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What Does the Yield Curve Control Policy Do?*

Shigenori Shiratsuka

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Abstract

The current monetary policy framework of the Bank of Japan (BOJ) is the Quantitative and Qualitative Monetary Easing (QQE) with Yield Curve Control (YCC). The YCC framework targets two interest rates with different maturity: the overnight policy interest rate at −0.1 percent and the longer-term 10-year Japanese Government Bond (JGB) yields at zero percent. It appears to work effectively in stabilizing interest rates from short- to long-term at low levels. This paper addresses the question of what the BOJ's YCC policy does through the lens of the yield curve dynamics in the JGB market and the overnight index swap (OIS) market, with due consideration of practical details of the BOJ's JGB market operations. Empirical evidence shows two points. First, the BOJ's JGB market interventions amplify the fluctuations of the overall yield curves, in contrast to its policy purpose of fostering the smooth formation of a mild upward-sloping shape of the JGB yield curve. Second, the BOJ's outright JGB purchases in high-stress times are seemingly aggressive but actually reactive to counter the market pressure on the YCC cap. These findings indicate that the YCC policy is carried out to sustain the YCC policy framework without producing effective easing effects but with significant side effects.

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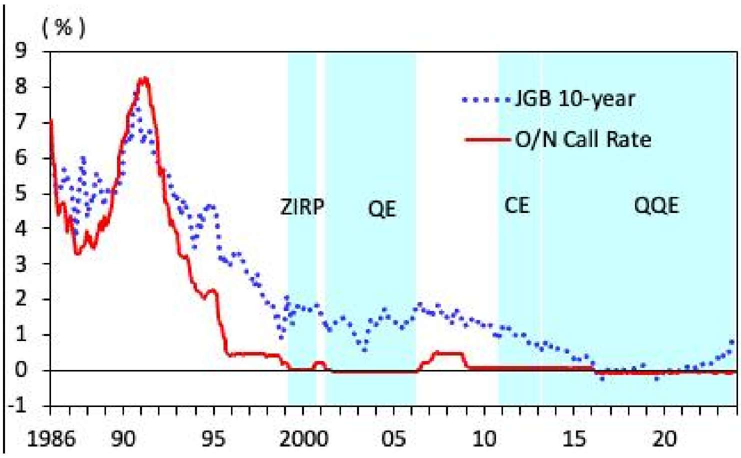
1 Introduction

The Bank of Japan (BOJ) currently employs the monetary policy framework of Quantitative and Qualitative Monetary Easing (QQE) with Yield Curve Control (YCC). This policy framework targets the overnight policy interest rates at −0.1%, and the longer-term 10-year Japanese Government Bond (JGB) yields at zero percent with the fixed fluctuation allowance range.[1] This paper addresses the question of what the YCC policy does through the lens of the yield curve dynamics in the JGB market and the overnight index swap (OIS) market with due consideration of practical details of the BOJ's JGB market operations.[2]

Looking back at the interest rate trend in Japan using Figure 1, the BOJ reduced its policy interest rate, uncollateralized overnight call rate, to 0.5 percent in 1995. Since then, the Japanese economy has faced the effective lower bound (ELB) constraint of nominal interest rates for more than 25 years. Long-term interest rates have also followed a downward trend and have remained near zero since the mid-2010s.

Figure 1: Short- and Long-term Interest Rates in Japan



Notes: Abbreviations in the figures correspond to the monetary policy regime 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-present).
Source: Bank of Japan

Under such financial conditions, the BOJ has continued to implement various unconventional monetary policy measures over time: Zero Interest Rate Policy (ZIRP) from February 1999 to August 2000, Quantitative Monetary Easing Policy (QE) from March 2001 to March

[1] As described later, the BOJ decided to abolish the strict YCC cap, stipulated by the fixed-rate purchases with unlimited amounts, on October 31, 2023. Since the decision implies the effective abolition of the YCC policy, this paper focuses on the YCC policy before that decision.

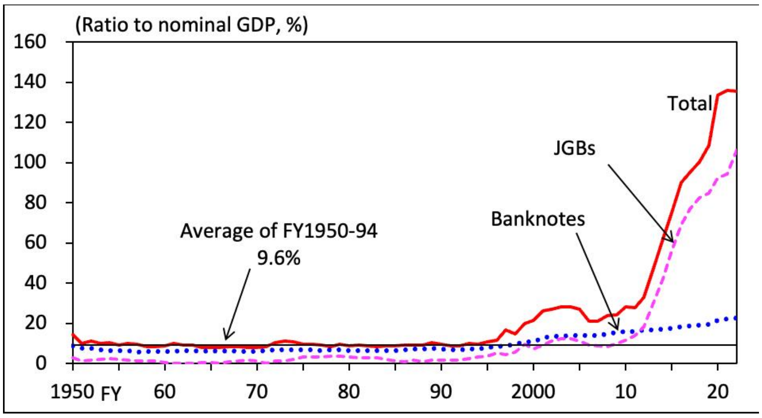
[2] The OIS is an interest rate swap contract that involves an exchange of floating and fixed interest rates over a given period using uncollateralized overnight call rates as its underlying reference rates for the floating component. The OIS rates are widely used as an indicator that more accurately reflects actual market conditions regarding long-term interest rates. Since the OIS market allows trading without the direct influence of BoJ's market operations, including the JGB outright purchases, it is considered to more clearly reflect market participants' views on the future course of monetary policy.

2006, Comprehensive Monetary Easing Policy (CE) from October 2010 to March 2013, and QQE from April 2013 to the present. QQE has then been modified from a short-term shock therapy strategy to an endurance strategy in a patchwork fashion: QQE with Negative Interest Rates (QQE w/ NI) from January 2016 to September 2016, and QQE with Yield Curve Control (QQE w/ YCC) from September 2016 to the present.[3]

A zero percent target level for the 10-year JGB yields in the YCC framework implies that the BOJ commits to guiding short-term interest rates to zero percent on average for the next ten years. As far as this commitment is credible, the yield curve remains near zero from short to long term. At the same time, the YCC commitment serves to lock the economy into a zero-interest-rate situation, entrenching the expectation of the continuation of stagnant economic conditions.[4]

Looking at the long-term trend of the BOJ's balance sheet size in Figure 2, it had remained extremely stable at a little less than 10% of nominal GDP for a long time 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 and reaching around 1.4 times nominal GDP.

Figure 2: 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 of 1950 to 1994 of 9.6% of nominal GDP.
Sources: Bank of Japan, Cabinet Office.

The figure also shows that the expansion of the BOJ's balance sheet size was accommodated by the large-scale outright purchases of long-term JGBs. Prior to the QQE, the purchases of long-term JGBs were conducted under the BOJ's banknote rule, which limits the BOJ's JGB

[3] The BOJ is currently conducting a review of its monetary policy management since the late 1990s from a broad perspective. For more information, see the BOJ's website at URL: https://www.boj.or.jp/en/mopo/outline/bpreview/index.htm.

[4] Okina and Shiratsuka (2004) point out that the policy commitment to keeping the policy interest rate low for an extended period into the future is unable to produce sufficient easing effects since the long-term forward rate in Japan already stays low, thus resulting in containing the policy interest rates at the ELB constraint. Bernanke (2020) emphasizes that the nominal natural rate needs to be high to create sufficient policy room for encountering large adverse shocks with unconventional monetary policy tools when considering the ELB of nominal interest rates.

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. In this case, about 80% of the BOJ's current holdings of long-term JGBs are regarded as unconventional financial assets.[5]

By widening the fluctuation allowance range several times, the YCC framework appears to effectively stabilize interest rates from short- to long-term maturities at low levels, persistently maintaining ultra-easy financial conditions. This experience shows that long-term interest rates cannot be controlled precisely as short-term interest rates. However, they can be controlled to some extent through continued and extremely large-scale market interventions.[6]

At the same time, the YCC policy is confirmed as a policy framework that symbolizes the very nature of the unconventional monetary policy, which actively intervenes in the market mechanism and intentionally influences the allocation of resources, thereby trying to extract easing effects under the ELB constraints of nominal interest rates.[7] This nature of the YCC policy sharply contrasts the previous principle of monetary policy management in normal times: central banks operate monetary policy with due consideration on minimizing the intervention to market mechanism. Thus, central banks control short-term interest rates and leave the formation of other financial asset prices to financial markets.

As a result of the prolonged massive intervention in the bond market, the functioning of the bond market has deteriorated significantly, and such deteriorated conditions have continued, as confirmed by the survey results for major market participants (Figure 3). This observation indicates that the balance between the policy effects of large-scale asset purchases under QQE and their side effects has changed over time.[8]

Still, econometric studies of the BOJ's YCC policy remain limited. Hattori and Yoshida (2023) examine the time-series properties of the JGB yields and interest-rate swap rates under the BOJ's YCC policy by applying an event study analysis with intraday data. Koeda and Ueno (2022) provide a preferred habitat view of the YCC policy, extending the term structure model in Vayanos and Vila (2021) by allowing the price elasticity of government bond demand by the central bank to depend on a targeted yield. Regarding more generally the effects of the BOJ's bond purchases, Fukunaga et al. (2015) examine the net supply effects of the JGBs, the

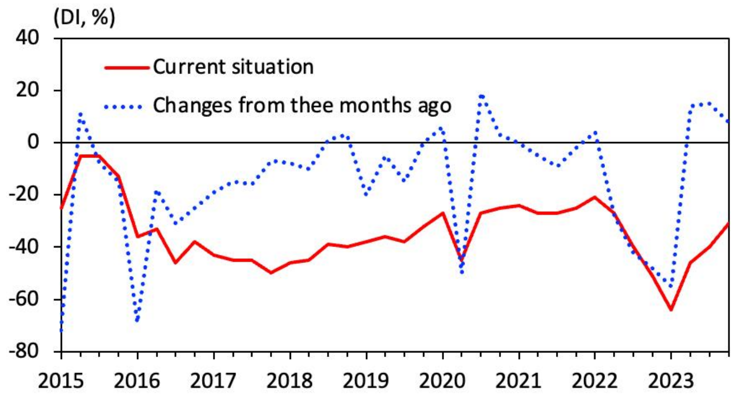
[5] Shiratsuka (2010) reviews the BOJ's Quantitative Monetary Easing (QE) policy from 2001 to 2006 from the viewpoints of the size and composition of the central bank balance sheet.

