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Measuring Policy Effects since the Introduction of Quantitative and Qualitative Monetary Easing (QQE): An Analysis Using the Macroeconomic Model Q-JEM*

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Abstract

This paper estimates the policy effects of the Bank of Japan's expansionary monetary policy measures since the introduction of Quantitative and Qualitative Monetary Easing (QQE) in 2013 using the Bank of Japan's large-scale macroeconomic model, the Quarterly Japanese Economic Model (Q-JEM). Specifically, we generate "counterfactual paths" for key financial variables, including nominal interest rates, as well as inflation expectations, in a hypothetical scenario where these policy measures are absent. Then, we conduct counterfactual analysis using Q-JEM to simulate the developments of real GDP and the CPI under those counterfactual paths, and estimate the policy effects as the differences between the actual values and the simulation results. The analysis shows that, during the period from the introduction of QQE in 2013 to the April-June quarter of 2023, the policy measures have on average pushed up the level of real GDP by around +1.3 to +1.8 percent and the year-on-year rate of change in the CPI (less fresh food and energy) by around +0.5 to +0.7 percentage points.

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1. Introduction

Since the Japanese economy fell into deflation, the Bank of Japan has implemented a variety of monetary easing measures that are believed to have had wide-ranging effects on financial markets and the real economy. In this paper, as part of the Bank's "Review of Monetary Policy from a Broad Perspective," we employ the macroeconomic model, Q-JEM, to measure the effects on the economy and prices of the unconventional monetary policy measures implemented by the Bank since the introduction of QQE in 2013. Q-JEM is a large-scale economic model developed by the Bank that comprehensively describes the Japanese economy (Fukunaga et al. (2011), Hirakata et al. (2019)). It consists of approximately 1,000 variables, including foreign economy and financial market variables, and hundreds of definition and estimation equations. Like the Federal Reserve's (Fed) "FRB/US" model and the European Central Bank's (ECB) "ECB-BASE" model, Q-JEM is a semi-structural model that is based on economic theories but has flexible specifications that take into account fit to the data. Therefore, it is highly convenient in practice and is used for economic forecasts and scenario analysis at the Bank. In fact, the Bank's "Comprehensive Assessment" in 2016 and "Assessment for Further Effective and Sustainable Monetary Easing" in 2021 have also used Q-JEM to measure policy effects (Kan et al. (2016), Kawamoto et al. (2021)). In these analyses, "counterfactual paths" are generated for key financial and expectations variables under a hypothetical scenario in which the Bank did not implement its unconventional monetary policy measures; then, the authors conduct counterfactual simulations of what developments in the economy and prices would have been had these paths been realized. The policy effects are measured as the differences between the simulation results and the actual values of economic and price variables. In this paper, following basically the same approach, we again estimate the policy effects of monetary easing, focusing mainly on monetary easing measures since QQE in 2013.[1]

The main results of this paper are as follows. In the period from the introduction of QQE through the April-June quarter of 2023, the effect of unconventional monetary policy on the level of real GDP was around +1.3 to +1.8 percent on average, and on the year-on-year rate of change in the CPI (less fresh food and energy) was around +0.5 to +0.7 percentage points on average. Given the fact that the year-on-year rate of change in the CPI remained positive at less than 0.5 percent for much of the second half of the 2010s, the latter result suggests that prices would have continued to fall for a long time during this period if a series of unconventional monetary easing policy measures had not been

[1] The quantitative easing policy in the early 2000s is discussed in the Appendix.

implemented. The results also confirm that the unconventional policy measures made a solid contribution to supporting the economy even during the COVID-19 pandemic. Looking at the policy effects on real GDP by transmission channel, the real interest rates channel is seen to have contributed the most to the boost to real GDP, although there were contributions from a wide range of channels, including the stock prices channel. By expenditure component, the policy effect on private non-residential investment was large, but private consumption also contributed. Decomposing the policy effects on the CPI based on the Phillips curve equation, both the output gap and medium- to long-term inflation expectations made similar contributions.

One thing to note about this analysis is that the effects of unconventional monetary policy are not necessarily measured comprehensively. For example, the potential growth rate and variables related to fiscal policy are taken as given and do not affect the estimated results of the policy effects. Therefore, mechanisms such as the possible effects of unconventional monetary policy on the potential growth rate and the interaction between fiscal and monetary policy are not taken into account.[2] Nor does this analysis explicitly take into account side effects such as a decline in the profits of financial institutions and market functioning, or the accumulation of financial imbalances.[3] When assessing unconventional monetary policy, it is necessary to evaluate it from multiple perspectives using a variety of approaches.

As summarized comprehensively by Bernanke (2020), many academic economists and economists at central banks have conducted research on the effects of unconventional monetary policies. Such studies have employed a variety of methods, including analysis using high-frequency data from financial markets and time series analysis, and some economists at central banks have also conducted analyses using semi-structural models, as in this paper. For example, Engen et al. (2015), Kiley and Roberts (2017), Chung et al. (2019), and others have used the Fed's large macroeconomic model FRB/US to analyze the effects of unconventional monetary policies implemented by the Fed such as Forward Guidance and Quantitative Easing. At the Bank of Japan, as noted above, Kan et al. (2016) and Kawamoto et al. (2021) have also examined policy effects using Q-JEM. In this paper, we supplement these measures of policy effects, extending the above studies by

[2] For the impact of monetary policy on the potential growth rate, see Haba et al. (2024).

[3] For the impact of unconventional monetary policy on the financial system, see Bank of Japan Financial System and Bank Examination Department (2024) and Abe et al. (2024). For the impact of monetary policy on the functioning of the JGB and corporate bond markets, see also Fukuma et al. (2024) and Ochi and Osada (2024).

reconsidering the scenarios and further developing the model,[4] in addition to including the period after the outbreak of COVID-19.[5]

This paper is organized as follows. Section 2 reviews the policies and financial environment since the Bank introduced QQE in 2013, and explains the policy transmission channels assumed in Q-JEM. Section 3 provides details about the generation of the counterfactual paths for key financial and expectations variables on which the simulation is premised. Section 4 shows the results of the simulation. Section 5 concludes.

2. Unconventional Monetary Policy by the Bank of Japan and its Transmission Channels

In this section, we briefly review the major policy changes and developments in financial markets since 2013 that are the main focus of our analysis in this paper (Chart 1) and then explain the transmission channels of those policies to the economy and prices assumed in Q-JEM. Please also refer to Charts 3 through 6 for the paths followed by each variable during this period.

2-1. Unconventional Monetary Policy and Developments in Financial Markets since 2013

In April 2013, the Bank introduced QQE, which included large-scale asset purchases, mainly of long-term Japanese Government Bonds (JGBs). Since the introduction of this policy, medium- to long-term inflation expectations have risen and long-term interest rates have fallen rapidly. The policy was expanded in stages, in response to weak demand after the consumption tax hike in 2014, a sharp drop in oil prices, and the slowdown in emerging economies after 2016: the Bank expanded QQE in October 2014, and then introduced "QQE with Negative Interest Rates" in January 2016 followed by "Yield Curve Control (YCC)" and the "Inflation-Overshooting Commitment" in September 2016. As a result, over the longer term, nominal interest rates have remained at a low level, the yen has depreciated compared to before the introduction of QQE, and stock prices

[4] Q-JEM is constantly updated to reflect the most recent data and changes in the economic situation, and several different versions are used depending on the purpose of the analysis. The version of Q-JEM used in this paper is unique in that it incorporates a term structure of interest rates from 1 to 10 years in order to precisely capture the effects of the Bank's Japanese Government Bond purchases and other measures by maturity (details are provided later).

[5] Hirata et al. (2024) analyze the effects and side effects of unconventional monetary policy based on a time series model as part of the "Review of Monetary Policy from a Broad Perspective."

(TOPIX) have continued to trend upward. In 2020, in response to the outbreak of the COVID-19 pandemic, the Bank, together with the government, launched measures to support corporate financing and strengthened monetary easing (increased purchases of CP, corporate bonds, and ETFs). Following these measures, a temporary decline in stock prices was reversed and the lending attitudes DI remained accommodative.[6]

Since 2021, the yen has weakened due to factors such as the widening of the interest rate gap between Japan and the U.S. following high inflation in the U.S. and interest rate hikes. Stock prices rose as the economy recovered from the COVID-19 pandemic, and then continued to rise on the back of the weak yen despite swings due to the situation in Ukraine. During this period, the lending attitudes of financial institutions remained accommodative overall, supported by the recovery in economic activity. Medium- to long-term inflation expectations rose out of a declining phase during the COVID-19 pandemic, partly due to the effect of the higher CPI inflation triggered by rising import prices. Nominal long-term interest rates, after remaining near 0 percent, showed a slight upward trend following modifications of the conduct of YCC in December 2022 and July 2023. During this period, nominal short-term interest rates continued to remain at low levels.

In March 2024, the Bank concluded that it came in sight that the price stability target of 2 percent would be achieved in a sustainable and stable manner toward the end of the Outlook Report projection period, and so ended its unconventional monetary policy. To put it another way, the Bank decided to conduct monetary policy as appropriate, guiding the short-term interest rate as its primary policy tool, in response to developments in economic activity and prices as well as financial conditions.

2-2. Transmission Channels of Monetary Policy in Q-JEM

As mentioned above, the Bank has implemented various unconventional monetary policy measures since 2013. These measures are thought to have affected the economy and prices through financial variables such as nominal interest rates and exchange rates, as well as inflation expectations. In this subsection, we explain the transmission channels of monetary policy assumed in Q-JEM (Chart 2). Q-JEM contains the following four channels through which monetary policy affects the economy and prices.[7]

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[6] For detailed information on developments up until the outbreak of COVID-19, see Kan et al. (2016) and Kawamoto et al. (2021).

[7] See References 1 and 2 for the specification of the key Q-JEM equations used in this analysis.

First, unconventional monetary policy lowers real interest rates. Specifically, the JGB purchases and negative interest rate policy lower nominal interest rates. At the same time, unconventional monetary policy and strong commitments directly raise inflation expectations, further lowering real interest rates. These policy effects on real interest rates boost private non-residential investment and residential investment through lower financing costs and also boost private consumption through intertemporal substitution effects.

Second, the easing of the lending attitudes of financial institutions due to measures to stimulate bank lending improves the availability of loans to firms in the lending market, exerting a positive effect on private non-residential investment. Q-JEM captures changes in financial institutions' lending stance that cannot be explained by lending interest rates alone using the DI for lending attitudes in the Bank of Japan's Tankan survey.

Third, lower interest rates also stimulate the real economy through the depreciation of the yen. Specifically, lower interest rates generate downward pressure on the yen relative to foreign currencies due to the widening gap between domestic and foreign interest rates, leading to an increase in exports and improved corporate profits.

Fourth, the improvement in corporate profits due to lower interest rates and the weaker yen have a positive knock-on effect on stock prices. Increased stock prices in turn boost private non-residential investment through an increase in "Tobin's Q", stimulating private consumption through an increase in the value of household assets (the wealth effect).

