Toward a Guidepost for Quantitative Tightening: The Case of the Bank of Japan*

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Abstract

An exit strategy from large-scale unconventional monetary policy requires central banks to adjust their policy interest rates and the size of their balance sheet. Adjustments of policy interest rates are carried out using neutral interest rates as a guidepost, even in the presence of measurement uncertainty. In contrast, adjustments of balance sheet size, or quantitative tightening (QT), are implemented through trial and error without any standardized guideposts. In this paper, I develop a framework for establishing a long-term guidepost for the QT process in Japan. To that end, I examine the long-term level of the balance sheet size of the Bank of Japan (BOJ) and the framework for monetary policy implementation under expanded reserve demand. I thus examine the room for reducing the balance sheet size of the BOJ by estimating the reserve demand curve to detect the satiating levels for liquidity demand. I thereby discuss a future framework for monetary policy implementation under the increased demand for reserves. I carry out a simulation analysis of the transition path of the BOJ's balance sheet size toward its long-term level. The QT process in Japan needs to be viewed as a long-term process requiring a timeframe of decades. I emphasize that, as a fundamental principle of the new conventional monetary policy, the size of the central bank balance sheet needs to be determined by the liability-side factors, i.e., the demand for central bank money.

Keywords: Central bank balance sheet size, Liquidity effects, Quantitative tightening, Extended banknote rule

JEL codes: E44, E52, E58, G21

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1 Introduction

In this paper, I develop a framework for establishing a long-term guidepost for the QT process in Japan. To that end, I examine the long-term level of the balance sheet size of the Bank of Japan (BOJ) and the framework for monetary policy implementation under expanded reserve demand. I thus estimate the reserve demand curve to detect the satiating levels for liquidity demand, serving as the basis for projecting the future size of the BOJ's balance sheet, providing a quantitative benchmark for the QT process.[1] I then carry out a simulation analysis of the transition path of the BOJ's balance sheet size toward its long-term level.

An exit strategy from the large-scale unconventional monetary policy requires central banks to adjust their policy interest rates and the size of their balance sheets. Adjustments of policy interest rates are carried out using the neutral interest rate as a guidepost, even in the presence of measurement uncertainty.[2] In contrast, adjustments of balance sheet size, or quantitative tightening (QT), are implemented through trial and error without any standardized guideposts. In this regard, at least for the time being, the central banks in major economies are expected to maintain balance sheets significantly larger than before the global financial crisis (GFC) of 2008.[3]

In response to the surge in inflation after the COVID-19 pandemic, central banks in major advanced economies proceeded with the monetary policy normalization in terms of policy interest rates and the size of their balance sheet from 2022. The BOJ, however, began the process of monetary policy normalization in March 2024, well behind the central banks in the major advanced economies. Because long-term inflation expectations are anchored at a level lower than the 2-percent price stability target, the BOJ has proceeded with the normalization of monetary policy extremely gradually to achieve sustainable price stability by pushing the long-term inflation expectations upward to the 2-percent target level.

When examining the BOJ's monetary policy normalization, it is essential to consider Japan's unique environment at the starting point of the process in two respects. First, short- and long-term interest rates have remained fairly low over the past 30 years since 1995. Second, the BOJ has an extremely large balance sheet, exceeding the nominal GDP.

In March 2024, the BOJ terminated the Quantitative and Qualitative Monetary Easing (QQE) with Yield Curve Control (YCC), including the yield curve control framework and the negative interest rate (NIR) policy.[4] The BOJ raised its target for the overnight uncollateralized call rate (the policy interest rate in Japan) from the range of -0.1 to zero percent to that of zero to 0.1 percent. The BOJ also abolished the 10-year JGB target of around zero percent with a soft al-

[1] Afonso et al. (2022) and Lopez-Salido and Vissing-Jorgensen (2024) estimate the reserve demand curve in the US and discuss the appropriate size of reserve balances. For analyses of the euro area, see, for example, Aberg et al. (2021), Brandao-Marques and Ratnovski (2024), and Gotti and Papadia (2024).

[2] See, for example, Obstfeld (2025) for the recent survey on neutral interest rates.

[3] Borio (2023) strongly argues that central banks should go back to a small balance sheet size. He points out that as reserves become more of a store of value under the large central bank balance sheet, the side effects will increase over time, such as distortions in resource allocation and an increase in uncertainty about reserve demand.

[4] Bank of Japan (2024) provides a comprehensive review of the BOJ's monetary policy from the late 1990s. See also Shiratsuka (2025) for a more detailed analysis of the BOJ's monetary policy operations under the YCC policy.

lowance range of 1 percent. In July 2024, the BOJ announced a plan to reduce its purchasing of Japanese government bonds (JGBs) from approximately 6 trillion yen to around 3 trillion yen in the first quarter of 2026, at a pace of 400 billion yen per quarter.[5] In July 2024, the BOJ also decided to raise the target level of call rate for the second time to around 0.25%, which was not necessarily fully factored into the market.[6]

In the above process, the BOJ communicated the policy interest rate adjustments with a strong focus on the nominal neutral level, which is defined as the sum of the equilibrium level of real interest rates and the target level of inflation.[7] Of course, there is certainly a considerable range in the estimates of the equilibrium real interest rate, with large differences depending on the methodology and the assumed neutral level. Also, it cannot be said that long-term inflation expectations in the public are anchored at the 2% target level. However, there is a shared understanding that the current level of the policy interest rate, which is considerably lower than the neutral level, will gradually adjust toward the neutral level.

By contrast, the BOJ did not talk much about what level it would target for its balance sheet when implementing the reduction plan of the JGB purchases. The situation is the same for the central banks in other major advanced economies, and they are still searching for the appropriate level at which to reduce the size of their balance sheets during the process of QT. In that sense, the urgent issue is to consider a guidepost for proceeding with the reduction of central bank balance sheets through QT.

The shape of the reserve demand curve is an important point to consider the long-term level of the central bank balance sheet size. Under the abundant reserve regime with huge amounts of reserves, the reserve demand curve becomes perfectly flat, and the policy interest rate does not respond to day-to-day fluctuations in reserve balances. As the decline in reserve balances continues, the sensitivity of the policy interest rate to reserve fluctuations is expected to be restored at some point.

The estimation of the reserve demand curve requires addressing two critical empirical issues, as thoroughly explored by Hayashi (2001) regarding the call market in Japan in the late 1990s: time aggregation of the policy interest rate and endogeneity arising from the simultaneous determination of demand and supply of reserves. A standard approach to addressing endogeneity exploits instrumental variable estimations. Hamilton (1997) estimates the liquidity effects in the US federal funds rate by using forecasts for the autonomous factors affecting reserve balances based on the estimated time-series models.[8] Uesugi (2002) follows the em-

[5] The JGB issuance has been hovering around 12 trillion yen per month for the past several years, and the 6 trillion yen purchase is equivalent to almost half of this amount, which will drop to about one-fourth if the amount is reduced to 3 trillion yen. The redemption amount of JGBs held by the BOJ averages just over 6 trillion yen per month, which is nearly equal to the purchase amount prior to July 2024, and the balance of JGBs held by the BOJ has remained unchanged. Therefore, the balance of JGBs held by the BOJ will decrease by the amount of reduction from the level in July 2024.

[6] The BOJ raised the policy interest rate further to 0.5% in January 2025 and showed its intention to continue raising interest rates according to economic and price developments.

[7] The BOJ assumes that the range of the nominal neutral interest rates is from 1.0% to 2.5%, based on the various estimation methods for natural rates. See, for example, Appendix 2 of Bank of Japan (2024).

[8] The Fed's forecasts of fund surplus and shortage are not readily available, and, thus, instead, forecasts based on the time-series model are widely used in empirical studies on the liquidity effects in the Fed fund market.

pirical strategy of Hamilton (1997) by employing the BOJ's forecasts for cash and fiscal factors for fund surplus and shortage. Hayashi (2001) addresses the two issues using novel data on intraday rates starting from different settlement time points, combined with estimates for the reserve balances at the corresponding settlement time points.

I will exploit the changes in the institutional arrangements in the call market after the introduction of the real-time gross settlement (RTGS) in the Bank of Japan Financial Network System (BOJ-NET) in 2001. The first issue of time aggregation is resolved by the changes in the contract and execution time for call transactions. The current call market transactions are mostly contracted in the early morning, from 8:30 to 9:30 am, and are executed during the morning session, which begins at 9:00 am. These observations indicate that the volume-weighted average of all transactions can be regarded as the morning or opening time data.

The second issue of endogeneity is closely related to the issue of time aggregation. The BOJ releases its forecast of current account balances at the end of the day, at 6:00 pm on the previous day, based on the forecast of the surplus and shortage of funds for the day and the BOJ's operations finalized by the previous day. Therefore, call market transactions are contracted on the basis of this forecast. Thus, the reserve demand curve can be estimated by the ordinary least squares (OLS) procedure using the spread of the call rate from the interest on excess reserves (IOER) as an explained variable and the BOJ's forecasts on the current account balances as an explanatory variable.

Under the abundant reserve regime, the reserve demand curve becomes perfectly flat, and the policy interest rate does not respond to day-to-day fluctuations in reserve balances. Japan entered this regime in late 2014, following the second-round expansion of the QQE, which was implemented in October of that year. The current account balances at that time were approximately 250 trillion yen, which was significantly below the starting level of the QT process in July 2024, at around 550 trillion yen.

Given the estimation results for the reserve demand in Japan, I will discuss the QT process in Japan in two respects: first, the long-term level of the BOJ's balance sheet size as the endpoint of the QT process, and second, the transition process to the long-term level. Of course, the BOJ has an extremely large balance sheet (larger than the nominal GDP) and plans to implement the QT process in a very gradual manner. It is thus deemed important to carry out the exit strategy with due consideration of the endpoint or the long-term level of the BOJ's balance sheet size.[9]

Central banks are expected to return to the previous operational framework of passively accommodating the demand for central bank money by purchasing and selling conventional financial assets.[10] That implies that the central bank balance sheet size is determined by the liability-side factors. However, considering the expanded reserve demand, central banks are also expected to maintain large-scale balance sheets for the time being. Under such circum-

[9] In this paper, I will not discuss the BOJ's finance issues in the quantitative tightening process. For the recent discussions on this point, see Ueda (2023) and Bank of Japan (2025). Fujiki and Tomura (2017) are a pioneering paper to estimate the finance problem of the BOJ under the QQE.