[6] Bernanke (2020) notes, "Yield curve control in the Japanese style—that is, pegging or capping very long-term yields—is probably not feasible, or at least not advisable, in the United States, given the depth and liquidity of US government securities markets."

[7] 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.

[8] Bernanke (2020) points out that central banks using quantitative easing (QE) have tried to ensure the well-functioning of securities markets, and major economies, except for Japan, have shown only limited evidence of declining market functioning.

Figure 3: Assessment of JGB Market Functioning



Notes: Survey results on the degree of bond market functioning regarding the current situation and the changes from three months ago. Survey respondents are eligible institutions for the BOJ's outright purchases and sales of the JGBs, major insurance companies, and asset management companies.
Source: Bank of Japan, "Bond Market Survey."

JGB new issuance minus the demand by the preferred habitat investors, including the BOJ, on the term structure of interest rates. Sudo and Tanaka (2021) examine the flow and stock effects of the BOJ's bond purchases by estimating a dynamic stochastic general equilibrium model assuming imperfect substitutability between short- and long-term bonds. Shiratsuka (2021) and Koeda and Wei (2023) review the BOJ's experiences with various unconventional monetary policy frameworks from the late 1990s, including the YCC policy, through the lens of yield curve dynamics. Shiratsuka (2021) applies the dynamic Nelson-Siegel model, while Koeda and Wei (2023) employ the macro-finance shadow rate model.

This paper is constructed as follows. Section 2 reviews Japan's experience of the YCC policy based on the yield curve dynamics, the BOJ's operations, and the size and composition of the BOJ's balance sheet. Section 3 examines the yield curve dynamics in the JGB market and the OIS market by employing the Nelson-Siegel model, proposed first by Nelson and Siegel (1987). Section 4 examines the distortions in the JGB market by using the decomposition results of the OIS-JGB spreads based on the estimation results of the Nelson-Siegel model. Section 5 empirically examines the BOJ's JGB market operations against the market pressures on the YCC policy framework. Finally, Section 6 concludes the paper.

2 Yield Curve Control Policy in Japan

2.1 The basic framework of the YCC policy

The BOJ introduced the QQE in April 2013, aiming at achieving the Price Stability Target of 2% CPI inflation sustainably within two years (see Table 1 for major monetary policy events in Japan since 2010).

The QQE sets the target for the growth rates of the monetary base by implementing an aggressive large-scale asset purchasing program with various ranges of financial assets, such

Table 1: Monetary Policy Events

	Date	Policy Events	YCC Allowance Range
(1)	Oct 5, 2010	Introduction of Comprehensive Monetary Easing (CE)	
(2)	Jan 22, 2013	Introduction of the Price Stability Target	
(3)	Apr 4, 2013	Introduction of Quantitative and Qualitative Monetary Easing (QQE)	
(4)	Oct 31, 2014	Expansion of QQE	
(5)	Jan 29, 2016	Introduction of QQE with Negative Interest Rates	
(6)	Sep 21, 2016	Introduction of QQE with Yield Curve Control	$-0.1/+0.1$ percent
(7)	Jul 31, 2018	Enhancing the sustainability of QQE with YCC	$-0.2/+0.2$ percent
(8)	Mar 16, 2020	Monetary easing to the outbreak of COVID-19	Unchanged
(9)	Mar 19, 2021	Further effective and sustainable monetary easing	$-0.25/+0.25$ percent
(10)	Dec 20, 2022	Modification of YCC	$-0.5/+0.5$ percent
(11)	Jul 28, 2023	Greater flexibility in the conduct of YCC	? / $+1.0$ percent
(12)	Oct 31, 2023	Further increasing the flexibility in the conduct of YCC	? / $+1.0+\alpha$ percent

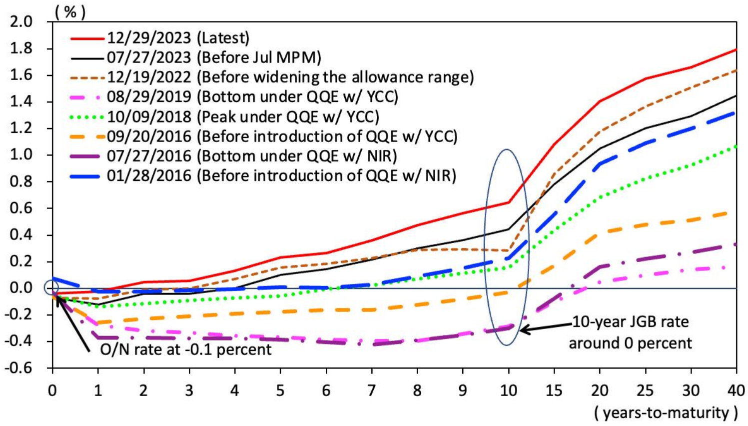
as JGBs, REITs, and ETFs . The QQE was expanded in the scale of financial assets purchased in October 2014. The QQE was then modified to target interest rates instead of the growth rates of the monetary base by introducing negative interest rates in January 2016 (QQE / NI). The policy was intended as a response to the rapid appreciation of the exchange rates. However, the policy drastically worsened the outlook for market participants, causing the yield curve to fall into negative territory for a wide range of maturities longer than ten years (see Figure 4 for the development of the yield curve under the QQE).[9]

The BOJ then tried to restore worsened market sentiment and introduced the YCC policy in September 2016 by shaping a moderately upward-sloping yield curve. The BOJ set two targets on interest rates: overnight interest rates at −0.1% and the 10-year JGB yields at zero percent with a fluctuation allowance range of 10bps. Under QQE w/ YCC, the BOJ widened the fluctuation allowance range five times: 20bps on July 31, 2018, 25bps on March 19, 2021, 50bps on December 20, 2022, 100bps on July 28, 2023, and 100bps+α on October 31, 2023.[10] From mid-2022 to early 2023, as market expectations of lifting the YCC policy grew, the shape

[9] This negative impact of introducing the Negative Interest Rate Policy in Japan can be understood as a materialization of the negative information effects of monetary policy. For the information effects of monetary policy, see Nakamura and Steinsson (2018) and Jarocinski and Karadi (2020). See also Tanahara et al. (2023) for the empirical application to Japan.

[10] On July 28, 2023, the BOJ decided to conduct YCC policy with greater flexibility. The 10-year JGB yields are allowed to move below 1.0%, instead of 0.5%, by changing the previous fluctuation allowance range of 50bps to the reference range (non-rigid limits) with a strict cap at 1% by the fixed-rate JGB purchase operations. On October 31, 2023, the BOJ decided to further increase the flexibility in the conduct of YCC policy by abolishing the fluctuation allowance range and the strict YCC cap with the fixed-rate purchases. With this modification, the BOJ will determine the offer rate for fixed-rate purchase operations each time, taking into account market rates and other factors. As noted in footnote 1, this policy decision implies the effective abolition of the YCC policy by removing the strict cap on the JGB yield stipulated by the fixed-rate operation rate.

Figure 4: JGB Yield Curve Developments



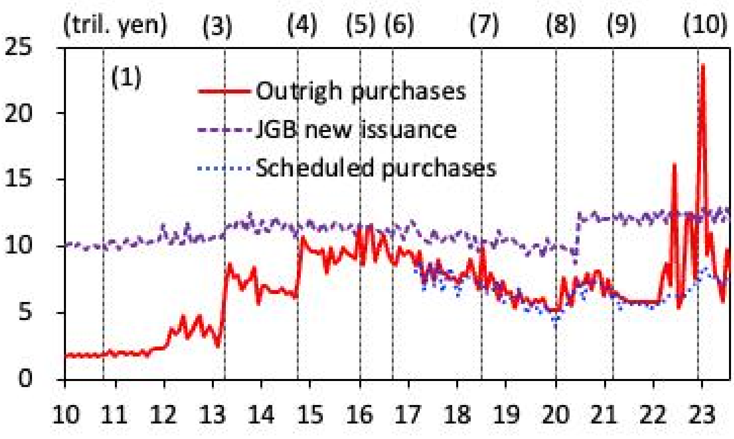
Sources: Ministry of Finance, Bank of Japan.

of the yield curve was distorted, with a large dip occurring near the 10-year maturity zone where the YCC target was set.

2.2 JGB market interventions under the YCC policy

Looking at the BOJ's JGB market operations, Figure 5 compares the BOJ's outright purchases of the JGBs with the monthly new issuance of the JGBs. The figure also plots the preannounced amounts of monthly scheduled purchases at the end of the previous month from March 2017.[11]

Figure 5: BOJ's JGB Purchases



Notes: Vertical dashed lines indicate policy events for item numbers in Table 1. Numbers in the parenthesis indicate the policy event number shown in the first row of the table.
Source: Bank of Japan

Since 2010, the JGB monthly new issuance has been stable at around 10 trillion yen. After introducing the QQE in April 2013, the BOJ's JGB purchases increased sharply to about 60% of

[11] The BOJ started releasing the scheduled amounts of the JGB purchases, in addition to the auction schedule, at least at the end of the previous month from the March 2017 operations. Thus, the data series on excess purchases starts at the beginning of March 2017.

new issuance. After the expansion of QQE in October 2014, it further increased, reaching about 90% of new issuance. After introducing the YCC policy in September 2016, the BOJ gradually reduced the size of the JGB outright purchases, around 60% of new issuance in 2019. Actual outright purchases steadily declined following the announced amounts of scheduled purchases after introducing the YCC in September 2016. However, the BOJ reaccelerated the outright JGB purchases in the face of the COVID-19 turmoil and further accelerated in mid-2022 to encounter speculative attacks on the YCC cap.

