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The effects of quantitative easing policy on bank lending: Evidence from Japanese regional banks

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ABSTRACT

This paper examines the response of Japanese regional banks to the quantitative easing operations conducted by the Bank of Japan (BOJ) using semiannual bank-level data from 2001 to 2020. Many regional banks predominantly focus on lending business in their local areas so that, unlike some previous literature, we control for the local economic conditions. We found that, compared with the pre-QQE period, the BOJ's government bond purchase has a remarkably greater impact on regional bank's lending after the introduction of QQE. These results suggest that the QQE policy is quite effective in promoting bank lending. Regarding the differences in bank characteristics, the magnitude of impact is larger for regional banks with a higher NPL ratio, a larger asset size, and a lower market share. The first result is consistent with the findings of Bowman et al. (2015) and Matousek et al. (2019), whereas the second and third results are novel. The Granger causality tests produce consistent results.

1. Introduction

After the 2008 global financial crisis (GFC), the central banks of developed countries successively adopted unconventional monetary policies to pursue further monetary easing. Considerable attention has been devoted to the topic in academic literature (Cour-Thimann and Winkler, 2013; Bowdler and Radia, 2012; Gambacorta et al., 2014). The essential characteristic of unconventional monetary policies is a tool used by a central bank or other monetary authority that distinguishes from traditional measures. Although unconventional monetary policies came to prominence during the GFC, the Bank of Japan (BOJ) had already implemented such policy tools since the early 2000s

In March 2001, the BOJ introduced an unprecedented monetary policy experiment, commonly referred to as "quantitative easing (QE)" to stimulate the nation's stagnant economy and overcome prolonged deflation.[1] The BOJ decided to end the QE policy in March 2006 and switched back to target the overnight call rate as its policy instrument. However, the BOJ started the "quantitative-qualitative easing (QQE)" in April 2013 by the large-scale purchase of Japanese Government Bonds (JGBs) and other financial assets. The main purpose of this policy was to achieve a two percent annual CPI inflation rate in the next two years. Additionally, the BOJ intended to encourage more bank lending to the private sector.

In academic literature, many studies have investigated the impact of QE on interest rates, asset prices, inflation, and output growth. In the case of the BOJ, several studies found that asset purchases of the BOJ have a significant effect on reducing the yields of government bonds (Kimura and Small, 2007; Oda and Nagahata, 2008; Ugai, 2006). Harada and Masujima (2009) and Honda et al. (2013) indicated that the BOJ's QE policy increased aggregate output through asset prices and bank reserves. In contrast, less attention has been paid to the response of bank lending using bank-level data. Bowman et al. (2015) investigated the impact of first QE using bank-level data from 2000 to 2009 and found a positive response of lending to liquidity positions, which is more intense for weaker banks. Matousek et al. (2019) focused on regional banks and analyzed the interaction between the BOJ's QE policy and banks' assets and liabilities composition using data from 2000 to 2015. They found that small-sized regional banks with high values of non-performing loans (NPLs) holdings tended to increase their lending.

To investigate the impact of recent QQE on bank lending, we analyzed the individual regional bank data following Bowman et al. (2015) and Matousek et al. (2019), but extend the sample period to

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[1] As well as the BOJ, The U.S. Federal Reserve (FED), the Bank of England and the European Central Bank (ECB) also adopted the QE policy after the GFC to increase the money supply by flooding financial institutions with liquidity to encourage and promote lending to the private sector.

