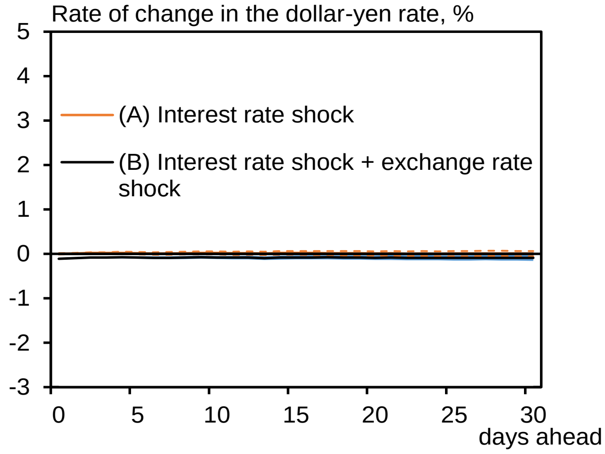
Note: Indicates the total of non-commercial and non-reportable yen positions against the U.S. dollar in currency futures transactions. 5-month central moving averages.

Source: Bloomberg.

Chart A-1: Impulse responses of the dollar-yen rate to monetary policy shocks (Japanese and U.S. interest rates as separate explanatory variables) (1)

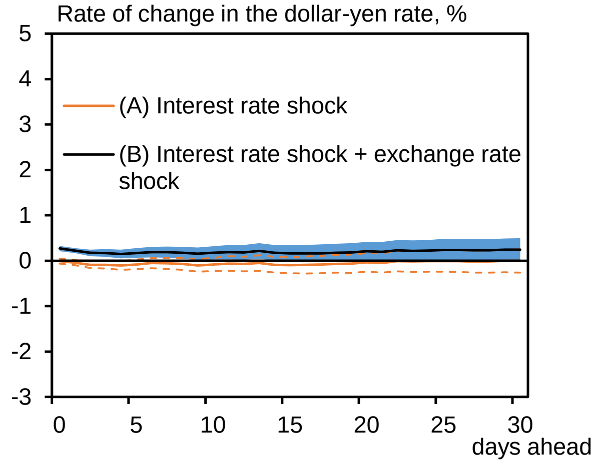
(1) April 30, 2003

Expansion of Quantitative Easing (to around 22 to 27 trillion yen)



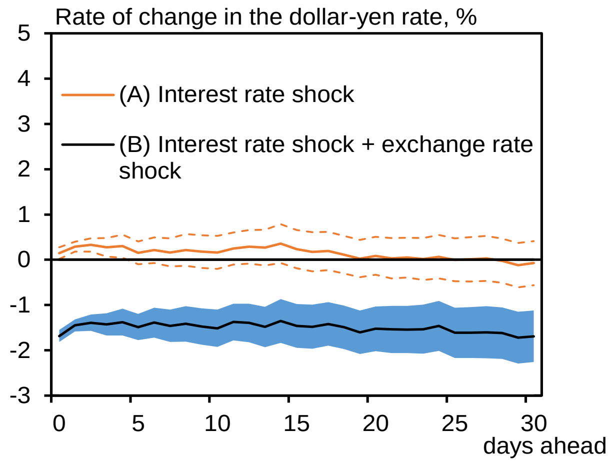
(2) May 20, 2003

Expansion of Quantitative Easing (to around 27 to 30 trillion yen)



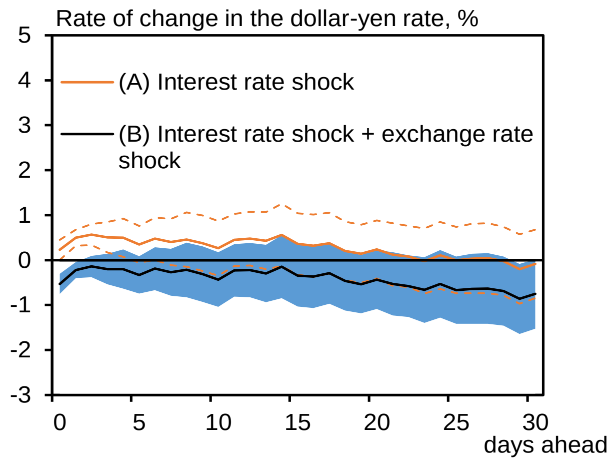
(3) October 31, 2008

Interest rate cut (0.5%→around 0.3%)