The figure also confirms the BOJ's implicit objective of introducing the YCC policy to reduce its long-term JGB purchases or "stealth tapering." The BOJ sought to reduce the JGB purchasing amounts by effectively switching the policy target back to interest rates from quantity. There are conflicting concerns about the large-scale JGB purchases. On the one hand, the large-scale JGB purchases will likely increase the risk of major market turmoil due to worsened JGB market liquidity. On the other hand, reducing the target for the JGB purchases would be understood as reversing monetary easing policy toward the policy normalization.

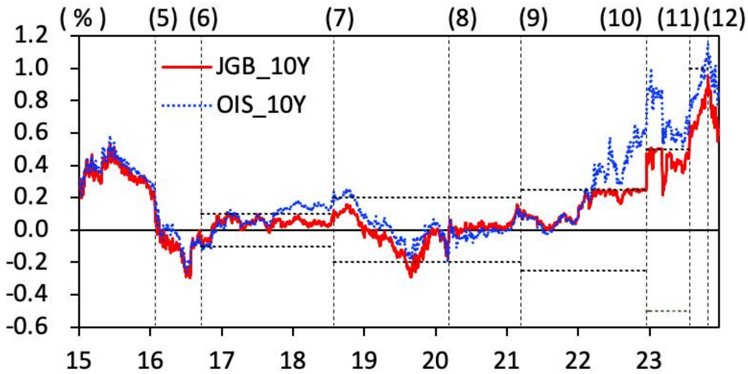
Looking at the effects of the YCC policy on the formation of the 10-year JGB yields, Figure 6 plots the 10-year JGB yields and its fluctuation allowance range in dashed horizontal lines, along with the 10-year OIS rates.[12] Even with the massive BOJ's JGB market interventions, the JGB yields and the OIS rates generally move closely within the fluctuation allowance ranges of the YCC in normal times with stable JGB market conditions. However, as stress in the JGB market becomes heightened, two rates begin to diverge significantly in two periods: from mid-2017 to mid-2019 and from early 2022 to the present. The OIS rates sometimes breach the YCC cap, and the 10-year JGB yields are constrained by the YCC cap. Especially, the 10-year JGB yields are severely constrained by the YCC cap at 0.25% from early 2022. Even though the fluctuation allowance range was expanded in December 2022, the deviations between the 10-year OIS rates and JGB yields remain large, and the 10-year JGB yields are strictly constrained by the YCC cap until March 2023.

2.3 YCC operational mechanism

Table 2 summarizes the types of the BOJ's JGB purchases. In normal times under the YCC policy, the BOJ purchases scheduled amounts of the JGBs on scheduled dates and allows the 10-year JGB yields to move within a fluctuation allowance range (denoted by SP). At the same time, the BOJ continues to reduce the scheduled JGB purchase gradually, as far as the credibility of the YCC framework is maintained. However, once confidence in the YCC framework is shaken and the JGB market becomes destabilized, the BOJ first tries to implement the additional JGB purchases (AP) in two ways: increase in amounts of purchases on scheduled dates or ad-hoc purchases on unscheduled dates. In addition, when speculative short-selling further expands, the BOJ attempts to defend the YCC cap by implementing fixed-rate purchases with

[12] Joyce et al. (2011) focus on the spreads between UK government securities (gilts) and OIS contracts as an indicator for gilt-specific premiums reflecting the quantitative easing by the Bank of England.

Figure 6: JGB and OIS Rates



Notes: JGB_10Y and OIS_10Y indicate the 10-year JGB yields and the 10-year OIS rates, respectively. Vertical dashed lines indicate policy events for item numbers in Table 1. Numbers in the parenthesis indicate the policy event number shown in the first row of the table. Horizontal dashed lines indicate the fluctuation allowance ranges for the 10-year JGB yields under the QQE with YCC, also shown in Table 1.
Source: Bloomberg

unlimited amounts (FP). The excess purchases (EP) are the sum of AP and FP, and the total purchases (TP) are the sum of SP and EP.

Table 2: BOJ's JGB Purchasing Operations

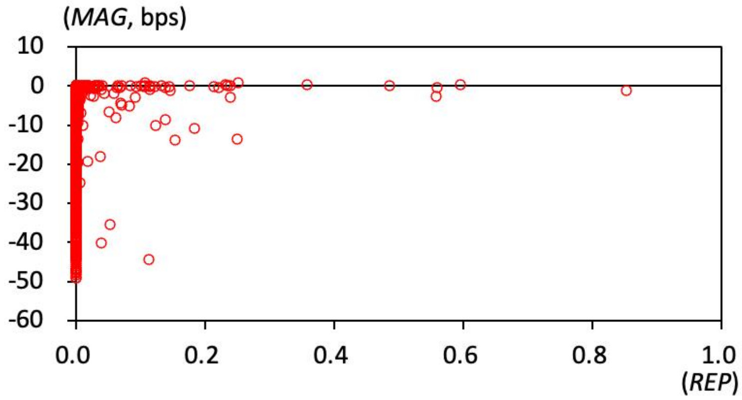
Types of operations	Abbreviation
Scheduled purchases	SP
Additional purchases	AP
Fixed-rate purchases with unlimited amounts	FP
Excess purchases (AP+FP)	EP
Total purchases (SP+EP)	TP

Figure 7 describes the YCC mechanism with scatter plots of two variables: the ratio of the excess purchases to the monthly scheduled purchases (*REP*) on the horizontal axis and margins to the YCC cap (*MAG*) on the vertical axis. *MAG* is computed as the differences between the YCC cap rates and the 10-year JGB yields. The data ranges from March 1, 2017, to October 31, 2023.[13]

This figure clearly shows two points. First, most observations are concentrated in the negative range of the vertical axis, indicating that the BOJ allows the 10-year JGB yields to move below the YCC cap by carrying out the scheduled purchases in normal times. Second, as margins to the YCC cap shrink, the BOJ quickly counters the market pressures on the YCC cap by expanding excess purchases beyond the scheduled amounts: first AP and the FP if necessary. The BOJ's operational framework under the YCC policy can be summarized in a diagram in Figure 8.[14]

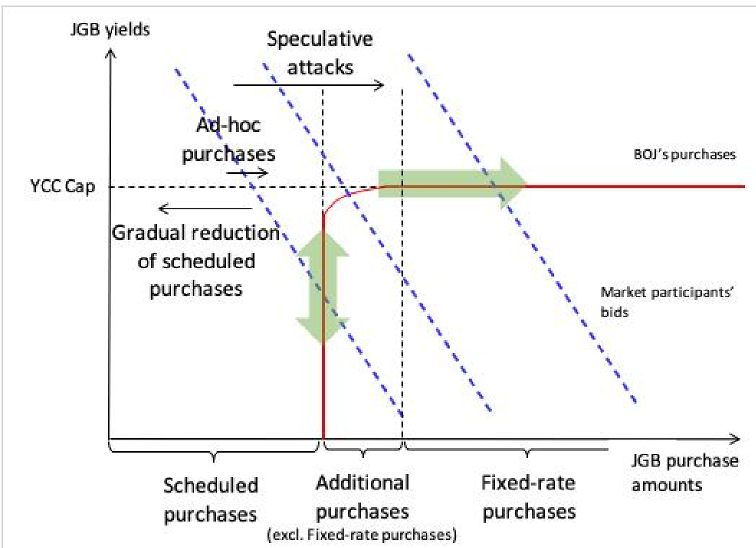
[13] Because the BOJ decided to remove the strict YCC cap on October 31, 2023, I set the end of the sample period for the data used in this paper on that date.
[14] Bernanke (2020) notes that the YCC can be understood as a form of the QE with a bond price target, leaving the quantity of bond purchased by the central bank to be determined endogenously.

Figure 7: BOJ's JGB Purchase Responses



Sources: Bank of Japan, Bloomberg.

Figure 8: YCC Operational Mechanism



3 Yield Curve Dynamics under YCC policy

In this section, I examine the yield curve dynamics under the YCC policy by estimating the Nelson-Siegel model for the JGB yields and the OIS rates.

3.1 Yield curve dynamics estimated by the Nelson-Siegel model

I first briefly explain the basic framework of the Nelson-Siegel model. Nelson and Siegel (1987) describe yield curve dynamics by three factors: level, slope, and curvature, supported by empirical studies on yield curve dynamics. This model has simple, parsimonious functional forms but is flexible enough to capture the general property of the yield curve for monetary policy analysis.[15]

[15] In previous studies of applying the Nelson-Siegel model to Japan, Fujiki and Shiratsuka (2002) and Okina and Shiratsuka (2004) employ the Nelson-Siegel model to analyze the policy commitment effects of monetary policy

The original version of the Nelson-Siegel model specifies the instantaneous forward rate (IFR) for time-to-settlement m at period t, denoted by $r_t(m)$, is given by

$$r_t(m) = L_t + S_t e^{-\lambda_t m} + C_t \lambda_t m e^{-\lambda_t m}, \tag{1}$$

where L_t, S_t, C_t, and λ_t are parameters to be estimated from the data. Three terms in the IFR curve generated by Equation (1), L_t, S_t, and C_t, correspond to level, slope, and curvature factors, respectively.[16] λ_t is the loading parameter, controlling the converging speed toward a long-term level.[17] L_t and λ_t are expected to be positive.

