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Fiscal Cost to Exit Quantitative Easing: The Case of Japan

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Abstract

This paper simulates the cash flows and balance sheets of the Bank of Japan (BoJ) before and after exiting from Quantitative and Qualitative Monetary Easing (QQE) under various scenarios. The simulations show that the BoJ will record significant accounting losses after exiting QQE. These losses are fiscal costs for the consolidated Japanese government as they represent increased interest expenses to the public and will arise because the BoJ will acquire a large amount of Japanese government bonds at very low interest rates during QQE, whose interest payments will then be insufficient to cover interest expenses on excess reserves after exiting QQE. Moreover, any cumulative accounting losses will ensure the BoJ's net asset position remains negative for a sustained period of time. We also find that the BoJ's accounting losses will increase with the duration of QQE and the interest rate elasticity of banknote demand, and decrease if the BoJ conducts tapering following the ending of QQE. Finally, the effect of tapering will be significantly stronger if there is no safety channel for the long-term interest rate.

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Abstract

This paper simulates the cash flows and balance sheets of the Bank of Japan (BoJ) before and after exiting from Quantitative and Qualitative Monetary Easing (QQE) under various scenarios. The simulations show that the BoJ will record significant accounting losses after exiting QQE. These losses are fiscal costs for the consolidated Japanese government as they represent increased interest expenses to the public and will arise because the BoJ will acquire a large amount of Japanese government bonds at very low interest rates during QQE, whose interest payments will then be insufficient to cover interest expenses on excess reserves after exiting QQE. Moreover, any cumulative accounting losses will ensure the BoJ's net asset position remains negative for a sustained period of time. We also find that the BoJ's accounting losses will increase with the duration of QQE and the interest rate elasticity of banknote demand, and decrease if the BoJ conducts tapering following the ending of QQE. Finally, the effect of tapering will be significantly stronger if there is no safety channel for the long-term interest rate.

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1 Introduction

The Bank of Japan (BoJ) commenced its “Quantitative and Qualitative Monetary Easing” (QQE) policy in April 2013. The purpose of this policy was to achieve a two percent annual CPI inflation rate at the earliest possible time, with a time horizon of about two years. The BoJ has since increased the size of monthly asset purchases after October 2014. To achieve its target, the BoJ has more than doubled the monetary base and the holdings of Japanese government bonds (JGBs). [1]The BoJ has also doubled the average remaining maturity of JGB purchases in place before QQE.

The QQE remains ongoing. In April 2015, two years after the onset of QQE, the BoJ announced that it expected to achieve the two percent annual inflation target in the first half of fiscal year 2016; thus, it failed to achieve its target within the desired two-year period. Nonetheless, the BoJ has not currently made any announcement on a QQE exit strategy. For example, in June 2015, at the Standing Committee on Audit, House of Councilors, National Diet of Japan, BoJ Governor Haruhiko Kuroda said that it was too early to discuss an exit strategy as this would depend on economic and financial market conditions at the time of exit.

However, we should be cautious about the BoJ's exit strategy before exit because it currently holds about 250 trillion yen (50% of nominal GDP) in JGBs. If the BoJ begins monetary tightening, it could then incur a capital loss associated with the decline in the market price of its long-term bond holdings, as suggested by Goodfriend (2000) and simulated by Fujiki, Okina, and Shiratuka (2001). While the BoJ has adopted an amortized cost method for its accounting since 2004, such that a capital loss will not appear on its balance sheet, it will still need to maintain current account (reserve) balance at a high level as long as it holds long-term assets purchased during QQE until maturity. In this case, the BoJ will need to pay interest on excess reserves to control the policy rate. It is then possible that

[1]The monetary base increased from 138 trillion yen at the end of 2012 to 326 trillion yen as of July 2015. Over the same period, its JGB holdings increased from 89 trillion yen to 249 trillion yen.

the interest expenses on the excess reserves exceed the interest revenues from asset holdings, causing the BoJ's net profit after operating costs to become negative. The BoJ's payments to the Japanese government will then be zero, or even negative, if it receives government payments to cover any losses. However, such a situation is not envisioned in present BoJ law.

In theory, the central bank is only one of many government agencies, so its negative profit per se should not matter as long as the government and the central bank arrange a loss-sharing rule in advance, such that the central bank can conduct monetary policy without any balance sheet constraint. However, Ueda (2004), a then Policy Board member at the BoJ, points out that if the government can be committed to a rule against the central bank, then central bank independence should not be an issue. Ueda also raises a concern that if the central bank runs negative equity, then the government may intervene in the central bank's monetary policy decision making through capital injection to enforce myopic monetary easing. Indeed, given the fiscal debt currently outstanding in Japan (which the OECD estimates to be 233% of nominal GDP), there is the possibility that fiscal policy will then dominate monetary policy to maintain a low interest rate on government fiscal debt (Ikeo 2013; Okina 2015).

In the US, some existing studies examine the US Federal Reserve's balance sheet as motivated by its Large-Scale Asset Purchases program operating between 2008 and 2014. For example, Carpenter et al. (2015) and Greenlaw et al. (2013) simulate the Federal Reserve's net profit and net assets after exiting from quantitative easing (QE). In addition, other studies consider the effect of the Federal Reserve's net assets on price stability. For example, Del Negro and Sims (2014) argue that the central bank cannot guarantee price stability if the government is not committed to sharing losses with the central bank because the central bank may tolerate a high inflation rate simply to earn seigniorage. They show that this possibility leads to multiple equilibria because of self-fulfilling public expectations.

Likewise, Reis (2015) classifies three types of central bank insolvency (negative current profit; violation of the rule for the distribution of current profit; and intertemporal insolvency), none of which matters if the government can be committed to sharing losses with the central bank. However, Reis (2015) also argues that the inflation rate will depend on which type of insolvency is applied to the central bank as the central bank will adjust seigniorage to achieve the given condition for its solvency. Regarding a loss-sharing rule between the central bank and the government, Goodfriend (2014) proposes that the Federal Reserve should retain its profit before the exit from QE to build a loss-absorbing capital buffer for exit.

In this paper, we simulate the transition of the BoJ's balance sheet to analyze how QQE will account for accounting losses to the BoJ in the course of the exit from QQE. Our analysis largely draws on Carpenter et al.'s (2015) work in the US and also Iwata et al. (2014), which applied Carpenter et al.'s (2014) analysis to Japan for June 2014. Iwata et al. (2014) shows that QQE will cause accounting losses to the BoJ, even without the expansion of the BOJ's asset purchase program in October 2014. The contribution of our analysis is to simulate the transition of the BoJ's balance sheet under various scenarios to identify key determinants of its losses after exiting from QQE. We find that a longer duration of QQE and a higher interest rate elasticity of banknote demand will increase the BoJ's accounting losses. Thus, the BoJ should allow for an increased cost when extending the duration of QQE, and should not take banknote demand, currently about 17% of nominal GDP, under an effective zero interest rate for granted. Further, we find that if the BoJ does not cease, but instead tapers its asset purchase program after exiting QQE, its accounting losses will decrease as it will also earn profit through the term spread. This effect is significantly stronger if there is no safety channel, i.e., the effect of the bond supply on the long-term interest rate.

The remainder of the paper is organized as follows. Section 2 models the BoJ's balance sheet. Section 3 sets up the simulation, including a description of the data and the calibration of the parameters. We report the results of the benchmark simulation in Section 4 and conduct a sensitivity analysis in Section 5. Section 6 concludes the paper.

2 Model of the Bank of Japan's Accounts

We consider a simple model of the BoJ's balance sheet, consisting of the following items:

JGBs	Reserve balances held by financial institutions
Other assets	Reserve balances held by the government
	Banknotes
	Other liabilities
	Net assets

Here, reserve balances are current account balances at the BoJ. Other assets and liabilities comprise various items, including Treasury bills (T-bills), commercial paper and bonds, exchange-traded funds (ETFs), loans and bills discounted, foreign currency assets, and repos.

To focus on the effect of large-scale purchases of JGBs on the BoJ's balance sheet, we simplify the balance sheet by defining the difference between other assets and liabilities as "net short-term assets". This approach ignores the presence of long-term assets other than JGBs, such as ETFs, real estate investment funds (REITs), and stocks, which are included in "Other assets" on the BoJ's balance sheet, as described above. As at March 31, 2015, the total book value of these items is 7.5 trillion yen while the BoJ's JGB holdings sum to 220 trillion yen. If a significant capital gain arises for these assets, then the BoJ's cumulative accounting profit over time may increase up to a few trillion yen in total. As shown below, this figure is small compared to the simulated change in the BoJ's cumulative accounting profit. Thus, our simplifying assumption does not affect the main results of the model described below.

In addition, in the model, we ignore the reserve balances held by the government. For most of the 2000s, the government's reserve balances are between 1 and 3 % of those held by financial institutions at the end of each fiscal year. Thus, ignoring these balances also does not significantly affect the results of the model.[2]

Accordingly, we consider the following simplified BoJ's balance sheet:

JGBs (B_t)	Reserve balances held by financial institutions (D_t)
Net short-term assets (S_t)	Banknotes (C_t)
	Net assets (E_t)

The notation of each item in the table is in parentheses. The subscript t denotes the fiscal year. Each variable represents the value at the beginning of the fiscal year. Reserve balances held by financial institutions are split into required reserves ($D_{REQ,t}$) and excess reserves ($D_{EX,t}$):

$$D_{REQ,t} + D_{EX,t} = D_t. \tag{1}$$

2.1 Demand for banknotes and required reserves

The BoJ supplies required reserves and banknotes passively in response to the demands for bank deposits and cash from the public. We assume the demand for banknotes depends on nominal GDP and the nominal interest rate:

$$C_t = \mu_t GDP_t, \tag{2}$$

where GDP_t denotes annual nominal GDP, and μ_t is the banknotes-to-GDP ratio. Additionally, we assume a regime shift in μ_t to capture the response of the demand for banknotes to the interest rate.

$$\mu_t = \begin{cases} \bar{\mu} & \text{if } t \leq \tau, \\ \underline{\mu} & \text{if } t > \tau, \end{cases} \tag{3}$$

where τ denotes the fiscal year when the BoJ achieves the inflation target. As assumed below, the BoJ raises the policy rate after this year. This simple specification of the interest rate elasticity is sufficient for our simulations, as our scenario analysis does not consider detailed

[2]We confirm this result by running simulations under the assumption that the government's reserve balances are 1% of those held by financial institutions.

business-cycle fluctuations in the nominal GDP growth rate and the nominal interest rate after t hits τ.

We set a similar assumption for the demand for required reserves:

$$D_{REQ,t} = \gamma \eta_t GDP_t \tag{4}$$

where γ is the average reserve requirement ratio and η_t is the bank deposits-to-GDP ratio. For a similar reason to (3), there is a regime shift in η_t when t hits τ:

$$\eta_t = \begin{cases} \bar{\eta} & \text{if } t \leq \tau, \\ \underline{\eta} & \text{if } t > \tau. \end{cases} \tag{5}$$

2.2 Supply of excess reserves

The BoJ's flow of funds constraint determines the supply of excess reserves, given the BoJ's asset purchase policy on JGBs and net short-term assets. The BoJ's flow of funds constraint is written as

$$\begin{aligned} D_{t+1} - D_t = V_t - R_t - P_t + S_{t+1} - S_t - i_{ST,t} S_t + i_{CB,t} D_{EX,t} \\ + J_t + F_t + T_t - (C_{t+1} - C_t), \end{aligned} \tag{6}$$

where V_t is the purchase value of newly purchased JGBs, R_t is the coupon payments on JGBs, P_t is the redemption of JGBs held by the BoJ at maturity, $i_{ST,t}$ is the short-term nominal interest rate, $i_{CB,t}$ is the central bank deposit rate on excess reserves, J_t is the payment of profit to the government, F_t is general and administrative expenses and costs, such as personnel expenses, and T_t is the corporate and residential taxes incurred by the BoJ. Note that on the right-hand side of (6), the BoJ's expenditures have a positive sign while the revenues have a negative sign. This is because the increment in reserve balances on the left-hand side of (6) is the BoJ's cash flow, but with the opposite sign. The new issue of banknotes, $C_{t+1} - C_t$, appears as the last term on the right-hand side of (6) with a minus sign, as banks obtain new banknotes by withdrawing their reserve balance holdings.

We assume that the short-term interest rate is anchored by the interest rate on excess reserves set by the BoJ:

$$i_{CB,t} = i_{ST,t}. \tag{7}$$

We simply assume that general and administrative expenses and costs grow at the same rate as GDP:

$$F_t = \phi GDP_t. \tag{8}$$

2.3 Accounting profit and net assets

The BoJ transfers a fraction of its accounting profit to the government as J_t. The BoJ's pretax accounting profit, π_t, is defined as

$$\pi_t = R_t + A_t + i_{ST,t}S_t - i_{CB,t}D_{EX,t} - F_t, \tag{9}$$

where A_t is the amortization of the discount on JGBs under the amortized cost method. Accordingly, the book value of JGBs, B_t, is updated through this method:[3]

$$B_{t+1} - B_t = V_t - P_t + A_t. \tag{10}$$

For simplicity, we assume that the corporate and residential taxes incurred by the BoJ are proportional to positive pretax profit:

$$T_t = \kappa \max\{0, \pi_t\}. \tag{11}$$

Under the current rule, the BoJ pays out a fraction of its after-tax annual accounting profit to the government the following year, and retains the remainder as part of its net assets. Thus, the payment of profit to the government, J_t, is determined by the following rule:

$$J_t = \max\{0,\ \theta(1-\kappa)\pi_{t-1}\},$$

[3]The BoJ has adopted this method since 2004, under which the difference between the face value and purchase value of JGBs held to maturity is evenly split over maturity to compute the amortization of the discount for each year. The amortized discount is then gradually recognized as part of interest revenues each year and added to the book value of JGBs, so that the book value equals the face value at maturity.

where θ is the proportion of accounting profit to be transferred to the government. Here, we assume that the BoJ does not make any transfer if it incurs an accounting loss for the year.

The BoJ's net assets are simply the difference between the book value of its assets and its liabilities:

$$E_t = B_t + S_t - D_t - C_t. \tag{12}$$

Overall, (1)-(12) determine the transition of the BoJ's balance sheet and accounting profit, given the characteristics of the JGBs held by the BoJ (R_t and P_t), the BoJ's asset purchase policy (V_t and $S_{t+1} - S_t$), macroeconomic variables ($i_{ST,t}$ and GDP_t), and the timing of the exit from QQE (τ).

3 Simulation setup

Hereafter, we simulate the model by inserting data including the current BoJ's asset purchase policy under simple macroeconomic scenarios. This exercise aims to identify important factors that determine the cost to exit from QQE through quantitative sensitivity analysis under transparent assumptions. The starting month of the simulations is June 2015.

