APIR Discussion Paper Series No.46
2018/10

The effectiveness of the negative interest rate policy in Japan: An early assessment

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October, 2018

ABSTRACT

This paper provides an early assessment of the effects of the negative interest rate policy (NIRP) introduced by the Bank of Japan in January 2016. We find that the NIRP has effectively stimulated private residential investment, and by lowering long-term interest rates, has likely also supported private nonresidential investment. There is also reason to believe the policy has likely halted the appreciation of the yen and arrested the downward trend in Japanese stock prices around August 2016. Overall, we find that the NIRP has had expansionary effects on the Japanese economy, and therefore serves as a legitimate policy tool in alleviating Japan's zero-interest rate lower bound, notwithstanding some potential negative side effects.

JEL Codes: E52

Keywords: Negative interest rates, Residential/nonresidential investment, Foreign exchange rates

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1. Introduction

From June 2015 until June 2016, the nominal effective exchange rate for Japanese yen appreciated by 19.4%, largely because of exogenous negative shocks from abroad. At the same time, many other Japanese macroeconomic indicators deteriorated, including the rate of inflation. In response to this weakening of the economy, in January 2016 the Bank of Japan (BOJ) decided to adopt a negative interest rate policy (NIRP), following the example set by the European Central Bank (ECB) and three other European central banks. In line with this policy, the BOJ began charging a fee of 0.1% on reserves held on behalf of private financial institutions, while after September 2016 the BOJ also began to control the term structure of interest rates, such that there was a zero yield on 10-year Japanese government bonds. In July 2018, the BOJ modified its target on 10-year government bonds yields to allow lower and upper bounds ranging roughly from a minimum of –0.2% to a maximum of 0.2%.

As it has only been about two-and-a-half years since the BOJ introduced the NIRP, it is still too early to draw any firm conclusions on its effectiveness given the small sample size of the necessary data. However, this does not lessen in any way the urgent need on the policy side to evaluate the effectiveness of this important policy tool. Problematically, the NIRP is an unprecedented macroeconomic policy with little supporting economic theory or empirical evidence. The purpose of this paper is to provide a preliminary report on the effects of the NIRP as recently introduced by the BOJ on the Japanese economy and to discuss any possible policy implications. Our tentative conclusion is that the NIRP has empirically observable expansionary effects. It, therefore, serves as a legitimate policy tool in alleviating zero-interest rate lower bounds, notwithstanding some potential negative side effects.

The remainder of the paper is organized as follows. Section 2 presents a simple analytic model to consider the effects of the NIRP, comprising a four-asset model based on Tobin (1969), Yabushita (2009), and Honda (2014). Section 3 discusses some limitations of this model, and Section 4 provides empirical evidence on the effects of the NIRP on the Japanese economy. In Section 5, we provide an interpretation of the statistical evidence and discuss some policy implications. Lastly, Appendix 1 includes details of some of the mathematical results presented in Section 2, while Appendix 2 provides some supporting evidence on our arguments in Subsection 4.3.2 on the impacts of the NIRP on the yen–dollar exchange rate.

2. A Simple Analytic Model

2.1 Analytic strategy

To our knowledge, there is no explicit analytic model in the literature appropriate to our chosen context given its inherent complexity. Accordingly, we instead propose a simple operational model which enables us to follow a logical reasoning of the behavior of asset markets. Taking the same analytic strategy as that of the well-known investment/saving (IS) and liquidity preference/money supply (LM) model (IS-LM), we assume that the spending decision in the goods market is independent of the portfolio decision in the assets market. In the IS-LM model, equilibrium total spending, or gross domestic product (GDP), is determined in the goods market for a given interest rate. The IS curve is then the set of GDP equilibria with their corresponding interest rates. In contrast, the equilibrium interest rate is determined as a result of portfolio decisions among money and bonds for a given GDP. The LM curve is then the set of equilibrium interest rates with their corresponding GDPs.

In the derivation of the LM curve, money and bonds are measured in stock balances, with the equilibria in the asset markets being for these stock variables. Alternatively, in the derivation of the IS curve, the equilibria in the goods market are for flow variables, including total spending, national output, national income, total savings, and total investment. Recalling the process of money creation in introductory macroeconomic texts, we appreciate that the traditional banking activities of receiving deposits and making loans are most closely associated with private investment, and we may, therefore, include deposits and bank loans among the flow variables.

Given the real-world complexity, we propose a simple partial analytic model. This is partial in the sense that it analyzes only asset markets and excludes the goods market, only incorporating it in the model as an exogenous variable. However, our model extends the two assets in the conventional LM curve to four assets. By extending the model to one with four assets, we can explicitly and logically assess the impact of each specific monetary policy tool on different asset markets. For example, making use of our operational model with four assets, we can explain that an injection of base money into an economy lowers the interest rate on bonds, reduces the required rate of return from capital stocks, and depreciates the value of the domestic currency. Indeed, this is exactly what was observed at the BOJ when the new governor, Haruhiko Kuroda, and vice governors took office in March 2013 and commenced the new quantitative and qualitative easing (QQE) monetary policy.[1]

2.2 Four-asset model

We assume the economy comprises four sectors: a private sector, a foreign sector, a government, and a central bank. The private sector includes both financial and nonfinancial institutions. For analytical purposes, we regard the income account variables as exogenous in determining portfolio choice behavior and identify the market equilibrium for the stock of assets conditional upon the assumed values of output, income, and the remaining flow variables, including deposits and bank loans. We also assume prices remain constant at the numeraire of one throughout the period. Extending the models in Tobin (1969), Yabushita (2009), and Honda (2014), we consider a model with four assets, namely, money, bonds, stocks, and foreign assets.

2.3 Demand for assets

The respective demands for money (M), bonds (B), stocks (V), and foreign assets (F) depend on their relative asset yields and the given wealth (W^S):

$$\begin{aligned}
&\text{Money:} && M = M(c, i, r, z, W^S) \\
&\text{Bonds:} && B = B(c, i, r, z, W^S) \\
&\text{Stocks:} && V = V(c, i, r, z, W^S) \\
&\text{Foreign assets:} && F = F(c, i, r, z, W^S). \qquad (1)
\end{aligned}$$

Money in this model is central bank money (or currency plus private bank demand deposits held at the central bank). In the model, we assume that the central bank pays interest (c) on reserves (or money).[2] Variable c is exogenous, and its domain extends from minus to plus infinity. When negative, c is the nominal carrying cost of reserves. Economic agents then hold money up to some nonpositive point for transaction purposes, even if the return is negative.

We also assume that bonds, stocks, and foreign assets yield returns of an interest rate (i), stock returns (r), and foreign asset returns (z), respectively. The domains of these variables also extend from minus to plus infinity. The expected rate of return from holding foreign assets (z) is then the sum of two components, the interest rate on foreign bonds and the expected rate of change in the exchange rate $E[\Delta e/e]$, where $E[*]$ denotes the expectation operator. We assume z is exogenous throughout.[3] The demand for each asset also depends on GDP. However, GDP is a flow variable and excluded from the right-hand side of equation (1) as an exogenous variable. Both deposits in banks and bank loans are also flow variables and exogenous in the model.

We assume that assets are gross substitutes as per standard microeconomics terminology. That is, the demand for each asset varies directly with its own rate of return and inversely with all other rates of return. The own-derivatives of the respective demand functions:

$$(\partial M/\partial c,\ \partial B/\partial i,\ \partial V/\partial r,\ \partial F/\partial z),$$

are then positive, and the cross-derivatives are nonpositive.