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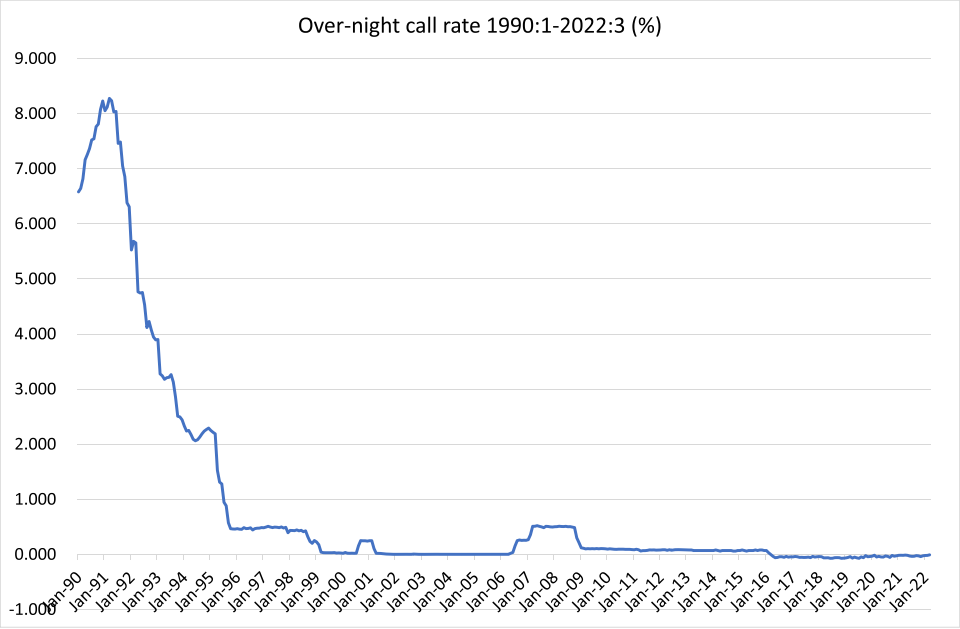

Fig. 1. Over-night call rate 1990:1–2022:3 (%).

2020. Many regional banks focus predominantly on lending business in their local areas, so, unlike Bowman et al. (2015) or Matousek et al. (2019), we control for local economic conditions. We newly discovered that the BOJ's government bond purchases during the QQE have a considerably larger impact on regional bank lending than they did before QQE. These results suggest that the QQE policy is quite effective in promoting bank lending. Regarding the differences in bank characteristics, the magnitude of impact is greater for regional banks with a higher NPL ratio, a larger asset size, and a lower market share. The first result is consistent with the findings of Bowman et al. (2015) and Matousek et al. (2019), whereas the second and third results are novel. The Granger causality tests produce consistent results.

One major reason for us to focus on regional banks is that they play a leading role in performing the financial intermediation function in the Japanese financial system. Wang (2016) investigated how differences in financial structure have been responsible for differences in approaches to unconventional monetary policy between the BOJ and the Fed and argued that the role of banks in Japan is more relevant in the transmission of unconventional monetary policy because of the bank-based financial structure. Moreover, their line of business is quite different from that of large "mega" banks with nationwide branch network. Mega banks have been expanding their overseas businesses and increasing non-interest income since the mid-2000s to overcome a decline in loan demand due to the stagnation. In contrast, many regional banks still focus predominantly on lending business and are struggling against unfavorable business conditions such as shrinking population and prolonged stagnation of the regional economies. Regarding the severe business environment that Japanese regional banks face recently, Fukuda and Okumura (2021) examined the impact of population aging on regional deposit and loans. They argued that, in rural economies, deposits are expected to decline and to result in a shortage of funds in the near future. Kobayashi and Bremer (2022) examined regional bank reorganizations using the event study methodology from 2008 to 2019. They found that, within the prefecture, mergers might result in the oligopolistic local banking markets, leading to poorer services and higher fees.

The remainder of the paper is organized as follows. Section 2 explains the Bank of Japan's non-traditional policy operations. Section 3 surveys the literature on the effectiveness of those policies and on the bank lending behavior. Section 4 describes the empirical methodology and the data. Section 5 presents and briefly discusses the empirical results. Finally, Section 6 concludes the paper with some caveats.

2. Background

The BOJ first lowered policy interest rates, namely the overnight call rate, from its peak of 8.3 % in March 1991 to a historic low of 0.5 % in September 1995 as can be seen in Fig. 1. This was the beginning of the era of the very low interest rate in Japan. Then, in March 1999, facing the severe recession following the Japan's own financial crisis triggered by the asset bubble burst in the early 1990s, the BOJ adopted the zero-interest-rate policy (ZIRP). Shortly after the ZIRP introduction, the BOJ added the commitment to continue it until "the deflation scare goes away." It intended to lower the longer-term interest rates to enhance the ZIRP's expansionary effects. This was among the first examples of the forward guidance.

In March 2001, the BOJ introduced the QE policy trying to fight against the mild but stubborn deflation. It radically shifted the policy tools from the price, the overnight call rate, to the quantity, amount of central bank reserves. To realize the quantitative target, the BOJ began to purchase large amount of JGBs. This was the beginning of the QE in the recent history, which other central banks adopted after the GFC. The BOJ several times increased its target on reserves: the private banks' current account balance at the BOJ. The BOJ ended the QE in March 2006, shortly before the end of its ZIRP.