The Nelson-Siegel model has a property that the limits of forward rates when maturity approaches zero and infinity, respectively, are equal to $L_t + S_t$ and L_t. In my estimation, I exploit the first feature to improve the estimation precision in the shorter maturity of the yield curve under the ELB constraint by restricting $L_t + S_t$ to the overnight uncollateralized call rate. I also use the second feature as a monetary policy indicator since it corresponds to the forward rates for settlements very far into the future.[18]

The spot rate at maturity m, denoted by $R_t(m)$, is derived by integrating Equation (1) from zero to m and dividing by m.

$$R_t\left(m\right) = \frac{1}{m}\int_{s=0}^{m} r_t\left(s\right) ds = L_t + S_t\left(\frac{1-e^{-\lambda_t m}}{\lambda_t m}\right) + C_t\left[\frac{1-e^{-\lambda_t m}}{\lambda_t m} - e^{-\lambda_t m}\right]. \tag{2}$$

I employ Equation (2) to estimate the Nelson-Siegel model using the JGB yields and the OIS rates.[19] In estimating the Nelson-Siegel model, I use the JGB yields for maturities of 6-month, 1- to 9-, 15-, 20-, and 30-year, while the OIS rates for those of 6-month, 1- to 10-, 15-, 20-, and 30-year. I exclude the JGB yields for 10-year maturity to deter the contamination of distortionary effects of the YCC policy in estimating the Nelson-Siegel model.[20] I repeatedly estimate the Nelson-Siegel model for the JGB yields and the OIS rates on a daily basis from January 4, 2013, to October 31, 2023, when the YCC policy was effectively lifted.

under the ELB constraints of nominal interest rates in Japan. Koeda and Sekine (2022) focus on the role of the loading parameter in the Nelson-Siegel model. Shiratsuka (2021) also applies the dynamic version of the Nelson-Siegel model, thereby reviewing the BOJ's unconventional monetary policy frameworks from the late 1990s through the lens of yield curve dynamics.

[16] Söderlind and Svensson (1997) extend the original version of the Nelson-Siegel model by considering an additional curvature term, thereby enabling to approximate more complicated shape of yield curves flexibly.

[17] The third term in Equation (1) takes maximum in an absolute value term when m is equal to $1/\lambda$. Since the coefficients for C are estimated with negative values almost throughout the sample period, the yield curves show a largest downward dip at the maturity of $1/\lambda$, and gradually converge to L in the longer maturities.

[18] The IFR curve reflects market expectations regarding the future course of short-term interest rates, thus providing important information, including market views on the future course of monetary policy. See, for example, Okina and Shiratsuka (2004) and Shiratsuka (2021) for the discussion on monetary policy indicators based on the Nelson-Siegel model.

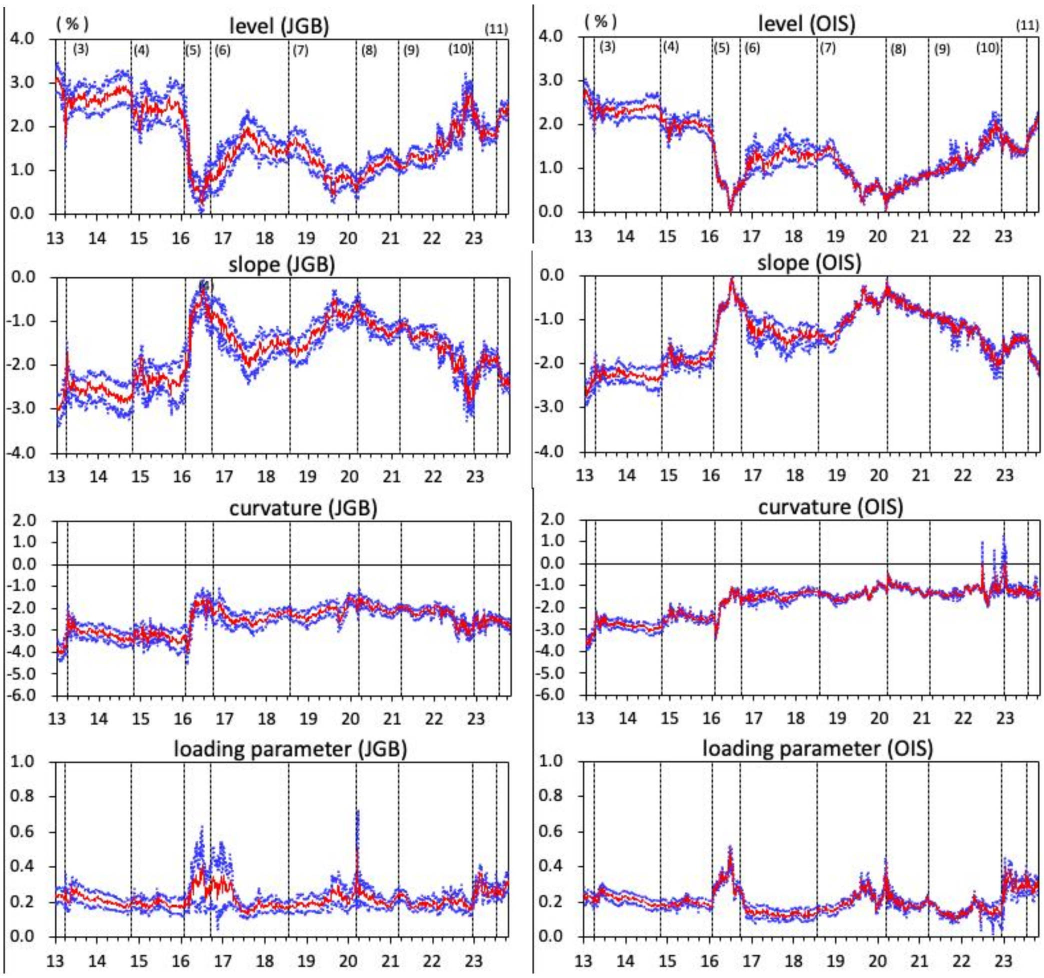
[19] It should be noted that, under an extremely low interest rate environment, the estimates for level and loading parameters are potentially contaminated with each other, thus making it difficult to identify these parameters precisely, as pointed out by Shiratsuka (2021).

[20] I excluded only the JGB yields for 10-year maturity since the further exclusion of 9-year maturity produced relatively minor impacts even for the period from April 2022 to January 2023, when the YCC cap attacks were heightened.

3.2 Estimation results

Figure 9 plots the estimated parameters, L, S, C, and λ for the Nelson-Siegel model using the JGB yields and the OIS rates, with their 95% confidence intervals on a daily basis, from January 4, 2013, to October 31, 2023.[21] The figure shows that estimated parameters for the JGB yields and the OIS rates are statistically significant over time, while the confidence intervals are generally tight for the OIS rates, reflecting a smoother formation of the yield curve in the OIS market.

Figure 9: Estimated Parameters over Time



Notes: Red bold lines and blue dashed lines are estimated coefficients and their 95% confidence intervals. Vertical dashed lines indicate policy events for item numbers in Table 1. Numbers in the parenthesis indicate the policy event number shown in the first row of the table.

As for the estimated parameters, the level factor L is higher, and the curvature factor C also tends to exhibit larger negative values in the JGB market. These observations indicate that the yield curves in the JGB market stay at a slightly higher level and show a slightly steeper upward-sloping shape with a greater degree of downward curvature. In addition, the level factor L for both the JGB yields and the OIS rates show very volatile movements over time,

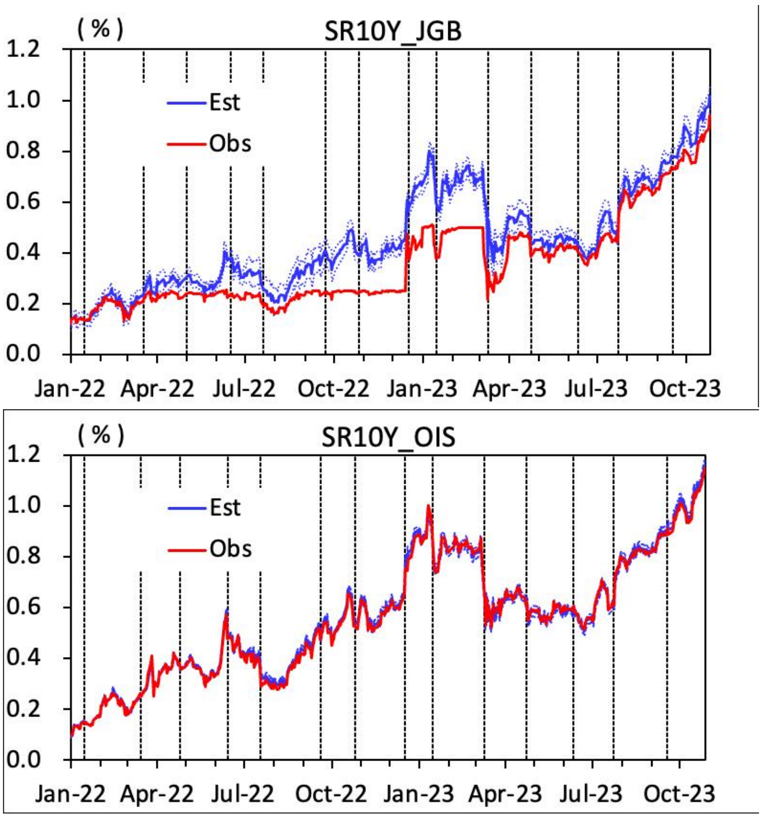
[21] In my estimation, maturities are defined in years, and as a result, the estimates of λ are larger than when maturities are defined in months.

and those for the JGB yields are more volatile than those for the OIS rates, especially after the introduction of the negative interest rates in January 2016.