There are four different rates of return on the right-hand side of equation (1) because the four assets are imperfect substitutes and thus their rates do not necessarily equalize. There are several sources of imperfect substitutability. First, money is a universal means of payment, a property no other assets possess. Thus, the rate of return from money should be lower. Second, the default risk of government bonds is generally considered to be smaller than for private stocks. Corporate bonds also have a prior claim to the net assets of firms than stocks with bankruptcy. Therefore, the required rate of return from bonds should be lower than for stocks.

Third, “home bias is a perennial feature of international capital markets” (Coeurdacier and Rey(2011)). Japanese equity and bond markets are no exceptions. The exchange rate risk is one of important sources to produce home bias in investors’ portfolios in Japan (Walker(2008)). Hence a premium is required to induce risk-averse investors to hold foreign assets subject to the risk of changes in foreign exchange rates.

Finally, some government organizations have restrictions on their portfolio decisions. For example, the Government Pension Investment Fund (GPIF) in Japan provides for a basic portfolio with maximum and minimum bands, the August 2018 baseline shares for domestic bonds, domestic stocks, foreign bonds, and foreign stocks being 35%, 25%, 15%, and 25%, respectively. Restrictions like this tend to increase the demand for safer assets and decrease the demand for riskier assets, which in turn tends to raise the required rate for riskier assets higher than it would be otherwise.

The total demand for the four assets sums to the total demand for wealth in economy W:

$$W = M(c, i, r, z, W^S) + B(c, i, r, z, W^S) + V(c, i, r, z, W^S) + F(c, i, r, z, W^S), \tag{2}$$

such that the total demand for assets W is a function of all variables on the right-hand side of equation (2). Consequently, when any one of the returns, c, i, r, or z, changes, the demand for each asset reacts, but the sum of the changes in demand for each asset is assumed zero. That is:

$$M_j + B_j + V_j + F_j = 0 \text{ for } j = 1, 2, 3, 4, \tag{3}$$

where subscript j denotes the partial derivatives of the demand functions, $M, B, V, F,$ with respect to the j-th argument on the right-hand side of equation (1).

Just as there is a budget constraint in standard microeconomics, our model includes a balance sheet constraint. That is, we assume that the total demand for assets W in (2) equals the exogenous total supply of assets W^S:

$$W = W^S.$$

As a result, when exogenous total wealth W^S increases, we have the following balance sheet restriction:

$$M_5 + B_5 + V_5 + F_5 = 1, \tag{4}$$

where the subscript denotes the partial derivative with respect to total wealth W^S, the 5-th argument in the respective functions for $M, B, V,$ and F in equation (1). We also assume that all four assets are normal goods, such that:

$$M_5 > 0, B_5 > 0, V_5 > 0, and\ F_5 > 0\ .$$

2.4 Supply of assets

We assume that the central bank exogenously supplies the money stock, M^S. Firms provide the supply of stocks, qK^S, where q and K^S denote the market value price of one unit of physical capital and the stock of physical capital, respectively, or alternatively, the stock price and the total number of stocks outstanding, respectively.

The government and firms supply bonds, $P^B B^S$, where P^B and B^S denote the market value of one unit of bonds and the total quantity of bonds outstanding, respectively. We assume that the respective total quantities of stocks and bonds outstanding in the economy, K^S and B^S, are exogenously given. However, their market prices, q and P^B, are endogenously determined through arbitrage, as explained below.

The total supply of foreign assets is given by eF^S, where e and F^S are the exchange rate (measured in yen per unit of foreign currency) and the total balance of foreign assets (measured in foreign currency), respectively. We assume that the quantity of foreign assets outstanding, F^S, is exogenously given, but that the exchange rate e is endogenously determined.

2.5 Inverse relations between market prices and returns

We assume an inverse relation between the bond price, P^B, and the interest rate, i:

$$dP^B/di < 0. \tag{5}$$

Similarly, we also assume that an inverse relation also holds for capital stocks:

$$dq/dr < 0. \tag{6}$$

However, unlike conventional models, we assume that the domains for variables i and r range from minus to plus infinity.

The rationale behind inequalities (5) and (6) is as follows. Suppose an economic agent holds one unit of bonds. The agent has two possible choices. The first is that the agent sells the bond immediately in the market. In this case, the agent obtains the current market price of the bond, P^B. The second is that the agent holds the bond and expects to earn the stream of fixed income produced by this bond in the future. The current value of the future stream of fixed income is discounted by the bond market interest rate i. We assume arbitrage works between these two choices, so there must be an inverse relation between the bond price P^B and the market interest rate i, as in inequality (5). One simple example is a consol bond with a return of one yen each year, such that the market value of this bond is $P^B = 1/i$. There is indeed an inverse relation between the price of bonds P^B and the interest rate i in this case.

In a similar manner, suppose an economic agent holds one unit of physical capital that produces a real return R (assumed exogenous) each year. Once again, the agent has two possible choices. The first is that the agent sells the physical capital in the market. In this case, the agent receives q, the current market price of equity. The second choice is that the agent holds the capital permanently and expects to earn a stream of fixed real returns R in the future. We then discount the current value of the future stream of fixed real returns by the rate of return on capital stocks r, where r is the rate of return on stocks required for market investors to hold capital stocks in their portfolios. Assuming arbitrage between the choices, we have the equation $q = R/r$. Hence, we have inequality (6).

We assume the reproduction cost of one unit of physical capital is one, and remains constant throughout the analysis. Hence, stock prices q in our model also represent Tobin's q, which is the ratio of the market value of capital to its reproduction cost.

2.6 Market equilibrium

The following four equations yield the market equilibrium conditions:

$$M^S = M(c, i, r, z, W^S), \tag{7}$$

$$P^B B^S = B(c, i, r, z, W^S), \tag{8}$$

$$qK^S = V(c, i, r, z, W^S), \tag{9}$$

$$eF^S = F(c, i, r, z, W^S). \tag{10}$$

One of these conditions is automatically satisfied when the other three are met because of the balance sheet constraint:

$$M^S + P^B B^S + qK^S + eF^S = W^S = W, \tag{11}$$

where W^S denotes the total supply of wealth. Therefore, we only have to consider any three of the above four equations. For our analysis, we select equations (7), (8), and (10). The three endogenous variables are the interest rate i, the returns on capital stocks r, and the foreign exchange rate e. Variables P^B, q, and W^S are also endogenous because of conditions (5), (6), and (11), respectively. The remaining variables in the system, (7) through (10), are exogenous.

Substituting equation (11) into equations (7), (8), and (10), we have:

$$M^S = M(c, i^*, r^*, z, M^S + P^B(i^*)B^S + q(r^*)K^S + e^*F^S), \tag{12}$$

$$P^B(i^*)\, B^S = B(c, i^*, r^*, z, M^S + P^B(i^*)B^S + q(r^*)K^S + e^*F^S), \tag{13}$$

$$e^*F^S = F(c, i^*, r^*, z, M^S + P^B(i^*)B^S + q(r^*)K^S + e^*F^S), \tag{14}$$

where superscript * denotes the equilibrium value.

2.7 The effects of an increase in interest on reserves c

We interpret an increase in the reserve carrying cost as a decrease in the interest on reserves *c* across its negative domain. Hence, we are interested in the effects of an exogenous decrease in interest on reserves *c* on the equilibrium endogenous variables (i^*, r^*, e^*). Assuming a smoothly differentiable function in our system of equations, we examine the comparative statics of an exogenous increase in interest on reserves *c*. The appendix 1 shows that an increase in the interest rate on reserves raises the interest rate, $di^*/dc > 0$, increases the required rate of returns from stocks, $dr^*/dc > 0$, and appreciates the value of the domestic currency, $de^*/dc < 0$. Lowering the negative interest rate on reserves further into a more negative range by the central bank then leads to lower interest rates on bonds. It also reduces the required rate of return from stocks and depreciates the value of the domestic currency. However, these conclusions are subject to important qualifications, as discussed in the following section.