[10] In this regard, Shiratsuka (2010) examines the roles and effectiveness of unconventional monetary policy, focusing on the size and composition of central bank balance sheets.

stances, central banks will need to expand the scope of conventional financial assets by re-defining previous unconventional financial assets as new conventional financial assets.

For example, prior to the QQE, the BOJ employed the banknote rule to limit the BOJ's JGB holdings at a level less than the outstanding amount of banknotes in circulation. The rule clarifies that the BOJ continues to purchase long-term JGBs to facilitate the smooth issuance and circulation of banknotes, drawing clear boundaries with the central bank fiscal financing. Considering the expanded demand for reserves, the banknote rule can be modified to the "extended banknote rule" by slightly expanding liabilities in the long term and incorporating the transition scheme.

I will also discuss the future design of the money market operations. In this regard, the Fed and two European central banks, the European Central Bank (ECB) and the Bank of England (BOE), are aiming in different directions. The Fed prefers to maintain the abundant reserve regime due to increased liquidity demand at financial institutions for various reasons, including tighter liquidity holding regulations.[11] In contrast, the ECB and the BOE aim to return to a less ample reserve regime with a demand-driven or liability-side-driven system. Such a process requires the revival of liquidity risk management operations at financial institutions as well as the more meticulous implementation of money market operations at central banks. The ECB refers to the framework of its money market operations as the "soft floor" system, guiding money market rates with the floor rate of the Deposit Facility Rate (DFR).[12] The BOE proposes the concept of the Preferred Minimum Range of Reserves (PMRR), which satisfies commercial banks' reserve demand for daily settlements and precautionary motives.[13]

This paper is constructed as follows. Section 2 summarizes the determinants of central bank balance sheet size and the relationship between the reserve balances and the framework for money market operations. Section 3 reviews the BOJ's monetary policy normalization, paying due consideration to the unique environment in two respects: prolonged extremely low interest rates and an extremely large balance sheet size. Section 4 explains the data used for estimating the reserve demand curve in Japan and examines empirical issues related to time aggregation and endogeneity. Then, the section presents the baseline estimation specifications and the estimation results to confirm the breakpoints in the reserve demand curve. Section 5 examines the long-term level of the BOJ's balance sheet size. This section then carries out a simulation analysis of the transition path of the BOJ's balance sheet size toward its long-term level. Finally, Section 6 concludes the paper.

[11] The US Fed announces its target range of the Fed fund rate at the fluctuation allowance band of 25bps, while the *de facto* corridor is the width of just 10bps within the target range, stipulated by the interest payment on reserves as a ceiling and the reverse repo rate as a floor. In this regard, Waller (2025) outlines the basic ideas of the US Fed's balance sheet management.

[12] The new framework of the "soft" floor system has a narrower and asymmetric allowance range of 40bps: the DFR as a floor, the Main Refinance Operation (MRO) rate as a midpoint with the 15bps spread from the DFR, and the Marginal Lending Facility (MLF) rate as a ceiling with 25bps spread from the MRO rate. For details, see European Central Bank (2024), European Parliamentary Research Service (2024), and Schnabel (2024).

[13] The BOE emphasizes the importance of striking a balance between costs and benefits when considering the framework for money market operations, such as risks to the central bank balance sheet and those of market distortions. See Hauser (2019) and Hauser (2023) for the details.

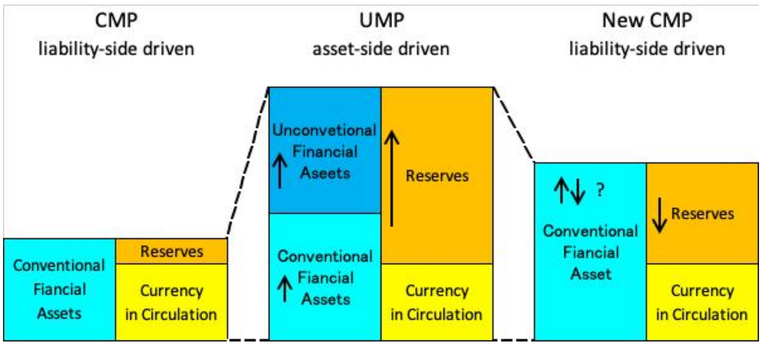
2 The Basic Framework for New Conventional Monetary Policy

In this section, I will examine a new framework for monetary policy under conditions where an elevated central bank balance sheet is considered standard.

2.1 The Determinants of Central Bank Balance Sheet Size

Figure 2.1 summarizes the determinants of the central bank balance sheet size in three monetary policy regimes: The conventional monetary policy (CMP) regime before the GFC of 2008, the unconventional monetary policy (UMP) regime in response to the GFC and the COVID-19 turmoil, and the new CMP regime under the current circumstances.

Figure 1: Determinants of Central Bank Balance Sheet Size



In normal times before the GFC of 2008, the size of the central bank's balance sheet was determined mainly by factors on the liability side of their balance sheet, i.e., demand for central bank money (CMP regime in Figure 1). It was not common for central banks to pay interest on excess reserves held by private financial institutions, and financial institutions held only the minimum reserves to meet their required reserves on average. As a result, demand for central bank money was roughly equivalent to the currency in circulation, which gradually increased over time, reflecting the settlement demand in the economy.

In response to the GFC, central banks in the major economies introduced various unconventional monetary policy measures, and the determinants of the size of the central bank's balance sheet shifted to factors on the asset side of their balance sheet (UMP regime in Figure 1).[14] Central banks carried out large-scale asset purchases in the range of financial assets being purchased and in the scale of such purchases. Central banks aggressively changed the size and composition of their balance sheets, thereby making the central bank balance sheet an active policy tool. Central banks started paying interest on reserves to accommodate such asset-side expansions, as the currency in circulation remains relatively stable over time. The supply of a huge amount of excess reserves by central banks satiated the reserve demand of private financial institutions, thereby keeping policy interest rates very close to the interest rate on reserves (IOR) and driving the opportunity cost of holding reserves to zero.

[14] At the initial responses to the GFC, central banks needed to provide a huge amount of reserves to mitigate the liquidity shortage concerns. These expansions of the central bank balance sheet were driven by liability-side factors.

In response to the surge in inflation after the COVID-19 turmoil in 2021, central banks turned to monetary tightening. Central banks were able to raise their policy interest rates with little difficulty by paying interest on excess reserves despite the large size of their balance sheet. Central banks then began to reduce the size of their balance sheets, lagging slightly behind the interest rate hikes. Under such circumstances, the determinants of the central bank balance sheet size shifted back to factors on the liability side of their balance sheet. However, central bank money demand for excess reserves has played a critical role on the liability side. Central banks have continued to supply huge reserves sufficient to satiate the reserve demand, thereby keeping policy interest rates very close to the IOR and driving the opportunity cost of reserve holdings close to zero.

As the size of the central bank balance sheet continues to shrink, its determinants are expected to return gradually to liability-side factors from asset-side factors. In this process, central banks gradually return to the previous operational framework of accommodating the demand for central bank money by purchasing and selling conventional financial assets (New CMP regime: new conventional monetary policy regime). Conventional financial assets under the new CMP regime could include the reclassification of previously unconventional financial assets as conventional financial assets. [15]

For example, prior to the QQE in Japan, the purchases of long-term JGBs were conducted under the BOJ's banknote rule, which limits the BOJ's JGB holdings to less than the outstanding amount of banknotes in circulation. The rule clarifies that the BOJ continues to purchase long-term JGBs to facilitate the smooth issuance and circulation of banknotes, drawing clear boundaries with the central bank government financing. Thus, the purchases of long-term JGBs exceeding the outstanding amount of banknotes in circulation should be considered unconventional financial assets, even if the operations are practically identical. However, suppose that the trend of increasing reserve demand by financial institutions continues and a considerable amount of excess reserves is maintained on a continuous basis, there is a high probability that it will become necessary to continue holding long-term JGBs in excess of the banknote rule to accommodate such core reserve demand stably. I will come back to this point later in Section 5.

2.2 Policy interest rate control

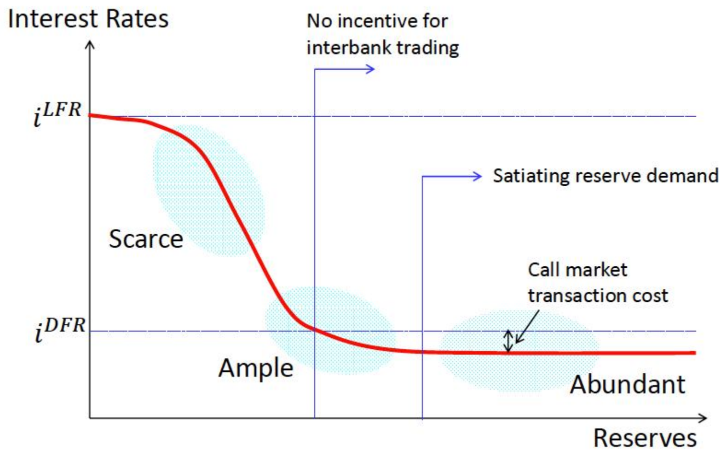
Turning to policy interest rate control, Figure 2 illustrates the demand curve for reserves across the three regimes for reserve supply: the scarce, ample, and abundant reserve regimes.[16]

In the left-side light blue shaded area of the scarce reserve regime, the demand curve is downward-sloping, and the policy interest rate is responsive to the fluctuations of the reserve supply. In normal times before the GFC, central banks guide their policy interest rates by supplying reserves to satisfy the day-to-day fluctuations in reserve demand using the corridor

[15] Reis (2016) argues the role of the liability side in the elevated central bank balance sheet.

[16] Brunnermeier and Reis (2023) summarize the monetary policy management under the abundant reserves.