3.1 Timing of the exit from QQE

Currently, the BoJ is committed to achieving its inflation target in the first half of fiscal year 2016. Accordingly, we set τ to 2016 for a benchmark. This assumption implies that the BoJ achieves the inflation target at the end of fiscal year 2016 (or March 2017) in the model, given the annual frequency of the model.

3.2 BoJ's asset purchase policy before the exit from QQE

In October 2014, the BoJ announced an expansion of QQE, which aims to increase the reserve balances held by financial institutions by 80 trillion yen per year until it achieves this

Table 1: Benchmark assumption on the BoJ's monthly purchases of JGBs before the achievement of the inflation target

Maturity (years)	20	10	5	2	10 (Inflation-indexed)	15 (Floating-rate)
Purchase value (trillion yen)	1.625	2.7	2.55	2.55	0.01	0.07

inflation target. Thus, we assume

$$D_{t+1} - D_t = 80 \text{ trillion yen} \quad \text{if } t \leq \tau. \tag{13}$$

To achieve this goal, the BoJ is committed to purchasing JGBs worth between 8 and 12 trillion yen each month. It will set a range for the monthly purchase value of JGBs for each maturity (see Appendix A). Using the median value of this range, we assume the BoJ's monthly purchases of JGBs for $t \leq \tau$ as shown in Table 1. The figures in the table imply

$$V_t = 114.06 \text{ trillion yen} \quad \text{if } t \leq \tau, \tag{14}$$

which satisfies the range of total monthly purchase value of JGBs described above.

We assume that the terms for the purchases at each maturity, such as the price and the coupon rate, are the same as in the primary market at the end of May, 2015.[4] Under this assumption, the average maturity of newly purchased JGBs is around eight years, which is consistent with the BoJ's policy that sets the average remaining maturity to between seven and 10 years.

In this regard, an alternative assumption is to follow Carpenter et al. (2015) and use an estimated yield curve to calculate the price of discounted bonds for each maturity. We do not select this option as we obtain a negative yield for short maturities if we insert the recent

[4]There has been no new issuance of floating-rate JGBs since 2008. For this category, we assume the BoJ purchase these bonds at the same purchases terms as those most recently issued in the secondary market at the end of May, 2015. For simplicity, the remaining maturity for this category of bonds is set to seven years for any year of purchase.

ultra-low long-term rate in Japan, which is below 0.5%, into the estimated yield curve.[5]

Given the JGB purchase policy set by (14), the BoJ adjusts its net short-term assets to increase the reserve balances held by financial institutions by 80 trillion yen per year. Thus, (6) implies that

$$S_{t+1} - S_t = -V_t + R_t + P_t + i_{ST,t}S_t - i_{CB,t}D_{EX,t} - J_t - F_t - T_t \\ + C_{t+1} - C_t + D_{t+1} - D_t \quad \text{if } t \leq \tau \quad (15)$$

where $D_{t+1} - D_t$ and V_t are set by (13) and (14), respectively.

3.3 BoJ's asset purchase policy after the exit from QQE

We assume that after the exit from QQE, the BoJ holds JGBs until maturity and does not make any new purchases:

$$V_t = 0 \quad \text{if } t > \tau. \quad (16)$$

Following the BoJ's policy in regular time, we also assume that the BoJ purchases T-bills, part of net short-term assets in the model, using the revenues from any redeemed JGBs for one year.[6] After that, the BoJ receives reserve balances from the government for the repayment of T-bills. Thus, reserve balances at the end of fiscal year, D_{t+1}, decline through (6) as JGBs held by the BoJ gradually mature.

In addition, the BoJ's balance of net short-term assets at the exit from QQE is higher than the value of redeemed JGBs in the previous year. We assume that the BoJ maintains this excess balance after the exit from QQE, because otherwise the balance of net short-term assets becomes unrealistically close to zero as JGBs held by the BoJ mature over time.

If reserve balances become insufficient for required reserves, then the BoJ supplies the necessary amount by adjusting net short-term assets. Overall, the BoJ's adjustment of net

[5]This observation implies that there is nonlinearity in the effect of the long-term interest rate on the yield curve.

[6]As the government rolls over part of its redeemed JGBs, this policy aims to mitigate the imbalance between demand and supply in the JGB market by rolling over redeemed JGBs for a short period of time.

short-term assets is specified as

$$S_{t+1}-S_t=\begin{cases} P_t-P_{t-1} & \text{if } t>\tau \text{ and } D_{t+1}\geq D_{REQ,t+1}, \\ -V_t+R_t+P_t+i_{ST,t}S_t-i_{CB,t}D_{EX,t}-J_t & \\ \quad -F_t-T_t+C_{t+1}-C_t+D_{REQ,t+1}-D_t & \text{if } t>\tau \text{ and } D_{t+1}<D_{REQ,t+1} \\ & \text{under } S_{t+1}-S_t=P_t-P_{t-1}, \end{cases} \tag{17}$$

where the right-hand side of the second line is derived by substituting $D_{t+1}=D_{REQ,t+1}$ into (6).

3.4 Data on BoJ's JGB holdings and balance sheet

The coupon payments (R_t) and redemption (P_t) of JGBs depend on the past asset purchases by the BoJ. The BoJ publishes the face value of its JGBs for each issuance date. We combine these data with the coupon rate and the maturity for each issuance date published by the Ministry of Finance. The BoJ, however, does not publish the book value of its JGBs for each issuance date, but only the book value for each maturity (i.e., each of those listed in the first row of Table 1). To compute the book value for each issuance date, we divide the book value for each maturity proportionally to the face value of each issuance date with the same maturity.

For the initial value of the balance sheet items, we use the Bank of Japan Accounts as at the end of May 2015.

3.5 Benchmark scenario on the path of the inflation rate, the short-term interest rate, and the nominal GDP growth rate

For a benchmark, we assume that the annual inflation rate remains at 0% until the BoJ hits the inflation target (i.e., $t\leq\tau$) and stays at the targeted rate, 2%, after the achievement of the target (i.e., $t>\tau$). The short-term interest rate is set to 0.1% for $t\leq\tau$, which is the same as the current interest rate of excess reserves, assumed to rise to 1.25% at $t=T+1$ and then

2.75% for $t \geq T+2$. These figures are based on the spread between the geometric averages of the overnight call rate and the CPI inflation rate over the period 1990–2013, which was 0.78%. Here we use the Lost Decades in Japan for the sample period.[7] We assume that the BoJ takes two years to raise the short-term interest rate to its long-run level following the exit from QQE, given the negative effect of a sudden large increase in the policy rate. The nominal GDP growth rate is set to the inflation rate plus 0.3%, which is the spread between the geometric averages of the two rates over the period 1990–2013 (see Figure 1 for the time path of the macroeconomic variables in the benchmark scenario).

Even though this simple scenario ignores feedback from the BoJ's balance sheet to aggregate economic activity, it allows us to run simulations under a more transparent assumption. In this paper, we choose the latter benefit of considering a simple scenario based on past data, given the difficulty in precisely forecasting the long-term trend of GDP and other macroeconomic variables. In addition, we do not use survey forecasts or financial market data, such as the yield curve, to set the benchmark scenario, because these data reflect the average expectations over different contingencies, including the case in which QQE does not achieve its target. Instead, we take as given the spreads of the macroeconomic variables to the annual inflation rate to set the benchmark scenario assuming the achievement of the inflation target by QQE.

3.6 Calibration of the remaining parameters

For the demand for banknotes before the achievement of the inflation target, we set $\bar{\mu} = 0.174$, which is the banknotes-to-GDP ratio in 2013. Here, we use the most recent year for which the Annual Report on National Accounts is available because if we use a sample average, the difference between the last data point and the sample average will create an artificial jump in the BoJ's net assets. For the period after the achievement of the inflation target, we set $\underline{\mu} = 0.0797$. This value is the sample average of the banknotes-to-GDP ratio

[7] The sample period ends in 2013, as it is the most recent year in which confirmed GDP data are available.

over the 1990s, which is the most recent period before QE in Japan in the 2000s.

We set a similar assumption for the demand for required reserves. The bank deposits-to-GDP ratios before and after the achievement of the inflation target (i.e., $\bar{\eta}$ and $\underline{\eta}$) are set to 2.05 and 1.53, respectively. These values are derived from the same sample periods as those used to set $\bar{\mu}$ and $\underline{\mu}$. We set $\gamma = 0.00593$, which is the average reserve requirement ratio between 1992 and 2014, as there was a regulatory change in reserve requirement ratios in October 1991.[8] The ratio between the general and administrative expenses and costs and GDP, ϕ, is set to 0.000393, which makes F_t equal 190 billion yen in 2013, as observed in the data. The corporate income and residential tax rate on the BoJ's pretax profit, κ, is set to 0.275, which is the average rate over the fiscal years between 2012 and 2014. We use only the most recent three years as the corporate income tax rate changed in 2012. Finally, the proportion of the BoJ's after-tax accounting profit to be transferred to the government, θ, is set to 0.75, according to the current rule announced by the BoJ in May 2015.

4 Benchmark results

In this section, we summarize the result of the benchmark simulation. Figure 2 depicts the transition of the balance sheet items for the BoJ. As shown, reserve balances gradually decline as JGBs held by the BoJ mature over time. It takes around 20 years until the excess reserves due to QQE disappear.

Figure 3 displays the major components of the BoJ's accounting profit. As shown, the BoJ records accounting losses between 2017 and 2032. Accordingly, the payment of profit to the government becomes zero for this period. The maximum annual loss amounts to 6.19 trillion yen in 2018.

These losses arise because of maturity transformation on the BoJ's balance sheet. Be-

[8]The reserve requirement ratio differs across different categories of bank deposits. To set the value of γ, we compute the ratio between the sum of required reserves and the balance of bank deposits subject to reserve requirements for each fiscal year, and then take the average over the period 1992–2014.

cause the low rates of return on JGBs purchased during QQE are predetermined, the interest expenses surpass the interest revenues as the BoJ raises the interest rate on reserve balances to increase the short-term interest rate after QQE. These losses continue until reserve balances sufficiently decline with the gradual redemption of JGBs.

The fiscal cost of QQE for the consolidated government appears in the BoJ's accounting loss. Note that if there were no QQE, the consolidated government would pay interest to the public on JGBs purchased by the BoJ. Thus, the consolidated government incurs a loss from QQE when the interest expenses on reserve balances exceed the interest revenues from JGBs on the BoJ's balance sheet. A caveat is that this loss is the gross fiscal cost under a given path of the short-term interest rate. To measure the opportunity cost of QQE, we need to know the precise path of the macroeconomic variables in the instance of no QQE.

Figure 4 illustrates the transition of the BoJ's net assets. As shown, the accumulation of the accounting losses over 15 years results in an extended period of negative net assets for the BoJ. In the benchmark simulation, the BoJ recovers positive net assets in 2084 by gradually offsetting the accumulated loss with normal profit from the interest margin between net short-term assets and banknotes. Does the BoJ remain intertemporally solvent in the benchmark scenario? Following Del Negro and Sims (2014) and Reis (2015), we compute the BoJ's net worth, which takes into account the present discounted value of future pretax profit.[9] We use the short-term interest rate for the discount rate, as the BoJ's assets consist of net short-term assets in the long run.

Figure 5 depicts the time path of the BoJ's net worth. As shown, given a small spread between the short-term nominal interest rate and the nominal GDP growth rate in the benchmark scenario, the present discounted value of future profit is sufficiently large to offset the negative net assets from the cumulative losses arising after the exit from QQE.

[9]The BoJ's tax payments to the government are equivalent to the dividend payouts by a private company to its shareholders. Thus, we include pretax profit in the computation of the BoJ's net worth.

5 Sensitivity analysis

The benchmark simulation yields an estimate of the BoJ's future profit based on one of a number of possible scenarios, rather than a point estimate of the BoJ's future profit based on macroeconomic projections. In this section, we discuss the sensitivity of the simulation result to alternative scenarios concerning the BoJ's behavior and the macroeconomic environment.

5.1 Longer duration of QQE

Figure 6 shows the BoJ's balance sheet when QQE lasts until 2018 (i.e., $\tau = 2018$). In this case, the BoJ's JGB holdings reach 500 trillion yen at their peak to achieve the large amount of annual reserve supply targeted under QQE. As a result, the BoJ's accounting losses after the exit from QQE increase because of the larger amount of maturity transformation on the BoJ's balance sheet, as shown in Figure 7. Thus, the fiscal cost after the exit from QQE should be taken into account when the BoJ compares the cost and benefit of extending the duration of QQE.

5.2 Interest rate elasticity of banknote demand

In the benchmark scenario, we assume that the banknotes-to-GDP ratio falls to its 1990s level after the exit from QQE. This assumption aims to capture the elasticity of banknote demand when the BoJ raises the short-term interest rate following the achievement of QQE. This assumption is important for the BoJ's accounting profit after the exit from QQE, because the BoJ's profit in normal times stems from purchasing interest-bearing assets to supply banknotes. The amount of reserve balances is small relative to banknotes in normal times.

We consider three alternative scenarios for the interest rate elasticity of banknote demand. The first scenario is that the banknotes-to-GDP ratio remains the same before and after the exit from QQE (i.e., $\bar{\mu} = \underline{\mu} = 0.174$). Thus, in this scenario, banknote demand does not respond to an increase in the short-term interest rate.[10]

The second scenario uses the statistical estimation of the real banknote demand function. We consider two specifications:

$$\ln(RC_t) \ = a_0 + a_1 \ln(RGDP_t) + a_2(CALL_t) + \varepsilon_{1t}, \quad (18)$$

$$\ln(RC_t) \ = b_0 + b_1 \ln(RGDP_t) + b_2 \ln(CALL_t) + \varepsilon_{2t}, \quad (19)$$

where RC_t is real banknote demand, $RGDP_t$ is real GDP, and $CALL_t$ is the nominal overnight call rate. Using annual data between 1959 and 2013 for Japan, we find that the second specification includes cointegration with a structural break in 2004. Following Hayashi (2000), we estimate the cointegration coefficients for 1959–2003 using dynamic ordinary least squares (DOLS). The estimation results are $b_1 = 1.029$ ($s.e. = 0.43$) and $b_2 = -0.133$ ($s.e. = 0.010$).[11] As DOLS does not identify the constant term, we set $b_0 = -3.31$ so that the fitted value of (19) coincides with the data in 2003. Given this specification, Figure 8 depicts the comparison between the data and fitted nominal banknote demand based on the estimation of (19) over the period 1959–2003. In the second scenario, we assume that the structural break in the real banknote demand function occurs because of the effective zero-interest rate policy adopted by the BoJ. Thus, the nominal banknote demand after the exit from QQE is determined by (19) with the DOLS estimates of the coefficients.