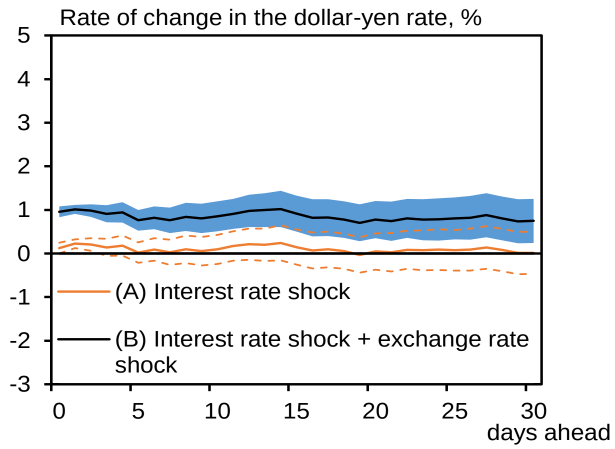
(4) December 19, 2008

Interest rate cut (0.3%→around 0.1%)



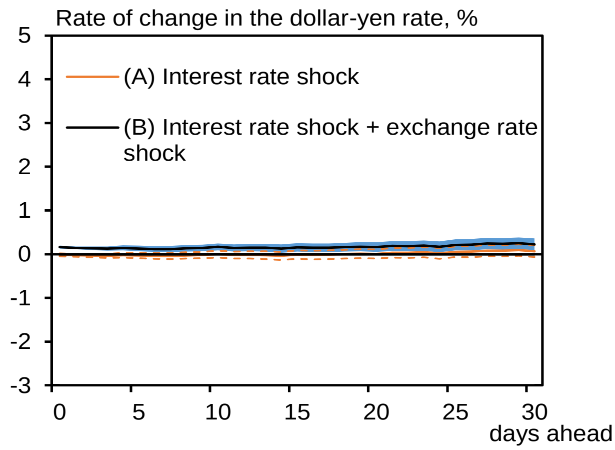
(5) December 1, 2009

Introduction of three-month term in the fixed-rate funds-supplying operation



(6) December 18, 2009

Clarification of the "understanding of medium- to long-term price stability"

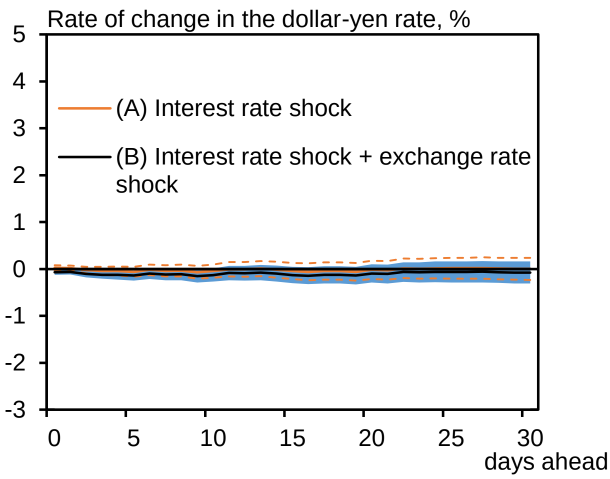


Note: Confidence intervals shown by shadows and dotted lines are 95% (calculated based on Newey-West standard errors).