In Q-JEM, consumer prices (less fresh food and energy) follow the concept of a hybrid Phillips curve and are a function of the output gap, lagged CPI inflation, and medium- to long-term inflation expectations. Direct increases in consumer prices, therefore, are effected mainly through (1) an improvement in the output gap due to the impacts of policy on the real economy, and (2) a rise in medium- to long-term inflation expectations. Medium- to long-term inflation expectations comprise two components: (i) forward-looking expectations formed with reference to the price stability target, and (ii) backward-looking expectations formed with reference to actual values of consumer prices. Thus, there is an additional mechanism in which (3) actual values of consumer prices rise in response to the policy effects, which raises medium- to long-term inflation expectations through backward-looking expectations formation, which in turn further raises consumer prices.

Note that the version of Q-JEM used in this simulation incorporates interest rates with a term structure of 1 to 10 years, capturing the policy effects in detail. Originally, Q-JEM had a simple interest rate term structure (Hirakata et al. (2019)). However, the effects of unconventional monetary policy may be not uniform at all points on the yield curve but may vary depending on the interest rate maturity. In addition, the impact of interest rate changes on the real economy may also differ depending on the maturity. Reflecting these points, this Q-JEM incorporates an interest rate term structure of 1 to 10 years along with necessary changes in the specifications of the interest rate transmission channels. Specifically, interest rates are aggregated by maturity into two rates: short- to medium-term interest rates (1-3 years) and medium- to long-term interest rates (4-10 years). A weighted average of the two is used as the explanatory variable for GDP components, etc., where the weights on the two interest rates are estimated to maximize explanatory power.[8]

3. Simulation Scenarios

In this section, we create "counterfactual paths" for key policy transmission variables (nominal interest rates, medium- to long-term inflation expectations, exchange rates, stock prices, and the DI for financial institutions' lending attitudes) under the hypothetical scenario that unconventional monetary policy was not implemented, as a premise for estimating the policy effects on the economy and prices through counterfactual simulation using Q-JEM in the next section.[9] In creating the paths, we use two methods for each variable as a means of checking the robustness of the policy effects measurement.

(Nominal Interest Rates)

The counterfactual paths for nominal interest rates are generated by directly extracting the policy effects through regression analysis using policy variables such as the Bank's share of JGB holdings. The estimation results are then used to create the counterfactual paths for nominal interest rates assuming that the policy was not implemented and the policy variables remained unchanged from the time immediately before the policy was introduced.

[8] As shown in References 1 and 2, private non-residential investment and residential investment are estimated to depend on both aggregated interest rates, while private consumption is estimated to depend only on short- to medium-term interest rates. We aggregate interest rates at each maturity into two in order to increase the stability of the estimation. In addition, medium- to long-term forward rates are used for medium- to long-term interest rates to avoid duplication of information between the two interest rates.

[9] Many methods employed in this analysis are based on the approach used in the 2016 "Comprehensive Assessment" (Kan et al. (2016)) and the 2021 "Assessment for Further Effective and Sustainable Monetary Easing" (Kawamoto et al. (2021)) with some modifications.

Method 1 basically follows the estimation approach of Kawamoto et al. (2021). Specifically, a nominal interest rate function is estimated for each maturity from 1 to 10 years, using policy variables such as the Bank's share of the JGB holdings for the corresponding maturity[10] and the call rate, and control variables such as the U.S. nominal interest rate as explanatory variables. Here, we assume that purchases of JGBs of a certain maturity only affect the price of JGBs of that maturity.[11] The following shows the estimation results for the 10-year interest rate as an example, where the Bank's 10-year JGB holdings ratio and the call rate are statistically significant.

Nominal long-term interest rate (10-year) (1)

$$
\begin{aligned}
&= \underset{[0.10]}{0.23} + \underset{[0.11]}{0.17} \times \text{Expected real GDP growth rate} \\
&\quad + \underset{[0.03]}{0.21} \times \text{U.S. Treasury bond yields} \\
&\quad - \underset{[0.001]}{0.01} \times \text{The Bank's share of JGB holdings} \\
&\quad + \underset{[0.15]}{0.69} \times \text{Call rate}
\end{aligned}
$$

The values in the brackets are the Newey-West adjusted standard errors of coefficients.

Estimation period: From Jun. 2001 to Jun. 2023

Adjusted R^2: 0.93, Standard error of regression: 0.16

The expected real GDP growth rate is from Consensus Forecast (forecast for 6 to 10 years ahead), the U.S. Treasury interest rate is the 10-year rate, and the Bank's share of JGBs is the share of bonds with remaining maturities of more than 9 years and less than 10 years.

[10] The Bank's share of JGBs by maturity was calculated by obtaining data on (1) outstanding JGB balances by maturity (outstanding JGBs by maturity that have not been redeemed or retired) and (2) the amount of JGBs held by the Bank by maturity. For (1), information on the remaining issues at each point in time was obtained from the auction information by issue (auction results and liquidity provision auction results) on the Ministry of Finance's website. Information on buy-backs was also obtained in the same way (information deleted from the Ministry of Finance's website was obtained from the archives of the National Diet Library's website). For (2), we obtained information on issues and the amounts of each held by the Bank at each point in time from the list of short-term JGB holdings and the list of JGB holdings on the Bank's website. The maturity information for each issue included in the issue information obtained in (1) was linked to the issues held by the Bank, and the remaining maturity of the issues held by the Bank at each point in time was calculated. The remaining amount of JGBs and the amount held by the Bank at each point in time were then tabulated by remaining maturity.

[11] For example, D'Amico and King (2013) estimate the "local-supply" effect, which means that the purchase of a certain government bond affects local prices, such as the prices of that government bond and government bonds with similar maturities. Our method can be interpreted as extracting changes in government bond prices due to this mechanism.

Using the estimation results, we calculated the nominal interest rate assuming that the Bank's share of JGB holdings and the call rate remained unchanged from the January-March quarter of 2013, and used this as the counterfactual path for nominal interest rates.

Chart 3 (1) shows the actual value and the counterfactual paths of the nominal interest rate (simple average of interest rates from 1 to 10 years); the differences (bars) between the actual value and counterfactual values estimated under Method 1 and 2 (detailed below), respectively, correspond to the policy effects. The path of the interest rate under Method 1 shows the policy effects gradually strengthening from the April-June quarter of 2013 until reaching around -0.5 percentage points and then remaining around this level thereafter. Chart 3 (2) shows the average policy effects on interest rates at each maturity, indicating how unconventional monetary policy has pushed down the entire yield curve. Looking more closely, the effect on longer-term interest rates is seen to be larger, with an average effect of just under -0.3 percentage points on the 1-year interest rate and around -0.6 percentage points on the 10-year interest rate.

Method 2 is based on estimation of the long-term interest rate function of Bank of Japan (2024).[12] The approach is basically the same as Method 1 but is extended in several respects to capture the policy effects more broadly than in Method 1. Specifically, for each maturity from 1 to 10 years, the nominal interest rate function is estimated using policy variables such as the forecast of the Bank's share of JGB holdings (on a risk-adjusted basis), the probability of exceeding the upper bound of the YCC range and the offer rate of fixed-rate purchase operations for consecutive days (YCC effect), and the call rate, as well as control variables such as the nominal interest rate in the U.S., as explanatory variables. We use the risk-adjusted share of JGB holdings, as in Kawamoto et al. (2021), assuming that the Bank's JGB holdings at each maturity can affect the entire yield curve, and we also include forecasts of the Bank's share of JGB holdings in future. In addition, we take into account the effect of YCC in pushing down the yield curve. Using these estimation results, we generate another counterfactual path for nominal interest rates in the absence of policy under the assumptions that the expected future share of JGB holdings and the call rate remain unchanged from the January-March quarter of 2013 and that the probability of the targeted long-term yield exceeding the upper bound of the YCC or the level of the offer rate of fixed-rate purchase operations is zero.

[12] Here, we use the average of the scenarios created using the estimation results of Model 1 and Model 2 in BOX 6, Chart B6-4 of Bank of Japan (2024). For the details of the analysis, see Nakazawa and Osada (2024).

Looking at the path of the interest rate in Method 2 in Chart 3 (1), the policy effects are seen to be around -0.6 percentage points on average since the policy was introduced in the April-June quarter of 2013. Compared to Method 1, the policy effects are estimated to be larger; furthermore, because the method incorporates the forecast of the Bank's future share of JGB holdings, it shows policy effects manifesting from the moment of the policy's introduction. Looking at the average policy effects on interest rates for each maturity in Chart 3 (2), as in Method 1, unconventional monetary policy can be seen to have pushed down the entire yield curve, with policy effects greater on longer-term interest rates than on shorter-term rates.

(Medium- to Long-term Inflation Expectations)

For medium- to long-term inflation expectations, we employ two methods: (1) a method that uses the value of medium- to long-term inflation expectations immediately before the introduction of the policy, and (2) a method that directly extracts the policy effects under certain assumptions through regression analysis. Note that there are various inflation expectations indicators for various economic entities, each with its own characteristics and biases. In this paper, as our indicator of medium- to long-term inflation expectations, we use the 10-year-ahead inflation expectations from the "Composite Index of Inflation Expectations by Forecast Horizon" by Osada and Nakazawa (2024), which aggregates information on inflation expectations of various economic entities using statistical methods.

In Method 1, following Kan et al. (2016) and Kawamoto et al. (2021), we create a path using the value of medium- to long-term inflation expectations in the October-December quarter of 2012, just before January 2013 when the 2 percent "price stability target" was introduced. In other words, we assume that in the absence of policies since the introduction of QQE, medium- to long-term inflation expectations would have remained unchanged at its level immediately prior to the introduction of the price stability target (Method 1 in Chart 4).

It is noteworthy that, in Method 1, the differences between the counterfactual path of medium- to long-term inflation expectations, which are assumed to be unchanged, and its actual values, i.e., all fluctuations in medium- to long-term inflation expectations during this period, are assumed to arise from policy effects. However, while the rise in medium- to long-term inflation expectations seen in recent years, for example, is likely to have been influenced at least to some extent by soaring commodity prices, this method takes no account of influences other than policy effects that may be included in these fluctuations in inflation expectations. For this reason, in Method 2, we seek to exclude factors that affect medium- to long-term inflation expectations other than policy effects through regression analysis. In addition, in Method 1, the rise in medium- to long-term inflation expectations from the introduction of the 2 percent price stability target in January 2013 to the introduction of QQE in April 2013 is also considered to be an effect of unconventional monetary policy. However, it is not obvious that the effect of the introduction of the price stability target itself should be included among the policy effects of introducing QQE. Therefore, in Method 2, the increase in medium- to long-term inflation expectations during this period is not included among the policy effects.[13]

First, using data prior to the introduction of QQE, we perform a linear regression of the medium- to long-term inflation expectations function with trend inflation and the commodity price gap.[14, 15] The reason we use data prior to the introduction of QQE in the estimation is to eliminate as much of the effects of the unconventional monetary policy implemented after the introduction of QQE as possible from the estimated values in creating a counterfactual path in the absence of the policy. The estimation results are as follows and have high explanatory power.