The third scenario uses an estimate of the cash stash held in household savings. The BoJ issues bills in denominations of one, two, five and 10 thousand yen, of which the one and 10 thousand yen notes are most commonly used. Otani and Suzuki (2008) assume that people only use 10 thousand yen notes when they hoard cash for savings, and that the transaction demands for one and 10 thousand yen notes are proportional to each other. Under these assumptions, Otani and Suzuki estimate the cash stash using the excess balance

[10] Iwata et al. (2014) adopted this same assumption for their simulation of the BoJ's balance sheet before and after QQE.

[11] Static ordinary least squares (SOLS) estimates are similar to the DOLS estimates (see Appendix B for details).

of 10 thousand yen notes above the transaction demand for these notes, which is assumed to grow at the same rate as the outstanding balance of one thousand yen notes. They set 1995 as the base year in which they assume there is no cash stash in Japan.[12]

Figure 9 displays the ratio of the balances of one and 10 thousand yen notes with the nominal overnight call rate in Japan. As shown, this declines as the call rate falls in the late 1990s, and stabilizes when the call rate hits the zero lower bound. This figure is consistent with the assumption set by Otani and Suzuki. Using Otani and Suzuki's method, we estimate the cash stash to be about 35 trillion yen (see Figure 10). For the third scenario, we assume that only the cash stash disappears as the BoJ raises the short-term interest rate, while the transaction demand for banknotes remains unaffected. This assumption implies that the banknotes-to-GDP ratio drops to 0.099 at the time of the exit from QQE (i.e., $\underline{\mu} = 0.099$).

Figures 11 and 12 show the BoJ's accounting profit and net assets under the benchmark and the three alternative scenarios. These demonstrate that the demand for banknotes is a crucial factor in the determination of the BoJ's accounting profit and the duration in which the BoJ records negative net assets.

5.3 Tapering after the exit from QQE

In the benchmark simulation, we assume that the BoJ rolls over its JGB holdings for only one year by purchasing T-bills with the revenues from any redeemed JGBs. As an alternative scenario, we consider the case in which the BoJ decreases its new purchases of JGBs gradually over a certain period of years after the exit from QQE. In this case, the amount of newly purchased JGBs each year is set to decline linearly so that it becomes zero after the adjustment period. The average maturity of newly purchased JGBs after the exit from

[12]The so-called Jyu-sen problem occurred in Japan in 1995. Jyu-sen is the abbreviation of a nonbank mortgage loan lender. Japanese banks made real estate loans through Jyu-sens in the late 1980s, and the losses to Jyu-sens came to the surface in 1995. Thus, Otani and Suzuki (2008) aim to measure the cash stash associated with the Japanese public's concerns with the financial health of Japanese banks.

QQE is assumed to be 10 years.[13]

In this case, we need to set a path for the long-term nominal interest rate to compute the yield on JGBs purchased after the exit from QQE. Following Krishnamurthy and Vissing-Jorgensen (2011), we assume the existence of a safety channel such that

$$i_{LT,t} = i_{ST,t} + \min\left\{0.01, \quad 0.003 - 0.0031 \min\left\{0, \ \ln\left(\frac{B_t}{GDP_t}\right) - \ln(0.041)\right\}\right\}, \qquad (20)$$

where $i_{LT,t}$ denotes the long-term nominal interest rate. On the right-hand side, 0.01 is the long-run term spread, 0.003 is the term spread under QQE, -0.0031 is the supply elasticity of the long-term interest rate implied by Krishnamurthy and Vissing-Jorgensen's (2011) estimate of the safety channel in the US, and 0.041 is the ratio of the book value of JGBs held by the BoJ and nominal GDP in December 2014.[14] The value of the long-run term spread equals the spread between the geometric averages of the 10-year JGB yield and the overnight call rate over the period 1990–2013, which is before QQE. The value of the term spread under QQE is based on the fact that the 10-year JGB yield fluctuates around 0.3–0.5% after the expansion of JGB purchases in December 2014, while the overnight call rate was set to 0.1% by the interest rate on reserve balances. For the supply elasticity of the long-term interest rate, we use Krishnamurthy and Vissing-Jorgensen's US estimate, as there is no comparable analysis using Japanese data.[15]

Under (20), the long-term interest rate gradually increases to the long-run level after the BoJ's JGB holdings-to-GDP ratio becomes smaller than the level before December 2014.

[13]More precisely, the outstanding balance of newly purchased JGBs follows a simple process such that

$$NB_{t+1} = V_t + 0.9NB_t,$$

where NB_t is the outstanding principal of JGBs purchased after the end of QQE at the beginning of fiscal year t and V_t is the amount of newly purchased JGBs in fiscal year t.

[14]The value of nominal GDP used here is the preliminary quarterly estimate for fiscal year 2014.

[15]Strictly speaking, Krishnamurthy and Vissing-Jorgensen (2011) compute the 10-year equivalent supply of Treasury bonds by using the remaining maturity of each issue of Treasury bonds as a weight. However, they also report that the simple sum of the market values of Treasury bonds is highly correlated with the 10-year equivalent supply of Treasury bonds. Given no public data on the market value of JGBs held by the BoJ, we use the book value of JGBs in (20).

We set this assumption because the long-term interest rate did not show a downward trend in 2015, despite continuing large-scale JGB purchases each month (see Figure 13). For simplicity, we set no coupon on JGBs purchased after the exit from QQE, and assume that the average yield on these JGBs equals the long-term nominal interest rate, $i_{LT,t}$.

Figure 14 shows the BoJ's balance sheet when the adjustment period for the BoJ's JGB purchases after the exit from QQE is set at 10 years. Because of the continuation of new purchases of JGBs, the BoJ's JGB holdings peak in around 2020.

Figure 15 compares the BoJ's pretax profit between the benchmark and alternative scenarios with adjustment periods of 10 and 20 years. As shown, tapering shortens the period in which the BoJ runs accounting losses. This is because the BoJ can profit from the term spread after the exit from QQE, as shown in Figure 16. Figure 17 illustrates that as a result, the duration of negative net assets is also shortened if the BoJ gradually adjusts its new purchase of JGBs after the exit from QQE.

The safety channel plays an important role in determining the effect of tapering. Figure 18 and Figure 19 compare the BoJ's pretax profit and net assets with and without the safety channel, given that the adjustment period for the BoJ's JGB purchases is set at 10 years. In the case of no safety channel, assume that the term spread immediately jumps to the long-run level (i.e., $i_{LT,t} = i_{ST,t} + 0.01$) after the exit from QQE. Figure 20 depicts the long-term interest rate in the two cases. These figures demonstrate that if the term spread returns to its pre-QQE level immediately after the exit from QQE, then the BoJ will earn significant profit from the term spread through continuing purchases of JGBs. As a result, the BoJ will record negative net assets only for a short period of time. Thus, tapering saves more fiscal cost for the consolidated government as the safety channel is less significant.

6 Conclusion

We simulated the BoJ's cash flows and balance sheet before and after the exit from QQE under various scenarios. The simulations show that the BoJ will record significant accounting losses after the exit from QQE. These losses are fiscal costs for the consolidated government, as they represent increased interest expenses to the public from the replacement of JGBs with reserve balances as a result of QQE. In addition, these cumulative accounting losses will make the BoJ's net assets negative for a sustained period of time, possibly more than 50 years. Even though the BoJ's net assets per se do not matter for the consolidated government, the BoJ and the Ministry of Finance should prepare a loss-sharing rule so that the BoJ's accounting losses do not impose a financial constraint on the BoJ or bias the BoJ's monetary policy decisions, as argued by Del Negro and Sims (2014). Loss sharing is not currently envisioned in BoJ law.

We also found that a longer duration of QQE and a higher interest rate elasticity of banknote demand increase the BoJ's accounting losses significantly. Thus, the BoJ should consider the consequences on fiscal cost when deciding the duration of QQE, and also should not take as given current banknote demand under an effective zero interest rate. Finally, the simulation results suggest that tapering after the exit from QQE mitigates the BoJ's accounting losses, and hence the fiscal cost of QQE for the consolidated government, as it generates profit from the term spread. This effect is significantly stronger if there is no safety channel for the long-term interest rate.

A caveat is that we consider only simple macroeconomic scenarios to run simulations under transparent assumptions. Thus, the simulation results in this paper should be taken as ballpark figures of the BoJ's future profit based on one of a number of possible scenarios, rather than a point estimate of the BoJ's future profit based on macroeconomic projections. It would be a significant challenge to predict the trend of macroeconomic variables after the exit from QQE. It would also be difficult to model the feedback between the BoJ's accounting losses and these macroeconomic variables. These issues are left for future research.

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Appendices

A BoJ's JGB purchase policy under QQE

In October 2014, the BoJ announced an expansion of QQE, which aimed to increase the reserve balances held by financial institutions by 80 trillion yen per year. In December 2014, it set a new JGB purchase policy such that it purchases JGBs worth between eight and 12 trillion yen in purchase value per month. The BoJ's policy on the approximate range of the monthly purchase value for each type of JGBs is shown in Table 2. The average remaining maturity of the purchased JGBs under this policy is set to be between seven and 10 years.

Table 2: Monthly purchase value of JGBs under QQE

Bond type	Remaining maturity	Approximate range of the purchase value of JGBs per month (billion yen)
Coupon-bearing bonds	$<$ 1 year	100-300
	1–5 years	3000-7200
	5–10 years	1800-3600
	$>$ 10 years	1250-2000
Floating-rate bonds		1400 (bimonthly)
Inflation-indexed bonds		200 (bimonthly)

The monthly purchase value for each maturity of JGBs in the model, i.e., the figure in Table 1, equals the median value of the following range in Table 2: two- and five-year bonds fall into the second row; 10-year bonds fall into the third row; and 20-year bonds fall into the fourth row. For two- and five-year bonds, we split into half the median value of the range shown in the second row of Table 2. The figures in Table 1 imply that the average maturity of newly purchased JGBs before the exit from QQE is 8.2 years. Thus, the BoJ's JGB purchase policy in the model satisfies actual policy on the average remaining maturity of purchased JGBs, i.e., between seven and 10 years.

B Estimation of the real banknote demand function

In the literature, Nakashima and Saito (2012) and Miyao (2002, 2005) analyze the interest rate elasticity of M1 (the sum of banknotes and demand deposits) in Japan by specifying real M1 as the dependent variable in (18) and (19), respectively. In addition, while Miyao (2002, 2005) set the income elasticity of M1, b_1, to zero, Fujiki and Watanabe (2004) use cross-sectional data across Japanese prefectures to set the value of b_1. In our analysis, we follow this literature to estimate the real banknotes demand in Japan.

For the estimation of (18) and (19), we use the following data for 1959–2013:

- C_t: the annual average balance of banknotes for each fiscal year.
- $NGDP_t$: GDP deflator for each fiscal year; 1993SNA data for 1993–2013 extended with the annual growth rates in 1968SNA data for 1959–1992.
- $Call_t$: the annual average overnight call rate; the collateralized rate until 1984 and the uncollateralized rate from 1985.

In the sample period, 2013 is the most recent year in which data on GDP in the Annual Report on National Accounts is available, and 1959 is the first year in which the call rate data exist. We define the real balance of banknotes and the real GDP by

$$RC_t = \frac{C_t}{PGDP_t}, \tag{21}$$

$$RGDP_t = \frac{NGDP_t}{PGDP_t}, \tag{22}$$

respectively.

We first conduct an augmented Dickey–Fuller (ADF) test and find that we cannot reject the null hypothesis of a unit root with a time trend, except for $CALL_t$ (see Table 3). For $CALL_t$, we cannot reject the null hypothesis of a unit root based on Elliott, Rothenberg and Stock (1996). (The test statistics is -1.762, and the 10% level critical value is -2.748.)

Table 3: ADF test on the components of the real banknote demand function

	ADF statistics	P-value	Lag	Time trend
$\ln(RC_t)$	-2.873	0.1713	1	Exist
$\ln(RGDP_t)$	-2.526	0.3151	1	Exist
$CALL_t$	-4.391	0.0023	3	Exist
$\ln(CALL_t)$	-2.448	0.3543	1	Exist

Notes: The sample period is the fiscal years between 1959 and 2013. We use the dfuller command in Stata 13.

Table 4: Engel–Granger test on cointegration

	Test statistics	Critical value		
		1%	5%	10%
Eq. (18)	-1.992	-4.572	-3.903	-3.569
Eq. (19)	-1.452	-4.572	-3.903	-3.569

Notes: The sample period is the fiscal years between 1959 and 2013. We use the egranger command in Stata 13.

Next, we conduct the Engel–Granger test and find that we cannot reject the null hypothesis of no cointegration among the variables appearing in each of (18) and (19) (see Table 4).

Given this result, we test a structural break in cointegration using Gregory and Hansen's (1996) test. In this test, the null hypothesis is no cointegration, and the alternative hypothesis is cointegration with a structural break. While we cannot reject the null hypothesis for (18), we find that there is a structural break in 2004 according to the ADF and Z_t statistics (see Table 5).

Given a cointegration relationship for (19) over the period 1959–2003, we estimate the cointegration coefficients using SOLS and DOLS, following Hayashi (2000) (see Table 6). The estimation result for DOLS does not change significantly, even if we set the number of lags to one year.