Figure 2: Reserve Demand Curve



Notes: i^{LFR} and i^{DFR} are interest rates for the on-demand lending facility and the deposit facility, respectively, which form the upper and lower bounds of the corridor system.

system to set the ceiling and floor of the policy interest rate, combined with the required reserve system (left-side light blue shaded area in Figure 2). This system attempts to keep the policy interest rate within the specified range by establishing standing facilities that set upper and lower limits for policy interest rate fluctuations. The standing on-demand lending facility sets the upper limit at i^{LFR} by allowing financial institutions to borrow at a slightly higher rate than the policy interest rate within the limit of pledged eligible collateral to the central bank in advance. In addition, the standing deposit facility, interest payments on reserves at i^{DFR} stipulates a lower limit by allowing financial institutions to leave surplus funds in reserve accounts. When the policy interest rate falls below i^{DFR}, financial institutions stop investing their surplus funds in the market and keep them as reserves.

The demand curve becomes flatter as the reserve supply by a central bank expands to the right on the horizontal axis: from the central light blue shaded area of the ample reserve regime to the right-side light blue shaded area of the abundant reserve regime. In the abundant reserve regime, the supply and demand curves intersect on the flat portion of the demand curve, and the policy interest rate does not respond to minor fluctuations of reserve demand-supply balances since the reserve demand is satiated. In this region, central banks adopt the floor system as a mechanism for controlling their policy interest rate, as there are always downward pressures on market interest rates.[17]

In fact, the policy interest rate generally stays below i^{DFR}, in contrast to the corridor system, where i^{DFR} provides a floor for the policy interest rate. This situation arises because transactions in the interbank money market become largely dominated by financial arbitrage between eligible and non-eligible financial institutions to the deposit facility for reserve accounts. Non-eligible financial institutions, mainly consisting of non-bank financial institutions, have

[17]See Ihrig et al. (2015) for the Fed's practice of the federal fund rate control after the GFC under the abundant reserves with interest payment on reserve balances.

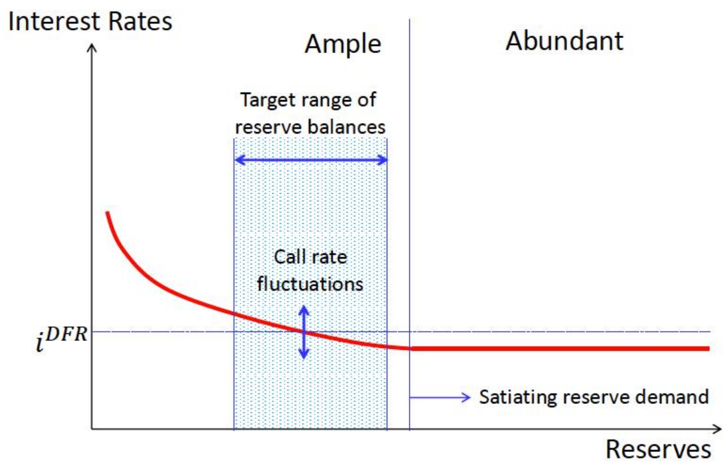
an incentive to lend excess funds at any rate above their opportunity cost in short-term money markets, such as Treasury Bill and repo markets. Eligible financial institutions do not need to borrow actively from one another due to their substantial reserve balances. At the same time, they have an incentive to borrow at rates below i^{DFR} and place those funds in the reserve balances at a central bank.[18]

2.3 Money market operations under the floor system

In designing the future framework for money market operations, central banks need to set a wide target range for reserve balances, considering the significant uncertainty in liquidity demand. However, to clarify that the size of the central bank balance sheet is determined by the liability-side factors, i.e., the demand for central bank money, the reserve supply needs to be reduced at a level lower than the satiating levels for reserve demand.[19]

Within the above framework, central banks aim to guide the policy interest rate to fluctuate around a floor level, or the level of i^{DFR}, as shown in Figure 3. This system is also expected to facilitate interbank money market transactions between eligible financial institutions, thereby restoring the risk-sharing function between financial institutions in the interbank money market.

Figure 3: Money Market Operations under the Floor System



Paying interest on excess reserves can be interpreted as reducing the opportunity cost of holding excess reserves to zero, thus achieving optimal resource allocation in the sense of the Friedman rule proposed by Friedman (1969).[20] However, to shape the policy interest rate in

[18] The US Fed employs the reverse repo facility to set a floor to the Federal Fund rate fluctuations below i^{DFR}. The BOJ also has a similar but temporary facility for the sale of Japanese Government Securities with repurchase agreements.

[19] The BOE proposes the concept of the Preferred Minimum Range of Reserves (PMRR) that satisfies commercial banks' reserve demand for daily settlement and precautionary demand. BOE emphasizes the importance of striking a balance between costs and benefits when considering the framework for money market operations, such as risks to the central bank balance sheet and risks of market distortions. See Hauser (2019) and Hauser (2023)for the details.

[20] Friedman (1969) points out that (1) efficient resource allocation requires a zero opportunity cost of holding

the interbank money market with extremely ample reserves, it is necessary to establish an institutional arrangement in which some financial institutions are eligible for the deposit facility of the reserve balances, and others are not. The creation of such an institutional arrangement can be interpreted as an intentional intervention in the resource allocation process.[21]

In this regard, transactions between eligible financial institutions are expected to be facilitated by keeping the policy interest rate slightly above but close to i^{DFR} on average, as shown in Figure 3. Establishing such management of monetary market operations will help restore the risk-sharing function between financial institutions in the interbank money market. It will also lead to a mechanism in which the liability side of the central bank balance sheet determines its size by passively accommodating demand for central bank money.

3 BOJ's Monetary Policy Normalization

In this section, I will review the BOJ's monetary policy normalization, focusing on its starting point.

3.1 Starting point for monetary policy normalization

When examining the BOJ's monetary policy normalization, it is essential to note Japan's unique environment at the starting point of this process in two respects. First, short- to long-term interest rates have remained fairly low over the quarter of a century since 1995. Second, the BOJ has an extremely large balance sheet, exceeding the nominal GDP.

First, looking at the interest rate trend in Japan using Figure 4, the BOJ reduced its policy interest rate, the uncollateralized overnight call rate, to 0.5 percent in September 1995. Since then, the Japanese economy has faced the effective lower bound (ELB) constraint of the policy interest rate for over 30 years. Long-term interest rates have also followed a downward trend, remaining near zero since the mid-2010s.

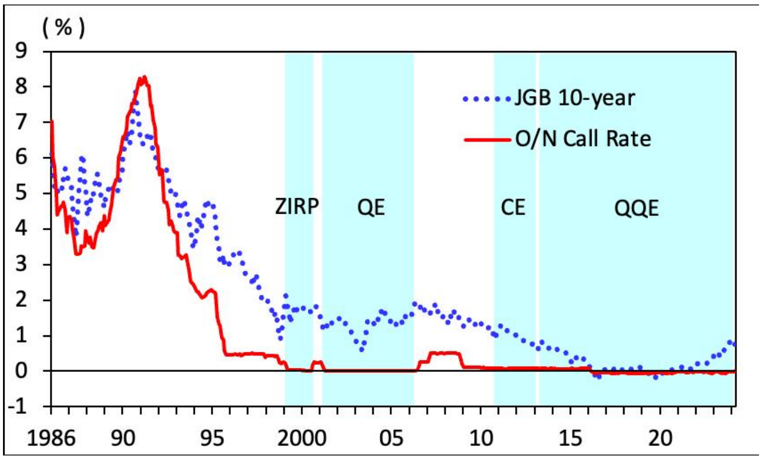
Under such financial conditions, the BOJ has continued to implement various unconventional monetary policy measures over time. Most of the unconventional monetary policy measures, comprehensively assessed by Bernanke (2022), were first introduced by the BOJ after the late 1990s (Table 1):[22] the Zero Interest Rate Policy (ZIRP) from February 1999 to August 2000, the Quantitative Monetary Easing Policy (QE) from March 2001 to March 2006, the Comprehensive Monetary Easing Policy (CE) from October 2010 to March 2013, and the Quantitative

money, i.e., zero nominal interest rates, implying price deflation at the equivalent rate of the real interest rate in absolute terms, and (2) an optimal monetary policy to achieve efficient resource allocation should steadily contract the money supply at a rate sufficient to bring the nominal interest rate down to zero. See Woodford (1990) for a detailed survey of this issue.

[21] Borio (2023) argues that central banks substitute for the role of the short-term money market by supplying reserves to satiate the reserve demand of financial institutions.

[22] During the Global Financial Crisis, the effectiveness of unconventional monetary policy measures is assessed with their impacts on the prices of various financial assets, such as long-term interest rates, foreign exchange rates, and stock prices. See, for example, Borio and Zabai (2016) for a comprehensive survey of the empirical studies on large-scale asset purchase programs in advanced economies.

Figure 4: Short- and Long-term Interest Rates in Japan



Notes: Abbreviations in the figures correspond to the monetary policy regimes below:
ZIRP: Zero Interest Rate Policy (February 1999-August 2000); QE: Quantitative Monetary Easing Policy (March 2001-March 2006); CE: Comprehensive Monetary Easing Policy (October 2010-March 2013); QQE: Quantitative and Qualitative Monetary Easing Policy (April 2013-January 2006); QQE w/ NI: QQE with Negative Interest Rates (January 2016-September 2016); QQE w/ YCC: QQE with Yield Curve Control (September 2016-March 2024).
Source: Bank of Japan, Ministry of Finance

and Qualitative Monetary Easing (QQE) from April 2013 to March 2024. The QQE was modified from a short-term shock therapy strategy to an endurance and buy-time strategy in a patchwork fashion: the QQE with Negative Interest Rates (QQE w/ NI) from January 2016 to September 2016 and the QQE with Yield Curve Control (QQE w/ YCC) from September 2016 to March 2024.[23] With the lifting of the QQE in March 2024, the BOJ returned to the conventional monetary policy framework to guide the policy interest rate in a positive region.[24]

[23] When the QQE was introduced in April 2013, the BOJ declared to achieve a 2-percent inflation target by doubling the monetary base in two years with very aggressive asset purchases. The BOJ shifted its policy instrument back to the policy interest rate by introducing the NIRs in January 2016. The BOJ then reformulated its policy framework by setting an additional target for the 10-year JGB yields in September 2016, known as the yield curve control (YCC) policy.

[24] As described later, the BOJ decided on October 31, 2023, to abolish the strict YCC cap stipulated by the fixed-rate purchases with unlimited amounts after judging cautiously that speculative short-selling attacks were substantially subdued. Since the decision implies the effective abolition of the YCC policy, this paper focuses on the YCC policy before that decision.