Chart A-1: Impulse responses of the dollar-yen rate to monetary policy shocks (Japanese and U.S. interest rates as separate explanatory variables) (2)

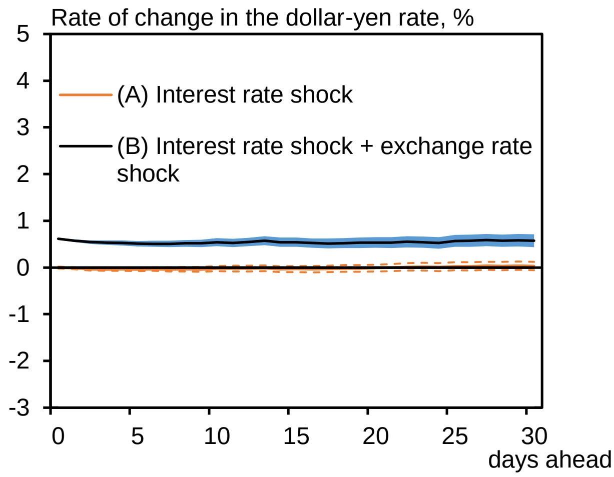
(7) October 5, 2010

Introduction of Comprehensive Monetary Easing



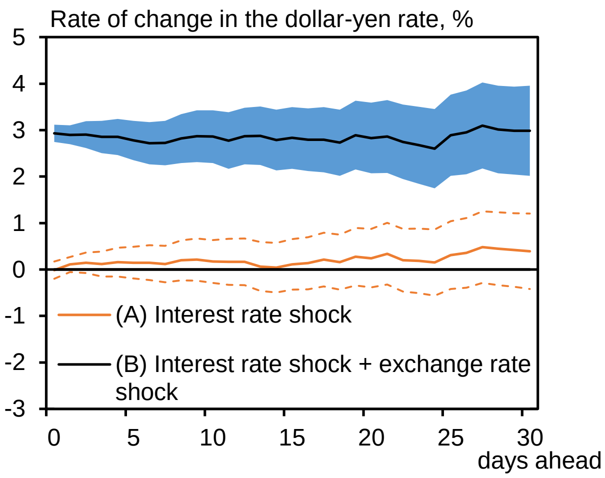
(8) February 14, 2012

Announcement of "price stability goal in the medium to long term"