Table 5: Gregory and Hansen's (1996) test for a structural break in cointegration

	Test statistics for each function		Critical value		
	Eq. (18)	Eq. (19)	1%	5%	10%
ADF	-4.02 (2003)	-5.59 (2004)	-5.44	-4.92	-4.69
Z_t	-4.42 (2003)	-5.64 (2004)	-5.44	-4.92	-4.69
Z_α	-29.08 (1999)	-40.92 (2004)	-57.01	-46.98	-42.49

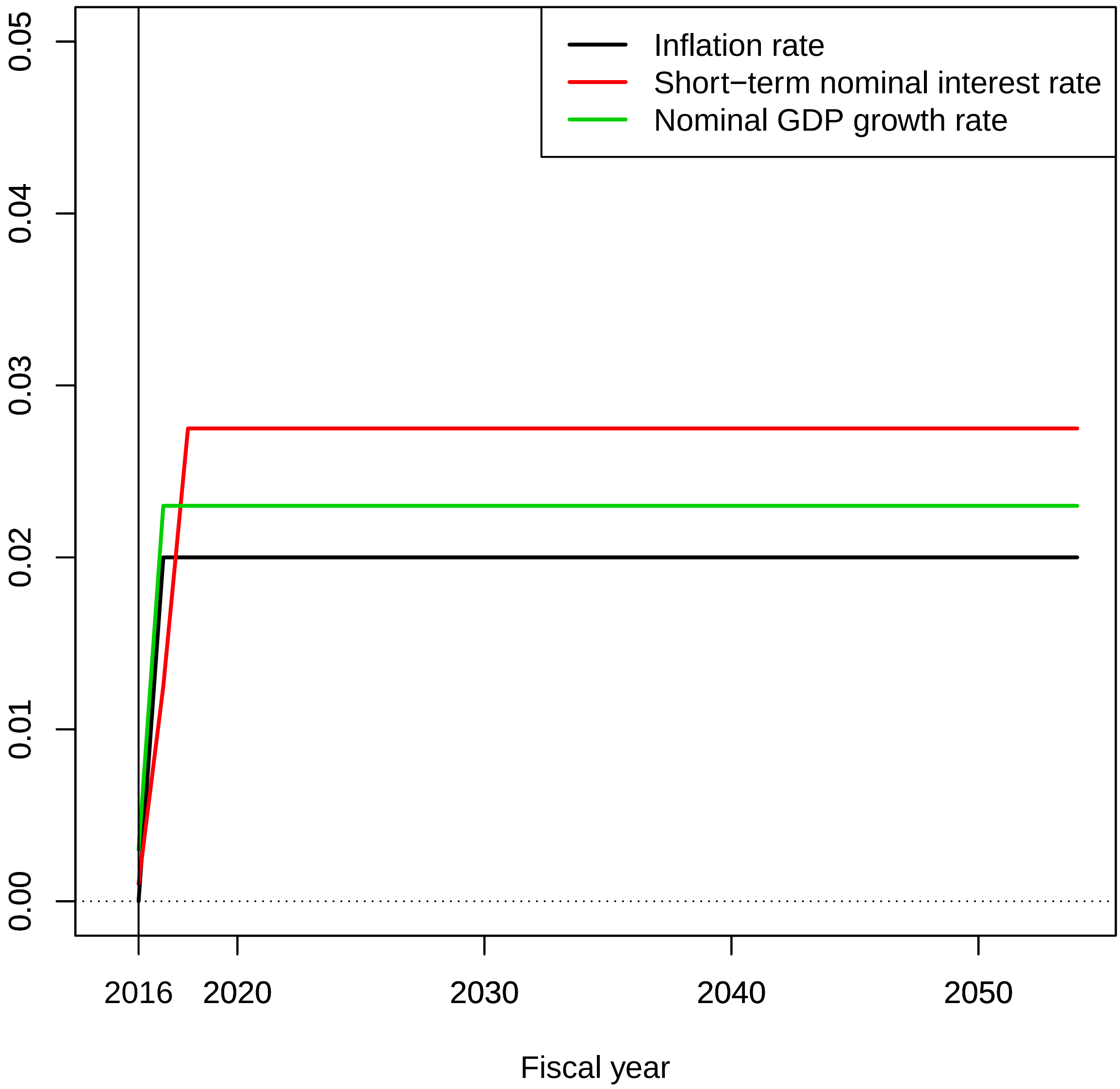
Notes: The sample period is the fiscal years between 1959 and 2013. We use the ghansen command in Stata 13. Each set of parentheses in the second and third columns provide the year of a structural break.

Table 6: Estimation of cointegration coefficients in Eq. (19)

	b_1	b_2
SOLS	1.121	-.090
DOLS	1.029	-.133
(s.e.)	(.043)	(.010)

Notes: The sample period is the fiscal years between 1959 and 2013. We use the ivreg2 command in Stata 13. The last row shows the standard errors of the coefficients estimated by DOLS. The number of lags for DOLS is set to two years.

Figure 1: Benchmark scenario on the path of the inflation rate, the short-term nominal interest rate, and the nominal GDP growth rate



Note: The interest rate on reserve balances is the same as the short-term interest rate.

Figure 2: Balance sheet items of the BoJ in the benchmark scenario

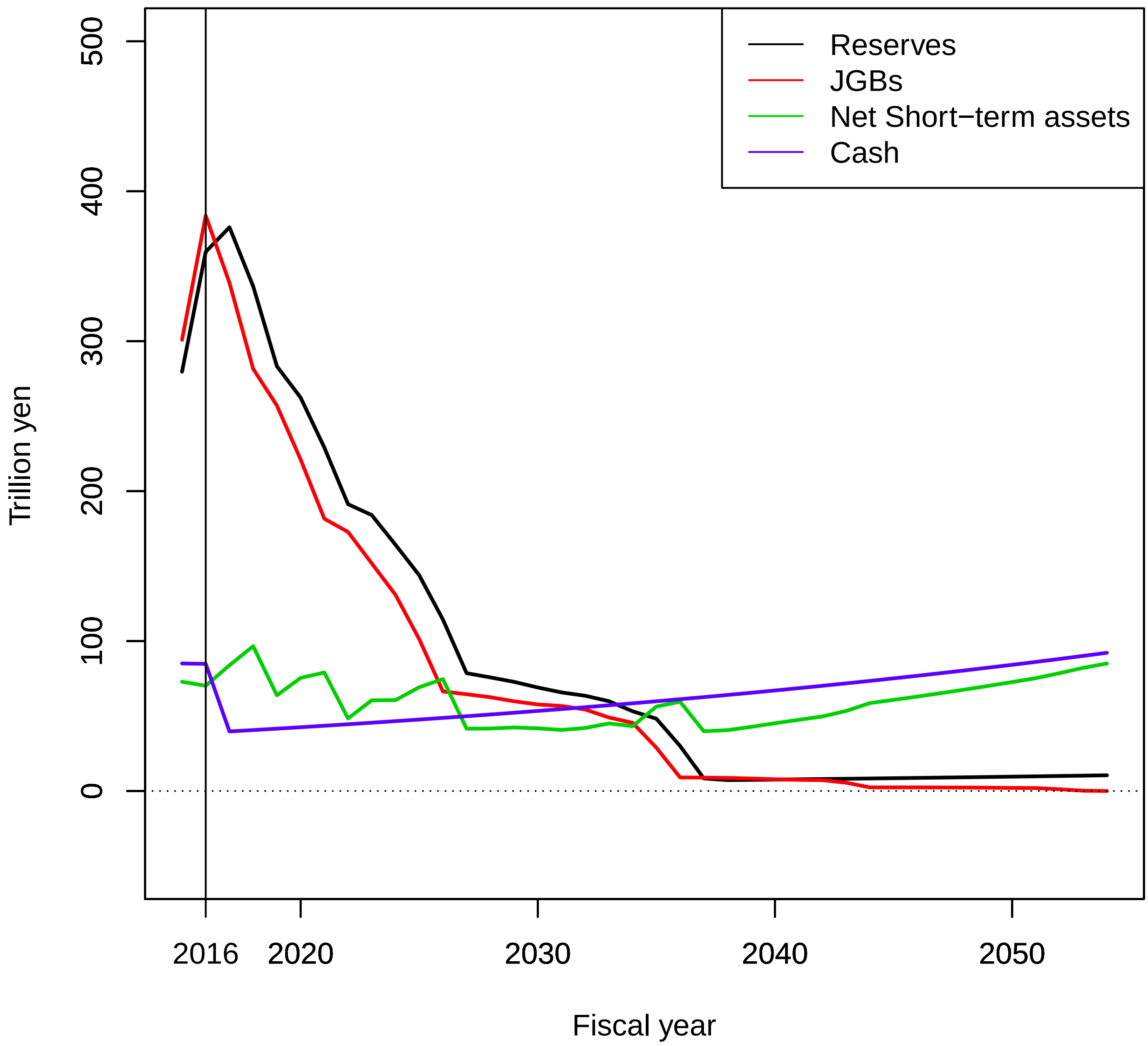
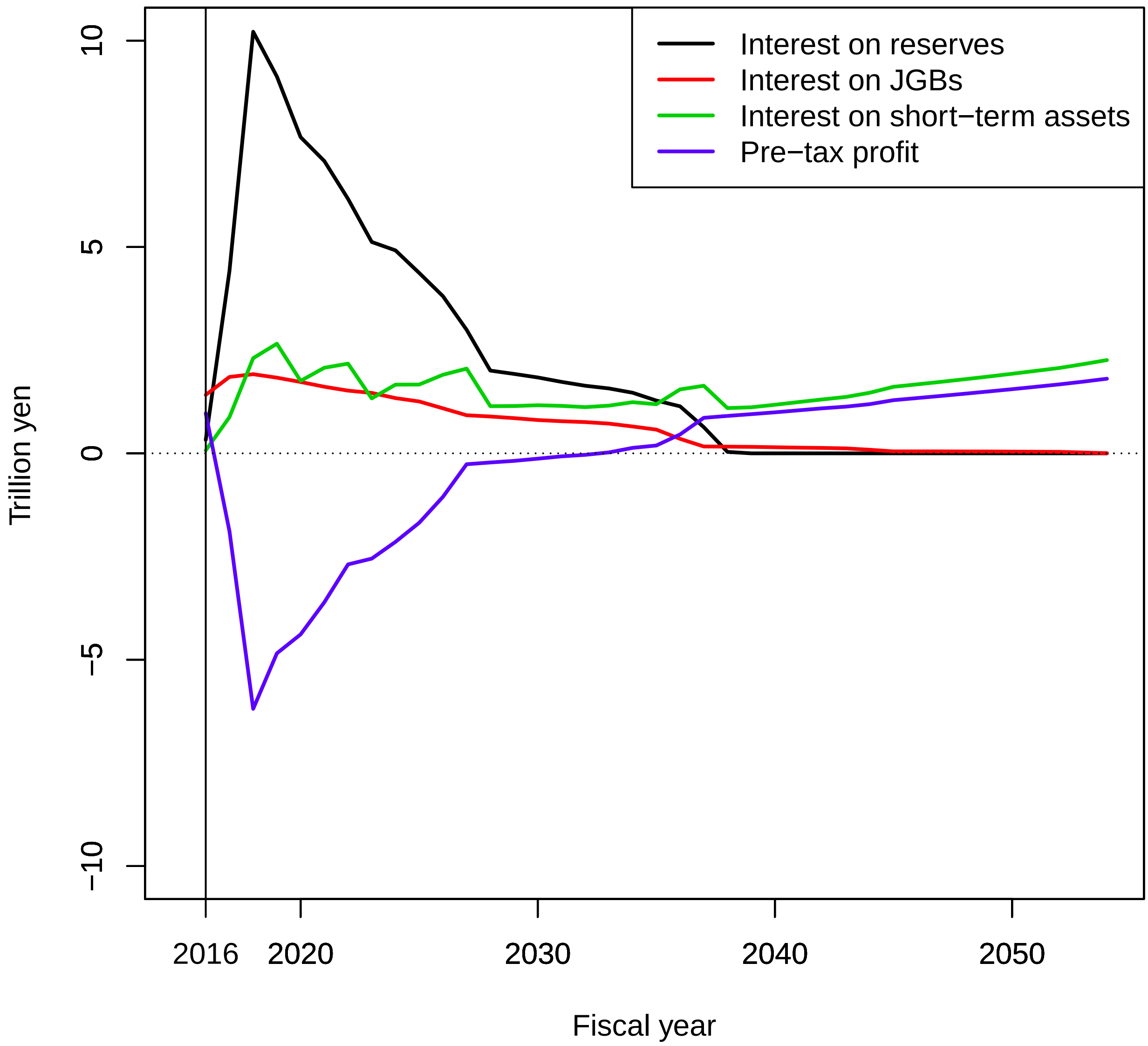


Figure 3: Major components of the BoJ's accounting profit in the benchmark scenario



Note: "Interest rate on JGBs" includes the amortization of the discount under the amortized cost method in each year.