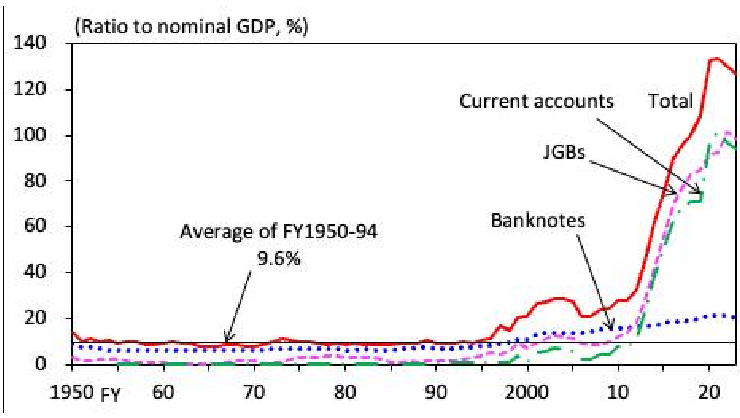
Table 1: Monetary Policy Events

	Regime	Period	Targets	Tools
1	Zero Interest Rate Policy (ZIRP)	Feb 12, 1999 to Aug 11, 2000	O/N call rate	FG
2	Quantitative Monetary Easing (QE)	Mar 19, 2001 to Mar 9, 2006	Current account balances	FG
3	Comprehensive Monetary Easing (CE)	Oct 5, 2010 to Apr 3, 2024	O/N call rate	LSAPs
4	Quantitative and Qualitative Monetary Easing (QQE)	Apr 4, 2013 to Mar 19, 2024	Monetary base	LSAPs, FG
	w/ Negative Interest Rate (QQE w/ NIR)	Jan 29, 2016 to Mar 19, 2024	O/N call rate	LSAPs, NIR, FG
	w/ Yield Curve Control (QQE w/ YCC)	Sep 21, 2016 to Mar 19, 2024	O/N call rate & JGB 10-y yield	LSAPs, NIR, YCC, FG

Notes: Abbreviations in the table are as follows. FG: forward guidance, SAPs: large-scale asset purchases, NIR: negative interest rate, YCC: yield curve control.

Second, looking at the long-term trend of the BOJ's balance sheet size in Figure 5, it remained extremely stable at a level slightly less than 10% of nominal GDP for a considerable period after World War II. However, after the uncollateralized overnight call rate was lowered to 0.5% in 1995, the ratio of balance sheet size to nominal GDP gradually increased under the virtually zero interest rate environment. The pace of expansion accelerated under the QQE, exceeding nominal GDP in early 2019. Such expansion of the BOJ's balance sheet was induced by the tremendous increase in JGB holdings, resulting in huge amounts of excess reserves held by financial institutions by paying interest on them. As of the end of fiscal 2023 (March 2024), the BOJ holds JGBs and current account balances equivalent to nominal GDP.

Figure 5: BOJ's Balance Sheet



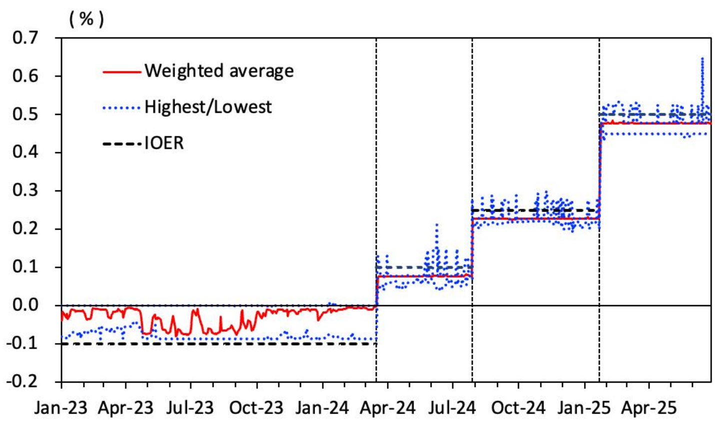
Notes: The horizontal bold line indicates the long-run average of the BOJ's balance sheet size from the fiscal year 1950 to 1994, which is 9.6% of nominal GDP.
Sources: Bank of Japan, Cabinet Office.

3.2 Policy interest rate adjustment

The BOJ initiated the process of monetary policy normalization in March 2024, which was well behind the central banks in the major advanced economies. At that time, the BOJ terminated the Quantitative and Qualitative Monetary Easing (QQE) with Yield Curve Control (YCC), including the yield curve control framework and the negative interest rate policy. The baseline approach for adjusting the policy rate is to gradually adjust the degree of monetary easing as underlying inflation rises. "Gradually" is assumed roughly once every six months, and the guideline level of interest rates in the near term is the lower bound of the neutral interest rate at around 1%.[25]

Figure 6 shows that the call rate was smoothly adjusted to a level slightly below the target level. The spread between the target level (equal to interest payment on excess reserves) and the call rate is two basis points, which corresponds to transaction fees in the call market. In March 2024, the BOJ raised its target for the overnight uncollateralized call rate (the policy interest rate in Japan) from the range of −0.1 to zero percent to that of zero to 0.1 percent. The BOJ also abolished the 10-year JGB target of around zero percent with the soft allowance range of 1 percent. Thereafter, the BOJ decided to raise the target level of the call rate twice to around 0.25% in July and to around 0.5% in January 2025.

Figure 6: Overnight Uncollateralized Call Rates



Notes: "Weighted average" indicates the weighted average of uncollateralized overnight call rate using transaction volume as weight. "Highest/Lowest" indicates the daily highest and lowest rates.
Source: Bank of Japan.

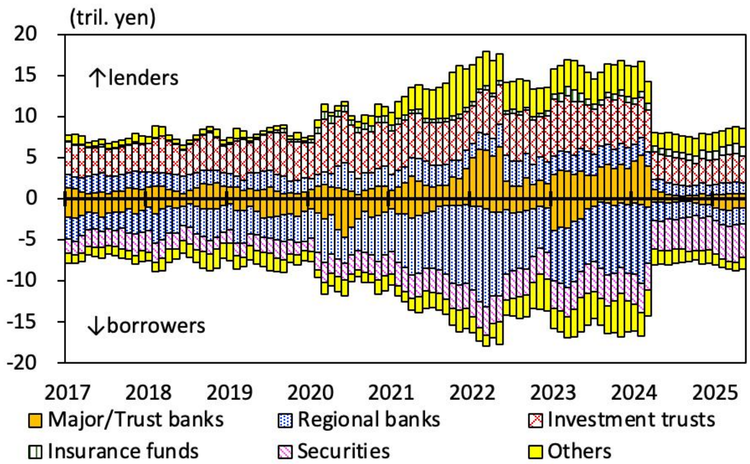
Figure 7 shows that call market transactions have undergone significant structural changes

[25] The neutral interest rate is the long-term nominal interest rate level at which various economic adjustments are completed and is a "neutral" interest rate level that is neither tight nor accommodative to economic activity. Since the long-term steady state corresponds to a state in which inflation aligns with the inflation target and the GDP gap is zero, the neutral rate is the intercept term of the Taylor rule, which is widely used as the standard monetary policy rule.

Note that the neutral interest rate differs from the terminal interest rate. A situation where the policy interest rate is below the neutral interest rate indicates that monetary conditions remain accommodative. If, during the process of raising interest rates, economic activity and inflation become overheated, and full-fledged tightening becomes necessary, the terminal interest rate will exceed the neutral interest rate.

after the termination of the QQE in March 2024.[26] Call market transactions declined significantly after the termination of the QQE, as arbitrage opportunities became limited to transactions between eligible and non-eligible financial institutions to the IOER. Currently, the largest lender sector is investment trusts, and the largest borrower sector is securities. Under the NIRs implemented in February 2016, the call market became the site of arbitrage transactions to avoid the application of the NIRs. As measures against COVID-19 were strengthened after 2020, exemptions from negative interest rates were expanded, mainly for regional banks, and call market transactions also increased.

Figure 7: Lenders and Borrowers in Call Market



Source: Bank of Japan.

The landscape of interbank money markets in major advanced economies changed dramatically under the massive expansion of central bank balance sheets in the aftermath of the Global Financial Crisis of 2008. Central banks responded to huge adverse shocks by expanding their balance sheets using unconventional monetary policy tools in facing the effective lower bound (ELB) constraint on nominal interest rates. It has become normal for banks to hold huge amounts of excess reserves. As a result, the interbank money markets no longer serve as liquidity risk-sharing devices between banks. It is left with only the function of formulating the policy interest rate, or the very short end of the yield curve, through the financial arbitrage between eligible and non-eligible financial institutions to the IOER.[27]

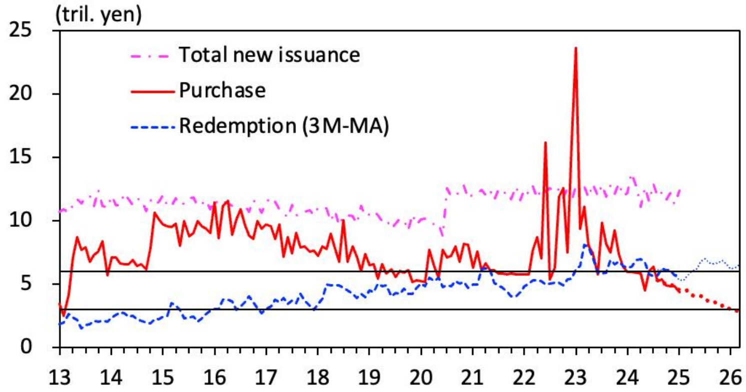
3.3 The BOJ's Plan for Reducing the JGB Purchases

At the MPM in July 2024, the BOJ decided to reduce its purchases of JGBs. The pace of reduction will be approximately 400 billion yen per quarter, and the amount of purchases will decrease

[26] This statistic covers only call market transactions through Tanshi, interbank money market brokers, and does not include direct dealings between financial institutions.