Regarding the effect of the BOJ's QE policy, Honda et al. (2013) applied the vector auto-regression (VAR) models to investigate the relationship between prices, output, and reserves by using monthly data and found that the impulse response of output to a reserve stock is positive. Schenkelberg and Watzka (2013) also argued that the QE policy led to a statistically significant decrease in long-term interest rates, which caused a significant, but transitory, increase in output and prices. Ijiri (2015) found that the QE policy affected production significantly, but the effect size varied over time.

In anticipation of the coming exit, the BOJ switched to buy only JGBs with short remaining maturities. Thus, after its announcement of exit, its JGB holdings shrank smoothly in several months without selling them. Around the exits of the QE and the ZIRP, the economic condition was not bad so that the BOJ seemed to proceed to normalize the monetary policy operations. They thought that those non-conventional measures were

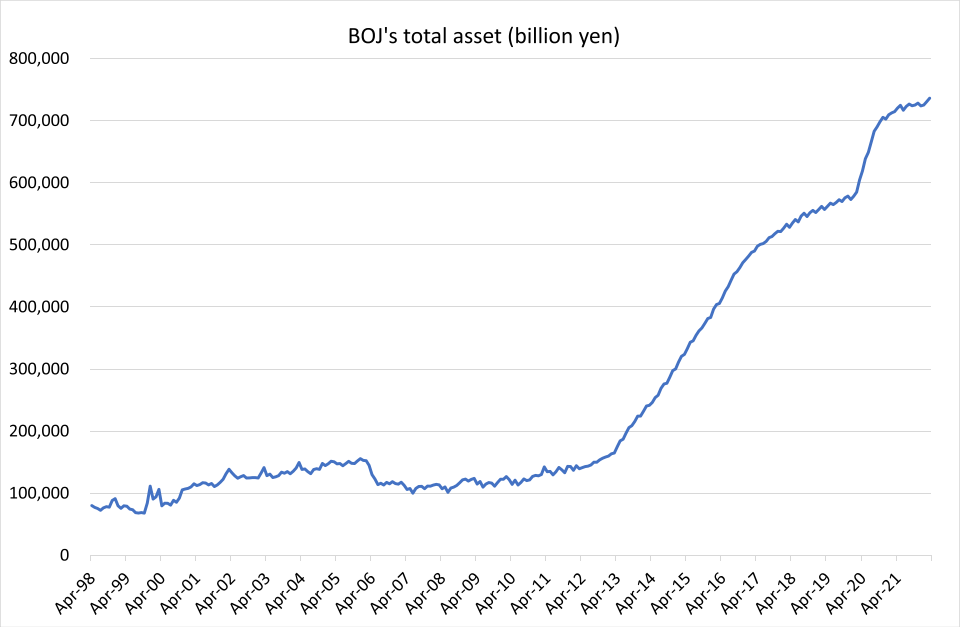

Fig. 2. BOJ's total asset (billion yen).

exceptional ones; they should raise the policy interest rate to the high enough level so that they have the room to maneuver it against the future shocks. However, inflation did not rise even to 1 % level, then. So, some critics argued that it should have continued those non-conventional measures to make inflation higher. They also argued, based on the theoretical analysis of the optimal policy operations constrained by the zero lower bound, that the BOJ should continue ZIRP longer than normally justified periods to compensate for the cumulative shortage of the monetary policy easing. The BOJ did not continue ZIRP long enough so that the inflation would not overshoot, they thought.

The U.S. financial crisis erupted after the collapse of the Lehman Brothers in September 2008, and its spillovers led to the world real sector economic crisis. The Japanese export decreased drastically, by about 40 % compared with a year ago in the 4th quarter of 2008 and 1st quarter of 2009.[2] This led to the severe recession and the BOJ had to jump start the ZIRP again in December 2008 and the modified version of QE shortly after. Facing the ongoing recession and deflation, the BOJ enhanced its policy stimulus by adopting the Comprehensive Monetary Easing (CME) in October 2010. The BOJ started to increase its balance sheet by purchasing assets at large scale. Thus, it was similar to QE but BOJ bought not only JGBs but also several additional assets like CP, ETF, and REIT.