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[13] Specifically, we use the change in medium- to long-term inflation expectations from the date of the introduction of the 2 percent "price stability target" (January 22, 2013) to the date of Governor Kuroda's policy speech at the Diet (March 4, 2013) as the increase in medium- to long-term inflation expectations due to the introduction of the price stability target. We use the change up to the policy speech because the policy speech strongly indicated the implementation of additional monetary easing measures, and we think that the effects of the new monetary easing measures will be incorporated into the medium- to long-term inflation expectations after that date. Note that the medium- to long-term inflation expectations used in this analysis are quarterly indicators. Therefore, the change in the break-even inflation rate (BEI, 10 years), which is available on a daily basis, is used to capture the effect of the introduction of the price stability target during the relevant period. Since the variance of the BEI is different from that of the medium- to long-term inflation expectations used in this analysis, we adjusted the change in the BEI to correspond to the change in the medium- to long-term inflation expectations used in this analysis by using the ratio of the standard deviations of the two indicators.

[14] The trend inflation rate in this paper is a variable that captures the long-term trend of past inflation. Specifically, it is defined as a variable that is updated to reflect the most recent value of the CPI (less fresh food and energy, the seasonally-adjusted quarter-on-quarter rate of change) by 5 percent each quarter. The commodity price gap is defined as the deviation of the commodity price index from its trend (a weighted index of various commodity price data such as energy including crude oil, agricultural and livestock products, and nonferrous metals <GSCI Commodity Index>). The commodity price trend was calculated using the same method as for the trend inflation rate.

[15] The formation mechanism of inflation expectations has not been clearly understood even in academia, and is particularly uncertain in Japan (analyzed in Fukunaga et al. (2025) and others). Here, as a simple specification for the period when the Bank did not explicitly adopt the inflation targeting policy, we assume that medium- to long-term inflation expectations depend only on the trend inflation rate and commodity prices.

Medium- to long-term inflation expectations (2)

$$= \underset{[0.06]}{0.35} + \underset{[0.02]}{0.41} \times \text{Trend inflation rate}$$
$$+ \underset{[0.06]}{0.45} \times \text{Commodity price gap}$$

The values in the brackets are the standard errors of coefficients.
Estimation period: From Oct.-Dec. 1991 to Oct.-Dec. 2012
Adjusted R^2 : 0.80, Standard error of regression: 0.13

Using these estimation results, we create a counterfactual path for medium- to long-term inflation expectations by substituting the actual values of the trend inflation rate and the commodity price gap after the end of the estimation period into the regression equation. It should be noted that the actual values of the trend inflation rate since the end of the estimation period could include policy effects. In light of this, we calculate a counterfactual path that excludes policy effects using the following estimation. First, we calculate a provisional measure of medium- to long-term inflation expectations by extrapolating the actual values of the trend inflation rate and the commodity price gap. Next, we employ Q-JEM to repeat the simulation using these extrapolated figures for provisional medium- to long-term inflation expectations, which enables us to calculate a trend inflation rate that excludes policy effects since the end of the estimation period. We then substitute this into equation (2) to create the final counterfactual path for medium- to long-term inflation expectations. The differences between the values along this counterfactual path and the actual values are counted as direct effects of policy.

Furthermore, the aforementioned decline in nominal interest rates due to unconventional monetary policy indirectly boosts medium- to long-term inflation expectations--an effect that is also accounted as a policy effect on medium- to long-term inflation expectations. A decline in nominal interest rates improves the output gap and raises consumer prices, thereby pushing up the trend inflation rate and, thus, medium- to long-term inflation expectations. We refer to these effects as indirect effects to distinguish them from the direct effects of the policy.[16] Here, by conducting a Q-JEM simulation using the abovementioned policy effects on nominal interest rates, we estimate the indirect effects on medium- to long-term inflation expectations. The counterfactual path

[16] In the following sections also, we will refer to the effects of a change in the relevant variable due to spillover effects of the policy on other financial and economic variables as indirect effects.

of medium- to long-term inflation expectations used in Method 2 is thus the actual value minus both the direct and indirect effects described above (Method 2 in Chart 4).[17]

Looking at the counterfactual paths for medium- to long-term inflation expectations, both Method 1 and Method 2 produce values well below the actual values immediately after the introduction of QQE, suggesting that the policy had a significant effect. After that, the policy effects seen using both methods diminish but continue up until the outbreak of COVID-19. While the policy effects estimated by Method 1 expand significantly after 2021, possibly due to the impact of rising consumer prices caused by the surge in commodity prices, this impact is muted in Method 2, where a certain degree of policy effect is maintained from the outbreak of COVID-19 up to the present. Note that in Method 2, the increase in medium- to long-term inflation expectations due to the recent rise in consumer prices is not counted among policy effects; shocks such as the surge in commodity prices are not considered to be the effects of policy, so their impact has been removed appropriately.[18]

(DI for Financial Institutions' Lending Attitudes)

To estimate the counterfactual path for the lending attitudes DI, we adopted a simple regression analysis approach based on Kawamoto et al. (2021). First, using data up until the introduction of QQE, we estimate a regression equation with the DI for financial institutions' lending attitudes in the Bank of Japan's Tankan survey as the dependent variable and the DI for business conditions (all industries and all enterprises) in the Tankan as the explanatory variable. The estimation results are as follows.

$$\text{Lending attitudes DI} = \underset{[0.71]}{11.70} + \underset{[0.03]}{0.56} \times \text{Business conditions DI} \qquad (3)$$

The values in the brackets are the standard errors of coefficients.
Estimation period: From Jan.-Mar. 1997 to Jan.-Mar. 2013
Adjusted R^2 : 0.84, Standard error of regression: 4.05

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17 In Method 2 depicted in Chart 4, the counterfactual path calculated for nominal interest rates when measuring indirect effects utilizes the method 2 approach, which takes into account the effects of YCC and other factors.

18 As noted above, GDP components are formulated so that the short- to medium-term, and medium- to long-term real interest rates have an effect; as a result, the calculation of real interest rates by maturity requires inflation expectations by maturity. Inflation expectations by maturity are formulated as the weighted average of medium- to long-term inflation expectations (assumed to be the 10-year ahead inflation expectations) and the actual inflation rate (the former has a larger weight for longer maturities).

As shown by Kawamoto et al. (2021), the lending attitudes DI is to a considerable extent explained by the business conditions DI, which is a measure of corporate business confidence. Based on this estimation result, we calculate a counterfactual path for the lending attitudes DI by substituting the business conditions DI since the introduction of QQE into the regression equation (extrapolation estimation); the difference between this and the actual value (i.e., the portion that cannot be explained by corporate performance) is then taken to be the direct policy effect. The downward deviation in the extrapolated lending attitudes DI after QQE shows an increase after the July-September quarter of 2014, suggesting that monetary easing has contributed to a more accommodative lending market. In this paper, we use this extrapolated estimate from the July-September quarter of 2014 onward as the counterfactual path of the lending attitudes DI.

Furthermore, in addition to the direct effects described above, we also take into account the indirect effects of the decline in real interest rates, which indirectly raises the lending attitudes DI by improving the economic situation. To capture this, we estimated the change in the lending attitudes DI by conducting a Q-JEM simulation using the policy effects from nominal interest rates and medium- to long-term inflation expectations mentioned above. The counterfactual path of the lending attitudes DI in the absence of the direct and indirect policy effects is thus the extrapolated estimate from the July-September quarter of 2014 onwards obtained from equation (3), minus the indirect effects arising from the decline in real interest rates (Method 1 in Chart 5).[19]

However, since the April-June quarter of 2020, the counterfactual path produced via Method 1 has diverged significantly from the actual DI values, indicating very strong policy effects. In addition to the impact of the Bank's "Enhancement of Monetary Easing in Light of the Impact of the Outbreak of the Novel Coronavirus (COVID-19)" initiated in March 2020, this may well include the effects of the government's measures launched in March 2020, such as the provision of effectively "interest-free and unsecured" loans to support SMEs in continuing their businesses. Therefore, we create another counterfactual path on the assumption that the Bank's policy had no additional direct effect on the lending market after the January-March quarter of 2020 (Method 2 in Chart 5).[20] The policy effects produced in Method 2 do not show the same rapid expansion as in Method 1, and

[19] In Chart 5, the counterfactual paths for real interest rates used to measure indirect effects utilize Method 2 for nominal interest rates, taking into account the effects of YCC, etc., and Method 2 for medium- to long-term inflation expectations, excluding the effects of commodity prices, etc.

[20] Specifically, the direct policy effect on the lending markets after the January-March quarter of 2020 is capped at the direct effect in the October-December quarter of 2019.

the chart considerably understates the effects of the Bank's policies in response to the COVID-19 pandemic.

(Exchange Rates)

Following Kawamoto et al. (2021), we create counterfactual exchange rates paths using two methods: (1) a regression analysis and (2) an event study. Using a regression analysis enables us to directly estimate the policy effects or eliminate factors other than the policy effects, but the results are sensitive to the specification of the regression equation. Not only is there no consensus on the specification of exchange rates and stock prices, but there is a risk in terms of robustness in estimating policy effects that depend on a certain specification. By contrast, an event study has the advantage of avoiding the specification problem, but it may include fluctuations other than the policy effects or may not fully capture the policy effects. Given the uncertainties associated with each method, we choose to employ both methods for the sake or robustness.

The regression analysis method uses the long-run equilibrium equation for the U.S. dollar/yen exchange rate in Q-JEM as follows. The long-run equilibrium equation is formulated as being explained by the difference between the nominal long-term interest rates in Japan and the U.S., as well as the difference between the CPI inflation rates in Japan and the U.S., taking into account relative purchasing power parity.

$$\begin{aligned} &\log(\text{Nominal U.S. dollar/yen exchange rate}) \qquad (4) \\ &= \underset{[0.05]}{4.79} + \underset{[0.02]}{0.13} \times (\text{U.S. nominal interest rate} - \text{Japan's nominal interest rate}) \\ &\quad - \underset{[0.01]}{0.13} \times (\text{U.S. CPI inflation rate} - \text{Japan's CPI inflation rate}) \end{aligned}$$

The values in the brackets are the standard errors of coefficients.
Estimation period: From Jan.-Mar. 1974 to Apr.-Jun. 2023
Adjusted R^2 : 0.32, Standard error of regression: 0.30
Consumer price inflation rates in Japan and the U.S. are annualized quarter-on-quarter rates averaged over the past four years.