[27] Reflecting two key roles for interbank money markets, theoretical modeling of the interbank money markets can be classified into two strands: the interest rate arbitrage view, such as Poole (1968), Furfine (2000), and Afonso, Armenter and Lester (2019); and the liquidity risk-sharing view, such as Bhattacharya and Gale (1987), Rochet and Tirole (1996), Freixas, Martin and Skeie (2011), and Allen, Carletti and Gale (2009).

Figure 8: BoJ's JGB Purchases and Redemptions



Notes: Redemption dates for long-term JGBs with maturities of five years or over are concentrated in the last month of the quarter in which they were issued. Considering this seasonality, the redemption amount is plotted as a moving average over the previous three months. The red and blue dashed lines represent the projected path of BOJ's JGB purchases and the amount of redemptions, based on the information available as of the end of July 2024. The two horizontal solid lines correspond to six trillion yen and three trillion yen, respectively, from top to bottom. Source: Bank of Japan.

from approximately six trillion yen in July 2024 to around three trillion yen in the first quarter of 2026.

Figure 8 shows that the amount of JGB issuance has been approximately 12 trillion yen per month over the last several years, and the BOJ's JGB purchases of six trillion yen are equivalent to about half of this amount.[28] When the amount is reduced to three trillion yen, it will fall to about a quarter. In addition, the amount of JGBs held by the BOJ that are redeemed each month averages just over six trillion yen, which is almost the same as the amount of purchases during the first half of 2024, and the BOJ's JGB holdings remain constant.

The BOJ intends to hold the JGBs it purchases until maturity and not to sell them before maturity. The increase or decrease in the BOJ's JGB holdings is equal to the amount of purchases deducted from the amount of redemptions at maturity. Based on the BOJ's JGB portfolio as of July 2024, the amount of redemptions is projected to stay around six trillion yen until the first quarter of 2026. Therefore, the BOJ's JGB holdings will decrease by the amount of the reduction from the current situation. The pace of the BOJ's balance sheet reduction will proceed extremely gradually since the BOJ's JGB holdings amount to nearly 600 trillion yen. Assuming (i) monthly average redemption at six trillion yen and (ii) a pace of reducing the BOJ's JGB holdings by three trillion yen per month, it would take 100 months, or 8.3 years, to reduce the BOJ's JGB holdings by half from 600 trillion yen to 300 trillion yen.

It should be noted that there is no guidepost for such a reduction in balance sheet size, unlike the neutral interest rate in policy interest rate adjustments. [29] The size of current account

[28] Following the introduction of the Yield Curve Control (YCC) policy in September 2016, the BOJ began flexibly adjusting the amount of its JGB purchases as long as the 10-year JGB yield remained within the target range and JGB purchases gradually decreased. This process was called "stealth tapering" because the BOJ reduced its purchases without making an official announcement.

[29] Under these circumstances, the minimum requirement would be to reduce the JGB holdings to a level where the "stock effect" of JGB purchases, which the BOJ has been emphasizing, is negligible. While the flow effect directly

balances on the liability side is an important point to examine when considering the extent to which the BOJ can reduce the size of its balance sheet. At present, however, changes in the BOJ's current account balances do not influence the call rate, as reserve demand from IOER-eligible financial institutions is satiated. If the BOJ's JGB holdings shrink, the BOJ's current account balances will also shrink. However, there is considerable uncertainty as to how much the shrinkage will begin to influence the call rate and to what extent.

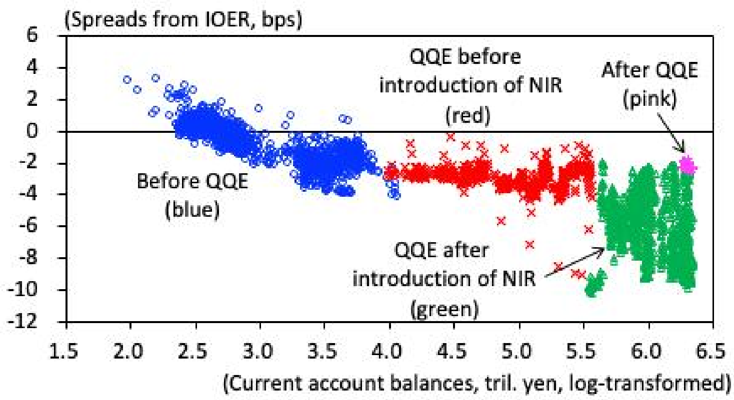
4 Liquidity Effects in the Call Market

In this section, I will estimate the reserve demand curve to examine the changes in the liquidity effect in the call market resulting from an increase in the reserve balance.

4.1 Data and endogeneity issues

Figure 9 plots the log-transformed current account balances at the BOJ (reserve balances) on the horizontal axis and the spreads of the call rate from the IOER on the vertical axis on a daily basis from January 5, 2009 to December 28, 2024. The plotted data is color-coded by period: before the QQE from January 5, 2009 to April 3, 2013 for blue circles; the QQE before the introduction of the NIR Policy from April 4, 2013 to February 15, 2016 for red crosses; the QQE after the introduction of the NIR policy from February 16, 2016 to March 18, 2024 for green triangles; and after the termination of the QQE from March 19 to August 31, 2024 for pink pluses.

Figure 9: Observed Reserve Demand Curve



Notes: The sample period is from January 5, 2009 to August 31, 2023 on a daily basis. Spreads from the IOER under the NIR policy from February 16, 2016 to March 19, 2024, reversed sign due to the penalties imposed on the excess reserves.
Source: Bank of Japan.

Overall, the figure shows a gradual and nonlinear downward-sloping relationship between the spreads from the IOER and the log-transformed current account balances. The relationship

reduces interest rates through JGB purchases, the stock effect is that large holdings of JGBs put downward pressure on interest rates for a variety of maturities.

becomes flattened when reserve balances are sufficiently large and reach a level above the satiating reserve demand. Casual observation suggests that the demand satiation level is located sometime during the initial QQE before the introduction of the NIR policy.

The figure also shows significant fluctuations under the NIR policy, as indicated by the green triangle plots. Such fluctuations are influenced by the artificial creation of arbitrage opportunities through the BOJ's fund-supplying operations, such as Special Funds-Supplying Operations to Facilitate Financing in Response to the Novel Coronavirus and Loan Support Program. In addition, the post-QQE observations are very limited compared to other periods. Thus, I will use data prior to the introduction of the NIR Policy to estimate the reserve demand curve in the next section.

It should also be noted that the figure shows equilibrium realizations over time and cannot necessarily be interpreted as a causality from reserve balances to interest rates. In this regard, it is required to address two critical empirical issues in estimating the reserve demand curve, as thoroughly explored by Hayashi (2001) regarding the call market in Japan in the late 1990s: time aggregation of the policy interest rate and endogeneity arising from the simultaneous determination of demand and supply of reserves.

The first issue of time aggregation is resolved by the changes in the call market practice after the introduction of the real-time gross settlement (RTGS) in the BOJ net system in 2001. The current call market transactions are mostly contracted in the early morning, from 8:30 to 9:30 am, and are executed during the morning session, which starts at 9:00 am. This change implies that daily data for call rates, computed as the volume-weighted average of all transactions, can be regarded as the morning or opening time data. In this regard, data on the number of contracts concluded in different periods is not readily available, and only anecdotal evidence exists.

The second issue of endogeneity is closely related to the issue of time aggregation. The BOJ releases its forecast of current account balances at the end of the day, at 6:00 pm on the previous day, based on the forecast of the surplus and shortage of funds for the day and the BOJ's operations finalized by the previous day. Therefore, call market transactions can be regarded as being contracted on the basis of this forecast. The BOJ's forecasts are extremely accurate, and with the exception of a few exceptional periods, such as the failure of Lehman Brothers and the Great East Japan Earthquake, the correlation coefficient between the forecast and actual values is almost one, as shown in Figure 10.

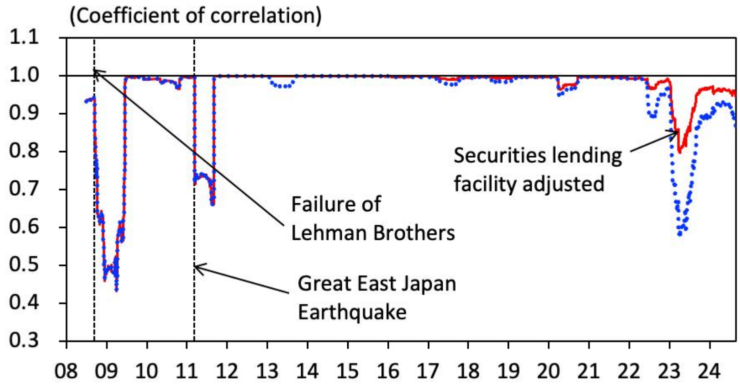
4.2 Empirical specification and preliminary estimation results

I will estimate the reserve demand curve, shown previously in Figure 2, using the specification below.

$$SPCI_t = \alpha + \beta LCF_t + \sum \delta_i DUM_{it} + \varepsilon_t. \tag{1}$$

The explained variable of $SPCI$ is the spread between the call rate and the IOER, and the ex-

Figure 10: Accuracy of BOJ's Forecast of Current Account Balances



Source: Bank of Japan.

planatory variable of LCF is the log-transformed forecast of the current account balances released at 6:00 pm on the previous day. DUM_i are dummy variables for controlling the calendar effects, such as the end of the month, and the first and last several days of the reserve maintenance period. α, β, δ_i, and ε are a constant term, a slope parameter, an estimated coefficient for dummy variable DUM_i, and an error term. DUM_i includes the last business day of each month (DEM), the first three business days of the reserve maintenance period ($DBRM1$, $DBRM2$, $DBRM3$), and the last three business days of the reserve maintenance period ($DERM1$, $DERM2$, $DERM3$).

Under the ample reserve regime with the very mild downward-sloping reserve demand curve, α and β are expected to be statistically significantly positive and negative, respectively. However, when entering the abundant reserve regime with satiated reserve demand, α and β are expected to be statistically significantly negative and insignificant, respectively. α becomes negative, reflecting that the call market transactions are dominated by the arbitrage between eligible and non-eligible financial institutions to the IOER.