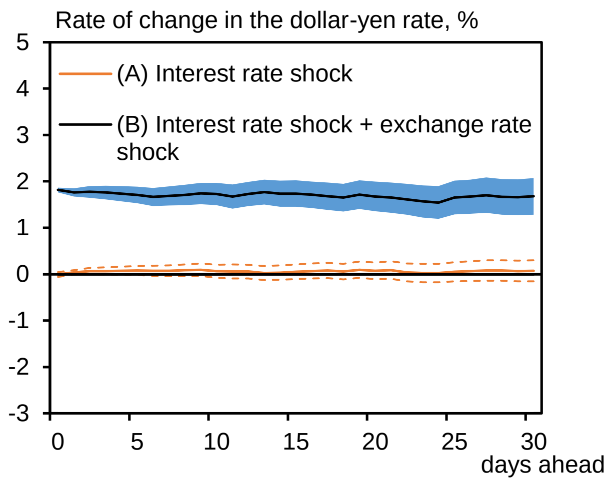
(9) April 4, 2013

Introduction of QQE



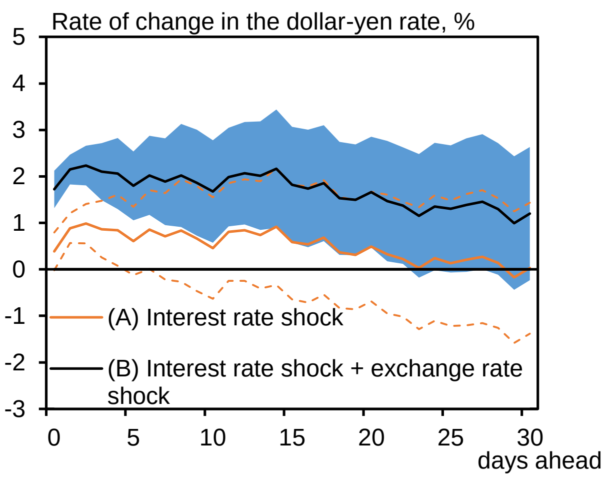
(10) October 31, 2014

Expansion of QQE



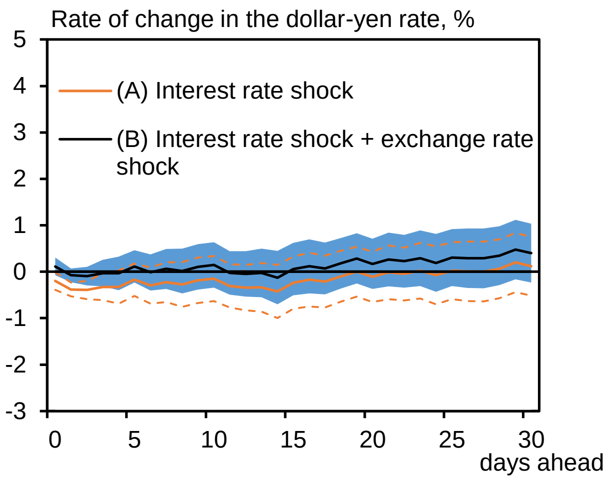
(11) January 29, 2016

Introduction of negative interest rate



(12) September 21, 2016

Introduction of yield curve control (YCC)

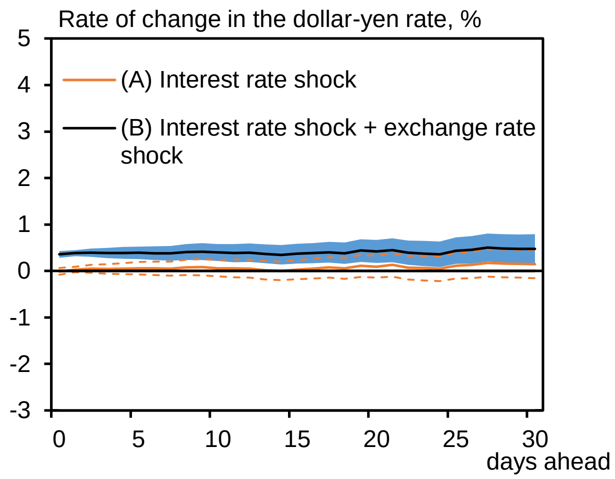


Note: Confidence intervals shown by shadows and dotted lines are 95% (calculated based on Newey-West standard errors).

Chart A-1: Impulse responses of the dollar-yen rate to monetary policy shocks (Japanese and U.S. interest rates as separate explanatory variables) (3)