The counterfactual path for the exchange rate is created by using this equation to calculate the impact on the exchange rate of the difference between the actual nominal long-term interest rate in Japan and the counterfactual rate described above. Here, we assume that U.S. long-term interest rates are not affected by the Bank of Japan's monetary policy. Looking at the estimated path of the yen-dollar rate, it appears that QQE has had the effect of weakening the yen by around 10-20 yen per dollar (Method 1 in Chart 6 (1)).[21]

The other method uses an event study approach to measure the policy effects of five major policy changes since the introduction of QQE. The five events are (1) the introduction of QQE (April 2013), (2) the expansion of QQE (October 2014), (3) the introduction of the negative interest rate policy (January 2016), (4) the introduction of YCC (September 2016), and (5) the enhancement of monetary easing in light of the impact of the outbreak of the Novel Coronavirus (March 2020). In the absence of policy changes, we assume that the exchange rate would have remained unchanged at the value on the business day before each event until the end of the following quarter, and the actual fluctuation during this period is assumed to be the policy shock. In subsequent periods, we assume that policy shocks will spill over endogenously in line with the specifications governing the behavior of each variable in Q-JEM. We also assume that the shocks accompanying policy changes are additive: when a policy change occurs, its impact is added to that of the previous policy shock. The path of yen-dollar rate calculated using the event study shows the yen weakening by around 10 yen per dollar due to the policy effects (Method 2 in Chart 6 (1)).

(Stock Prices)

As with exchange rates, we utilize two methods to create counterfactual paths for stock prices: regression analysis and an event study.

In the method using regression analysis, we create a counterfactual path using the following long-run equilibrium equation for stock prices (TOPIX) in Q-JEM. In Q-JEM, TOPIX is formulated as an error correction model consisting of a long run equilibrium equation and a short-run dynamic equation. The long-run equilibrium is captured by the following.

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[21] In Method 1 of Chart 6 (1), we used Method 2 to produce the counterfactual path for the nominal long-term interest rate.

$$\log(\text{TOPIX/Firms' profits}) = \underset{[0.03]}{-8.70} + \underset{[0.27]}{1.04} \times \text{Oct.-Dec. 2008 dummy} + \underset{[0.27]}{1.22} \times \text{Jan.-Mar. 2009 dummy} \quad (5)$$

The values in the brackets are the standard errors of coefficients.
Estimation period: From Jan.-Mar. 2000 to Apr.-Jun. 2023
Adjusted R^2 : 0.13, Standard error of regression: 0.28

This long-run equilibrium equation assumes that the macro-level PER (price to earnings ratio) will converge to a certain level over the long run. The short-run dynamic equation is then expressed as follows.

$$\text{dlog(TOPIX)} = \underset{[0.007]}{-0.0005} - \underset{[0.02]}{0.10} \times \log(\text{Error correction term}) + \underset{[0.03]}{0.24} \times \text{dlog(Firms' profits)} \quad (6)$$

The values in the brackets are the standard errors of coefficients.
"dlog" stands for log-difference.
Estimation period: From Apr.-Jun. 2000 to Apr.-Jun. 2023
Adjusted R^2 : 0.43, Standard error of regression: 0.06

The short-run dynamics are explained by the movement of stock prices to converge towards the long-run equilibrium level (the error correction term, which is the rate of deviation between the long-run equilibrium value and the actual value one period ago) and the rate of change in earnings. Using the above equations to describe the evolution of stock prices, we run a Q-JEM simulation by exogenously fixing the counterfactual paths of real interest rates, the DI for lending attitudes, and exchange rates; the endogenous value of TOPIX obtained is then used as the counterfactual path for stock prices. Looking at the counterfactual path derived for stock prices following this method, we can confirm that stock prices have remained below their actual values since the introduction of QQE; they have been pushed up by about 400 points on average due to the effects of policy during this period (Method 1 in Chart 6 (2)).[22]

[22] In Chart 6 (2), we used Method 2 to produce the counterfactual paths of nominal interest rates and medium- to long-term inflation expectations, and Method 1 for the DI for lending attitudes and exchange rates.

Turning to Method 2, the counterfactual path based on the event study extracts policy shocks for the five major policy changes since the introduction of QQE, using the same methodology as for the exchange rates. Looking at the counterfactual path of stock prices calculated using the event study, these can be seen to have tracked slightly higher than under the regression analysis; had QQE not been implemented, stock prices would have been about 360 points lower on average during the period (Method 2 in Chart 6 (2)).

4. Simulation Results

In this section, we conduct simulations of hypothetical real GDP and consumer prices assuming that the various policies were not implemented, by exogenously feeding the counterfactual paths for each variable explained in the previous section into Q-JEM. In the previous section, we generated two counterfactual paths for each of the five variables: nominal interest rates, medium- to long-term inflation expectations, the DI for lending attitudes, exchange rates, and stock prices, as summarized in the table below. In this section, we conduct simulations for each combination (16 combinations in all[23]). The simulation period is approximately 10 years, from the April-June quarter of 2013, when QQE was introduced, to the April-June quarter of 2023.

[23] Fixing the same combination of methods for exchange rates and stock prices, a total of 16 (= 2^4) different simulations were conducted.

	Method 1	Method 2
Nominal Interest Rates	Estimation using the Bank's actual JGB holding ratio etc. as policy variables	Estimation using the Bank's JGB holding ratio forecast etc. as policy variables
Medium- to Long-Term Inflation Expectations	Constant from the level just before the introduction of "the price stability target" of 2 percent	Estimation of both the direct effects on inflation expectations and indirect effects through economic stimulation due to lower nominal interest rates
Lending Attitudes DI	Estimation of both the direct effects on the lending attitudes DI and indirect effects through economic stimulation due to lower real interest rates	Same as left (excluding the effects of government funding support measures etc. during the COVID-19 pandemic)
U.S. Dollar /Yen Rate, Stock Prices (TOPIX)	Estimation of the effects of lower real interest rates and the improvement of loan availability in lending market	Changes in the exchange rate and stock prices around the time of monetary policy events are measured as policy shocks (event study approach)

Chart 7 shows the simulation results for real GDP and the CPI (less fresh food and energy). The solid line shows the actual values and the shaded area shows the range of the results of the 16 different simulations. Here, the differences between the actual values and the simulation results are interpreted as the policy effects of monetary easing. Looking at the average over the period from the April-June quarter of 2013 to the April-June quarter of 2023, policy effects of the unconventional monetary policy measures on the level of real GDP have been around +1.3 to +1.8 percent,[24] while the effect on the year-on-year rate of change in consumer prices has been around +0.5 to +0.7 percentage points. Looking more closely, policy effects since the introduction of QQE can be seen to have cumulatively boosted the level of real GDP and to have supported the economy even after the outbreak of COVID-19 in 2020. As for the CPI, the year-on-year rate of change has been continuously boosted, suggesting that in the period since 2016 when the actual rate declined due to the slowdown in emerging economies and the appreciation of the yen,

[24] The effect on the year-on-year rate of change in real GDP was around +0.2 to +0.3 percentage points on average for the period from the April-June quarter of 2013 to the April-June quarter of 2023.

the inflation rate may have remained in negative territory if unconventional monetary policy had not been implemented.

Chart 8 shows the decomposition of the policy effects.[25] The decomposition of policy effects on real GDP is shown in (1), where the left-hand chart decomposes the effects by transmission channel and the right-hand chart by expenditure component. Among transmission channels, the contribution of the real interest rates channel is conspicuous, although a wide range of other channels, such as stock prices, exchange rates, and lending attitudes, were also active in the policy boost to GDP. Turning to expenditure components, the largest contribution can be seen to come from private non-residential investment, with private consumption playing a certain role. The chart in (2) shows the decomposition of policy effects on the year-on-year rate of change in the CPI (less fresh food and energy) based on the Phillips curve equation. The largest effect comes from the improvement in the output gap, derived mainly through the real interest rate channel, but the positive policy effect on medium- to long-term inflation expectations also makes a considerable contribution. In other words, the results suggest that unconventional monetary policy was working to boost the economy and prices by lowering the financing costs of households and firms and raising medium- to long-term inflation expectations.

The above results are generally consistent with the results of previous analyses, such as Kan et al. (2016) and Kawamoto et al. (2021). The policy effects measured in this analysis are generally within the range of the policy effects measured in Kan et al. (2016) for both the level of real GDP and consumer prices (our results are located within the lower end of their range).[26] Our findings on the extent of policy effects are broadly similar to those of Kawamoto et al. (2021).[27] The latter authors also decompose the

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[25] As mentioned in the previous section, the contribution of the lending attitudes channel after the outbreak of COVID-19 varies depending on whether the policy effect of this channel is attributed to unconventional monetary policy or not. We, therefore, decompose the policy effects before the outbreak of COVID-19. For the other channels, we used Method 2 for nominal interest rates, which takes into account the effects of YCC and other factors, Method 1 for inflation expectations, which assumes that the inflation expectations remain unchanged at their level after the October-December quarter of 2012, and Method 1 for exchange rates and stock prices, which uses regression analysis as the counterfactual paths.

[26] In Kan et al. (2016), the policy effects on the level of real GDP are +0.4 to +3.2 percent for FY2014 and +0.6 to +4.2 percent for FY2015, while in this analysis they are around +0.3 to +0.6 percent and around +0.7 to +1.2 percent, respectively. In addition, the policy effects in Kan et al. (2016) on the year-on-year rate of change in the CPI (less fresh food and energy) are +0.2 to +0.9 percentage points in FY2014 and +0.3 to +1.5 percentage points in FY2015, while in this analysis they are around +0.3 percentage points and around +0.4 to +0.6 percentage points, respectively.

[27] In Kawamoto et al. (2021), the policy effects on the level of real GDP are around +0.9 to +1.3 percent on average for the period from the introduction of QQE to the July-September quarter of 2020,

contribution of policy effects, finding that the largest contribution to real GDP is through a decline in real interest rates, while the largest contribution by expenditure component comes through private non-residential investment; these findings are qualitatively the same as ours. As in our analysis, they also report that both medium- to long-term inflation expectations and the output gap are important channels mediating the effects of policy on consumer prices.

5. Summary

In this paper, we use Q-JEM, a macroeconomic model owned by the Research and Statistics Department of the Bank of Japan, to measure the policy effects of unconventional monetary policy since the introduction of QQE on the economy and prices. First, we use several methods to estimate the policy effects of unconventional monetary policy on nominal interest rates, medium- to long-term inflation expectations, exchange rates, stock prices, and lending attitudes, by creating "counterfactual paths" for these variables under the hypothetical scenario that the QQE policies were not implemented. Next, we utilize Q-JEM to extrapolate these results and, through counterfactual simulations, to produce measures of what real GDP and consumer prices would have been under the hypothetical scenario. Finally, we compare the simulation results with the actual values of real GDP and consumer prices to estimate the policy effects on real GDP and consumer prices. According to our estimation, the unconventional monetary policy implemented by the Bank since the introduction of QQE have pushed up the level of real GDP by around +1.3 to +1.8 percent and the year-on-year change in the CPI (less fresh food and energy) by around +0.5 to +0.7 percentage points, on average, over the period from the introduction of QQE to the April-June quarter of 2023. The results also show that monetary easing has boosted real GDP, predominantly private non-residential investment, with the policy being transmitted mainly through the real interest rates channel, but also through various other transmission channels, including stock prices and exchange rates. The results also show that the policies have continuously boosted consumer prices through an improvement in the output gap and an increase in medium- to long-term inflation expectations.