Table 2 summarizes the preliminary OLS estimation results using the full sample period data (from Jan 5, 2009 to Feb 15, 2016) and the two subsample period data before and after the introduction of the QQE (from Jan 5, 2009 to Apr 3, 2013, and from Apr 4, 2013 to Feb 15, 2016).[30] The estimation results using data for the full sample period and the first half of the sample period show that α and β are statistically significantly positive and negative, indicating the liquidity effects of the current account balances on the call rates. In contrast, the estimation results using the second half of the sample period show that α and β are significantly negative and insignificant, showing no liquidity effects.

These estimation results suggest that the call market in Japan entered the abundant reserve regime and satiating reserve demand during the QQE. In the following, I will estimate Equation (1) to examine the levels of current account balances satiating banks' reserve demand.

[30] I use data prior to the implementation of NIR on February 15, 2016 since the call rates become the penalty rate and are traded based on very different incentives.

Table 2: Preliminary OLS Estimations

Dependent variable: *SPCI*

	Full sample			Subsample (pre-QQE)			Subsample (QQE)		
Sample period	Jan 5, 2009 to Feb 15, 2016			Jan 5, 2009 to Apr 3, 2013			Apr 4, 2013 to Feb 15, 2016		
	Coeff.	S.E.		Coeff.	S.E.		Coeff.	S.E.	
Const	2.303	(0.222)	**	5.720	(0.377)	**	−2.508	(0.478)	**
LCF	−1.064	(0.054)	**	−2.189	(0.126)	**	−0.071	(0.100)	
DEM	−0.360	(0.150)	*	0.155	(0.114)		−1.035	(0.306)	**
*DBRM*1	0.061	(0.100)		0.106	(0.114)		0.019	(0.105)	
*DBRM*2	0.064	(0.096)		0.090	(0.107)		0.055	(0.108)	
*DBRM*3	0.099	(0.084)		0.167	(0.099)		0.072	(0.091)	
*DERM*1	0.044	(0.095)		0.053	(0.111)		0.007	(0.083)	
*DERM*2	0.062	(0.089)		0.028	(0.108)		0.000	(0.083)	
*DERM*3	0.083	(0.094)		−0.045	(0.115)		0.160	(0.106)	
Adj. R_sqrd	0.598			0.634			0.634		
Obs.	1,743			1,042			701		

Notes: The figures in parentheses are heteroscedasticity and autocorrelation consistent (HAC) standard errors for estimation coefficients based on Newey and West (1987). ** and * indicate that the estimated coefficients are statistically significant at 99% and 95% levels, respectively.

Since the reserve demand curve is nonlinear, I will confirm the robustness of the estimation results by comparing the results from two estimation methods: OLS estimation with unknown breakpoints and discrete threshold estimation.

4.3 Detecting turning points

In the following, I will estimate the levels of current account balances satiating banks' reserve demand, considering its nonlinearity, by applying two estimation methods: the OLS estimation with unknown breakpoints and the discrete threshold estimation.

4.3.1 OLS estimations with unknown breakpoints

I apply the OLS estimation with unknown breakpoints, proposed by Bai and Perron (2003), to examine the time-varying nature of the constant term and the slope parameter for *LCF*, as shown in Equation (2).

$$SPCI_t = \begin{cases} \alpha_1 + \beta_1 LCF_t + \sum \delta_i DUM_{it} + \varepsilon_t & if\ t < \tau_1 \\ \alpha_2 + \beta_2 LCF_t + \sum \delta_i DUM_{it} + \varepsilon_t & if\ \tau_1 \leqq t < \tau_2 \\ \alpha_3 + \beta_3 LCF_t + \sum \delta_i DUM_{it} + \varepsilon_t & if\ t \geqq \tau_2 \end{cases} . \quad (2)$$

Note that only the constant term α and the slope parameter β take different values depending on the period divided by the estimated breakpoints, and other estimates for dummy variables take the same values over the whole sample period.

Table 3 summarizes three specifications: full-sample period estimations assuming one or two unknown breakpoints and subsample period estimation assuming one unknown breakpoint. Among the three estimation results, full sample estimations assuming two unknown breakpoints show the highest adjusted R-squared and best capture the nonlinear shape of the reserve demand curve.

Table 3: OLS estimations with unknown breaks

Dependent variable: *SPCI*
Sample period: from January 5, 2009, to February 15, 2016

	Full sample Jan 5, 2009 to Feb 15, 2016						Subsample Jan 5, 2009 to Apr 3, 2013		
	Coeff.	S.E.		Coeff.	S.E.		Coeff.	S.E.	
Period 1	Jan 5, 2009 to Aug 2, 2011			Jan 5, 2009 to Aug 2, 2011			Jan 5, 2009 to Aug 2, 2011		
Const	9.567	(0.889)	**	9.564	(0.883)	**	9.619	(0.895)	**
LCF	−3.602	(0.317)	**	−3.601	(0.317)	**	−3.629	(0.319)	**
Period 2	Aug 3, 2011 to Dec 8, 2014			Aug 3, 2011 to Feb 15, 2016			Aug 3,2011 to Apr 3, 2013		
Const	1.842	(0.323)	**	0.300	(0.431)		0.116	(3.264)	
LCF	−1.028	(0.074)	**	−0.628	(0.104)	**	−0.551	(0.932)	
Period 3	Dec 9, 2014 to Feb 15, 2016								
Const	−7.408	(3.999)							
LCF	0.866	(0.732)							
Non-breaking variables									
DEM	−0.280	(0.153)		−0.283	(0.146)		0.210	(0.113)	
DBRM1	0.080	(0.061)		0.080	(0.063)		0.125	(0.090)	
DBRM2	0.086	(0.062)		0.085	(0.066)		0.106	(0.092)	
DBRM3	0.128	(0.053)	*	0.123	(0.055)	*	0.159	(0.083)	
DERM1	0.025	(0.059)		0.032	(0.060)		0.047	(0.094)	
DERM2	−0.032	(0.058)		−0.025	(0.058)		−0.039	(0.090)	
DERM3	−0.012	(0.065)		−0.006	(0.065)		−0.116	(0.089)	
Adj. R_sqrd	0.796			0.766			0.766		
Obs	1,743			1,743			1,042		
Obs (Period-1)	631			631			631		
Obs (Period-2)	824			1,112			411		
Obs (Period-3)	288								

Notes: The figures in the parenthesis are heteroscedasticity and autocorrelation consistent (HAC) standard errors for estimation coefficients based on Newey and West (1987). ** and * indicate that the estimated coefficients are statistically significant at 99% and 95% levels, respectively.

Focusing on the estimation result for the first specification, the two breakpoints are August 3, 2011 and December 9, 2014, respectively, and Periods 1, 2, and 3 correspond to the ample reserve regime and transition phase from the ample reserve to the abundant reserve regime (transition regime), and the abundant reserve regime. Estimates for α and β are all consistent with the nonlinear shape of the reserve curve over the three periods. α and β are statistically significantly positive and negative, respectively, in both Periods 1 and 2, and the absolute values of the estimates are larger for Period 1. α is statistically significantly negative, but β is insignificant for Period 3.

4.3.2 Threshold estimations

I next apply the threshold regression model to estimate the reserve demand curve, considering the transitions between the ample and the abundant reserve regimes in response to arbitrage opportunities in the short-term money markets. I employ the two indicators, lagged spread between TB 3-month and call rate (*SPTC_L*) and lagged spread between 3-month general collateral repurchase agreement (repo) rate and call rate (*SPRC_L*), as the threshold variables (*THV*) with unknown threshold values τ_1 and τ_2, as shown in Equation (3),

$$SPCI_t = \begin{cases} \alpha_1 + \beta_1 LCF_t + \sum \delta_i DUM_{it} + \varepsilon_t & if\ THV < \tau_1 \\ \alpha_2 + \beta_2 LCF_t + \sum \delta_i DUM_{it} + \varepsilon_t & if\ \tau_1 \leqq THV < \tau_2 \\ \alpha_3 + \beta_3 LCF_t + \sum \delta_i DUM_{it} + \varepsilon_t & if\ THV \geqq \tau_2 \end{cases} . \tag{3}$$

Note that I assume that the maximum number of states is three. A constant term and a slope parameter are α_1 and $\beta_1$when $THV < \tau_1$ (ample reserve regime), α_2 and β_2 when $\tau_1 \leqq THV < \tau_2$ (transition regime), α_3 and β_3 when $THV \geqq \tau_2$ (abundant reserve regime).

Table 4 summarizes the estimation results for the threshold regressions with three states, using *SPTC_L* and *SPRC_L* as the threshold variables. The table shows that Akaike information criteria (AIC) is smaller when using *SPTC_L* as a threshold variable than when using *SPRC_L*, suggesting that the estimation results are more precise when using *SPTC_L* as a threshold variable. However, estimates for α and β are all consistent with the nonlinear shape of the reserve demand curve over the three states when using *SPRC_L* as a threshold variable. α and β are statistically significantly positive and negative, respectively, in both State-1 and State-2, and the absolute values of the estimates are larger for State-1. α is statistically significantly negative, but β is insignificant for State-3. Turning to the estimation results when using *SPTC_L* as a threshold variable, α and β are statistically significantly positive and negative, respectively, in both states, and the absolute values of the estimates are larger for State-1. Nevertheless, looking at the estimates for State-3, α is statistically significantly negative, but β is statistically significantly positive, not insignificant.