In April 2013, its new governor Kuroda found the CME was insufficient so that he decided to increase radically the asset purchase size. The BOJ announced to attain the 2 % inflation goal by doubling the money supply in 2 years. It named the new policy measure as the QQE; the term "qualitative" mainly means to purchase long-term JGBs rather than shorter maturity ones, which were the main asset purchased in the first QE in the early 2000s. They tried hard to differentiate the new policy from the early ones to stimulate inflation expectations. The financial markets responded vividly to this policy. Stock prices started to rise substantially, and the Japanese Yen depreciated significantly.

The QQE was considered as a second component of the government stimulus package of the Abe Cabinet, Abenomics, which was planned to contain the active fiscal policy management as its first component and the radical deregulations as the third component. The Abe cabinet did increase the government spending though the deregulation might not be so radical. The Japanese economy started to get out of the recession and its inflation rate rose to largely positive area although lower than the 2 % goal.

The BOJ was criticized for not to attain the 2 % inflation goal even with the radical policy measures as QQE. Since the BOJ had bought huge amount of JGBs, the remaining room for its large-scale purchase seemed to become limited.[3] As a result, the BOJ's balance sheet has grown spectacularly from 2013 (Fig. 2). The macroeconomic condition has become quite good, but the inflation did not rise to its goal.

Responding to the persistence of the low inflation, the BOJ introduced the Negative Interest Rate Policy (NIRP) in January 2016; in this aspect, it followed several European central banks. It was a shift back from the quantitative target to the interest rate target. The financial markets initially responded vividly again. However, its effects faded away soon. The financial institutions started to highly criticize the BOJ since they were afraid of the lower revenue with the flattened yield curve. The BOJ responded to this criticism by adding the Yield Curve Control (YCC) in September 2016. It kept the NIRP unchanged but added the target for 10-year JGB rate at 0 % to somewhat steepen the yield curve.[4]

Regarding the differences between QE and QQE, Matsuki et al. (2015) pointed out that QE leads to a decline in short-term interest rates and increase in prices, while QQE stimulates economic activity proxied

[2] It is now considered to be initiated by the sudden stop of the trade finance. The Japanese banks started to reject the letters of credit issued by the U.S. banks to the U.S. importers since they worried about the soundness of the U.S. banks in the midst of the crisis. Some argued falsely that the Japanese banks suffered a lot by the crisis so that they could not finance the Japanese exporters. Actually, the Japanese banks were healthy enough to finance the Japanese importers; the Japanese imports did not decrease as much as its exports.

[3] Fujiki and Tomura (2017) simulated the BOJ's cash flows and balance sheet before and after the end of QQE and found that the BOJ will record significant accounting losses after the end of QQE.

[4] Ijiri and Jinushi (2017) showed that the Japanese M1 shock was effective onto Japanese stock price through the QQE period 6 months to 1.5 years later but onto the Japanese output only in its beginning 1–1.5 years later. It also stimulated the U.S. economy significantly.

by electric power consumption.[5] Moreover, Miyao and Okimoto (2017) also demonstrated that the introduction of QQE substantially raises real output and prices. Michaelis and Watzka (2017) compared all the unconventional monetary policies and confirmed that a substantial effect on real output and prices only in the QQE policy.

3. Literature review

Whether monetary policy affects the real economy through the credit channel has received considerable attention over the last three decades. As Bernanke and Gertler (1995) pointed out, the credit channel has traditionally been characterized into two separate channels: the balance sheet channel and the bank lending channel. The balance sheet channel highlights how monetary policy affects the credit portfolio of financial intermediaries as well as other economic agents. Thus, it postulates the potential impact of changes in interest rates on borrowers' balance sheets and income statements. On the other hand, the bank lending channel emphasizes the special role of bank loans in monetary transmission, indicating that monetary policy influences bank funding costs and leads to an additional response in bank lending. There has been significant empirical work on both the bank lending channel and the balance sheet channel, but the results are mixed.[6]

Recently, there is a growing literature focusing on the effectiveness of unconventional monetary policies. There are also several influential survey papers about the empirical evidence (Bech and Malkhozov, 2016; Belke, 2018; Papadamou et al. 2020). As for the bank lending channel, there are plenty of papers reporting positive effects in a range of countries. For instance, Carpenter et al. (2014) revealed that non-standard policy measures lowered bank funding volatility in the US and the Euro area, and lower bank funding volatility in turn increased loan supply in both regions.[7]