However, there are a few points to keep in mind regarding the results of this paper.

while in this analysis they are around +1.1 to +1.4 percent. In addition, the policy effects in Kawamoto et al. (2021) on the year-on-year rate of change in the CPI (less fresh food and energy) are around +0.6 to +0.7 percentage points, while in this analysis they are around +0.5 to +0.6 percentage points.

First, our quantitative results should not necessarily be interpreted literally. It should be borne in mind that some of the measured policy effects may include, for example, the effects of government measures or policy changes by other central banks. There are also issues such as the (mis)specification of the macroeconomic model itself and estimation errors. A further point relates to what the model does not explicitly take into account, including the side effects of unconventional monetary policy. For example, the potential growth rate and fiscal policy are taken as given and do not affect the policy effects measured in this analysis. The analysis thus ignores the possible effects of unconventional monetary policy on the potential growth rate and the interaction between fiscal and monetary policy. In addition, side effects such as the impact of unconventional monetary policy on financial institutions' profits, adverse effects on the economy due to the deterioration of market functioning, and the increased risks due to the accumulation of financial imbalances should also be considered. In evaluating unconventional monetary policy, it is necessary to assess them from various aspects using multiple approaches, taking into account the limitations and scope of each approach.

Appendix: Policy Effects of Quantitative Easing in the 2000s

In this section, we will briefly introduce the results of analysis using Q-JEM on the macroeconomic effects of the Quantitative Easing (QE) policy implemented between 2001 and 2006. After the collapse of the bubble in the early 1990s, the Japanese economy entered a prolonged period of stagnation. Excessive debt in the corporate sector and the resulting non-performing loans in the banking sector have often been pointed to as forming the backdrop of the downturn. During this period, the year-on-year rate of change in the CPI continued to decline gradually and had been negative since 1998. Against this macroeconomic backdrop, the Bank of Japan introduced the so-called zero interest rate policy in 1999. Although the policy was lifted once in mid-2000, QE was introduced in 2001 in response to the collapse of the global IT bubble, and the policy remained in place until March 2006.

Much previous research has concluded that QE had only a limited effect in boosting the real economy and consumer prices. Ugai (2007) provides a comprehensive survey of empirical studies of QE conducted since 2001. According to this survey, while QE had some effect stabilizing financial markets, its direct impact on aggregate demand and prices was limited.

Here, we basically follow the methodology for evaluating QQE in this paper to measure the effects of QE. Specifically, we create counterfactual paths for nominal interest rates, the DI for lending attitudes, stock prices, and exchange rates from March 2001 to March 2006 under the hypothetical scenario that QE was not implemented.[28] We use Q-JEM to extrapolate these and conduct counterfactual simulations to estimate the impact of the policy on the macroeconomy by looking at the differences between these counterfactual values and actual real GDP and consumer prices. The results show that in the January-March quarter of 2006, when QE ended, the policy had boosted the level of real GDP by about +0.5 percent and the year-on-year rate of change in the CPI (less fresh food and energy) by about +0.1 percentage point.

As noted above, the methodology used in this paper shows that QE lowered interest

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[28] For nominal interest rate, we use the macro-finance methodology by Oda and Ueda (2007) to measure the commitment effect of QE on interest rates by maturity, and obtained results that were generally similar to those of previous studies. For the DI of lending attitudes, we regressed the DI on the TOPIX banking industry to directly capture factors of the banking sector, and created a scenario by placing a counterfactual path for the TOPIX banking industry. The counterfactual path was assumed to be slightly higher than the actual path. For stock prices and exchange rates, counterfactual paths were created using the same method as in Method 1 of this paper (a method using regression analysis), but the results showed that the policy effect was limited.

rates and had a certain impact in boosting the real economy and consumer prices. However, in order to evaluate QE, it is necessary to consider factors that are not incorporated in Q-JEM. For example, the effect of QE in supporting the financial system as a whole is not captured in the analysis. In this regard, Baba et al. (2005) find that QE prevented the recurrence of a liquidity crisis like that in 1997-98. If our hypothetical scenario envisaged the occurrence of a liquidity crisis in the absence of QE, then the policy effects on the real economy would be considerably greater than those estimated here. Similarly, Shioji (2019) also shows, using individual bank data, that the increase in reserves due to QE had the effect of increasing bank lending. The assessments in this paper are estimates based on certain assumptions, and such considerations should be taken into account in order to comprehensively evaluate QE.

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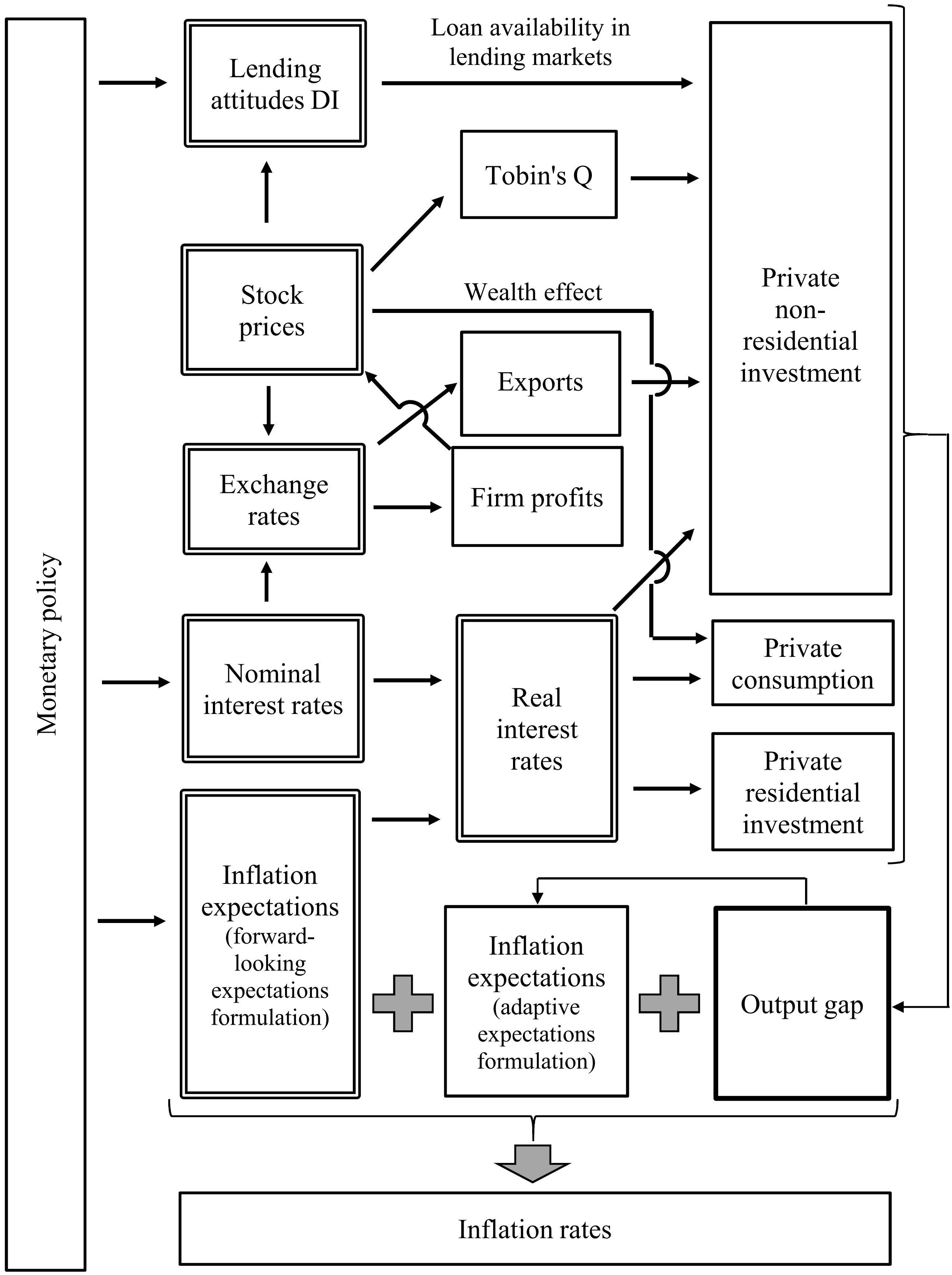
Overview of Major Monetary Policy Actions since the Introduction of QQE

Release date	Summary of monetary policy actions
Apr. 4, 2013 (I)	**Introduction of QQE** Monetary base: Annual increase of about 60-70 tril. yen JGBs: Annual increase of about 50 tril. yen ETFs: Annual increase of about 1 tril. yen
Oct. 31, 2014 (II)	**Expansion of QQE** Monetary base: Accelerating the annual pace of increase to about 80 tril. yen (about 10-20 tril. yen additional) JGBs: Increasing the amount outstanding at an annual pace of about 80 tril. yen (about 30 tril. yen additional) ETFs: Increasing the amount outstanding at an annual pace of about 3 tril. yen (tripled)
Jan. 29, 2016 (III)	**Introduction of QQE with a Negative Interest Rate** Applying a negative interest rate of minus 0.1 percent to the Policy-Rate Balance
Sep. 21, 2016 (IV)	**Introduction of QQE with Yield Curve Control** Introducing yield curve control and inflation-overshooting commitment
Mar. 16, 2020 (V)	**Enhancement of Monetary Easing in Light of the Impact of the Outbreak of the Novel Coronavirus (COVID-19)** CP and Corporate Bonds: Increasing the upper limit of purchases by 1 tril. yen for each asset ETFs: Increasing the amount outstanding at an annual pace with the upper limit of 12 tril. yen
Mar. 19, 2024	**Changes in the Monetary Policy Framework** Policy rate: Encouraging the uncollateralized overnight call rate to remain at around 0 to 0.1 percent ETFs: Discontinuing new purchases CP and Corporate Bonds: Reducing gradually the amount of purchases and discontinuing the purchases in about one year