Table 4: Threshold Regressions

Dependent variable: *SPCI*
Sample period: from January 5, 2009, to February 15, 2016

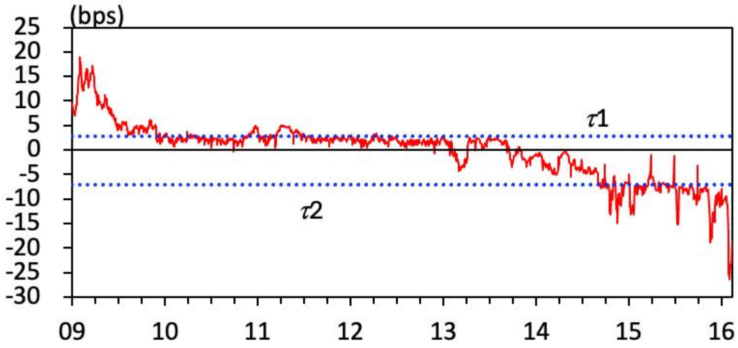
	Full sample Jan 5, 2009 to Feb 15, 2016					
Threshold variables	*SPTC_L*			*SPRC_L*		
τ_1	2.700			3.100		
τ_2	−7.200			−2.800		
	Coeff.	S.E.		Coeff.	S.E.	
State-1						
Const.	9.432	(0.815)	**	8.022	(0.530)	**
LCF	−3.535	(0.286)	**	−3.016	(0.188)	**
State-2						
Const.	2.489	(0.207)	**	2.727	(0.419)	**
LCF	−1.162	(0.050)	**	−1.219	(0.106)	**
State-3						
Const.	−11.353	(3.617)	**	−6.460	(5.154)	
LCF	1.610	(0.666)	*	0.705	(0.953)	
DEM	−0.314	(0.146)	*	−0.364	(0.154)	*
*DBR*1	0.066	(0.062)		0.074	(0.093)	
*DBR*2	0.080	(0.061)		0.069	(0.087)	
*DBR*3	0.106	(0.054)		0.138	(0.078)	
*DER*1	0.009	(0.058)		0.048	(0.094)	
*DER*2	−0.020	(0.057)		−0.001	(0.083)	
*DER*3	0.008	(0.066)		0.026	(0.090)	
AIC	1.959			2.505		
Obs.	1,743			1,743		
Obs. (State-1)	400			860		
Obs. (State-2)	1,076			603		
Obs. (State-3)	267			280		

Notes: The figures in parentheses are heteroscedasticity and autocorrelation consistent (HAC) standard errors for estimation coefficients based on Newey and West (1987). ** and * indicate that the estimated coefficients are statistically significant at 99% and 95% levels, respectively.

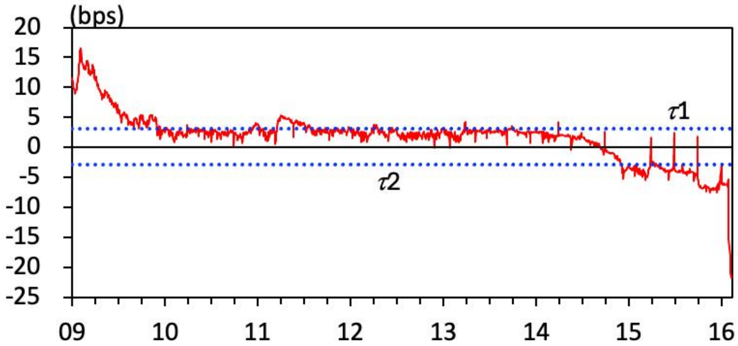
Figure 11 plots *SPTC_L* and *SPRC_L* with the two estimated threshold values for dividing the three states as dashed horizontal lines. The figure shows that the threshold values are generally consistent with the estimated breakpoints in the OLS estimation results with unknown breakpoints. However, the two threshold variables exhibit a downward trend in the latter half of the sample period, which potentially influences the estimation results for the threshold values.

Figure 11: Estimated Threshold Values

(1) *SPTC_L*



(2) *SPRC_L*



Source: Bloomberg.

5 BOJ's Future Monetary Policy Implementations

In this section, I will discuss the future of monetary policy implementations by the BOJ in three respects: the long-term balance sheet size under elevated demand for central reserves, the money market operations to accommodate such elevated demand for reserves, and the transition process to the long-term level.

5.1 Long-term balance sheet size

As discussed in Section 2, reserves, in addition to banknotes in circulation, will continue to comprise a significant portion of the liabilities side of the central bank balance sheet. There exists considerable uncertainty about the long-term size of the central bank balance sheet under this new regime.

Looking again at the long-term trend of the BOJ's balance sheet size in Figure 5, shown in Section 3, it had remained extremely stable at a little less than 10% of nominal GDP for a long time after World War II until 1995 when the uncollateralized overnight call rate was lowered to 0.5% in 1995. During this period, the liability side of the BOJ's balance sheet was dominated by banknotes in circulation, which remained extremely stable at around 8% of nominal GDP. After the uncollateralized overnight call rate was lowered to 0.5% in 1995, the ratio gradually increased under the virtually zero interest rate environment, reaching about 20% of nominal

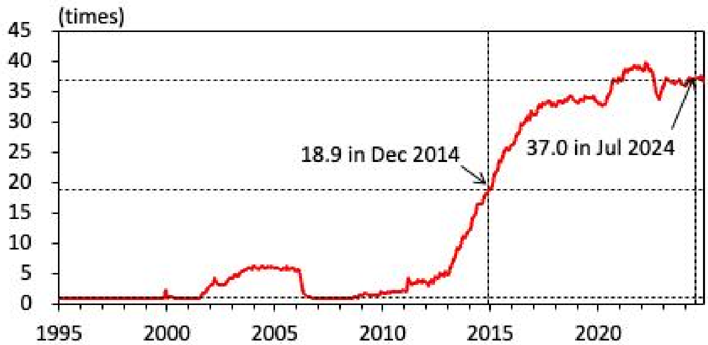
GDP (119.9 trillion yen as of July 2024). Although the Japanese preference for cash remains persistent, it is difficult to predict long-term cash demand as financial digitization progresses.[31]

In addition, the current account balances expanded rapidly in line with the expansion of the JGB holdings under the QQE. Of course, it is assumed that quantitative tightening will progress and the current account balances will shrink, but the long-term level can be difficult to predict at this stage.

To consider the required size of the reduction in the current account balances in the long run, Figure 12 plots the reserves to required reserves ratio (R-RR ratio) from 1995. This ratio stays at one when no excess reserves exist on average during the reserve maintenance period. The ratio increased under the QE from March 2001 to March 2006, reaching its peak at 6.9 times in February 2004. The ratio starts increasing under the CE under the GFC and reaches 6.0 in March 2013. The ratio increases rapidly after the introduction of the QQE in April 2013, reaching its peak at 39.8 in March 2022. The ratio remained at a high level even after the termination of the QQE and was 37.0 in July 2024, at the starting point of the BOJ's reduction plan for JGB purchases.

Figure 12: Adjustments for Target Current Account Balances

Reserves to required reserves ratio



Notes: The two vertical dashed lines indicate December 2014 and July 2024, from left to right. The first vertical line indicates the satiating point of reserve demand, and the second one indicates the starting point of the BOJ's reduction plan for the JGB purchases. The two horizontal dashed lines indicate one and the level corresponding to December 2014, from bottom to top.
Source: Bank of Japan

The figure includes the vertical dashed line on December 9, 2014, which corresponds the second breakpoint for the estimated reserve demand curve applying OLS with unknown breakpoints, as shown in the previous section. The current account balances at the second breakpoint, 168.7 trillion yen, are the tentative target level for the current account balances. When the current account balances exceed the second breakpoint, the reserve demand is satiated, and the slope of the reserve demand curve becomes perfectly flat. Of course, the call rate will likely begin to respond to changes in current account balances from a higher level, as incentives for liquidity management at financial institutions greatly declined due to the existence of extremely large excess reserves for prolonged periods.

[31] See Fujiki and Nakashima (2021) for the long-term trend of cash demand in Japan.

Considering the changes in the economic and financial environment since 2014, I will adjust the target levels using the R-RR ratios as of December 2014. Although deposit liabilities covered by the required reserve system grew last ten years, reserves expanded faster than them under the QQE. Thus, I assume that the R-RR ratio declines to, at least, the level in December 2014.

Table 5 summarizes the assumptions on the long-term level of the BOJ's balance sheet size. The total size is assumed to be at 370 trillion yen, corresponding to 62 percent of nominal GDP, which is the sum of the banknotes in circulation and reserves. Banknotes in circulation remain at the current level of 120 trillion yen, and reserves decline to 250 trillion yen, which is the required reserves of 13 trillion yen multiplied by the R-RR ratio of 19 times. The size of the central bank balance sheet is still fairly large compared to other advanced economies, and it is deemed appropriate to consider this assumption as an upper limit.

Table 5: Long-term Level of BOJ's Balance Sheet Size

	Total	Banknotes	Reserves	Req. Reserves	R-RR Ratio
Amounts (tril. yen)	370	120	250	13	19 (times)
GDP Ratio (%)	62	20	42		

5.2 Transition to the long-term level

Given that the BOJ's balance sheet size is broadly consistent with the level of JGB holdings over the long term, the next question is the transition process to this long-term level. As mentioned earlier, it will take more than eight years to halve the outstanding amount of the long-term JGB holdings from 600 trillion yen to 300 trillion yen. This transition process is likely to take longer than a single interest rate hike phase.

To examine the transition process, I will simulate the path of the BOJ's JGB holdings with four scenarios in Table 6. All the scenarios assume that the BOJ will maintain the average remaining maturity of its JGB holdings at the starting point level of 6.5 years.

The baseline scenario assumes that the BOJ will follow its updated reduction plan for JGB purchases, decided in June 2025, at the pace of about 400 billion yen per quarter from July 2024 to March 2026, and 200 billion yen per quarter from April 2026 to March 2028. Under this scenario, the monthly purchasing amounts are projected to decline from approximately 5.7 trillion yen in July 2024 to around 2.9 trillion yen in the first quarter of 2026, and then to 2.1 trillion yen in the first quarter of 2027. This scenario further assumes that the BOJ will continue to purchase the JGBs at a monthly pace of 2.1 trillion yen thereafter.