3. Limitations of the Overly Simplified Model

3.1 Exogenous financial sector

In the overly simplified model above, financial institutions play no role in the transmission mechanism of monetary policy shocks. They are exogenous and mechanical actors. In reality, this is not the case. The assumption of an exogenous financial sector is solely for analytic purposes. Avoiding the complicated task of making the financial sector endogenous, we simply complement the above model analysis using a narrative approach.

To start, there are at least two kinds of impacts from the NIRP, comprising immediate and long-lasting effects. First, a decrease in the interest rate on reserves immediately removes net profits from banks. However, the potential negative effects on the financial sector are not limited to this alone. As soon as the BOJ commenced the NIRP in January 2016, all market rates plunged through arbitrage. Even the yields on 15-year Japanese government bonds dipped below 0% by July 2016.

This large downward shift in and flattening of the entire term structure of interest rates made the management of financial institutions quite difficult, partly because Japanese banks have a long-lasting tradition of charging little or no fees on deposits. As a result, there is virtually a zero-lower bound on deposit rates. In addition, partly because portfolio management in insurance companies and pension funds over the longer-term horizon is based on the presumption of a positive term premium, the lower the (positive) term premium, the greater the risk of failing to meet the yield promised to customers.

In response to its concerns about these negative effects on financial institution management and the possible instability of the whole financial system, the BOJ introduced a New Framework for Strengthening Monetary Easing, known as the Quantitative and Qualitative Monetary Easing with Yield Curve Control (QQE with

YCC) on September 21, 2016. This set an interest rate target of 0% for 10-year government bonds. This change provided for a small margin between short- and longer-term interest rates and also raises rates longer than 10 years to a positive level to ensure a more favorable business environment for insurance companies and pension funds.

From the perspective of the BOJ as the central bank, there are at least three interrelated concerns. First, the excessive erosion of profitable opportunities by the NIRP weakens the once sound foundation for financial business, and could indeed invite possible instability in the Japanese financial system. Second, with reduced profits, banks may become more cautious in taking risks and thus less willing to make loans to customers. The magnitude of the loss of their profits from the central bank's policy change could be large. Indeed, there is the possibility that the incentive of private banks to avoid taking risks in making loans could overwhelm the expansionary monetary policy intent of the central bank. In that case, lowering the already negative interest rate on reserves further would not increase but rather decrease private bank lending, contrary to the central bank's intention.

Finally, if private banks attempt to avoid any reduction in their net profits, they will pass their losses on to depositors, and charge larger fees on deposits. Depositors would then cease depositing their cash into banks and instead hoard any surplus cash. This sort of disintermediation is likely to cause significant problems in real terms in the economy and should be avoided at all costs by the monetary authorities.[4]

3.2 Expectations

Variables in financial markets are forward-looking and so expectations play an important role in the real world. However, for simplicity, our model ignores the role of expectations. When expectations change, they could shift the demand for assets in the equations in (1). Strictly speaking, when we then wish to analyze the effects of a NIRP, we should specify the demands for money M, bonds B, stocks V, and foreign assets F as:

$$M = M(c, i, r, z, W^S, \varphi^M(c)),$$

$$B = B(c, i, r, z, W^S, \varphi^B(c)),$$

$$V = V(c, i, r, z, W^S, \varphi^V(c)),$$

$$F = F(c, i, r, z, W^S, \varphi^F(c)), \tag{15}$$

instead of the corresponding equations in (1), where $\varphi^M(c)$, $\varphi^B(c)$, $\varphi^V(c)$, and $\varphi^F(c)$ denote the impacts of an increase in the interest on reserves on the demands for money, bonds, stocks, and foreign assets, respectively, through changes in expectations among market participants. In such a complicated model with expectations, our standard results, $di^*/dc > 0$, $dr^*/dc > 0$, and $de^*/dc < 0$, may no longer hold.

Our simple model with no expectations certainly has some limitations for real-world analysis. It is certainly desirable to extend our model and to formally incorporate expectations. However, this is beyond the scope of this paper and remains an open question.

4. Some Tentative Empirical Evidence

Given the limited passage of time since the introduction of the NIRP by the BOJ in January 2016, little data have been accumulated, so our purposes in this empirical section are modest. We neither attempt to estimate our analytic model in Section 2, nor attempt to formally test the validity of the model. Instead, we provide the most relevant empirical information available at present on the effectiveness of the NIRP and show that the available evidence thus far is not inconsistent with the results implied by our analytic model.

4.1. Some literature

There is only limited literature on the effects of the NIRP in Japan, including Fukuda (2017) and Spiegel and Tai (2017) who explored the possible spillover effects of Japan's NIRP on financial markets in selected Asian economies. The analysis most related to the present analysis is Hameed and Rose (2017). Using daily panel data of 61 currencies, including Japanese yen, from January 2010 to May 2016, they found that negative interest rates appear to have little effect on observable exchange rate behavior. However, "[t]he authors also suggest that the consequences of NIRP for the financial sector are largely unknown, and may be larger in the long run than in the short run" (Aizenman et al., 2017, p. 4). Indeed it is this unknown part that the present paper is trying to make clear.

4.2. The immediate impact on asset markets

Figures 1 and 2 depict the immediate impact of the introduction of the NIRP (in January 2016) and of the QQE with YCC (in September 2016), respectively, on the stock market.

The shaded areas indicate the effects within three days of the introduction of the respective policy measures. We believe that these effects within this period are less contaminated by the effects of other exogenous factors. Figures 1 and 2 show that the Nikkei Stock Average generally reacted favorably to the introduction of both NIRP and the QQE with YCC within three days. However, the effects differ by industry, with three possible types of reaction, being favorable to the market, unfavorable, or mixed.

<FIGURE 1 ABOUT HERE>

<FIGURE 2 ABOUT HERE>

Panels (a) and (b) in Figure 1 plot the stock market price indexes for the banking and insurance industries, respectively, relative to the Nikkei Stock Average. We standardize all indexes to one as of January 28, 2016 to correspond with the time the BOJ announced the NIRP. In anticipation of a more severe market environment, the stock indexes for both the banking and insurance industries fell sharply relative to the Nikkei Stock Average.

In contrast, the real estate industry received news of the NIRP more favorably. Panels (c) and (d) in Figure 1 plot the stock market price index of the real estate industry and the Japan Real Estate Investment Trust (J-REIT) index, respectively. As shown, the plots of the stock market prices for both real estate-related industries lie above the Nikkei Stock Average. Panels (e) and (f) in Figure 1 illustrate the reactions of the indexes of securities and commodity futures, and other financial services (such as leasing), respectively. In these industries, it appears that news of the NIRP was at first favorable but was followed by a negative response.

Overall, Figure 2 shows that the news concerning the modification of the yield curve by the BOJ in September 2016 was most favorably received by Banks and Insurance, and largely favorably by Securities and Commodity Futures and Other Financing Business. However, the J-REIT Index dipped slightly negative, reflecting the rise in interest rates with longer maturities.

4.3. Effects on financial variables

4.3.1. Market interest rates

The BOJ announced the NIRP in January 2016, and it came into effect in February that year. Figure 3 illustrates that both short- (1-month LIBOR; solid line) and long-term (10-year government bonds; dashed line) interest rates fell sharply (some 50 basis points for 10-year government bonds) and became negative as soon as the NIRP was announced. Subsequently, the long-term interest rate quickly increased to about zero percent and remained there by September 2016 when the BOJ began to use the long-term interest rate as an operating target and set it to zero percent.