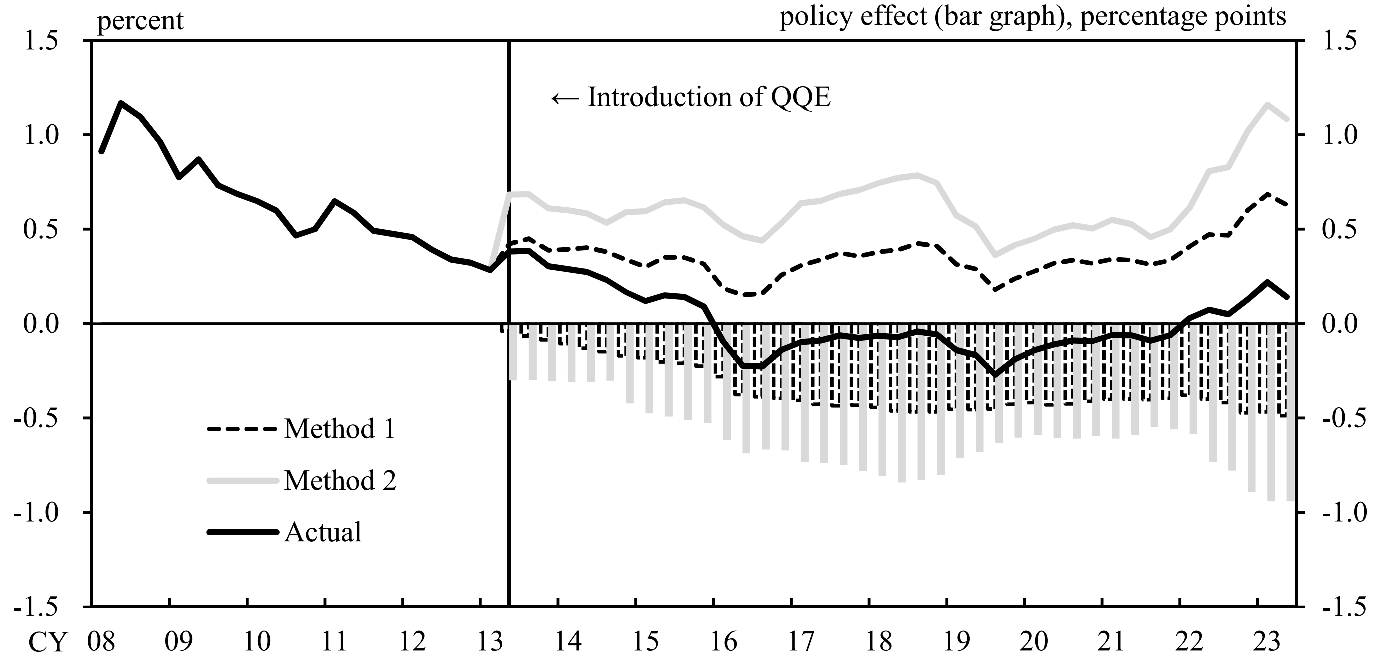
Note: Index (I-V) in Release date above indicates the policy action used for the estimation of the policy effects in the event study approach.

Main Transmission Mechanisms of Monetary Policy in Q-JEM

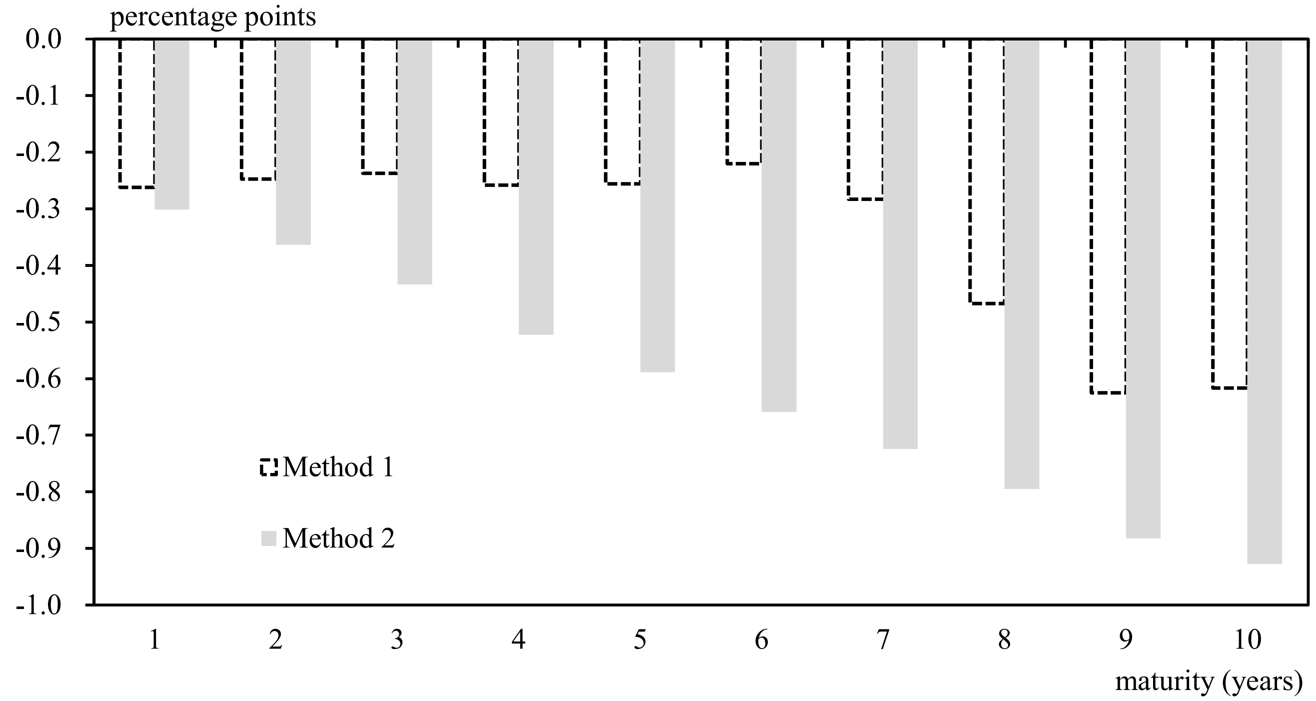


Nominal Interest Rates

(1) Nominal Interest Rates (the average of one to ten year rates)

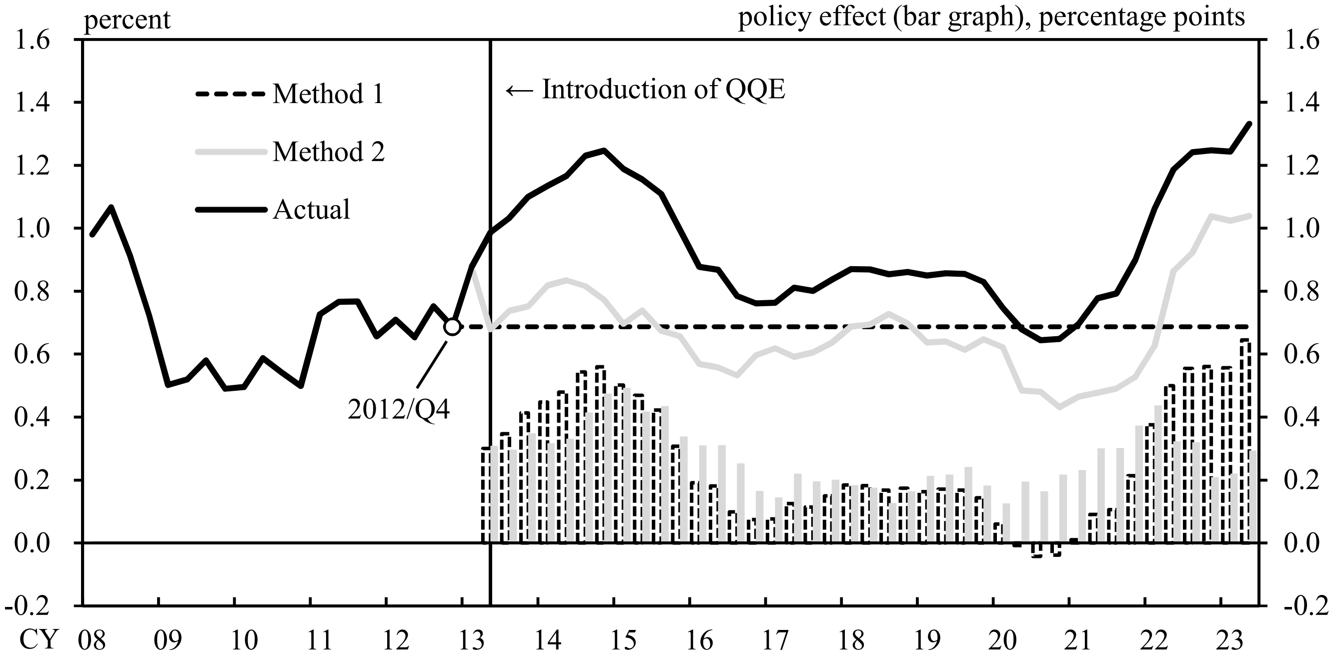


(2) Average Policy Effect on Nominal Interest Rates by Maturity



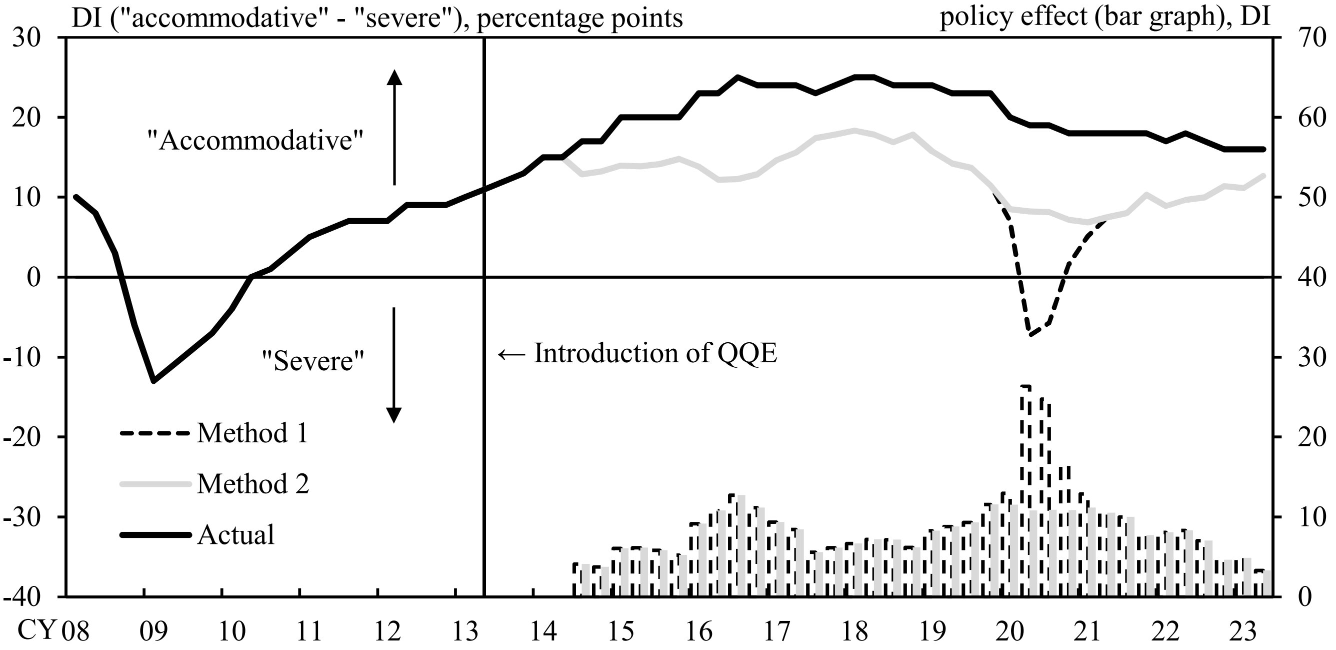
Source: Ministry of Finance.