The other three alternative scenarios assume the further acceleration of the JGB purchase reductions. The first alternative scenario (alternative-1) assumes that the BOJ will continue to

Table 6: Simulation Scenarios

Unit: tril. yen

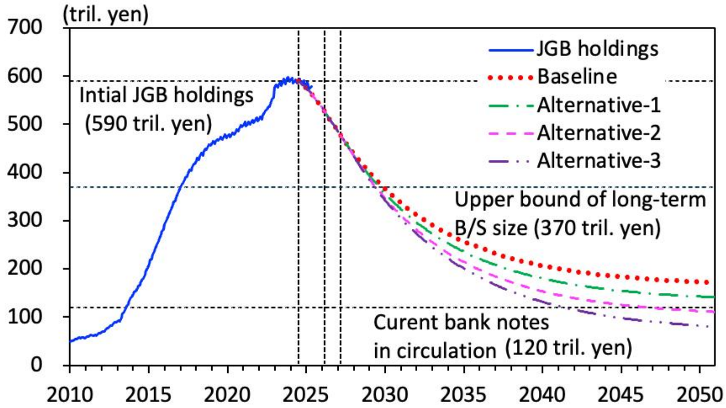
	Monthly purchasing amounts							Maturity
	Jul-24		Mar-26		Mar-27		Mar-28	(years)
Baseline	5.3	→	2.9	→	2.1	→	2.1	6.5
(Pace)		▲0.4		▲0.2		0.0		
Alternative-1	5.3	→	2.9	→	2.1	→	1.7	6.5
(Pace)		▲0.4		▲0.2		▲0.1		
Alternative-2	5.3	→	2.9	→	2.1	→	1.3	6.5
(Pace)		▲0.4		▲0.2		▲0.2		
Alternative-3	5.3	→	2.9	→	1.7	→	0.9	6.5
(Pace)		▲0.4		▲0.3		▲0.2		

reduce the monthly purchasing amounts at a pace of 100 billion yen per quarter for one more year, from 2.1 trillion yen to 1.7 trillion yen. The second alternative scenario (alternative-2) assumes that the BOJ will continue to reduce the monthly purchasing amounts at a pace of 200 billion yen per quarter for one more year, from 2.1 trillion yen to 1.3 trillion yen. The last third alternative scenario (alternative-3) assumes the BOJ will take a slightly faster reduction pace beyond March 2026: 300 billion yen per quarter to March 2027 and 200 billion yen per quarter to March 2028. The monthly purchasing amounts will decline to 1.7 trillion in March 2027 and 0.9 trillion yen in March 2028.

Figure 13 plots the simulated path of the BOJ's JGB holdings until the end of 2050. In March 2028 at the end of the BOJ's current reduction plan, the BOJ's JGB holdings are projected to decline to slightly below 480 trillion yen, including the alternative-3 scenario. All the scenarios exibit very close trends up to 2030 when the simulation paths reach the upper bound of the long-term JGB holdings at 370 billion yen. The simulation paths, however, start deviating thereafter, and the three alternative scenarios exhibit slightly faster declining trends. The alternative-2 and 3 scenarios reach the current level of banknotes in circulation of 120 trillion yen by 2046 and 2041, respectively. Of course, there exists significant uncertainty regarding banknote demand under a positive interest rate environment. These simulation results, however, indicate that the BOJ needs more than 15 years to reduce its JGB holdings below the level of banknotes in circulation.

To get an overall picture of the future level of JGB holdings, Table 7 calculates the long-term JGB holdings corresponding to monthly JGB purchases and the average remaining maturity. Assuming the average maturity of 6.5 years is maintained, monthly JGB purchases of 2.1 trillion yen will result in JGB holdings of 163.8 trillion yen over the long term. If the BOJ reduces its monthly purchasing amounts to 0.9 trillion yen, the long-term JGB holdings decline to 70.2. However, suppose the BOJ maintains its monthly purchasing amounts at 2.1 trillion yen, while lowering the average remaining maturity to 4.5 years, which corresponds to the average life of 10,000 yen banknotes of 4 to 5 years. In this scenario, the long-term level declines to 113.4 trillion yen. These results suggest that the BOJ needs to examine the maturity composition of its JGB holdings, in addition to the monthly purchasing amounts.

Figure 13: Simulation on BOJ's JGB Holdings



Notes: Three vertical dashed lines indicate the starting point for the simulation in July 2024, March 2026, and March 2027. Three horizontal dashed lines indicate the initial JGB holdings, the upper bound of the BOJ's balance sheet size, shown in Table 5, and the current banknotes in circulation. The baseline and three alternative scenarios are shown in Table 6.

Table 7: Long-term Level of JGB Holdings

Unit: tril. yen

Monthly Purchases	Average Remaining Maturities (years)			
	6.5	5.5	4.5	3.5
5.3	413.4	349.8	286.2	222.6
2.9	226.2	191.4	156.6	121.8
2.1	163.8	138.6	113.4	88.2
1.7	132.6	112.2	91.8	71.4
1.3	101.4	85.8	70.2	54.6
0.9	70.2	59.4	48.6	37.8

To sum up the above simulation results, in the long run, the BOJ will be able to reduce its JGB holdings to below the outstanding amount of banknotes in circulation, thereby returning to the banknote rule in the long term. In doing so, the BOJ will be able to operate its long-term JGB purchase operations more flexibly by considering, in combination, the monthly purchasing amount and the average remaining maturity of long-term JGB holdings.

At the same time, the BOJ needs to work on reducing its long-term JGB holdings over a fairly long period, beyond several cycles of interest rate hikes and cuts. Thus, it is deemed important to clarify that the reduction of the JGB holdings is irrelevant to the degree of monetary easing.

5.3 Framework for monetary policy implementation

The final issue is how the BOJ accommodates a large demand for central bank money using conventional tools in money market operations in a stable and sustainable manner. As briefly mentioned in Section 2, the BOJ needs to redefine conventional financial assets as instruments

Table 8: Long-term Mechanism

Liability items	Outstanding amounts (as of July 2024, tril. yen)	Interest payment	Operational tools
Banknotes	119	No	Long-term JGB purchases
Required reserves	13		
Excess reserves	473	Yes	Short-term fund supplying operations

of money market operations in normal times.[32] I will discuss this issue in two steps: The accommodation mechanism for the long-term demand for central bank money and the transition scheme.

5.3.1 Long-term view

Prior to QQE, the BOJ employed the "banknote rule" to limit the BOJ's JGB holdings to a level less than the outstanding amount of banknotes in circulation. The rule clarifies that the BOJ continues to purchase long-term JGBs to facilitate the smooth issuance and circulation of banknotes, drawing clear boundaries with the central bank government financing. This rule implies that long-term JGB holdings are regarded as conventional financial assets, with a ceiling at the outstanding amounts of banknotes in circulation.

Given the huge additional demand for the central bank money as reserves, it is unlikely that the BOJ will be able to return to the previous banknote rule soon. The BOJ thus needs to clarify how the demand for central bank money will be accommodated in the long term.

The BOJ provides two types of central bank money, banknotes and reserves. Reserves are decomposed into two categories, required reserves and excess reserves. Among these three items, banknotes and required reserves are non-interest-bearing liabilities, and excess reserves are interest-bearing liabilities. Thus, the banknote rule can be extended to include required reserves, as they are non-interest-bearing liability and are considered a stable source of seigniorage ("extended banknote rule in the long term"). In contrast, excess reserves are interest-bearing liablities that are perfectly linked to the policy interest rates and are expected to be accommodated through short-term fund supplying operations with a closer link to the policy interest rate.

Table 8 summarizes the above discussions. It should be noted that the transition to the long-term mechanism is a critically important issue, as the BOJ had a substantial portion of interest-bearing liabilities at the starting point of its QE process and needs to work on this process for a fairly long time.

[32] There exists the issue of how to dispose of the two risky assets with indefinite maturities, the ETFs and REITs, which remain on the asset side of the Bank of Japan's balance sheet.

5.3.2 Transition scheme

Given the simulation results for the BOJ's JGB holdings until 2050, it is deemed difficult to set a ceiling on JGB holdings for the time being. It is thus more practical to map out a rule for JGB purchases on a flow basis, rather than a stock basis, when considering the "extended banknote rule in transition." I propose a rule to ensure JGB purchases are consistent with long-term JGB holdings by defining the monthly purchasing amounts and the average remaining maturity.

The “extended banknote rule in transition” plays a crucial role in addressing concerns about fiscal discipline, as the boundary between fiscal financing and monetary policy becomes blurred under the QQE. The introduction of the extended banknote rule in transition makes it clear that the BOJ purchases long-term JGBs to accommodate the demand for central bank money as the sum of banknotes and required reserves in the long term, thereby drawing a clear boundary with central bank government financing. Considering the expanded demand for reserves, the banknote rule can be modified to the "extended banknote rule" by slightly expanding liabilities in the long term and incorporating the transition scheme.

Note that when considering long-term JGBs as a conventional financial asset, the BOJ's JGB purchases are required to minimize their impact on market liquidity and price formation. The long-term level of JGB holdings is determined by the combination of the monthly purchasing amount and the average remaining maturity of the BOJ's JGB portfolio. Such a purchasing scale also needs to be confirmed from the perspective of practical feasibility by considering the amount of each purchase, the frequency of purchases, and the allocation of the remaining maturity. The BOJ may need to reduce its JGB purchases further to minimize the impact on market liquidity and price formation in the JGB market.

In addition, the BOJ needs to reduce excess reserves through trial and error during the QT process. It is thus particularly important to clarify that the CB balance sheet size is determined by liability-side factors.

6 Concluding Remarks

In this paper, I developed a long-term guidepost for the QT process in Japan, with a focus on the BOJ's future balance sheet configuration.

By estimating the reserve demand curve using OLS with unknown breakpoints and threshold regression, the analysis identified a likely floor level of reserves under current institutional settings. This estimate serves as the basis for projecting the future size of the BOJ's balance sheet, providing a quantitative benchmark for the QT process.

In considering the long-term level of the central bank balance sheet size, it is deemed critical to restore the liability-side-driven mechanism. The size will be determined by the demand for central bank money, consisting of currency in circulation and reserves. The composition will depend on how a central bank accommodates the demand for central bank money by purchasing and selling conventional financial assets.

The above framework implies that central banks need to return to the pre-GFC policy philosophy: monetary policy implementation should be neutral with respect to the resource allocation in the economy, and money market operations should be implemented to minimize the effects on market liquidity and price formation. In this sense, such analyses were closely related to designing money market operations by linking to the views on the appropriate size of the central bank balance sheet and operational facilities to accommodate it.

In addition, the QT process in Japan needs to be considered from a long-term viewpoint with a time frame of decades. It is deemed important to address concerns about fiscal discipline, considering that the boundary between fiscal financing and monetary policy becomes blurred under the QQE. I proposed the "extended banknote rules," both in the long term and in transition, and they play a crucial role in addressing concerns about fiscal discipline. The rule enables the BOJ to clarify the upper limit on the long-term JGB purchases during the transition process, based on a long-term balance sheet and a ceiling on long-term government bond holdings to accommodate that balance sheet.

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