The above features of the yield curve dynamics in the JGB market, compared with the OIS market, have an important implication for monetary policymaking. In a standard setting, the level factor L is stable over time, and monetary policy actions, including various unconventional policy measures of forward guidance and quantitative easing, are transmitted through the downward shifts in the yield curve. However, the volatile level factor implies that the monetary policy space fluctuates, reflecting the unstable expectations regarding the future course of the economic fundamentals and monetary policy. This observation suggests that while the higher level factor provides more monetary policy space, this monetary policy space is only a sham.

I next compute the 10-year sport rates, denoted by $R^{JGB}(10)$ and $R^{OIS}(10)$, with their 95% confidence intervals from the beginning of 2022, using the estimates of the Nelson-Siegel model for the JGB yields and the OIS rates, as shown in Figure 10. The figure also shows the observed 10-year spot rates in the JGB and OIS markets.

Figure 10: Observed and Estimated 10-year JGB Spot Rates



Notes: Blue dotted lines indicate the 95% confidence intervals for the estimated 10-year spot rates for the JGB and OIS markets. Dashed vertical lines indicate the second day of the Monetary Policy Meeting of the Bank of Japan.
Source: Bloomberg

The estimated and observed 10-year JGB spot rates begin to deviate from around April 2022, and the observed rates move outside the confidence interval from September 2022 to

March 2023, even though their confidence intervals gradually widen over time. The estimated 10-year JGB spot rates follow a mild upward trend toward early 2023, while the 10-year JGB yields are constrained by the YCC caps after mid-2022, regardless of the widened fluctuation allowance range for 10-year JGB yields on December 20, 2022.

In contrast, the estimated and observed 10-year OIS rates move almost in line with each other, and the observed rates stay within the fairly tight confidence interval, even though the OIS rates follow a mild upward trend toward early 2023, just as the JGB yields. The figure clearly shows the distorted rate formations in the JGB market.

3.3 Sources of high volatility of the level factor

The level factor L can be interpreted as the long-term forward rate, or LFR (same unit as interest rates), which measures the steady-state nominal interest rates, implying the convergence level of the yield curve in the long run, as discussed in Okina and Shiratsuka (2004) and Shiratsuka (2021). Using Fisher's Equation, L or LFR is decomposed into a steady-state real interest rate, a steady-state inflation rate, and a term premium.

$$L_t = LFR_t = r^* + \pi^e + TP_t, \tag{3}$$

where r^*, π^e, and TP denote the equilibrium level of real interest rates, long-term inflation expectations, and a term premium. $r^*$and π^e are assumed to be constant over time. Equation (3) describes that LFR consists of three factors: equilibrium level of real interest rates, long-term inflation expectations, and term premium, denoted by r^*, π^e, and TP, respectively.

Thus, LFR for the JGB yields and the OIS rates can be described as:

$$LFR_t^{JGB} = r^* + \pi^e + TP_t^{JGB}, \tag{4}$$

$$LFR_t^{OIS} = r^* + \pi^e + TP_t^{OIS}, \tag{5}$$

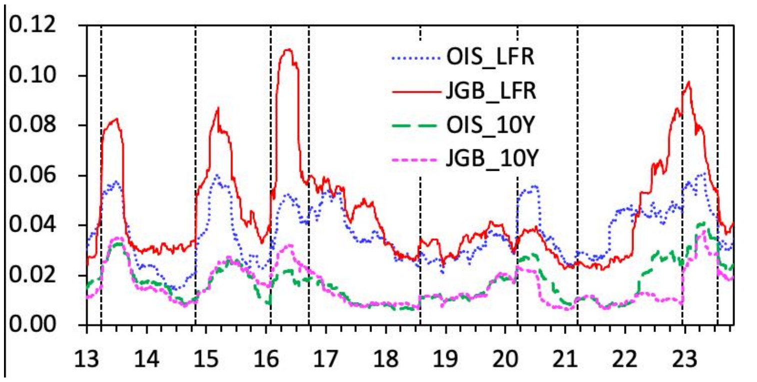
where the super-subscript of JGB and OIS indicate the indicators for the JGB and OIS markets, respectively. It is natural to assume that r^* and π^e are common to the JGB and OIS markets. Thus, differences between LFR^{JGB} and LFR^{OIS} are attributable to the differences in TP in the two markets, TP^{JGB} and TP^{OIS}, implying that TP^{JGB} continues to remain high, compared with TP^{OIS} under the YCC policy.[22]

One possible explanation for higher TP^{JGB} than TP^{OIS} is the higher volatility of LFR^{JGB} than LFR^{OIS}, as shown in Figure 11. The volatility of LFR^{JGB} jumps at particular policy events, such as the introduction of the QQE in April 2013, the expansion of the QQE in October 2014, the introduction of negative interest rate policy in January 2016, and the recent speculative attacks to the YCC cap from the Spring of 2022. In contrast, the volatility of the 10-year JGB yields and the 10-year OIS rates remain relatively low. The above observations suggest that the

[22] Joyce et al. (2011) regard the gilt-OIS spreads in the UK market as an indicator of gilt-specific premiums.

YCC policy amplifies fluctuations in the overall JGB yield curve while stabilizing fluctuations in the 10-year JGB yields. The high volatility of LFR^{JGB} reflects high uncertainty of the overall yield curve dynamics, contrary to the YCC policy intention of fostering a smooth formation of the overall yield curve with a mild upward-sloping shape. As a result, long-term forward rates, which is one of the important monetary policy indicators, become a very distorted indicator.[23]

Figure 11: Volatility of Long-term Forward Rates



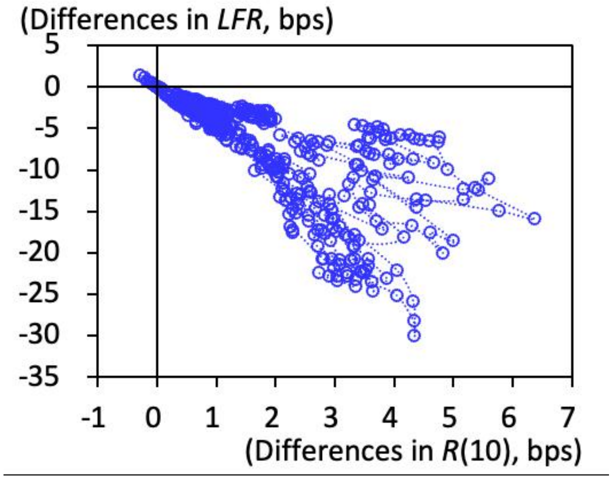
Notes: Plotted figures are standard deviations computed using the subsample data for 90 business days, ending at the date on the horizontal axis. OIS_LFR, JGB_LFR, OIS_10Y, and JGB_10Y represent the volatilities for the estimated LFR for the OIS rates, that for the JGB yields, the 10-year OIS rates, and the 10-year JGB yields, respectively.

However, a more convincing but technical explanation is the effects of the distorted JGB yield curve under the YCC policy. The constrained JGB yields at low levels up to 10-year maturity produce steeper yield curves in the maturities exceeding ten years, pushing up the estimates of LFR^{JGB} at higher levels.

To examine the effects of the distorted JGB yield curves, I estimate the Nelson-Siegel model using the JGB yields by including the 10-year maturity, computing the differences in the estimates for LFR^{JGB} and $R^{JFG}(10)$ without or with including 10-year JGB yields. Figure 12 exhibits the scatter plots of these differences from January 2022 to October 2023 on a daily basis: differences for estimates of $R^{JGB}(10)$ without or with including the 10-year JGB yields on the horizontal axis and differences for estimates of LFR^{JGB} with or without including the 10-year JGB yields on the vertical axis. The figure shows a clear negative correlation with a steep downward-sloping shape. This observation suggests that downward pressures on $R^{JGB}(10)$ have a large leverage of pushing LFR^{JGB} upward.

[23] Shang (2022) points out that the yield curve becomes more sensitive to monetary policy surprises when uncertainty is high, based on the dynamic Nelson-Siegel model with regime shifts.

Figure 12: Effects on the estimates for *LFR* and *R*(10)



Notes: Figures are computed from data on the JGB yields from January 4, 2022, to October 31, 2023.

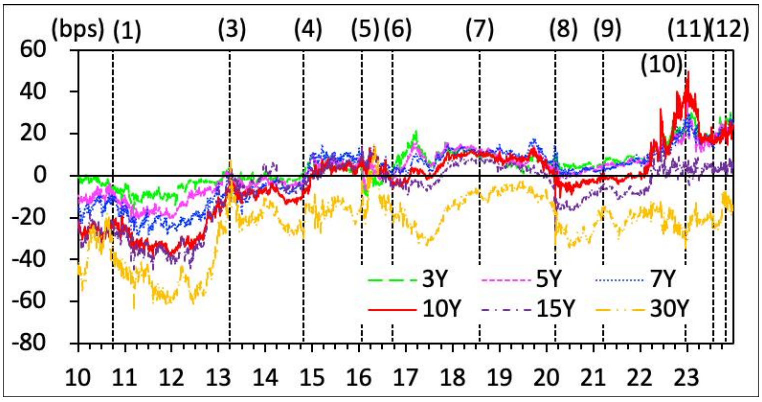
4 OIS-JGB Spreads as an Indicator for Market Distortions

In this section, I propose the decomposition of the OIS-JGB spreads using the estimates for the Nelson-Siegel model for the JGB yields and the OIS rates. The OIS-JGB spreads are widely used to trace distortions in the JGB market. The JGB and OIS markets trade highly substitutable financial assets, and market interest rates are assumed to be highly synchronized through financial arbitrage between the two markets in normal times.

4.1 OIS-JGB spreads

Figure 13 plots the OIS-JGB spreads for major six maturities (3-, 5-, 7-, 10-, 15-, and 30-year) from January 4, 2010, to December 29, 2023, which covers the 10-year term of former BOJ Governor Kuroda.