<FIGURE 3 ABOUT HERE>

<FIGURE 4 ABOUT HERE>

4.3.2. Foreign exchange rates

Figure 4 depicts the movements in the nominal effective yen exchange rate using a 26-country index (2010 = 100). Largely because of exogenous shocks outside Japan, the yen’s effective exchange rate appreciated by 19.4% from June 2015 to June 2016. This appreciation weakened the competitiveness of Japanese firms, and the macro indicators for core machinery, retail sales, and production deteriorated over this period. The appreciating trend in the yen evident since June 2015 finally halted around August 2016, as shown in Figure 4. We argue that it is the introduction of the NIRP in January 2016 that likely halted the yen appreciation. The introduction of the NIRP lowered the long-term interest rate by roughly 0.5% immediately after January 2016. Facing this major change in Japanese government bond yields, Japanese insurance companies and/or pension funds increased their purchase of foreign securities by roughly 5 trillion yen per quarter after the first quarter of 2016, which likely stopped the appreciation in the yen. We provide four pieces of evidence consistent with this scenario in Appendix 2.

After August 2016, the yen's effective exchange rate began to depreciate, for which there are two possible reasons. First, the election of Donald Trump as US president in November 2016 seems to have contributed to a surge in the value of the US dollar given the expected expansionary fiscal policy stance of the new administration. Second, in December 2016, the US Federal Reserve raised the operating target of the federal funds rate to between 0.5% and 0.75%, which also contributed to the US dollar appreciation evident in February 2017. Looking at the movements of the nominal effective exchange rate of the Euro in Figure 9 below, we can discern a similar depreciation relative to the US dollar over the same period, and this may reconfirm our speculation concerning the reasons for the depreciating yen.

4.3.3. Stock prices

Figure 5 provides a graph of the Tokyo Stock Price Index (TOPIX), showing that it moved closely with the nominal effective foreign exchange rate after 2015. The TOPIX stopped falling in mid-2016, and rose sharply after November 2016. The movement in stock prices parallels that in the nominal effective exchange rate.

<FIGURE 5 ABOUT HERE>

4.4. Effects on real variables

4.4.1. Nominal effective exchange rate and production

Industrial production in Japan is extremely sensitive to changes in the yen exchange rate because the exchange rate directly affects the competitiveness of Japanese firms. We often tend to think that changes in the exchange rate only have an impact on export-related companies, but this is not the case. Changes in the exchange rate influence the competitiveness of Japanese firms in general, and have wider impacts on demand in both foreign and domestic markets. This is partly because some domestic products compete with imported goods, and also partly because electricity price crucially depends on imported oil price.

Figure 6 plots the index of Japanese industrial production (IIP). Comparing Figures 4 and 6, we can observe a close correlation between the nominal effective yen exchange rate and Japanese industrial production. For example, the nominal effective exchange rate appreciated by about 20% from June 2015 to August 2016. We confirm that industrial production declined for this period in Figure 6. As soon as the yen turned toward depreciation in August 2016, production in Figure 6 also turned and continued expanding until the end of 2017. The comparison of Figures 4 and 6 reconfirms that Japanese industrial production is actually quite sensitive to changes in the yen exchange rate. In Subsection 4.3.2, we argued that it was the NIRP that likely halted the appreciation of the yen in August 2016. Therefore, we also argue that it was the NIRP that likely halted the decline in industrial production in August 2016.

<FIGURE 6 ABOUT HERE>

4.4.2. Residential investment

Table 1 is an official statement by the Japanese government on the preliminary estimates (released February 13, 2017) of the seasonally-adjusted real GDP for the second (April–June) and third (July–September) quarters of 2016.

<TABLE 1 ABOUT HERE>

As shown in the first and third columns of Table 1, private residential investment grew by 3.3% and 2.4% (percent change from the previous quarter), respectively.[5] The values in parentheses for private residential investment shown in the second and fourth columns in Table 1 are both about 0.1, suggesting that this increase in private residential investment increased GDP growth by 0.1% (about 0.4% annually) per quarter. These jumps in private residential investment clearly coincided with the introduction of the NIRP.

4.4.3. Nonresidential investment

Despite the sharp appreciation of the yen, nonresidential investment grew by +1.3% in the second quarter (the first column in Table 1). The growth rate is negative in the third quarter (–0.3% in the third column of Table 1), but relatively small in magnitude, likely owing to the substantial reduction in the long-term interest rate under the NIRP. Indeed, the Ministry of Finance's "Financial Statements Statistics of Corporations by Industry (April–June, 2016)" reports that the growth rate of fixed investment over the previous quarter was a respectable +3.1%, seemingly despite the 3.5% fall in sales and 10.0% decline in earnings in the second quarter of 2016.[6] We surmise that the lower long-term interest rate associated with the NIRP supported private fixed investment.

4.4.4. Exports

The growth rate in the exports of goods and services in the second quarter of 2016 (the first column in Table 1) was as weak as –1.2% because of the sharp appreciation in the yen. Around August 2016, the yen appreciation halted, and the growth of exports of goods and services improved to +2.1% in the third quarter (the third column in Table 1).

5. Some Interpretations and Policy Implications

This final section summarizes our main findings, provides an interpretation, and discusses the policy implications. First, although as small as –0.1% in magnitude, the introduction of the NIRP in January 2016 substantially increased residential investment and thereby supported the growth of the overall Japanese economy. Second, the introduction of the NIRP lowered the long-term interest rate by roughly 50 basis points, which likely supported private nonresidential investment.

Third, given that the NIRP substantially lowered both long- and short-term interest rates in Japan, the NIRP must have widened the spread in yields, pushing the exchange rate toward a yen depreciation and likely halting the appreciating trend in the yen around August 2016. We provide four pieces of evidence in Appendix 2 supporting these arguments. As Hamada et al. (2010, pp. 30–40) correctly argue, changes in exchange rates have a great impact on the Japanese real economy. This also holds in the present context. If there were no NIRP in January 2016, the growth of the Japanese economy would likely have been much weaker in the second quarter of 2016.

Fourth, the NIRP was also likely to have contributed to slowing the downward trend in stock prices in around August 2016. As demonstrated in our analytic model in Section 2, a NIRP has expansionary effects on stock prices, and these combined with the impact on the real estate industry helped stimulate the real sector through various channels. Overall, we found the NIRP has had significant expansionary effects on the Japanese economy.[7] It is, therefore, a legitimate policy tool for alleviating Japan's zero-interest rate lower bound, notwithstanding the potential negative side effects discussed earlier.

Finally, also using a four-asset model, Honda (2014) showed that an increase in central bank money has expansionary policy effects. Our paper demonstrates that a decrease in the interest rate on reserves has the same qualitative effects as an increase in central bank money. As these comparative statics results are independent, it implies that each policy tool has independent policy effects.