Medium- to Long-Term Inflation Expectations



Sources: Bank of Japan; Bloomberg; QUICK, "QUICK Monthly Market Survey <Bonds>"; Consensus Economics Inc., "Consensus Forecasts."

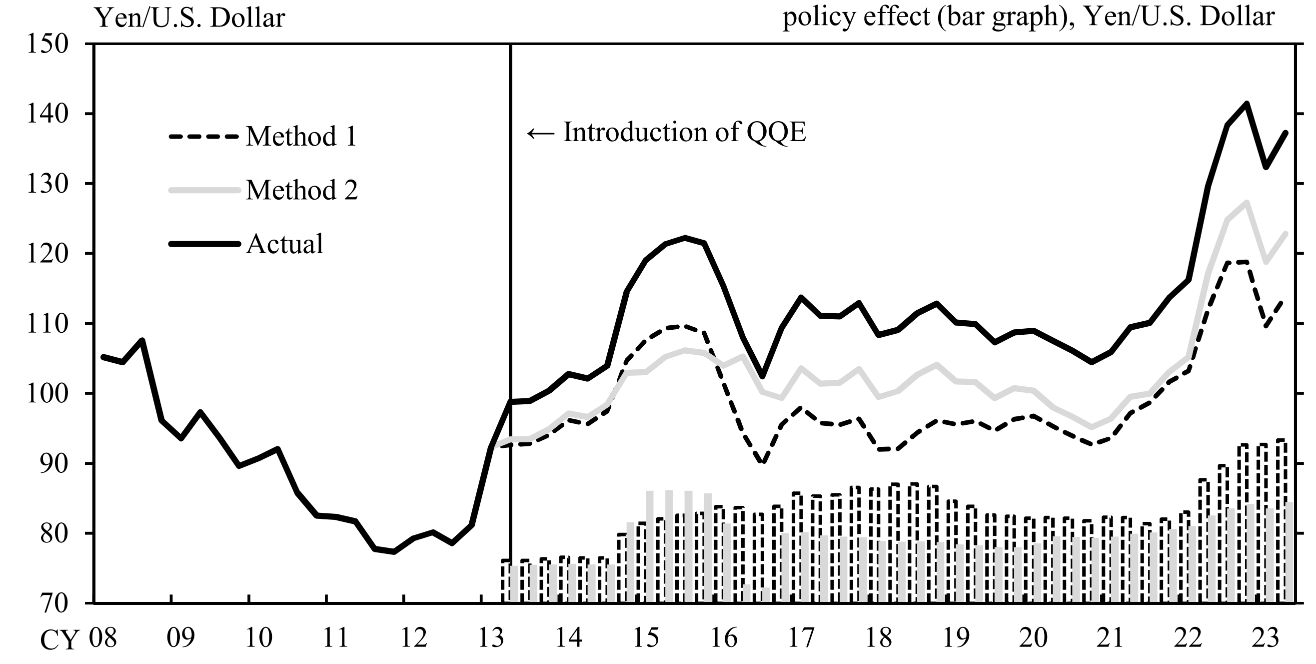
Loan Availability in Lending Markets (Lending Attitudes DI)



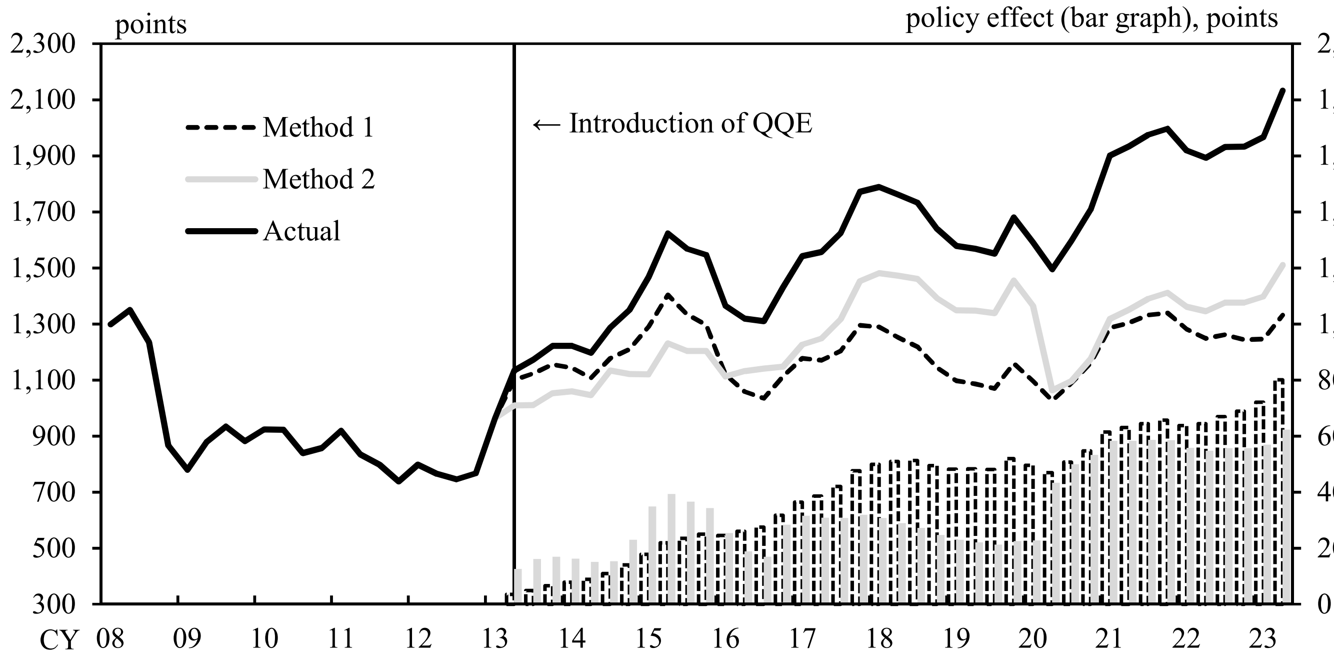
Source: Bank of Japan.

Foreign Exchange Rates and Stock Prices

(1) U.S. Dollar/Yen Rate



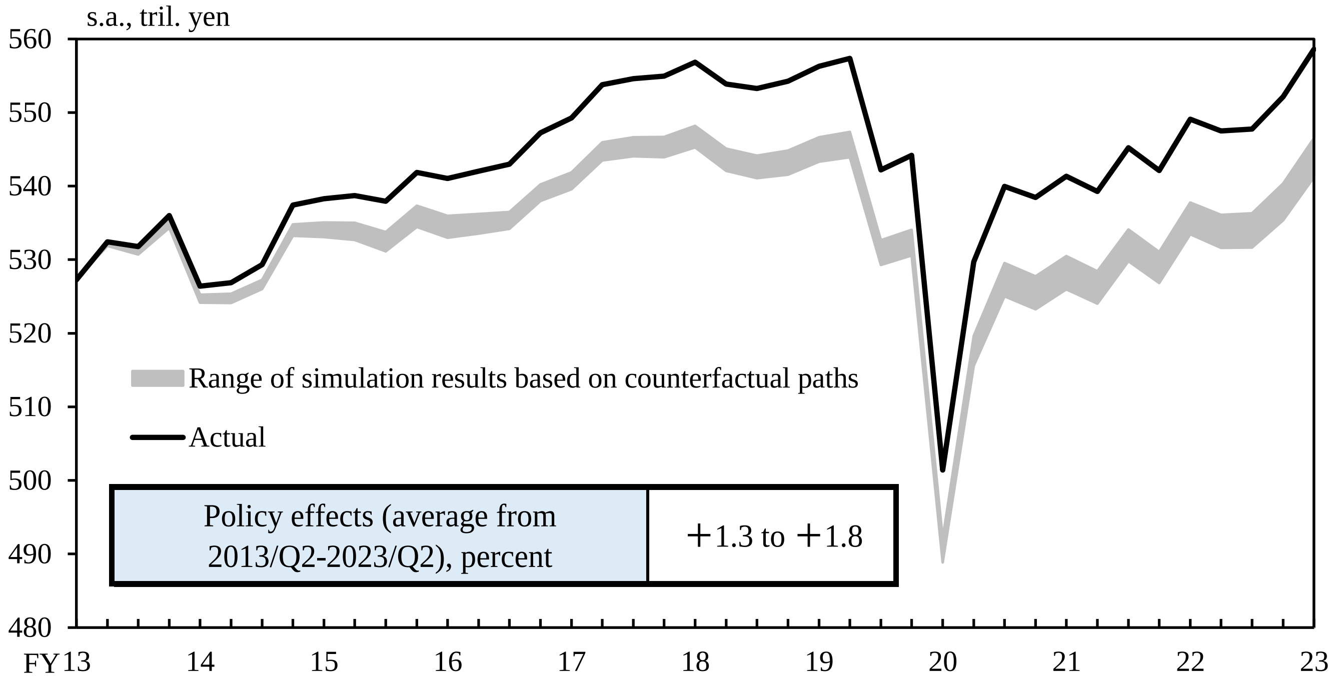
(2) Stock Prices (TOPIX)



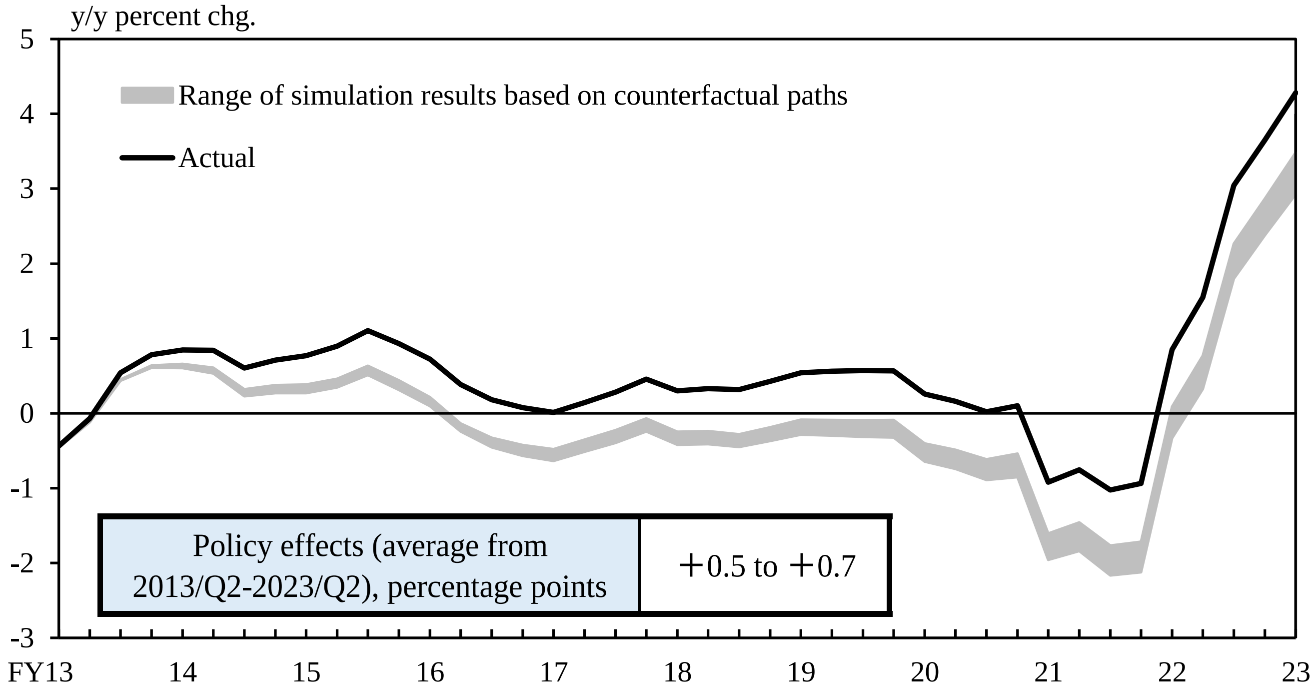
Sources: Bank of Japan; Bloomberg.