Figure 4: BoJ's net assets in the benchmark scenario

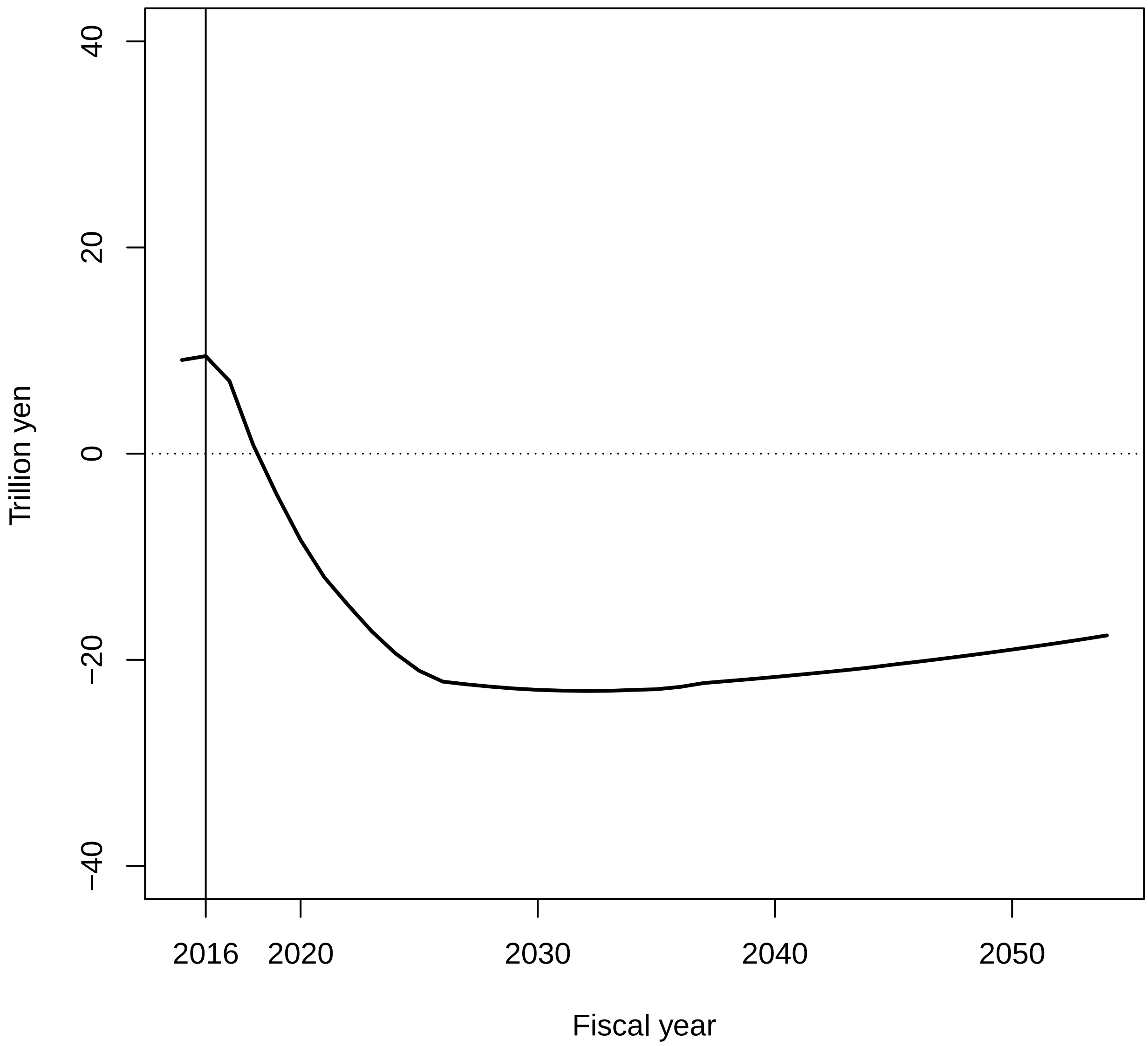
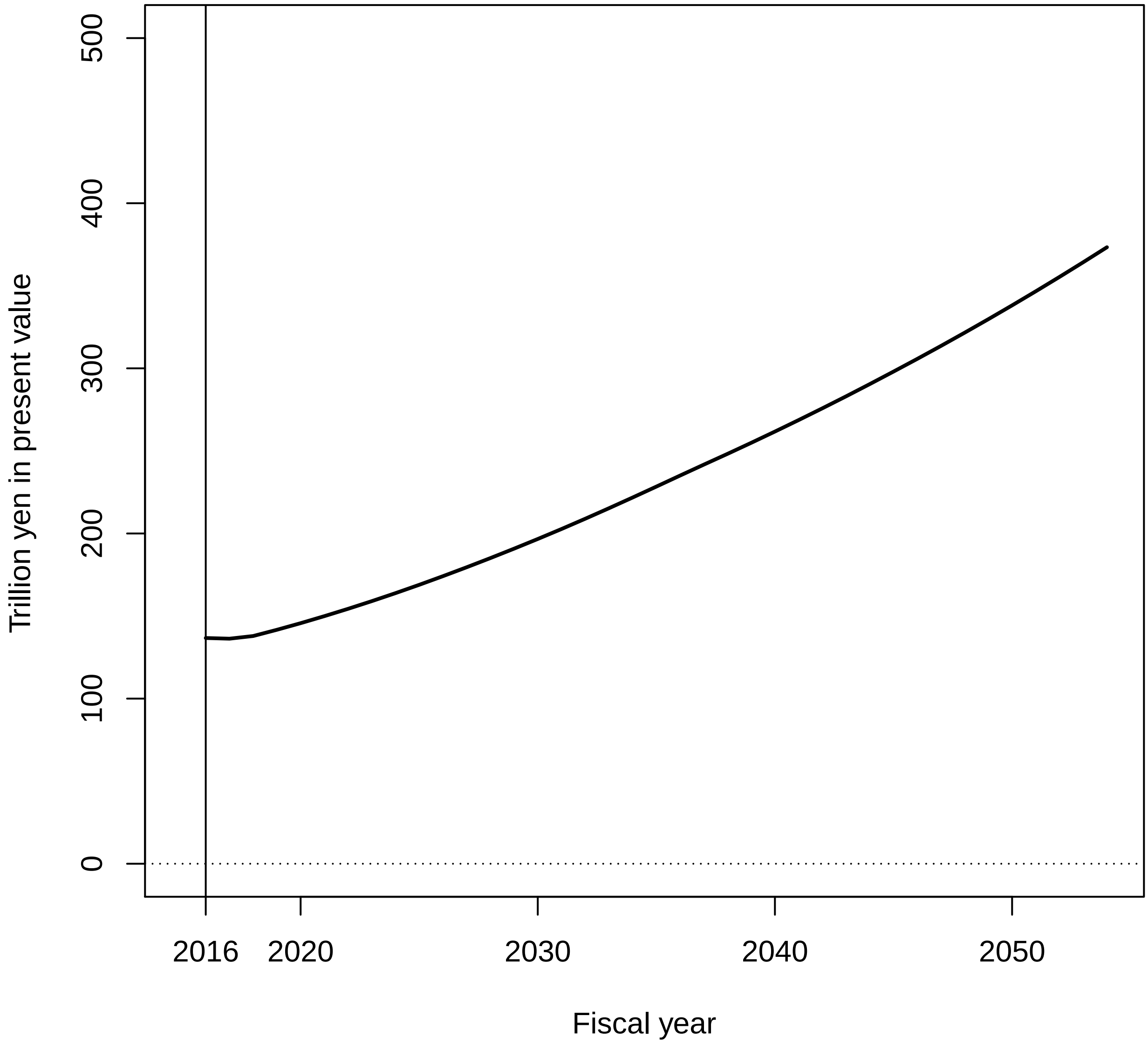


Figure 5: BoJ's net worth in the benchmark scenario



Notes: The BoJ's net worth is the sum of net assets recorded on the Bank of Japan Accounts and the present discounted value of future pretax profit, including losses. The discount rate for future pretax profit is the short-term nominal interest rate.

Figure 6: BoJ's balance sheet when QQE lasts until 2018

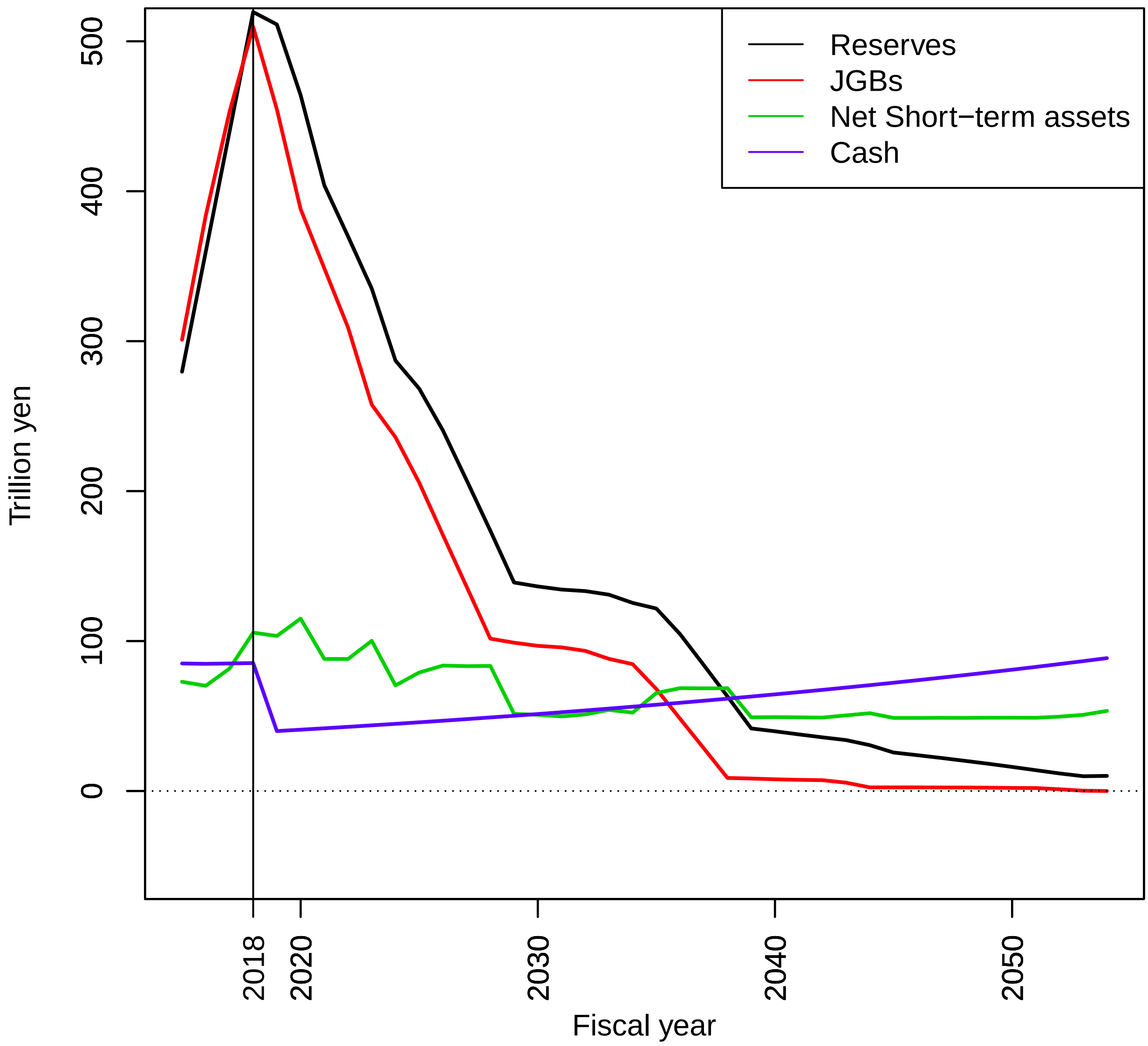
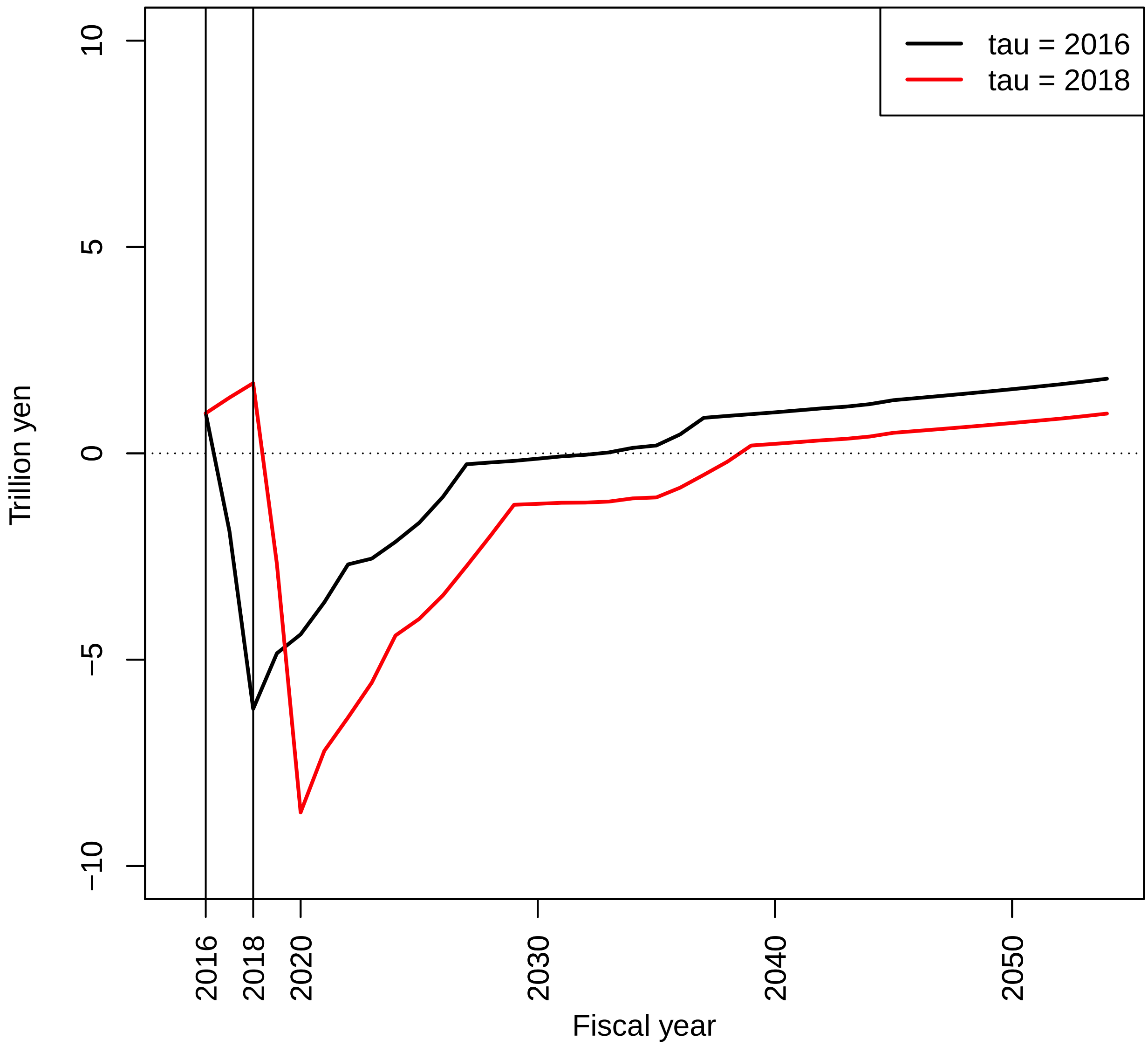
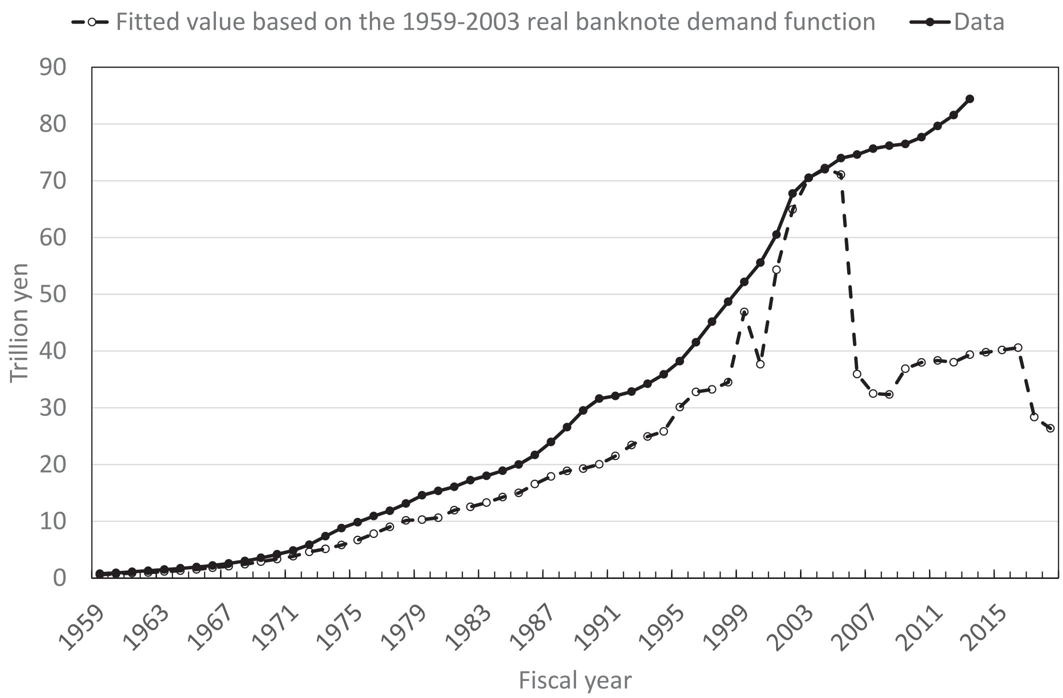


Figure 7: Sensitivity of BoJ's pretax profit to the duration of QQE



Notes: The solid line is the benchmark; the dotted line is where the BoJ achieves the inflation target in 2018.

Figure 8: Banknote demand based on the pre-2004 cointegration relationship



Notes: Shown until 2013 due to the availability of GDP data. "The fitted value" is derived from the estimation of (19). The fitted value after 2013 is the benchmark scenario for the short-term nominal interest rate and the real GDP growth rate.