Appendix 1: Effects of an exogenous increase in the interest on reserves *c*

This appendix provides the basis for the three inequalities, $\frac{di^*}{dc} > 0, \frac{dr^*}{dc} > 0, and\ \frac{de^*}{dc} < 0,$ asserted in Subsection 2.7. There are three endogenous variables, (i^*, r^*, e^*), and three equations in (12), (13), and (14). Differentiating equations (12), (13), and (14) with respect to *c*, we have:

$$-\begin{bmatrix} \mathrm{M}_1 \\ B_1 \\ \mathrm{F}_1 \end{bmatrix}$$

$$= \begin{bmatrix} \mathrm{M}_2 + \mathrm{M}_5\mathrm{B}^\mathrm{S}(\mathrm{dP}^\mathrm{B}/\mathrm{di}) & \mathrm{M}_3 + \mathrm{M}_5 K^S(\mathrm{dq}/\mathrm{dr}) & \mathrm{M}_5\mathrm{F}^\mathrm{S} \\ \mathrm{B}_2 - (1-\mathrm{B}_5)\mathrm{B}^\mathrm{S}(\mathrm{dP}^\mathrm{B}/\mathrm{di}) & \mathrm{B}_3 + \mathrm{B}_5 K^S(\mathrm{dq}/\mathrm{dr}) & \mathrm{B}_5\mathrm{F}^\mathrm{S} \\ \mathrm{F}_2 + \mathrm{F}_5\mathrm{B}^\mathrm{S}(\mathrm{dP}^\mathrm{B}/\mathrm{di}) & \mathrm{F}_3 + \mathrm{F}_5 K^S(\mathrm{dq}/\mathrm{dr}) & (\mathrm{F}_5 - 1)\mathrm{F}^\mathrm{S} \end{bmatrix} \begin{bmatrix} (\mathrm{di}^*/\mathrm{dc}) \\ (\mathrm{dr}^*/\mathrm{dc}) \\ (\mathrm{de}^*/\mathrm{dc}) \end{bmatrix}, \text{(A1)}$$

where M_j, B_j, V_j, and F_j (*j* = 1, 2, 3, 4, 5) denote the partial derivatives of demand for money *M*, bonds *B*, stocks *V*, and foreign assets *F*, with respect to the *j*-th argument in (1), respectively. Solving this system of equations, we obtain:

$$\frac{\mathrm{di}^*}{\mathrm{dc}} = -\mathrm{F}^\mathrm{S}[F_3(M_5B_1 - M_1B_5) + M_3\{B_1(1-F_5) + B_5F_1\} + B_3\{M_1(F_5-1) - M_5F_1\} + (M_5B_1 - M_1B_5)K^S(\mathrm{dq}/\mathrm{dr})]/\Delta, \quad \text{(A2)}$$

$$\frac{\mathrm{dr}^*}{\mathrm{dc}} = -F^S[M_1B_2(1-F_5) + M_1B_5F_2 - M_2B_1(1-F_5) - M_5B_1F_2 - M_2B_5F_1 + M_5B_2F_1 - \{M_1(1-B_5-F_5) + M_5B_1 + M_5F_1\}B^S(\mathrm{dp}^\mathrm{B}/\mathrm{di})]/\Delta, \quad \text{(A3)}$$

$$\frac{\mathrm{de}^*}{\mathrm{dc}} = -[M_1(B_2F_3 - B_3F_2) + B_1(\mathrm{M}_3F_2 - \mathrm{M}_2F_3) + F_1(M_2B_3 - M_3B_2) + \{M_1(B_5F_3 - F_3 - B_3F_5) + B_1(M_3F_5 - M_5F_3) + F_1(M_5B_3 + M_3 - M_3B_5)\}\mathrm{B}^\mathrm{S}(\mathrm{dp}^\mathrm{B}/\mathrm{di}) + \{M_1(B_2F_5 - B_5F_2) + B_1(M_5F_2 - M_2F_5) + F_1(M_2B_5 - M_5B_2)\}K^S(\mathrm{dq}/\mathrm{dr}) +$$

$$(M_5F_1 - F_5M_1)\mathrm{B^S}K^S(\mathrm{dp^B/di})(\mathrm{dq/dr})]/\Delta, \tag{A4}$$

where Δ denotes the determinant of the (3×3) matrix on the right-hand side of equation (A1), and is given by:

$$\Delta = \mathrm{F^S}\Bigg[\mathrm{M_2\{B_3(F_5-1)-B_5F_3\}+M_3\{B_5F_2+B_2(1-F_5)\}+M_5(B_2F_3-B_3F_2)} - M_5(B_3+F_3)\mathrm{B^S}\left(\frac{\mathrm{dp^B}}{\mathrm{di}}\right) + M_3(F_5+B_5-1)B^S\left(\frac{dp^B}{di}\right) + (\mathrm{M_5}B_2 - M_2B_5)K^S(\mathrm{dq/dr}) - \mathrm{M_5B^S}K^S(\mathrm{dp^B/di})(\mathrm{dq/dr})\Bigg]. \tag{A5}$$

First, using equations (3) and (4), and the assumption of gross substitutes between the demands for assets, we can show that each of the seven terms on the right-hand side of equation (A5) is negative. Thus, Δ is negative. Second, we can show that each of the four terms in the numerator on the right-hand side of equation (A2) is also negative. Therefore, we obtain the inequality $\frac{di^*}{dc} > 0$.

Third, we can also show that the sum of the first six terms in the square brackets on the right-hand side of equation (A3) is positive, that the sum of the three terms in the curly brackets on the right-hand side of equation (A3) is also positive, and thus the numerator on the right-hand side of equation (A3) is negative. Therefore, we have the inequality $\frac{dr^*}{dc} > 0$.

Finally, the sum of the first three terms in the square brackets on the right-hand side of equation (A4) is negative, the sum of the next three terms in the curly brackets on the right-hand side of equation (A4) is positive, the sum of the three terms in the curly brackets in front of $K^S(\mathrm{dq/dr})$ on the right-hand side of equation (A4) is also positive, and $(M_5F_1 - F_5M_1)$ is negative. Therefore, we have the inequality $\frac{\mathrm{de}^*}{\mathrm{dc}} < 0$.

Appendix 2: Some evidence on why the rapidly appreciating yen halted around August 2016

In Subsection 4.3.2, we argued that it was the NIRP that increased the yield difference between US and Japanese securities and likely arrested the rapidly appreciating yen in August 2016. There is roughly a seven-month time lag between the sharp decline in the long-term interest rate in January 2016 arising from the introduction of the NIRP and the halt of yen appreciation in August 2016. It seems difficult to capture this causal relationship between these two events using statistical analysis. Consequently, we provide four separate pieces of evidence supporting our claim in Subsection 4.3.2.

(1) Using Granger causality tests and impulse–response analysis, Honda and Inoue (2015) empirically showed that differences in US and Japanese bond yields have significantly affected, with some lag, the yen–dollar exchange rate over the last 30 years. Hence, it is not unusual that there was about a seven-month lag between the change in the yield margin between US and Japanese bonds in January 2016 and the change in the yen–dollar exchange rate in August 2016.

(2) Figure 7 plots the flow of funds accounts for foreign securities in the insurance and pension funds sector over the period 2011 to 2016. Clearly, there is a large increase in the first quarter of 2016, immediately after the introduction of NIRP. The average of the 20 data points available for the period from the first quarter of 2011 to the fourth quarter of 2015 is 56.8 billion yen, while that for the last three data points is 4,838.3 billion yen. The difference of –4,781.5 billion yen is significantly different from zero at the 1% level, thereby

supporting the argument that the NIRP involved significant portfolio rebalancing effects.[8] Facing lower yields on domestic securities, the insurance and pension funds sector increased its purchase of foreign securities, and in purchasing foreign assets, they must have bought US dollars and thereby raised the price of the dollar against the yen.[9]

<FIGURE 7 ABOUT HERE>

(3) Both insurance companies and pension funds (including the GPIF) have their respective baseline plans for each year, and change their portfolios gradually in accordance with these plans. Therefore, it is not surprising that it takes some time for changes in bond yield margins to affect the exchange rate.

In addition, as the demand for foreign securities with a hedge against foreign exchange rate risk increases, the hedging cost also increases. When the hedging cost exceeds some threshold point, some insurance companies might begin to purchase foreign securities without hedging. This might be another reason why we observe lags between the changes in bond yield margins between the US and Japan and those in the exchange rate. To support these claims, we quote several newspaper articles at the time.

(a) "Life insurance and nonlife insurance companies pursue 'Less Japanese government bonds' policy and increase investment in foreign bonds. On April 27, 2016, 14 major insurance companies disclosed their investment plans for the period from April 2016 to March 2017. According to their plans, their total investment in foreign securities exceeds 5 trillion yen.