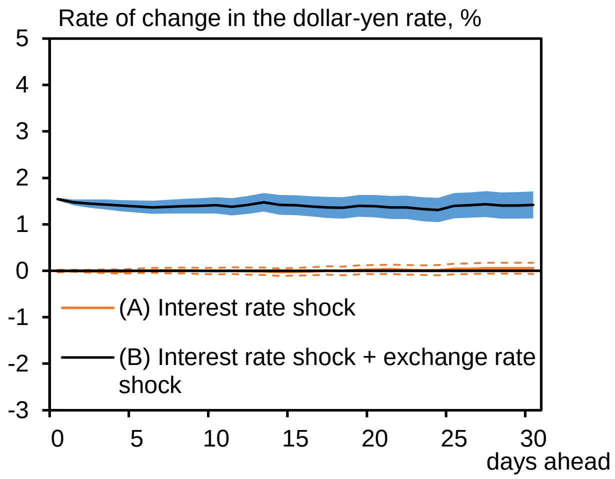
(13) July 31, 2018

Strengthening the framework for continuous powerful monetary easing



(14) April 28, 2022

Statement on fixed-rate purchase operations for consecutive days



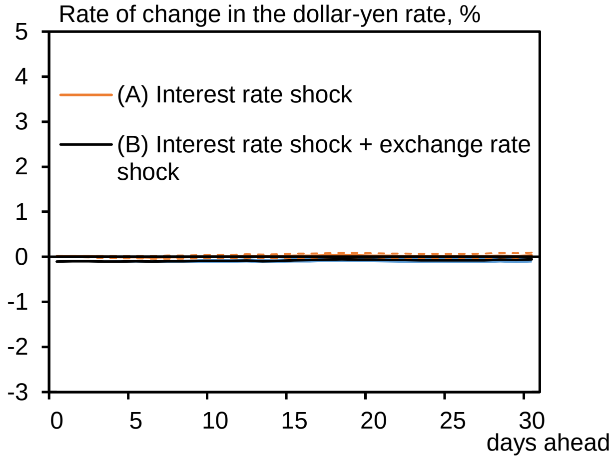
Note: Confidence intervals shown by shadows and dotted lines are 95% (calculated based on Newey-West standard errors).

Chart A-2: Impulse responses of the dollar-yen rate to monetary policy shocks (Separating sample periods) (1)

(1) April 30, 2003

Expansion of Quantitative Easing

(to around 22 to 27 trillion yen)



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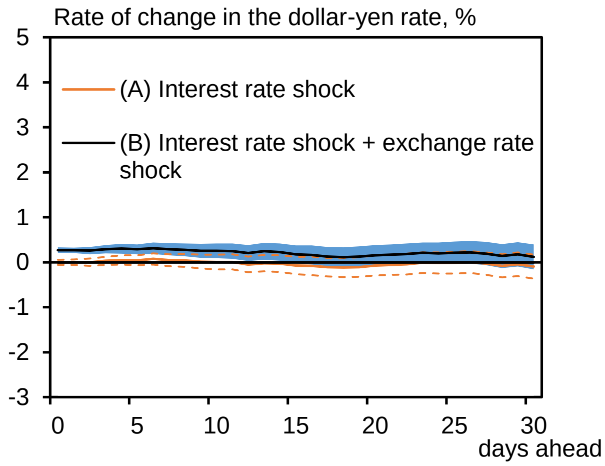
(to around 27 to 30 trillion yen)



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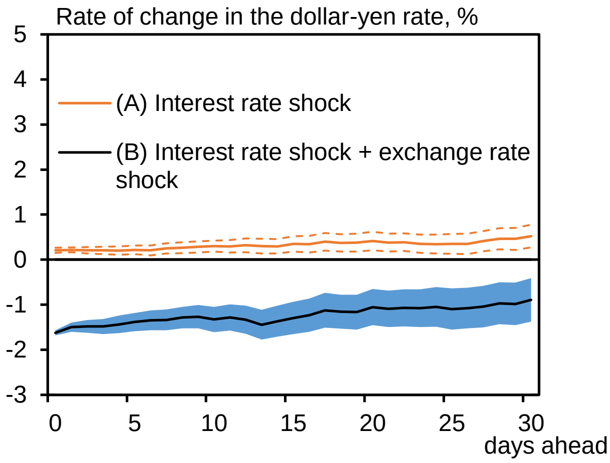
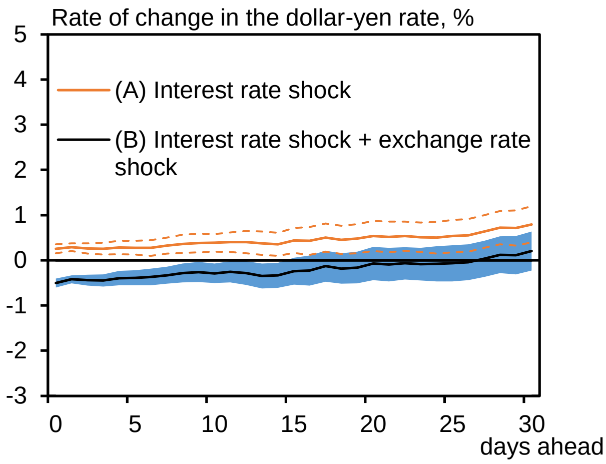
Interest rate cut (0.5%→around 0.3%)