Figure 9: Ratio of 10,000 and 1,000 yen notes in circulation

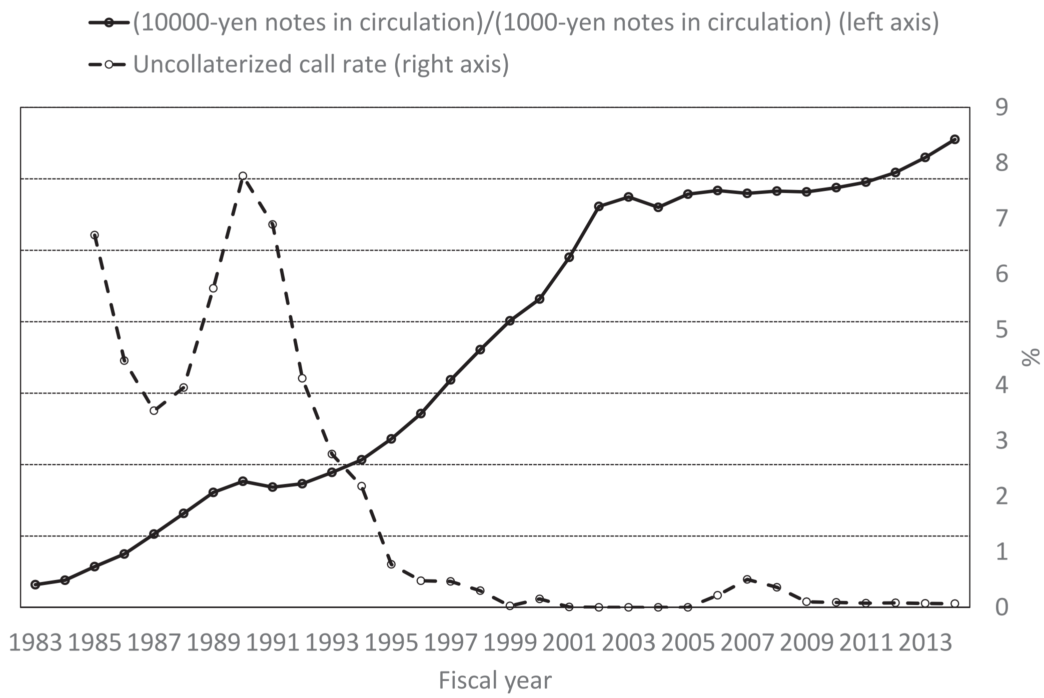
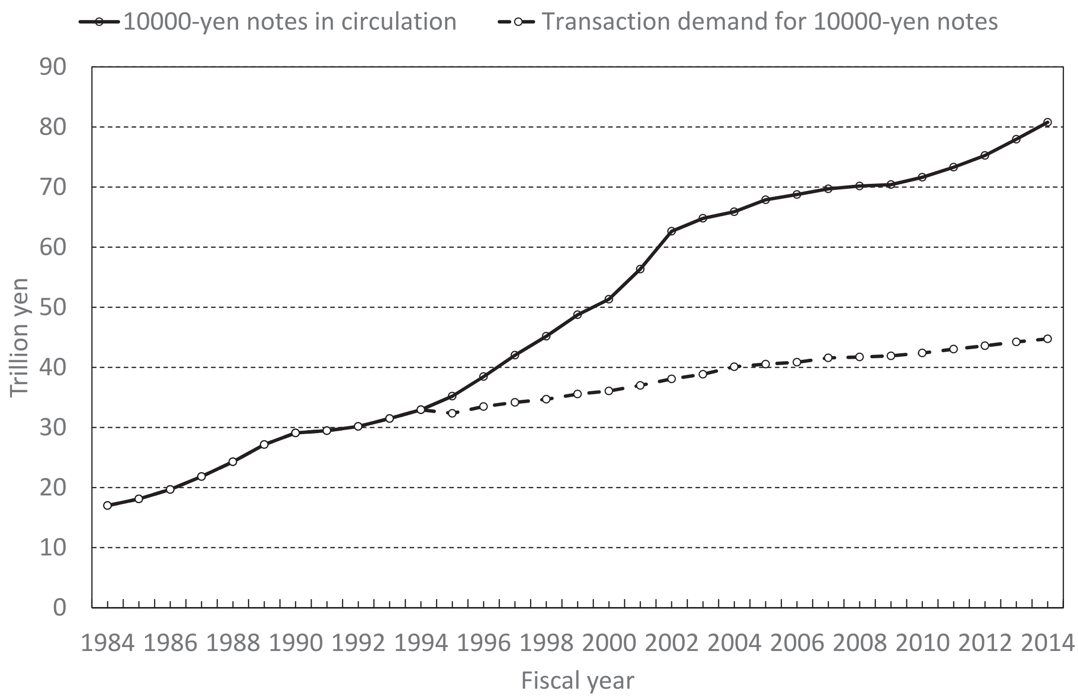
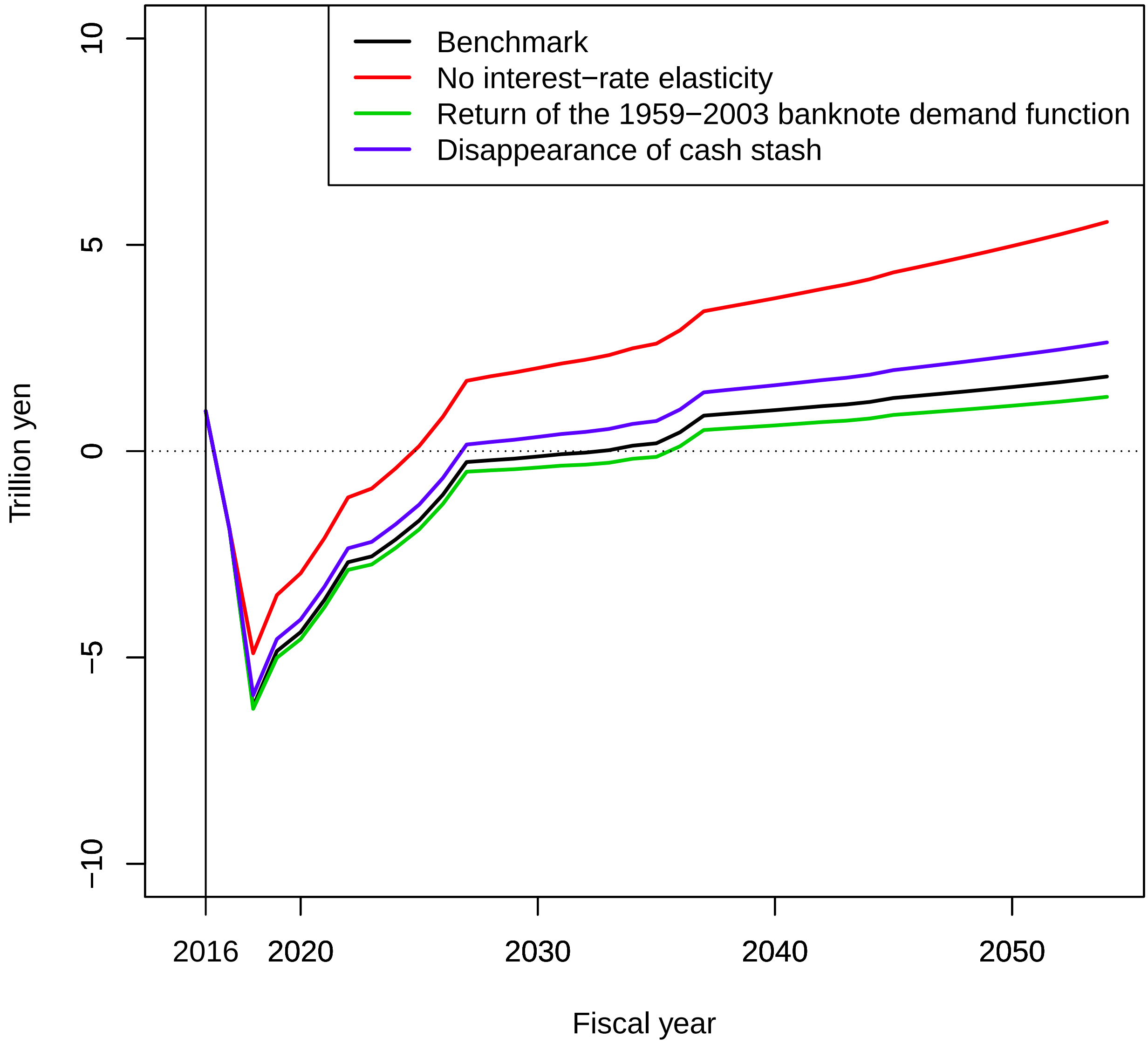


Figure 10: 10,000 yen notes in circulation and transaction demand for 10,000 yen notes



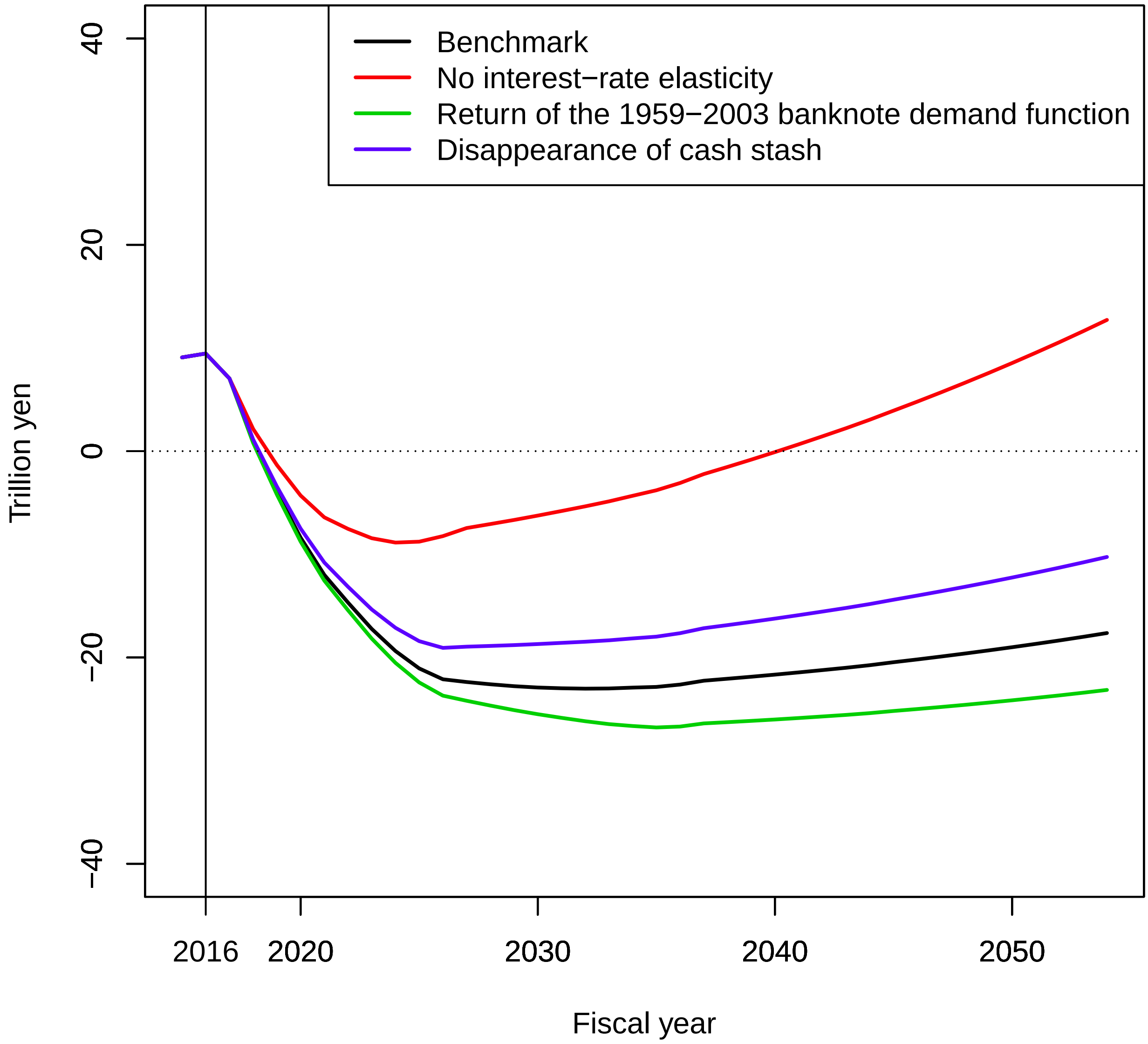
Note: "Transaction demand for 10000 yen notes" is the hypothetical balance of 10,000 yen notes that grows at the same rate as 1,000 yen notes in circulation from 1995.

Figure 11: Sensitivity of BoJ's pretax profit to interest rate elasticity of banknote demand



Notes: The black line is the benchmark; the red line is where the banknotes-to-GDP ratio (μ_t) remains the same before and after the exit from QQE; the green line is where the real banknote demand takes its pre-2004 form after the exit from QQE; and the blue line is where the nontransaction demand for 10,000 yen banknotes disappears immediately after the BoJ raises the short-term interest rate after the exit from QQE.

Figure 12: Sensitivity of BoJ's net assets to the interest rate elasticity of banknote demand



Notes: The black line is the benchmark; the red line is where the banknotes-to-GDP ratio (μ_t) remains the same before and after the exit from QQE; the green line is where the real banknote demand takes its pre-2004 form after the exit from QQE; and the blue line is where the nontransaction demand for 10,000 yen banknotes disappears immediately after the BoJ raises the short-term interest rate after the exit from QQE.