Figure 13: OIS-JGB Spreads

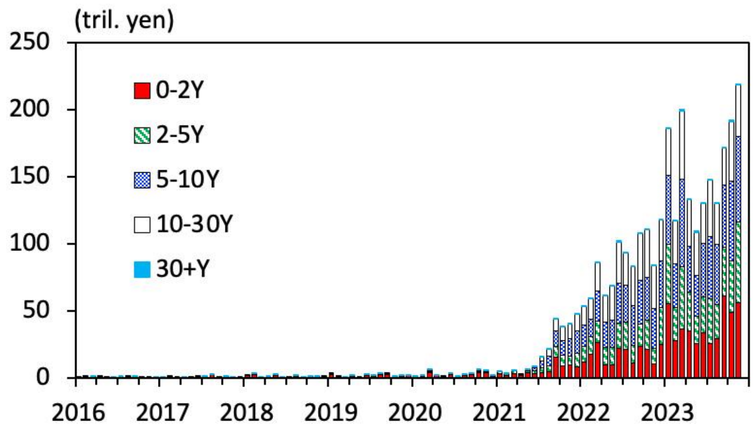


Notes: Vertical dotted lines indicate the policy events listed in Table 1. Numbers in the parenthesis indicate the policy event number shown in the first row of the table.
Source: Bloomberg

The OIS-JGB spreads with different maturities moved in a parallel manner before introducing the QQE in April 2013. However, since then, the OIS-JGB spreads for 30-year maturity deviated from the trend for other matures. In addition, after the COVID-19 turmoil, the OIS-JGB spreads for 15-year maturity also started deviating from other maturities. These observations suggest that large-scale JGB purchases influence the financial arbitrage between the JGB and OIS markets.

Of course, there are concerns about the low market liquidity of the OIS transactions and the reliability of price information. As shown in Figure 14, the cleared notional amounts of the OIS transactions through the Japan Securities Clearing Corporation (JSCC) remain at very low levels until mid-2021. However, they continue to increase since then partly due to the permanent suspension of the Japanese Yen LIBOR (London Interbank Offered Rate) publication at the end of December 2021. Thus, it is deemed reasonable that the transaction volume in the OIS market recover sufficiently for the period after 2022, which is the focus of most attention in this paper.

Figure 14: Cleared Notional Amounts for OIS Transactions



Notes: Figures are notional amounts of the OIS transactions cleared through the Japan Securities Clearing Corporation (JSCC). 0-2Y, 2-5Y, 5-10Y, 10-30Y, and 30+Y denote the OIS transactions for maturities between 0 and 2-year, between 2- and 5-year, between 5- and 10-year, between 10- and 30-year, and over 30-year, respectively.
Source: Japan Securities Clearing Corporation

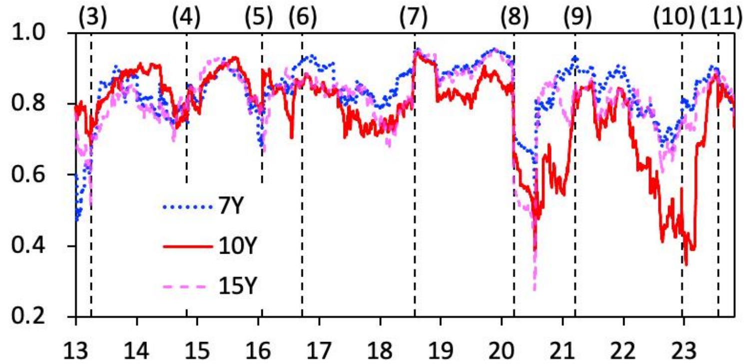
I next compute the correlations of daily rate changes between the JGB yields and the OIS rates for maturities of 7-, 10-, and 15-year using the subsample data of 90 business days. Figure 15 plots the correlations between the JGB yields and the OIS rates for maturities of 7-, 10-, and 15-year in the upper panel, while the figure plots the correlation between adjacent maturities in the JGB and OIS markets, respectively, in the lower panel. The upper panel shows that the declines in the correlations between the JGB and OIS markets are particularly significant from 2022 to 2023.[24] In addition, such declines are mainly attributable to the declines in the correlations between adjacent maturities in the JGB market, considering the high and stable correlations in the OIS market, as shown in the lower panel. The correlations between the JGB

[24] Correlations between the JGB and OIS markets also decline during the COVID-19 turmoil from 2020 to early 2021. However, it is mostly stemmed by the decline in correlations in the OIS markets.

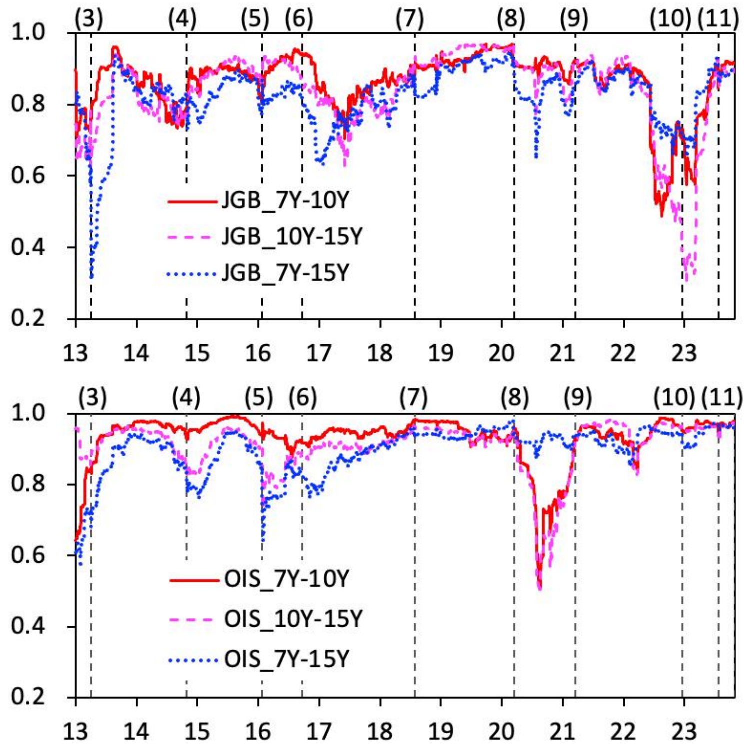
and OIS markets as well as between the adjacent maturities in both markets decline around some major policy events, while they show relatively high and stable movements in normal times. In addition, the declines in the correlations are limited compared with the period from 2022 to 2023.

Figure 15: Correlations of Daily Changes

(1) Between the JGB and OIS markets



(2) Between Adjacent Maturities



Notes: Plotted figures are correlations computed using the subsample data of 90 business days ending at each date on the horizontal axis.

4.2 Decomposition of the OIS-JGB spreads

Using the estimated spot rates for the JGB yields and the OIS rates at 10-year maturity, $R^{JGB}(10)$ and $R^{OIS}(10)$, the OIS-JGB spreads, denoted by $OJS(10)$, can be decomposed into three components, as shown by Equation (6).

$$
\begin{aligned}
OJS(10) &= OIS(10) - JGB(10) \\
&= \left[OIS(10) - R^{OIS}(10)\right] + \left[R^{OIS}(10) - R^{JGB}(10)\right] \\
&\quad + \left[R^{JGB}(10) - JGB(10)\right] \\
&= EE\_OIS(10) + E\_OJS(10) + EE\_JGB(10),
\end{aligned} \tag{6}
$$

where the first and third components are estimation errors for 10-year spot rates of the OIS rates and the JGB yields, based on the Nelson-Siegel model, denoted by $EE\_OIS(10)$ and $EE\_JGB(10)$, respectively. The second component is the estimated OIS-JGB spreads at 10-year maturity as the differences between $R^{JGB}(10)$ and $R^{OIS}(10)$, denoted by $E\_OJS(10)$.

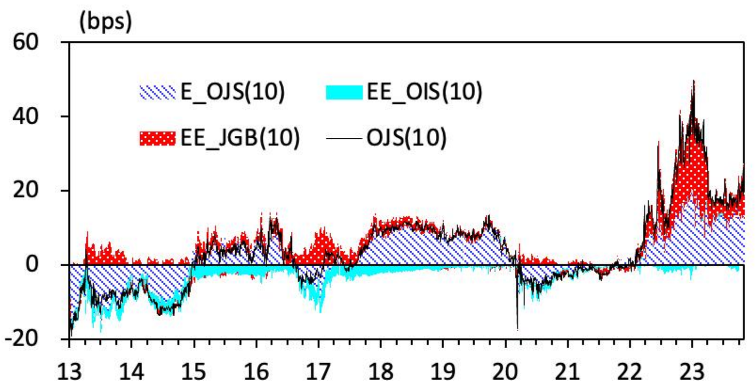
Note that, among the three components, $E\_OJS(10)$ is expressed by Equation (7).

$$
\begin{aligned}
E\_OJS(10) &= R^{OIS}(10) - R^{JGB}(10) \\
&= \frac{1}{10}\int_{m=0}^{10} \left\{r^{OIS}(m) - r^{JGB}(m)\right\} dm
\end{aligned} . \tag{7}
$$

This equation shows that $E\_OJS(10)$ traces the overall downward pressures on the JGB yields up to 10-year maturity.

Figure 16 plots the decomposition results for the OIS-JGB spreads or $OJS(10)$. The figure shows that the overall fluctuations in $OJS(10)$ are mostly captured by the fluctuations in $E\_OJS(10)$. However, the figure also shows significant deviations between $OJS(10)$ and $E\_OJS(10)$ from the Spring of 2022 to early 2023, when the YCC cap was attacked. The $EE\_JGB(10)$ hike at that time suggests that $EE\_JGB(10)$ indicates that the shape of the JGB yield curves becomes more distorted with the intensified market pressures on the YCC cap.