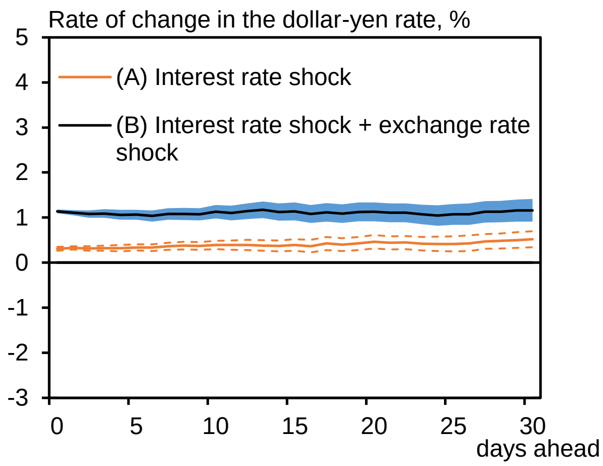
(4) December 19, 2008

Interest rate cut (0.3%→around 0.1%)



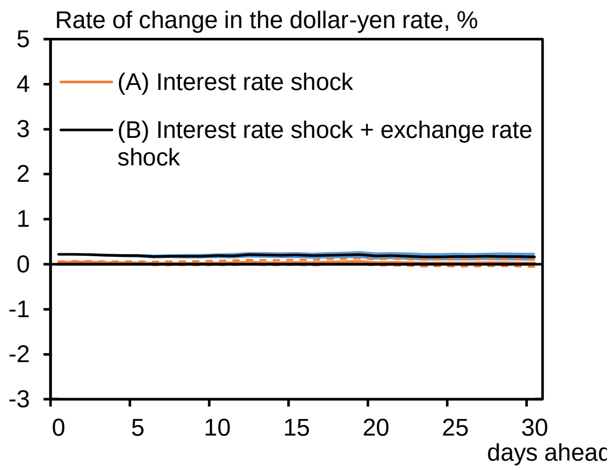
(5) December 1, 2009

Introduction of three-month term in the fixed-rate funds-supplying operation



(6) December 18, 2009

Clarification of the "understanding of medium- to long-term price stability"

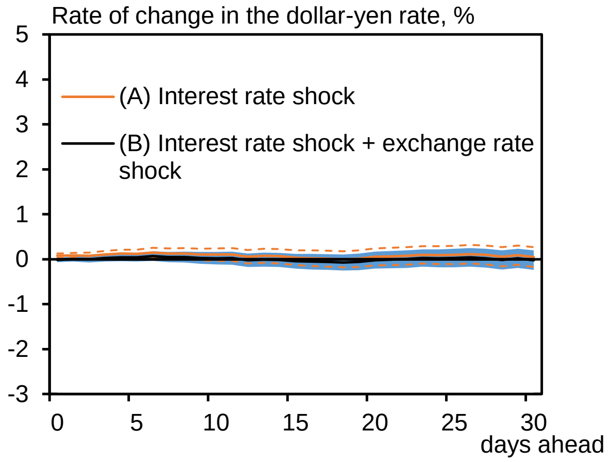


Note: Confidence intervals shown by shadows and dotted lines are 95% (calculated based on Newey-West standard errors).

Chart A-2: Impulse responses of the dollar-yen rate to monetary policy shocks (Separating sample periods) (2)

(7) October 5, 2010

Introduction of Comprehensive Monetary Easing



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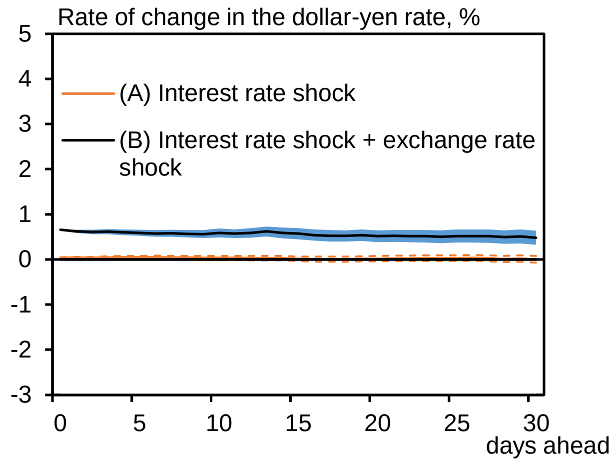
Announcement of "price stability goal in the medium to long term"