Figure 13: Term spread in Japan

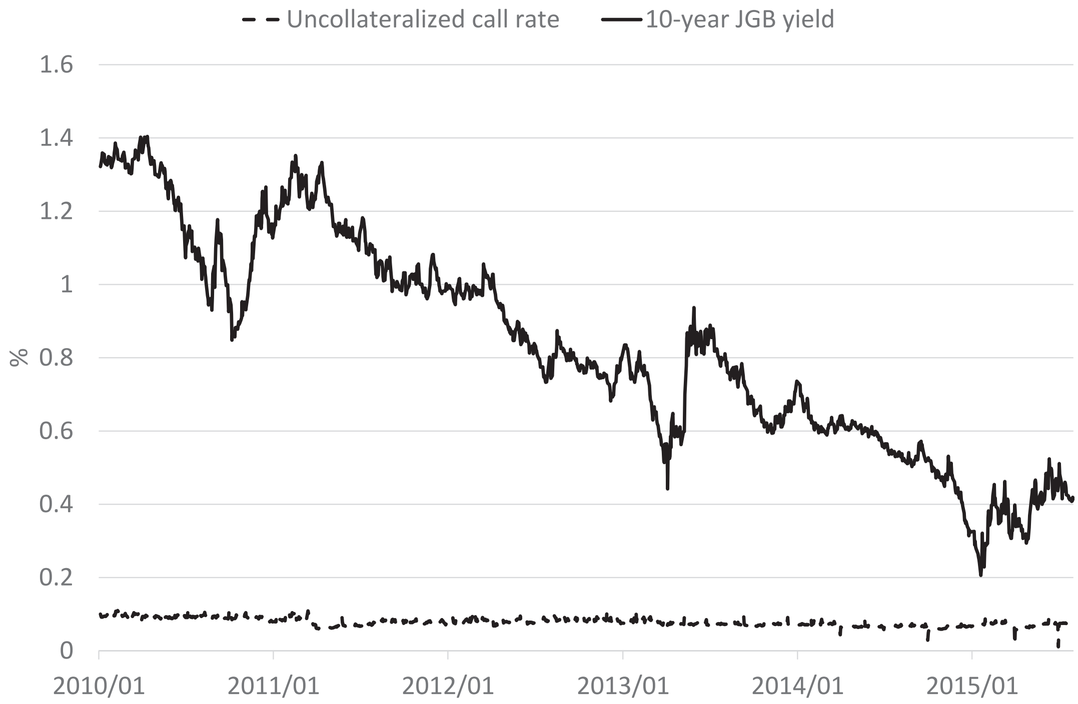
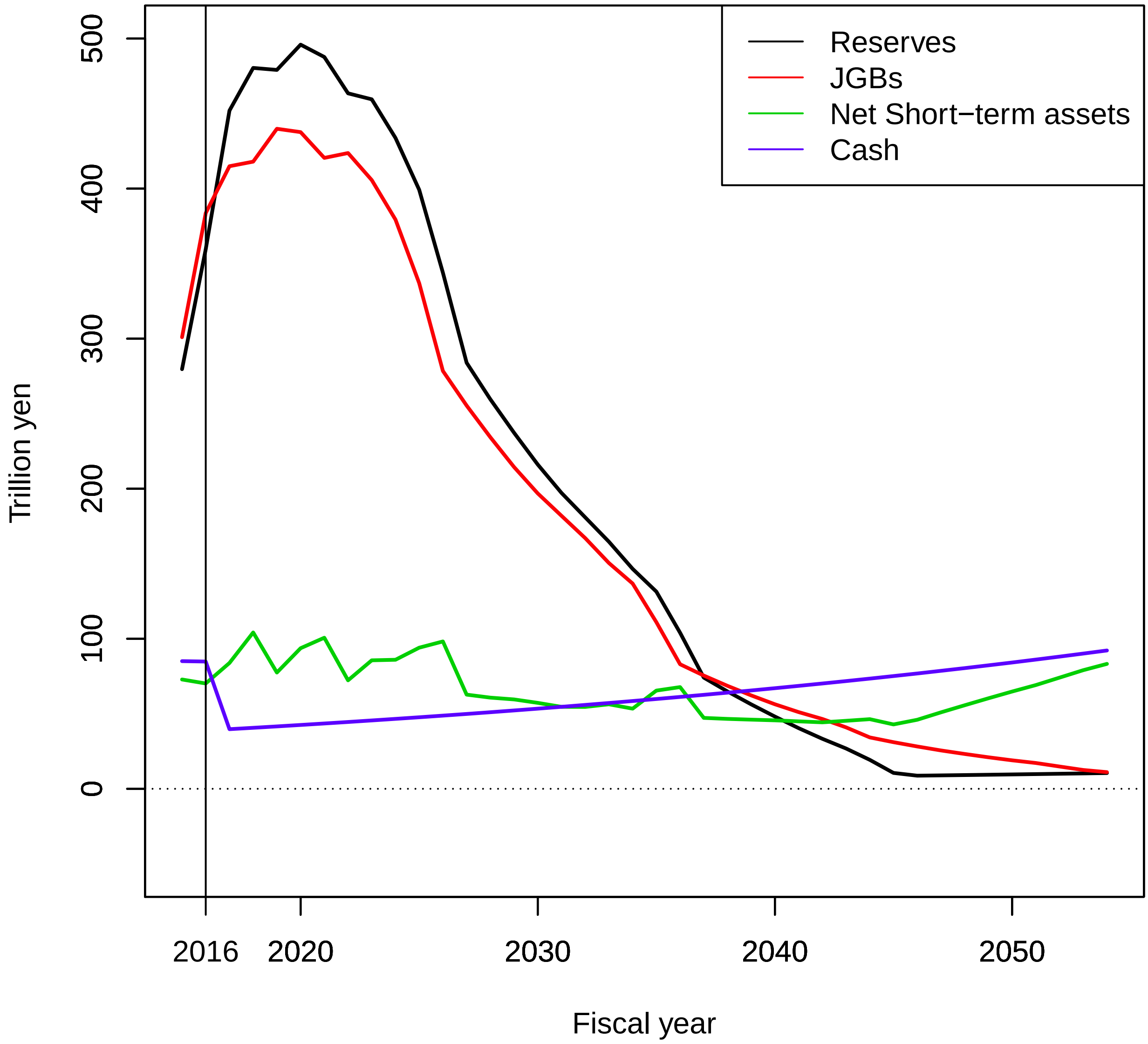
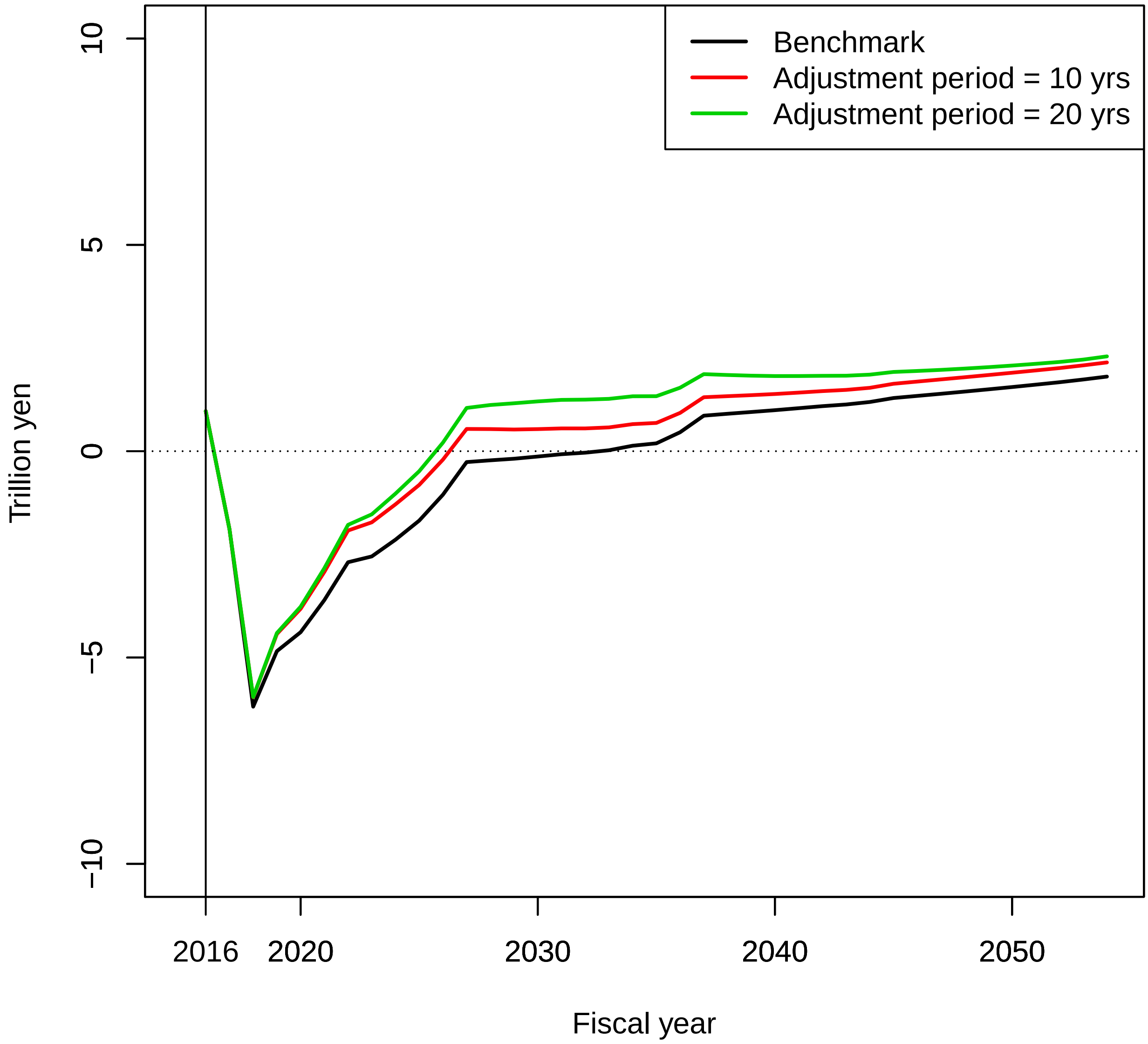


Figure 14: BoJ's balance sheet when new purchases of JGBs are gradually decreased over the 10 years after the exit from QQE



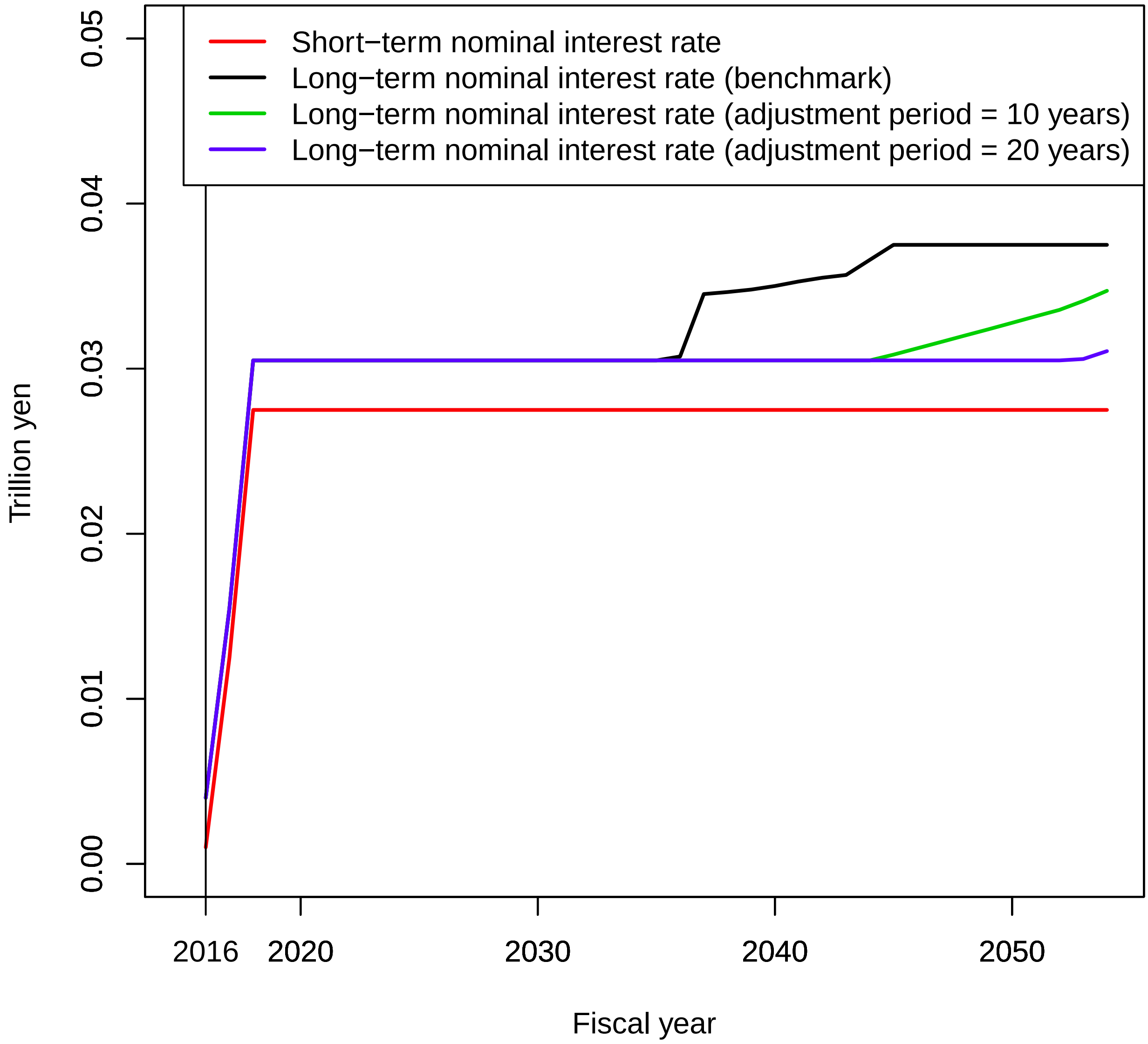
Note: The amount of new purchases of JGBs each year after the exit from QQE is linearly reduced so that it becomes zero after 10 years.