They try to secure their profit in investment as much as possible in the severe environment where the Japanese government bond yield with 10 year maturity comes to stay around 0%." (Nihon Keizai Shinbun, April 28, 2016)

(b) "Domestic institutional investors, including life insurance companies, keep unabated strong appetite for investment in foreign securities. Despite the increasing transaction costs to hedge against foreign exchange rate risk, they keep buying foreign securities actively to pursue higher yields. The purchase of foreign securities by these investors plays the role of curbing the further appreciation of yen." (Nihon Keizai Shinbun, October 4, 2016)

(c) "Major life insurance companies are reducing their investment in Japanese government bonds. On October 28, 2016, 10 major life insurance companies disclosed that they have decreased their investment in Japanese government bonds by 2.2 trillion yen in total from April to September 2016. If they had increased the number of Japanese government bonds with now dramatically lowered yield, they would probably have had the higher risk of failing to meet the yield promised to their customers. Every company is cautious in investing in Japanese government bonds, and seems to keep purchasing foreign bonds on and after October 2016." (Nihon Keizai Shinbun, October 29, 2016)

(d) "Domestic investors' net purchase of foreign bonds (with medium and long term maturities) are now getting close to 25 trillion yen, the largest amount over the last 20 years." (Futoshi Oguri, Nihon Keizai Shinbun, November, 2016)

<FIGURE 8 ABOUT HERE>

<FIGURE 9 ABOUT HERE>

(4) Figures 8 and 9 plot the nominal effective exchange rates of US dollars and the Euro, respectively. Although the nominal effective yen exchange rate appreciated by about 20% from June 2015 to August 2016 in Figure 4, both the nominal effective US dollar in Figure 8 and the Euro exchange rate in Figure 9 were relatively stable for the period immediately before August 2016. This suggests that it was neither movement in US dollars nor the Euro that stopped the yen appreciation trend around August 2016.

Footnotes

* We would like to thank two anonymous referees for their useful comments, Shin-ichi Fukuda and Etsuro Shioji as the editors of this special issue for their careful guidance, and participants in a seminar held at Otemachi in Tokyo on May 18, 2018 for their stimulating discussion. We also thank Shin-ichi Kitasaka, Ryuzo Miyao, and Kazuhiko Nishina for their helpful insights on an earlier version of this paper, and the assistance of Yoshiko Matsuo and Kengo Nakayama in preparing the manuscript. The usual disclaimer applies. The original manuscript of this paper is Honda and Inoue(2017), which we have substantially revised.

1. See also Honda (2014) for details.
2. We take c to be a weighted average of the interest payments on reserves at the central bank and the return on the currency, which is zero.
3. This assumption is composed of two parts. The first is that the interest rate on foreign bonds is exogenous to investors. The second is that the expected rate of change in the exchange rate remains the same, or E[Δe/e] is constant, throughout the period. Alternatively, the time horizon in our model is the period over which the expected rate of change in the exchange rate is unchanged. Note also that the condition that E[Δe/e] is constant is equivalent to an assumption that the elasticity of the expected exchange rate at the end of the period with respect to the current exchange rate is one, or $(\frac{d\hat{e}}{de})(e/\hat{e}) = 1$, where $\hat{e}$ denotes the expected exchange rate at the end of the period.
4. There are at least three ways of eliminating or at least alleviating these side effects. First, facing the introduction of fees on deposits, depositors may not reduce the amount of deposits, but may instead increase risky investments in their portfolio choices, and thereby stimulate the real economy. Second, under a lower interest rate environment, some banks with relatively strong balance sheet positions might aggressively offer lower lending rates to gain new customers, even if they incur certain losses in the short run. Third, new financial agents could emerge and enter these financial markets. These include new nonbank and/or foreign financial firms that do not currently exist in Japanese financial markets.
5. Multiplied by four, these provide rough estimates of the annual growth rates.
6. Financial Statements Statistics of Corporations by Industry (April–June, 2016) from the Ministry of Finance covers only large corporations with capital exceeding 10 million yen.
7. See also Honda (2017) for a similar discussion of the effects of the NIRP in the Euro area.
8. This statistical result is robust to changes in the sample size. Varying the size of the first sample from three to 20 does not alter the result of the rejection of the null hypothesis of equal means at the 1% significance level.
9. There is a conundrum concerning the interpretation of the statistical data in the flow of funds accounts for the insurance and pension funds sector. While we observe a distinct difference in the mean before and after the introduction of the NIRP in January 2016 in the BOJ flow accounts data, as shown in Figure 7,

there is a much less marked difference in the corresponding stock accounts data. To solve this little mystery, recall that there was a sharp depreciation in the US dollar against the Japanese yen over the period from June 2015 until August 2016. With the US dollar depreciation, the value of dollar assets in stock accounts fell, and this obscured in the data the increase in the flow of foreign securities.

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Table 1

Real GDP growth rate and its components.

	2016 Q2		2016 Q3	
GDP	0.4		0.3	
Private Consumption	0.2	(0.1)	0.3	(0.2)
Private Residential Investment	3.3	(0.1)	2.4	(0.1)
Private Nonresidential Investment	1.3	(0.2)	–0.3	(–0.1)
Government Consumption	–1.1	(–0.2)	0.3	(0.0)
Public Investment	1.1	(0.1)	–0.7	(–0.0)
Exports of Goods and Services	–1.2	(–0.2)	2.1	(0.4)
Imports of Goods and Services	–1.0	(0.2)	–0.2	(0.0)

Notes: Underlying data are seasonally-adjusted quarterly series (percent changes from the previous quarter) released on February 13, 2017 by the Cabinet Office, Government of Japan. Figures in parentheses are contributions to changes in GDP.