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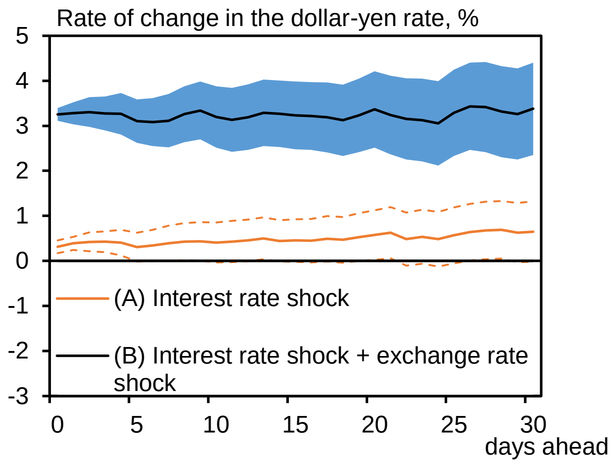
Introduction of QQE



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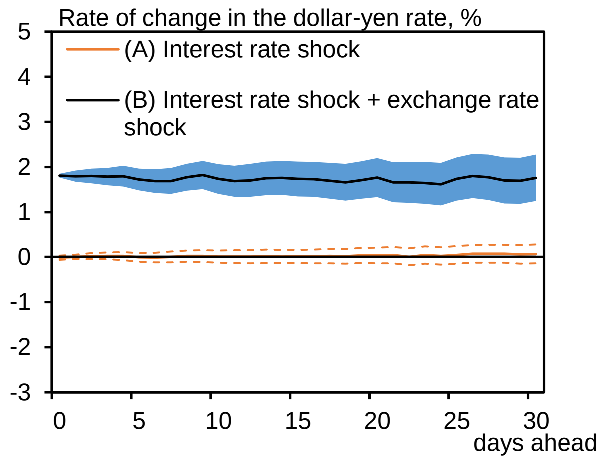
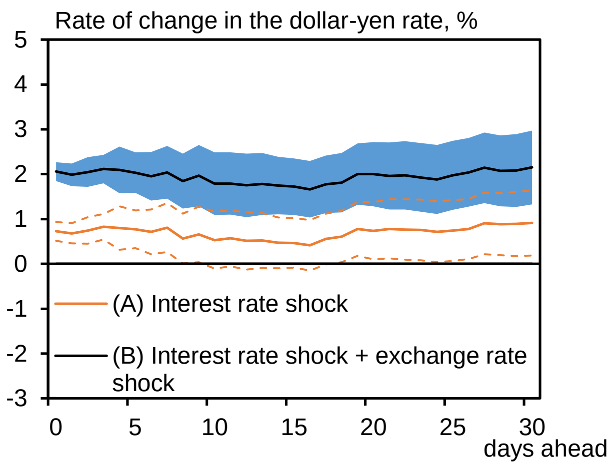
Expansion of QQE