Figure 15: Sensitivity of BoJ's pretax profit to the adjustment period for the new purchases of JGBs after the exit from QQE



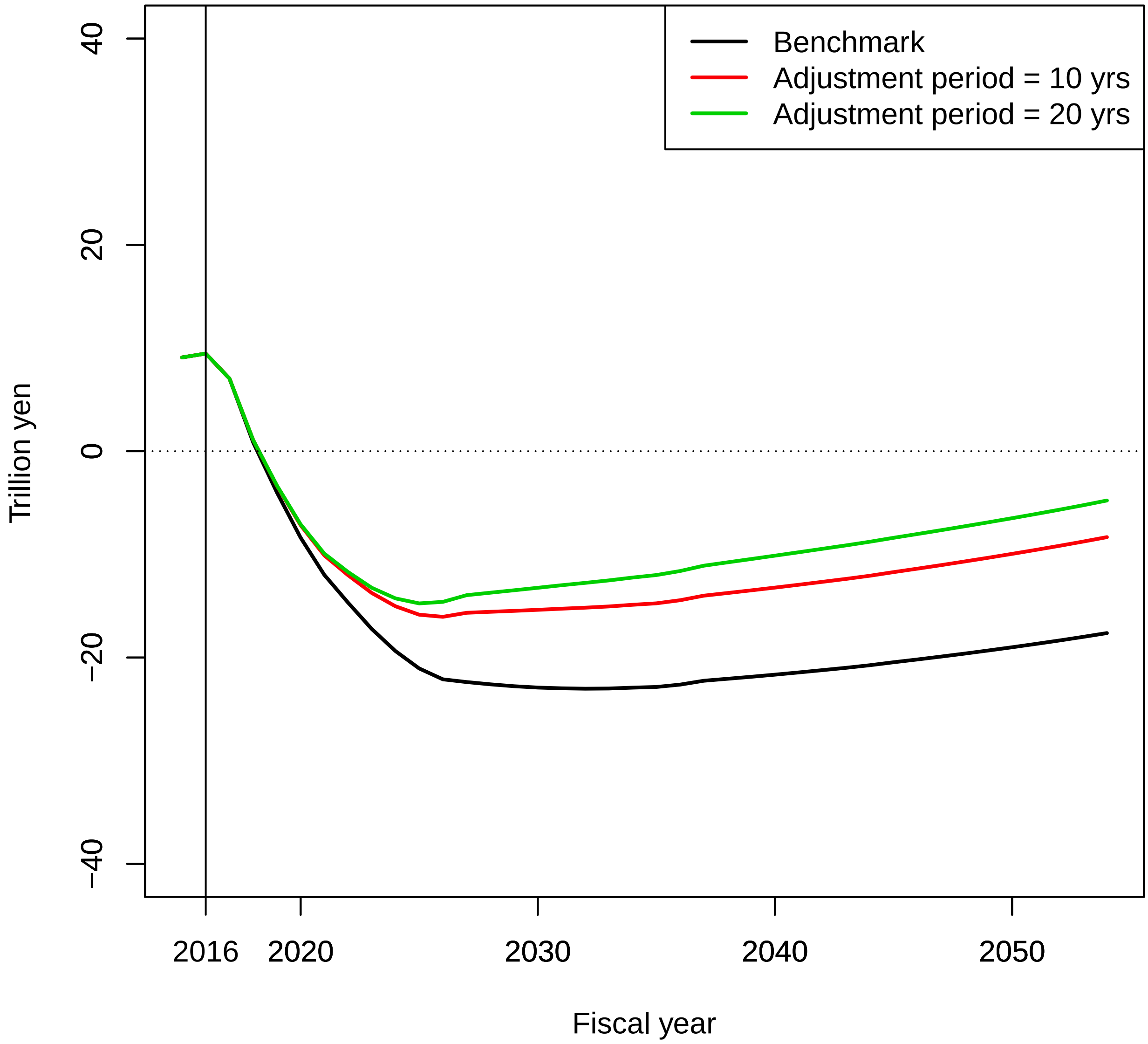
Note: The amount of new purchases of JGBs each year after the exit from QQE is linearly reduced so that it becomes zero after the adjustment period.

Figure 16: The path of the long-term nominal interest rate with the adjustment of new purchases of JGBs after the exit from QQE



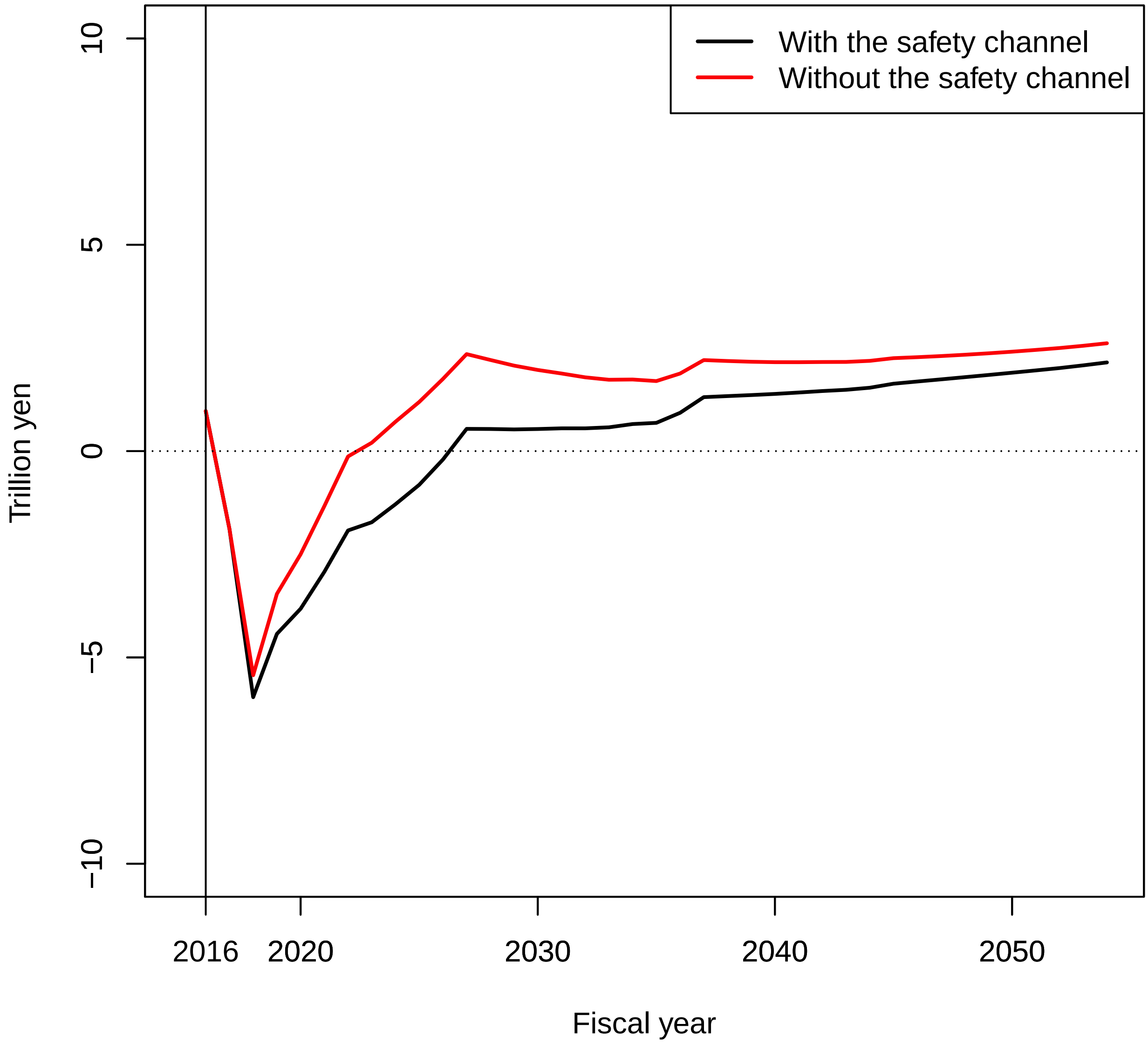
Note: The amount of new purchases of JGBs each year after the exit from QQE is linearly reduced so that it becomes zero after the adjustment period.

Figure 17: Sensitivity of BoJ's net assets to the adjustment period for the new purchases of JGBs after the exit from QQE



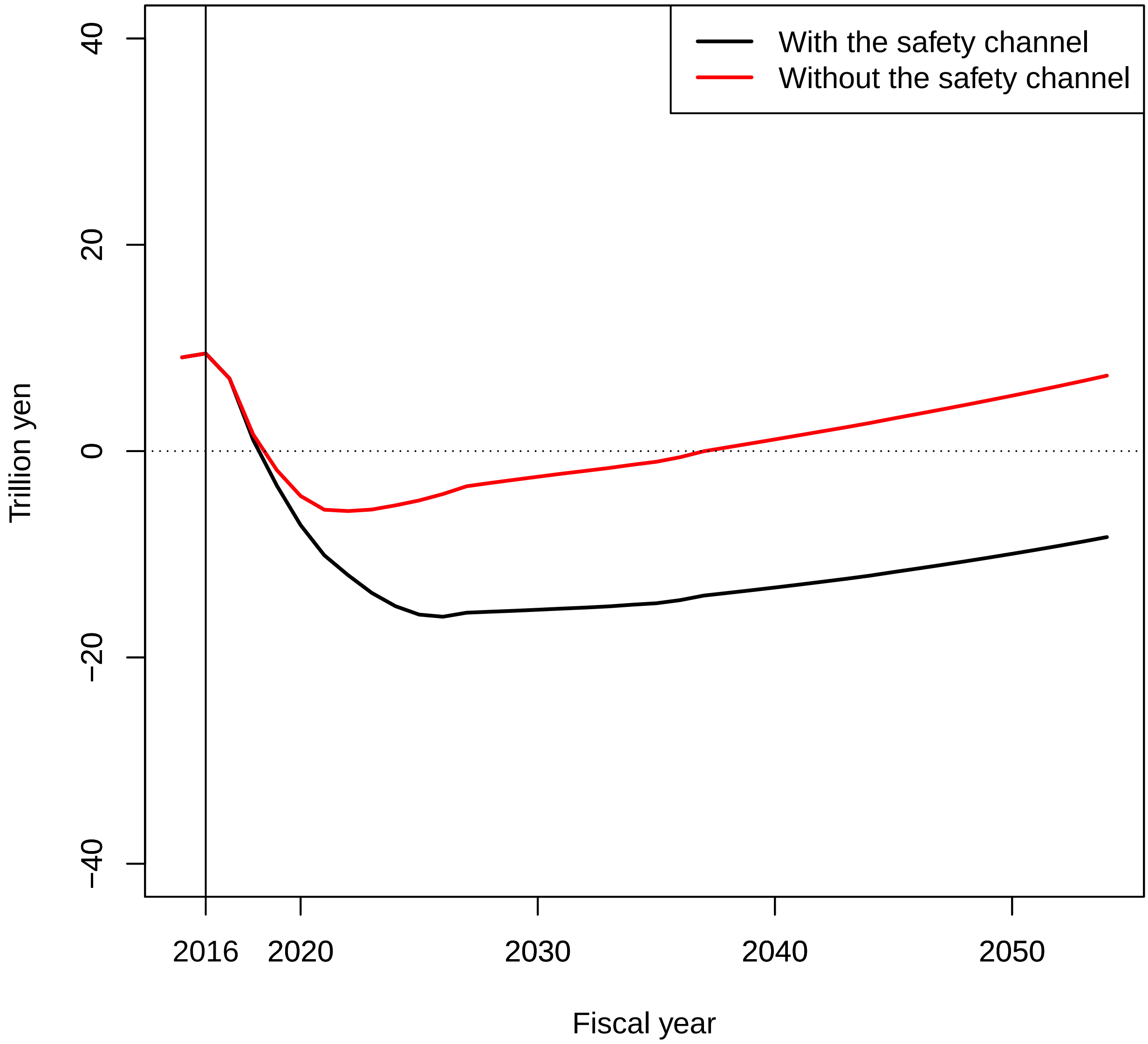
Note: The amount of new purchases of JGBs each year after the exit from QQE is linearly reduced so that it becomes zero after the adjustment period.

Figure 18: Sensitivity of BoJ's pretax profit to the safety channel for the long-term nominal interest rate



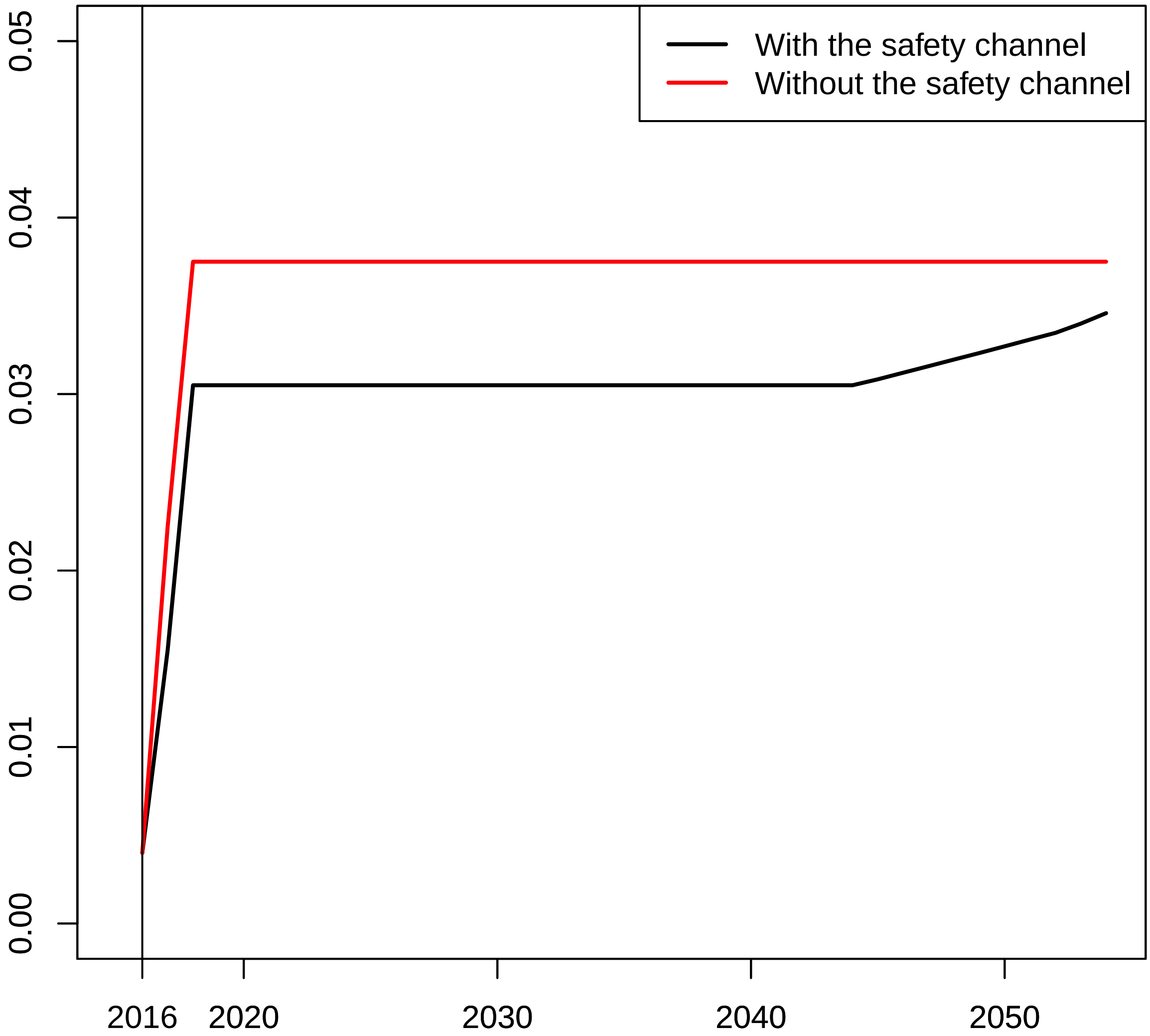
Note: For both cases, the amount of new purchases of JGBs each year after the exit from QQE is linearly reduced so that it becomes zero 10 years after the exit from QQE.

Figure 19: Sensitivity of BoJ's net assets to the safety channel for the long-term nominal interest rate



Note: For both cases, the amount of new purchases of JGBs each year after the exit from QQE is linearly reduced so that it becomes zero 10 years after the exit from QQE.

Figure 20: The path of the long-term nominal interest rate with and without the safety channel



Note: For both cases, the amount of new purchases of JGBs each year after the exit from QQE is linearly interpolated so that it becomes zero after 10 years.