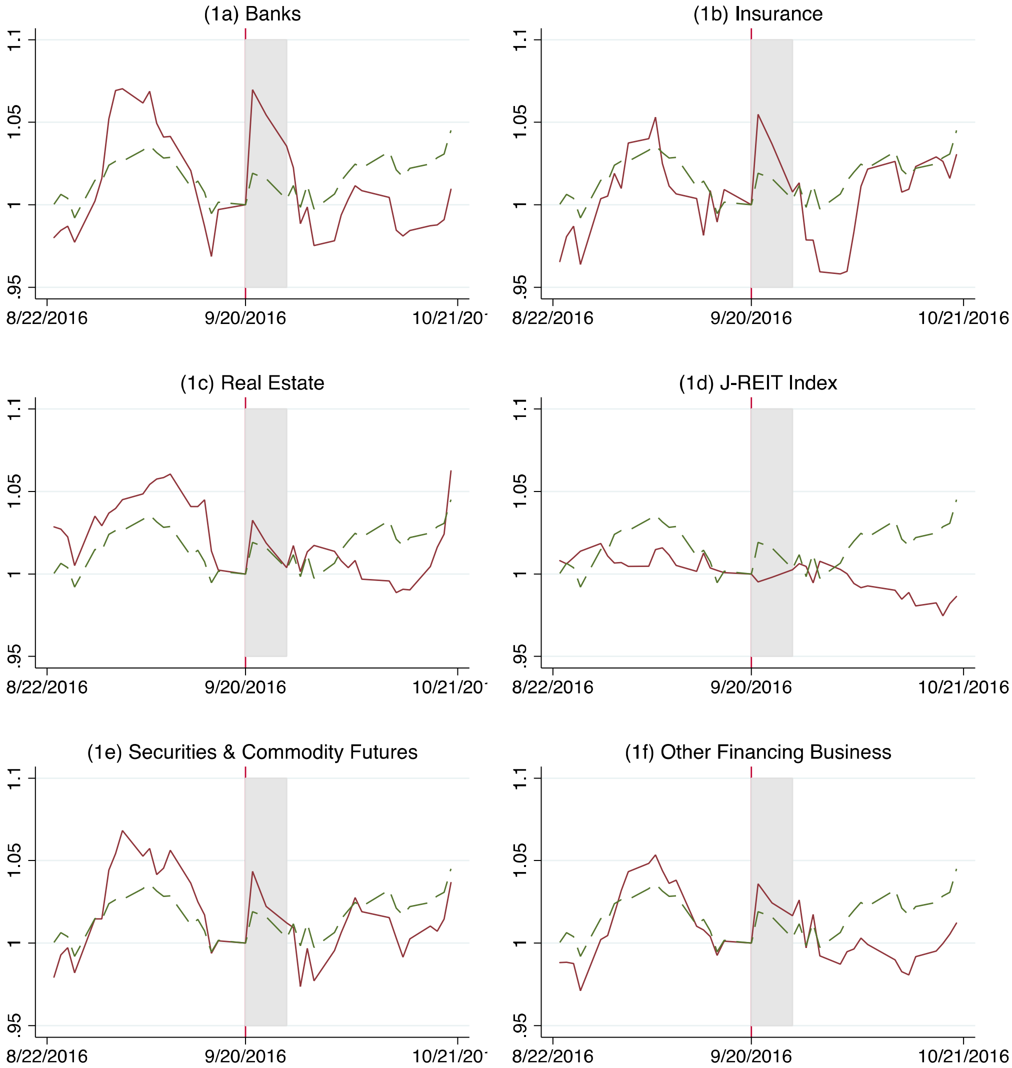
Figure 1

Impact of NIRP on the stock market.

Notes: All indexes standardized to one as of January 28, 2016 to correspond with a working day just before the announcement of the NIRP by the BOJ. Dashed lines denote the Nikkei Stock Average. Shaded areas indicate three working days from the policy announcement.

Fig. 2

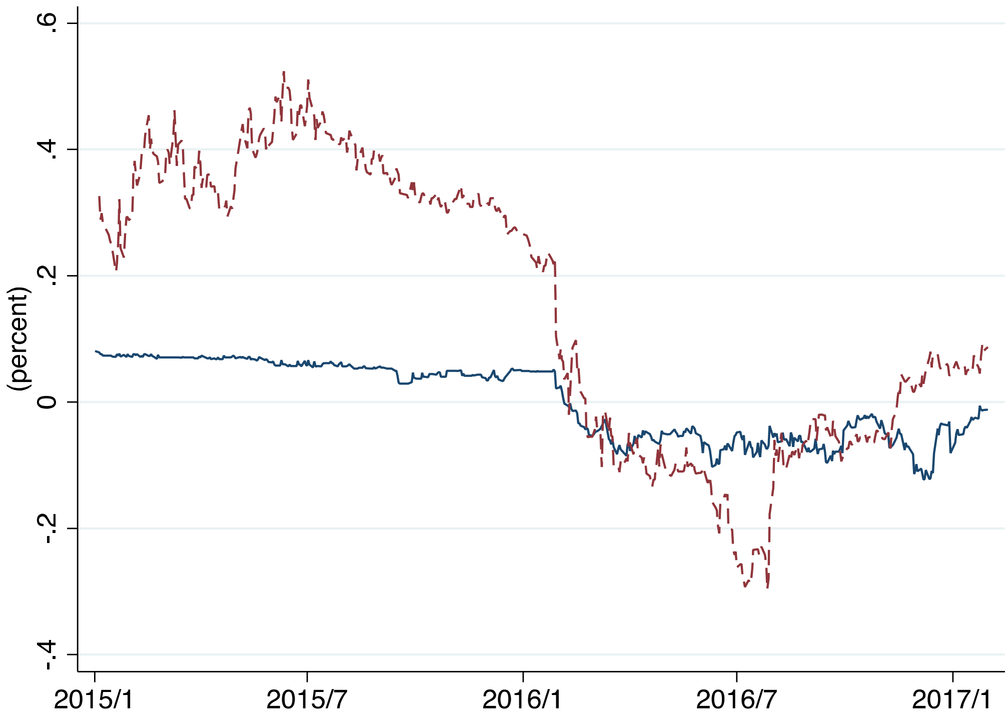
Impact of QQE with YCC on the stock market.



Notes: All indexes standardized to one as of September 20, 2016 to correspond with a working day just before the announcement of the QQE with YCC by the BOJ. Dashed lines denote the Nikkei Stock Average. Shaded areas indicate three working days from the policy announcement.

Fig. 3

Short- and long-term interest rates.



Notes: Solid line denotes the short-term interest rate (one-month LIBOR based on Japanese yen). Dashed line denotes the long-term interest rate (10-year Japanese government bond rate).

Fig. 4

Nominal effective yen exchange rate

Notes: The data source is the monthly series (2010 = 100) released on the BOJ website.

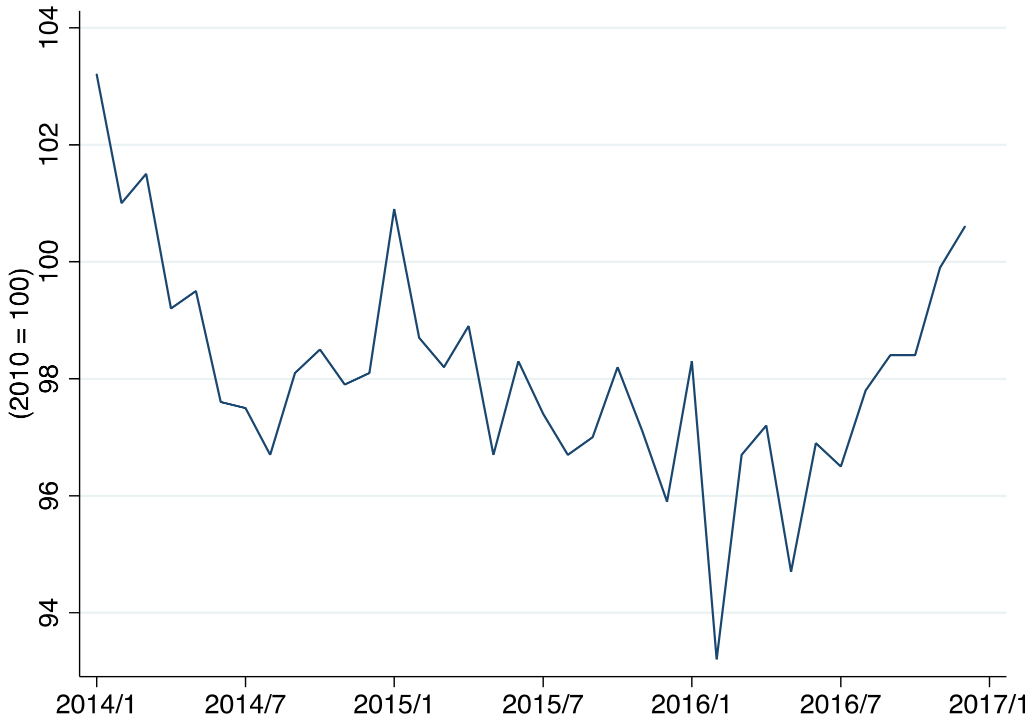
A higher value is associated with an appreciating yen.