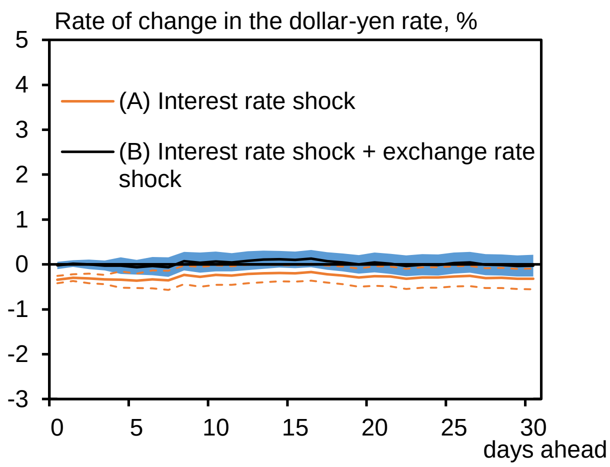
(11) January 29, 2016

Introduction of negative interest rate



(12) September 21, 2016

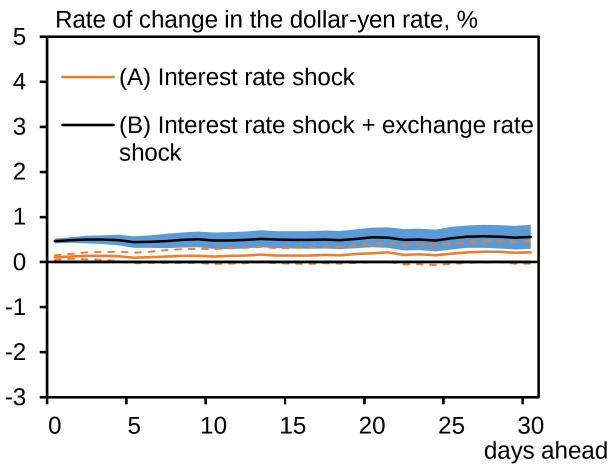
Introduction of yield curve control (YCC)



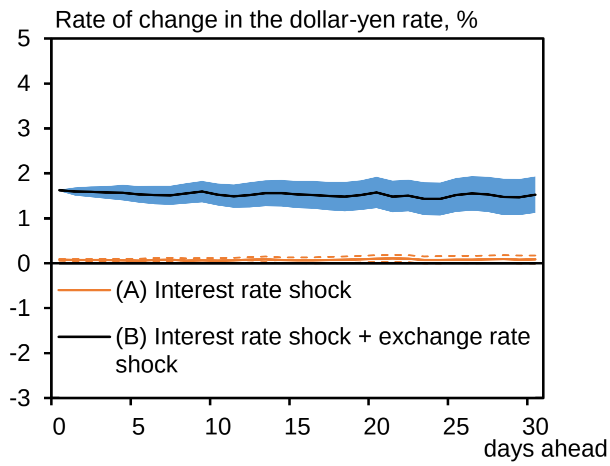
Note: Confidence intervals shown by shadows and dotted lines are 95% (calculated based on Newey-West standard errors).

Chart A-2: Impulse responses of the dollar-yen rate to monetary policy shocks (Separating sample periods) (3)

(13) July 31, 2018
Strengthening the framework for continuous powerful monetary easing



(14) April 28, 2022
Statement on fixed-rate purchase operations for consecutive days



Note: Confidence intervals shown by shadows and dotted lines are 95% (calculated based on Newey-West standard errors).

Table 1: Monetary easing decision events analyzed

(1)	April 30, 2003	Expansion of Quantitative Easing (from around 17 to 22 trillion yen to around 22 to 27 trillion yen)
(2)	May 20, 2003	Expansion of Quantitative Easing (from around 22 to 27 trillion yen to around 27 to 30 trillion yen)
(3)	October 31, 2008	Interest rate cut (0.5%→around 0.3%)
(4)	December 19, 2008	Interest rate cut (0.3%→around 0.1%)
(5)	December 1, 2009	Enhancement of easy monetary conditions (Introduction of three-month term in the fixed-rate funds-supplying operation)
(6)	December 18, 2009	Clarification of the "understanding of medium- to long-term price stability"
(7)	October 5, 2010	Introduction of Comprehensive Monetary Easing
(8)	February 14, 2012	Announcement of "price stability goal in the medium to long term"
(9)	April 4, 2013	Introduction of "Quantitative and Qualitative Monetary Easing (QQE)"
(10)	October 31, 2014	Expansion of QQE
(11)	January 29, 2016	Introduction of negative interest rate
(12)	September 21, 2016	Introduction of yield curve control (YCC)
(13)	July 31, 2018	Strengthening the framework for continuous powerful monetary easing
(14)	April 28, 2022	Statement on fixed-rate purchase operations for consecutive days