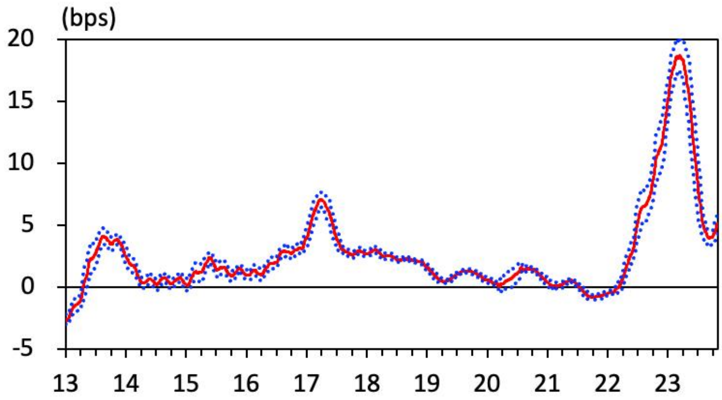
Figure 16: Decomposed OIS-JGB Spreads



Source: Bloomberg.

I then compute the moving average of $EE\_JGB(10)$ by regressing a constant term on $EE\_JGB(10)$ using subsample data of 90 business days. Figure 17 plots the estimated coefficients and their 95% confidence intervals. The figure clearly shows persistent deviations from zero toward the positive direction, with a spike from the spring of 2022 to early 2023. This observation confirms the fact that distortions in the JGB market are very long-lasting and expand significantly from spring 2022 to early 2023. Thus, $EE\_JGB(10)$ is deemed appropriate to employ as a proxy for the market pressures on the YCC cap. In addition, *E_OIS*(10) is effective in monitoring the effects of the BOJ's bond purchasing operations on the overall yield curve by adjusting the distortions on the 10-year JGB yield by the YCC policy.

Figure 17: Size of *EE_JGB*(10) over Time



Notes: Red bold lines and blue dashed lines are estimated coefficients and their 95% confidence intervals, computed using the subsample data of 90 business days ending at each date on the horizontal axis.

5 BOJ's JGB Market Interventions

Given the above results of the decomposition of the OIS-JGB spreads, I will estimate the BOJ's JGB purchasing behavior in response to the changes in the market pressures on the YCC cap.

5.1 Data

Table 3 exhibits summary statistics for data used in the estimation in this section, ranging from March 1, 2017, to October 31, 2023. *RSP*, *RAP*, *RFP*, *REP*, and *RTP* denote the ratio of scheduled purchases, ad-hoc purchases, fixed-rate purchases, excess purchases, and total purchases to the monthly scheduled amounts of purchases, respectively. *MAG* is the margin of 10-year JGB yields to the YCC cap, defined in Section 2. *OJS*, *EOJS*, and *EEJ* are the abbreviations of *OJS*(10), *E_OJS*(10), and *EE_JGB*(10), which are defined by Equation 18 in the previous section. Hereafter, I will use these abbreviations for simplicity.

The table shows two important features regarding data for the BOJ's JGB purchases. First, the data shows that out of a sample period of 1,630 days, only 667 days, or about 40% of the total, of JGB purchases from any source were implemented. Although there is a possibility that additional purchases may be conducted even on days when no purchases were planned, depending on market conditions, about 60% of the data observed in reality was for zero purchases. Second, the data distribution has a mode at zero and is skewed to the right. The focus is then on the relationship between the BOJ's JGB purchases and the JGB market conditions at the tail of the distribution.

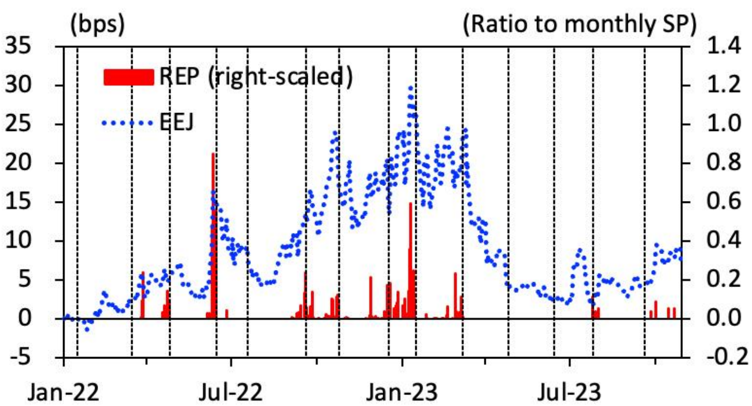
Table 3: Summary Statistics

Sample period: from January 4, 2013, to October 31, 2023

	Ratio to monthly announced amounts				
	RSP	*RAP*	*RFP*	*REP*	*RTP*
	a	b	c	$d = b + c$	$e = a + d$
obs.	1,630	1,630	1,630	1,630	1,630
obs. (non zero)	583	82	93	159	667
mean	0.049	0.002	0.004	0.006	0.055
median	0.000	0.000	0.000	0.000	0.000
max	0.263	0.265	0.702	0.852	0.852
min	0.000	0.000	0.000	0.000	0.000
st. dev.	0.075	0.016	0.034	0.042	0.086
skewness	1.213	11.244	12.922	11.876	2.232
ex. kurtosis	0.075	143.731	199.682	176.041	10.052
	MAG	*OJS*	*EOJS*	*EEJ*	
obs.	1,630	1,630	1,630	1,630	
mean	−14.112	7.921	5.562	3.327	
median	−12.250	7.625	7.102	1.827	
max	0.900	49.725	24.154	29.686	
min	−49.100	-17.250	−16.557	−6.080	
st. dev.	10.842	10.327	6.448	5.010	
skewness	−0.759	1.137	0.008	2.344	
ex. kurtosis	0.051	1.235	−0.711	5.593	

Figure 18 plots *EEJ* and *REP* with the right- and left-scaled from January 2022, when *EEJ* started to increase, respectively. The figure shows that *REP* is generally concentrated in several business days prior to the end of the Monetary Policy Meeting, when incentives for speculative attack for the YCC cap become heightened from March 2022 to April 2023.

Figure 18: Excess Purchases and Market Distortions



Notes: Dashed vertical lines indicate the second day of the Monetary Policy Meeting of the Bank of Japan.
Sources: Bank of Japan, Bloomberg

5.2 BOJ's responses to market conditions

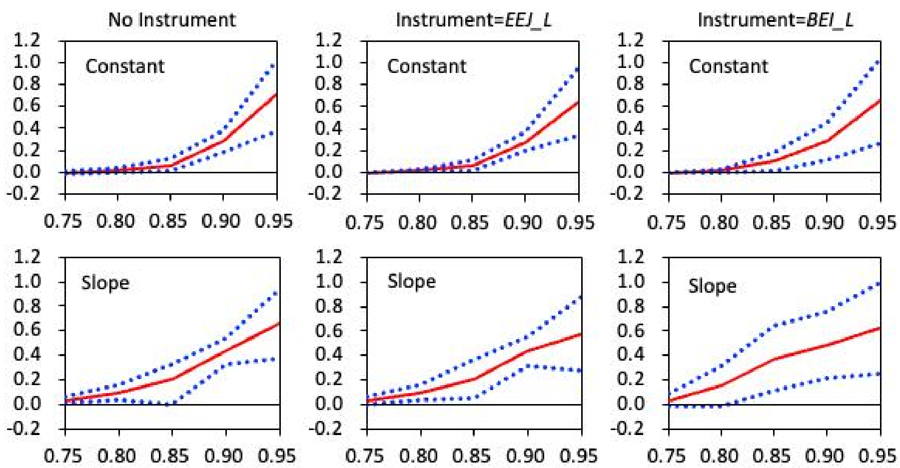
I first estimate the BOJ's response function against market conditions traced by *EEJ* using the regression equation below:

$$REP_t = \alpha + \beta EEJ_t + \varepsilon_t, \tag{8}$$

where α, β, and ε_t are a constant term, a slope parameter, and an error term, respectively. I apply the quantile regression by focusing on the higher percentiles than 75th, considering the data features that a large portion of *REP* is censored at zero. In addition, to examine the robustness against the possible endogeneity problem, I also compare the estimation results using the instrumental quantile regression.[25] Given the limited availability of daily indicators as instruments, I use lagged *EEJ* (denoted by *EEJ_L*) and lagged break-even-inflation at 10-year maturity (*BEI_L*) as an instrument.[26] The sample period is from March 1, 2017, to October 31, 2023.

Figure 19 summarizes the estimation results for the quantile regressions without or with using instruments. The left-hand column shows the baseline quantile regression results without using instruments, and the center and right-hand columns show the instrumental quantile regress results using *EEJ_L* and *BEI_L* as an instrument, respectively. In each column, the upper panels show estimates for α and their 95% confidence intervals, and the lower panels show those for β.

Figure 19: BOJ's Responses to Market Conditions: Quantile Regressions



Notes: Red bold lines, green dashed lines, and blue dotted lines correspond to the estimated coefficients, the estimated coefficients for the quantile regressions without using instruments, and 95% confidence intervals, respectively.

The figures in the left-hand column without using instruments show that both constant

[25] In addition to the endogeneity problem, the problems with errors-in-variables and omitted variables need to be considered.

[26] I do not report the estimation results using *EEJ_L* and *BEI_L* as instruments at the same time since the estimation results are almost identical to those using only *EEJ_L* as an instrument.

terms and slope coefficients stay around zero from the 75th percentile to the 85th percentile and then show sharp increases from the 90th percentile to the 95th percentile. These results suggest that the BOJ's JGB purchase operations become suddenly aggressive as the stress in the JGB market is heightened.