Simulation Results

(1) Real GDP



(2) CPI (less fresh food and energy)



Notes: 1. The range of the simulation results shows the maximum to minimum values at each time point across 16 simulation results.

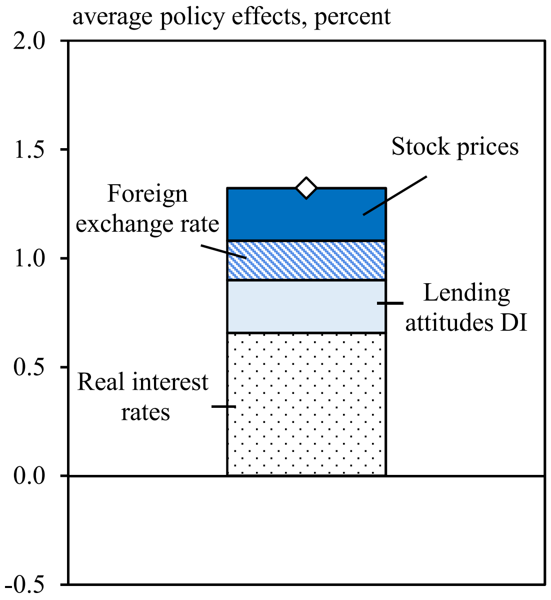
2. The CPI figures are staff estimates and exclude the effects of consumption tax hikes, policies concerning the provision of free education, and travel subsidy programs.

Sources: Ministry of Internal Affairs and Communications; Cabinet Office.

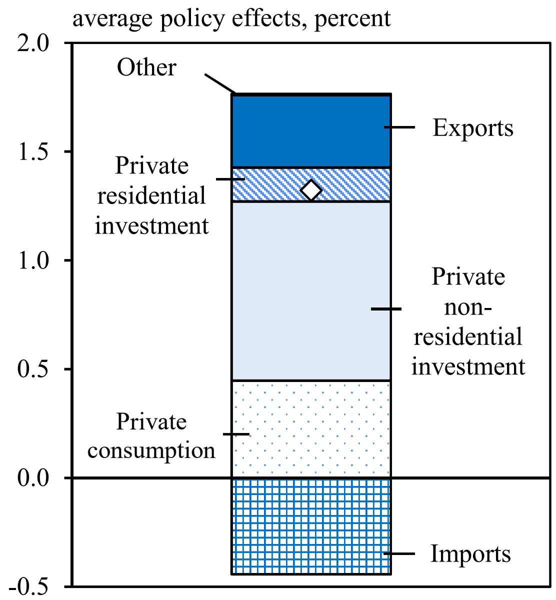
Decomposition of Policy Effects

(1) Real GDP

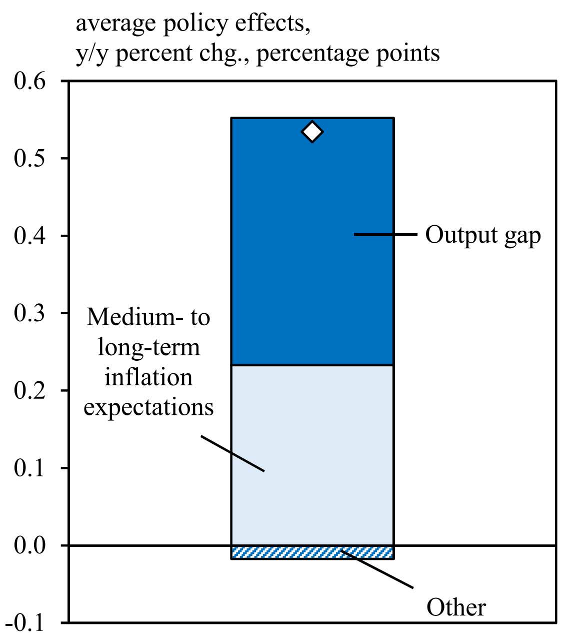
▽ by Transmission Channels



▽ by Expenditure Components



(2) CPI (less fresh food and energy)



Notes: 1. The figures show the average policy effects from the Apr.-Jun. quarter of 2013 to the Oct.-Dec. quarter of 2019.
2. The diamond markers show the total.
3. Contributions in (2) are calculated by sequentially substituting the contribution of each explanatory variable into the lagged inflation.

Key Equations in Q-JEM (1)

Private consumption (CP)

[Long-run equilibrium]

$$\text{CPN / YDN} = \text{Const} - 0.01 \times (\text{IRSM} - \text{GDPQ (y/y chg)}) + 0.02 \times \text{FASSET / YDN}$$

[Short-run dynamics]

$$\text{CP (q/q chg)} = \text{Const} - 0.13 \times \text{EC} + 0.23 \times (\text{GDP less CP (q/q chg)})$$

Private non-residential investment (INV)

[Long-run equilibrium]

$$\log(\text{INV / KF}) = \text{Const} + 0.21 \times \log(\text{TOB}) - 0.03 \times ((0.54 \times \text{IRSM} + 0.46 \times \text{FRML}) - \text{GDPQ (y/y chg)} + \text{DEPRATE}) + 0.002 \times \text{LOANDI}$$

[Short-run dynamics]

$$\text{INV (q/q chg)} = \text{Const} - 0.20 \times \text{EC} + 0.28 \times \text{EX (q/q chg)} - 0.02 \times \log(\text{VI}) + 0.40 \times \text{CF (q/q chg)}$$

Private residential investment (IH)

[Long-run equilibrium]

$$\log(\text{IH / GDP}) = \text{Const} - 0.35 \times \log(\text{SH / GDP}) - 5.43 \times \text{POP50 / POP15} - 0.04 \times ((0.56 \times \text{IRSM} + 0.44 \times \text{FRML}) + \text{SPREAD} - \text{GDPQ (y/y chg)}) + 0.74 \times \log(\text{YWN / PIH})$$

[Short-run dynamics]

$$\text{IH (q/q chg)} = \text{Const} - 0.15 \times \text{EC}$$

Notes: 1. EC is the error correction term. For abbreviations of other variables, see Reference 3.
2. To simplify the equation expressions, some dummy variables are omitted.

Key Equations in Q-JEM (2)

Exports (EX)

[Long-run equilibrium]

$$\log(EX) = Const + 0.86 \times \log(FGDP) - 0.27 \times \log(FXR)$$

[Short-run dynamics]

$$EX\ (q/q\ chg) = Const - 0.15 \times EC + 3.91 \times FGDP\ (q/q\ chg)$$

Lending attitudes DI (LOANDI)

$$LOANDI = Const + 0.91 \times PROF / GDPN + 12.66 \times SP\ (y/y\ chg)$$

Nominal compensation of employees (YWN)

$$YWN = WHN \times H \times LW$$

Nominal wage (per capita per hour, WHN)

[Long-run equilibrium]

$$\log(WHN / PGDP) = Const + \log(GDP / (H \times LW))$$

[Short-run dynamics]

$$WHN\ (q/q\ chg) = Const + 0.64 \times ZWIL - 1.47 \times U - 0.10 \times EC$$

Consumer price index (less fresh food and energy, CPI)

$$\begin{aligned} CPI\ (q/q\ chg) = {} & 0.74 \times \text{Lagged CPI (q/q chg, two-quarter moving average)} \\ & + 0.26 \times ZPIL + 0.09 \times GAP \\ & + 0.005 \times PMAT\ (q/q\ chg) + 0.012 \times WGAP \\ & - 0.22 \times \text{Period dummy (from 1994 to 2012)} \end{aligned}$$

Notes: 1. EC is the error correction term. For abbreviations of other variables, see Reference 3.
2. FXR is determined by the U.S. dollar/yen exchange rate and the ratio between domestic and foreign general prices.
3. WGAP is the error correction term from the nominal wage equations.
4. To simplify the equation expressions, some dummy variables are omitted.

List of Selected Variables in Q-JEM

Name	Description
CF	Real cash flow of firms
CP	Real private consumption
CPI	Consumer price index (less fresh food and energy)
CPN	Nominal private consumption
DEPRATE	Depreciation rate of fixed capital
EX	Real exports of goods and services
FASSET	Financial assets of households
FGDP	Real gross domestic product of foreign economy
FRML	Real medium- to long-term forward rate
FXR	Real effective exchange rate
GAP	Output gap
GDP	Real gross domestic product
GDPN	Nominal gross domestic product
GDPQ	Potential GDP
H	Total hours worked (per capita)
IH	Real private residential investment
INV	Real private non-residential investment
IRSM	Real short- to medium-term interest rate
KF	Net real capital stocks of private non-residential fixed assets
LOANDI	Lending attitudes DI
LW	Employees
PGDP	GDP deflator
PIH	Private residential investment deflator
PMAT	Material prices
POP15	Population 15 years old or more
POP50	Population 50 years old or more
PROF	Firm profits
SH	Real housing stock
SP	Stock prices
SPREAD	Difference between interest rate on loans and short- to medium-term interest rate
TOB	Tobin's Q
U	Unemployment rate
VI	Stock volatility index
WHN	Nominal wage (per capita per hour)
YDN	Nominal disposable income (excluding net property income) of households
YWN	Nominal compensation of employees
ZPIL	Medium- to long-term price inflation expectations
ZWIL	Medium- to long-term nominal wage inflation expectations

Notes: 1. IRSM and FRML are calculated by subtracting the price inflation expectations for the corresponding maturity from each nominal interest rate.
2. ZWIL is defined the sum of ZPIL and the growth rate of real potential labor productivity (= dlog(GDPQ / (potential total hours worked × potential employees))).