Fig. 5

Tokyo Stock Price Index (TOPIX)

Fig. 6

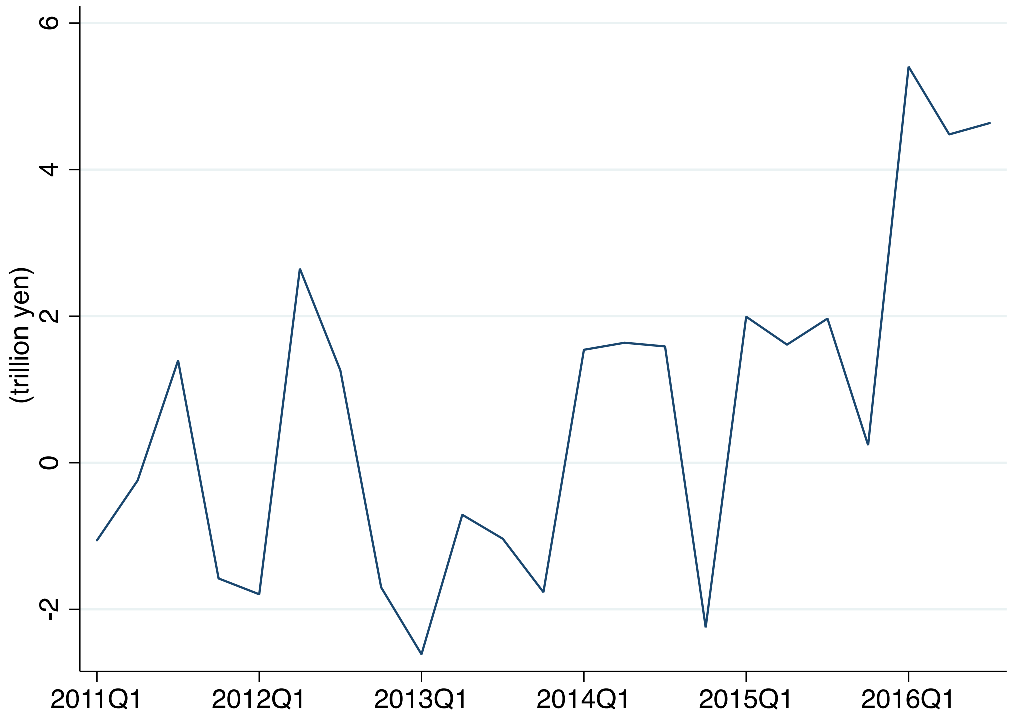
Index of industrial production



Notes: The data source is the seasonally-adjusted monthly series released on the Ministry of Economy, Trade and Industry website.

Fig. 7

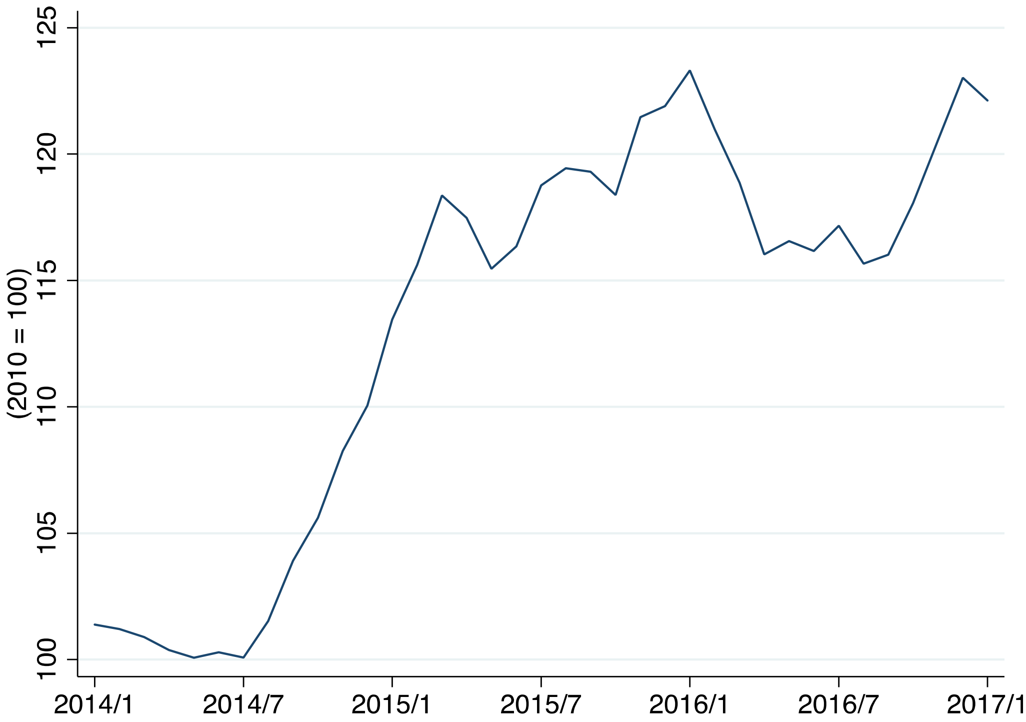
Flow of funds of foreign securities in the insurance and pension funds sector



Notes: Data source is “Outward investment in securities” by the “Insurance and pension funds” sector in the Flow of Funds Accounts compiled by the BOJ.

Fig. 8

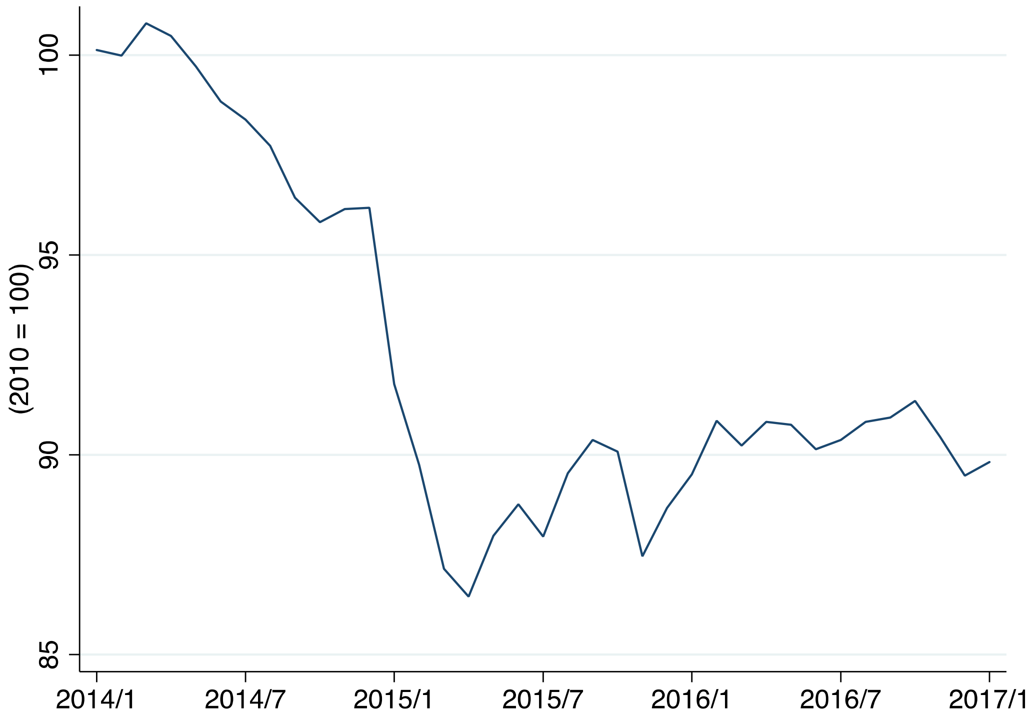
Nominal effective exchange rate of US dollar



Notes: The data source is the narrow index of nominal effective exchange rate for United States (2010 = 100) released by the Bank for International Settlements.

Fig. 9

Nominal effective exchange rate of Euro



Notes: The data source is the narrow index of nominal effective exchange rate for Euro area (2010 = 100) released by the Bank for International Settlements.