The figures in the center and right-hand columns show that point estimates remain almost unchanged using two instruments separately. When using *EEJ_L* as an instrument, the confidence intervals generally become tighter, except for β of the 90th percentile. In contrast, when using *BEI_L* as an instrument, the confidence intervals for both α and β become widened, suggesting the deterioration of the reliability of the estimation results.

Table 4 shows Kolmogorov–Smirnov statistics for the instrument exogeneity proposed by Chernozhukov and Hansen (2006). The instrument exogeneity cannot be rejected at the 95% significant level when using *EEJ_L* as an instrument, while it is rejected when using *BEI_L*. This result indicates that *EEJ_L* is a more valid instrument than *BEI_L* in the instrumental quantile regressions.

Table 4: Tests for Instrument Validity

	Instruments	
	EEJ_L	*BEI_L*
KS Stat. for Exogeneity	1.183	2.306
	[2.865]	[2.310]

Notes: Figures in the brackets are 95% critical values using bootstrapping.

Summing up the estimation results, the aggressive responses only at the high percentiles, 90th and 95th percentiles, indicate that the BOJ's outright JGB purchase operations are seemingly aggressive but actually reactive to stressed conditions in the JGB market. This result implies that the BOJ's JGB purchases are implemented just to sustain the YCC policy framework under the stressed conditions in the JGB market. As I argued in Section 2, the BOJ's outright JGB purchase operations passively react to the market pressure on the YCC cap by combining the ad hoc fixed-amount purchases and the fixed-rate outright purchases with unlimited amounts.

5.3 BOJ's JGB purchasing behavior

I next estimate simple BOJ's JGB purchase function, discussed in Subsection 2.3, by applying the discrete transition regression model, considering the sudden transitions of the BOJ's JGB purchasing behavior between normal times and high-stress times in the JGB market. I employ *EEJ_L* as the threshold variable with unknown threshold values τ_1 and τ_2, as shown in Equation (9),

$$REP_t = \begin{cases} \alpha_1 + \beta_1 MAG_t + \varepsilon_{1,t} & if\ EEJ\_L < \tau_1 \\ \alpha_2 + \beta_2 MAG_t + \varepsilon_{2,t} & if\ \tau_1 \leqq EEJ\_L < \tau_2 \\ \alpha_3 + \beta_3 MAG_t + \varepsilon_{3,t} & if\ EEJ\_L \geqq \tau_2 \end{cases} . \quad (9)$$

Note that a constant term, a slope parameter, and an error term are α_1, β_1, and $\varepsilon_{1,t}$ when $EEJ\_L < \tau_1$ (normal times), α_2, β_2, and $\varepsilon_{2,t}$ when $\tau_1 \leqq EEJ\_L < \tau_2$ (early-stress times), α_3, β_3, and $\varepsilon_{3,t}$ when $EEJ\_L \geqq \tau_2$ (high-stress times). Estimation coefficients for normal times are expected to be insignificant and close to zero. In contrast, those for early-stress times and high-stress times are expected to be statistically significantly positive.

I assume the maximum number of the states is three: normal times, early-stress times, and high-stress times, based on the observations in Subsection 2.3. In normal times, the BOJ allows the 10-year JGB yield to fluctuate within the YCC fluctuation allowance range with scheduled purchases. In early-stress times, the BOJ first tries to maintain confidence in the YCC framework by implementing additional JGB purchases in two ways: increase purchases on scheduled dates or ad-hoc purchases on unscheduled dates. In high-stress times when speculative short-selling further expands, the BOJ attempts to maintain the YCC framework by implementing fixed-rate purchases with unlimited amounts. It should be noted that the number of states can be two since early-stress times could be encompassed by either high-stress times or normal times.

Table 5 summarizes the estimation results for the discrete transition regressions with two and three states using *EEJ_L* as a threshold variable. The table shows that Akaike information criteria (AIC) is marginally smaller in the estimation with two states than those with three states, suggesting that the estimation results for the two states are slightly more precise. The difference between the two estimation results depends on whether the data are split between normal times and early-stress times.

In the estimation results for the two-state specification, all the estimates, except for the slope parameter for State-1, are statistically significant at the 99% level. Estimates for State-2 of high-stress times become far larger than those for State-1, indicating the BOJ's aggressive responses to intensified market pressures on the YCC cap. Combining data for normal times and early-stress times improves the overall estimation precisions, but the estimates for State-1 are difficult to interpret. Note that the estimates for high-stress times are the same as the estimation results for the three-state specification since the threshold values are the same in both specifications.

In the estimation results for the three-state specification, the estimates for State-1 of normal times are all statistically insignificant, confirming that the BOJ allows the 10-year JGB yield to move within the YCC fluctuation allowance range with scheduled purchases. Estimates for State-2 of early-stress times become larger for both the constant term and the slope parameter, but only the constant term becomes statistically significant at just the 95% level. Thus, amounts of the BOJ's JGB purchases increase, but responses to *MAG* are still insignificant. As noted above, estimates for State-3 of high-stress times are the same as the estimation results for State-

Table 5: BOJ's JGB Purchasing Responses: Discrete Threshold Regressions

Dependent variable: *REP*
Sample period: from March 1, 2017, to October 31, 2023

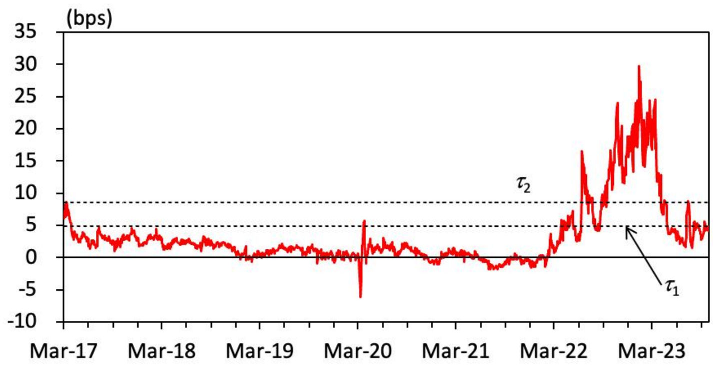
Threshold variable	*EEJ_L*					
τ_1	4.845	[25,942]		8.629	[26,184]	
τ_2	8.629	[26,184]				
State-1						
Const.	0.130	(0.071)		0.365	(0.137)	**
MAG	0.002	(0.004)		0.010	(0.006)	
State-2						
Const.	1.779	(0.828)	*	4.864	(1.011)	**
MAG	0.011	(0.036)		0.160	(0.060)	**
State-3						
Const.	4.864	(1.011)	**			
MAG	0.160	(0.060)	**			
AIC	4,537.8			4,533.8		
Obs.	1,630			1,630		
Obs. (State-1)	1,339			1,450		
Obs. (State-2)	111			180		
Obs. (State-3)	180					

Notes: Figures in the brackets and the parenthesis are the sum of squared residuals and robust standard errors for estimation coefficients, respectively. ** and * indicate that the estimated coefficients are statistically significant at 99% and 95% levels, respectively.

2 for the two-state specification.

Figure 20 plots *EEJ* with the two estimated threshold values for dividing the three states as dashed horizontal lines. The figure shows that high-stress times cover the period of the intensified market attacks on the YCC cap from the Spring of 2022 to early 2023. Early-stress times cover the periods in March 2017, March 2020, March to April 2022, and April to October 2023.

Figure 20: Estimated Threshold Values



6 Concluding Remarks

This paper addressed what the BOJ's Yield Curve Control Policy does through the lens of the yield curve dynamics in the JGB market and the OIS market with due consideration of practical details of the BOJ's JGB market operations. A short answer to this question is that the BOJ's JGB market operations are implemented to sustain the YCC policy framework, producing substantial side effects.

This paper offered empirical evidence to support the answer. Under the YCC policy, in normal times, the BOJ purchases scheduled amounts of JGBs on scheduled dates and allows 10-year JGB yields to move within the fixed fluctuation allowance range. However, once confidence in the YCC framework is shaken and the JGB market becomes destabilized, the BOJ suddenly starts implementing aggressive operations. The BOJ first implements additional JGB purchases either by increasing amounts of purchases on scheduled dates or adding ad-hoc purchases on unscheduled dates. When speculative short-selling further expands, the BOJ implements fixed-rate purchases with unlimited amounts. Such BOJ's operations are seemingly aggressive but actually reactive to sustain the YCC policy framework.

In addition, the YCC policy amplifies fluctuations in the entire JGB yield curve while capping fluctuations in the 10-year JGB yields by fixed-rate purchases with unlimited amounts. These intense market interventions distort the formation of the JGB yield curve around 10-year maturity, contrary to the YCC policy intention of fostering a smooth formation of the entire yield curve. As a result, the volatility of the estimated long-term forward rates in the JGB market (LFR^{JGB}) stays at high levels, indicating high uncertainty of the overall JGB yields.

Is it desirable for long-term interest rates to remain stable at a fixed low level? Of course, it is necessary to reduce interest rates to stimulate economic activity when the economic condition deteriorates. That is only possible if monetary policy functions as a macroeconomic stabilizing policy as long as long-term interest rates stay significantly positive even under the ELB constraint of policy interest rates.

Looking ahead, the YCC policy also plays an important role as a government debt management policy that enhances the sustainability of government debt by stabilizing long-term interest rates at low levels. Under the COVID-19 turmoil, economies worldwide have continued to expand fiscal expenditure to mitigate the adverse shocks to the economy, swelling government debt, and Japan's budget deficits and outstanding government debt are particularly outstanding. Keeping long-term interest rates stable at low levels is important for ensuring the stability of the financial system, which holds large amounts of government bonds. However, consideration of financial system stability in monetary policymaking, whether intended or not, will contribute to practically making monetary policy a government debt management policy.

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