Since Japan was the first country that adopted a series of unconventional monetary policy, numerous studies have been conducted on this topic. Bowman et al. (2015) examined the effects of the BOJ's QE policy from 2001 to 2006, specifically injections of liquidity into the interbank market, in promoting bank lending.[8] They found that QE has only limited effects on bank lending because much of the BOJ's reserve injections on bank liquidity was offset as banks reduced their lending to each other. Shioji (2016) examined the similar data for longer period up to 2014. He found that increase in the excess reserve led to modest increase in bank lending in the next period after 2000 including the QE periods. In particular, some diversities among banks were found; the liquidity-constrained banks tended to respond strongly. Tachibana, et al. (2017) also examined the individual bank data for the ZIRP period from 1995 to 2014. They found that, responding to quantitative easing actions, the bank lending increased most among regional banks and in the first QE period in the early 2000s Wang (2016) compared QE effects between Japan and the US and found that impacts of the BOJ's long-term government bonds purchase on bank lending are larger than that of its liquidity provision although the overall size of their impacts are quite small. Although significantly positive and larger impacts on lending by large banks were found in the US, the existence of such a leading force caused by large banks is not suggested in Japan. Matousek et al. (2019) provided evidence for the effectiveness of QE policies on GDP and inflation by focusing on regional banks with low versus high NPLs holdings. Their findings are consistent with those of Kobayashi et al. (2006) that financially weaker banks gain more benefits from the QE through positive excess stock returns.

In more recent studies, Shioji (2019) investigated how bank lending reacts when the supply of excess reserves increases using individual bank data for the ZIRP period and found that QE caused weaker, less creditworthy banks to increase their lending. Moreover, Koeda (2019) investigated the macroeconomic effects of the BOJ's QQE policy measures using macroeconomic and financial data from the mid-1990s to the end of 2016. The author showed that the BOJ's QQE policy increased the output through "pure" quantitative easing when the first-year QQE level effect was controlled and complemented by qualitative easing. Honda and Inoue (2019) theoretically considered the effect of NIRP and argued that it may have supported the economy through the exchange rate channel.

Thus, although many studies have investigated the effects of a series BOJ's unconventional monetary policy tools, those regarding the QQE policy are scarce. In particular, the policy's impact on banks' lending activities is not fully examined.

4. Method and data

4.1. Dynamic panel GMM

This study investigates the impact of the BOJ's government bonds purchase on bank lending by using dynamic panel models, which contain dependent variable with one or more lags in according with its time-series characteristics. The inclusion of the lagged dependent variables in the baseline specification implies that there is correlation between the regressors and the error term. To deal with such endogeneity problem, Arellano and Bond (1991) and Arellano and Bover (1995) proposed generalized method of moments (GMM) estimators; it was later extended by Blundell and Bond (1998). The GMM estimator ensures efficiency and consistency, provided that the models are not subject to serial correlation of order two and that the instruments used are valid. The GMM methodology has also been used extensively in the bank lending channel literature (e.g., Ehrmann et al., 2003; Altunbas et al., 2009; Matousek and Sarantis, 2009; Heryán et al., 2017).

The model is given by the following equation where the total outstanding balance of loan is regressed on monetary policy indicators which is measured by the BOJ's JGB purchase amount, and lagged bank specific characteristics.

$$\Delta\ln\left(L_{i,t}\right) = \alpha\Delta\ln\left(L_{i,t-1}\right) + \beta\Delta\ln(JGB_{t-1}) + \gamma DM_{QQE} + \delta\Delta\ln(JGB_{t-1}) \bullet DM_{QQE} + \varphi' \boldsymbol{X}_{i,t-1} + \eta_i + \mu_{it} \quad (1)$$

Specifically, in Eq. (1), the first difference of logarithmic loans ($\Delta\ln(L_{i,t})$) is regressed on lagged dependent variable ($\Delta\ln(L_{i,t-1})$), the first difference of logarithmic of the BOJ's JGB purchase amount ($\Delta\ln(JGB_{i,t-1})$), a dummy variable for the period of the QQE (DM_{QQE}), the interaction term between the BOJ's JGB purchases and the QQE dummy, and a vector of control variables such as bank characteristics and regional indicators ($\boldsymbol{X}_{i,\ t-1}$). In addition, η_i is bank-specific effect, and μ_{it} is the remaining error terms. Both of them are assumed to be independently and identically distributed over time.

We use a two-step estimation in the system GMM that estimates the covariance matrix of the moment conditions using the first-step residuals. The bias in the two step standard errors is corrected by Windmeijer's (2005) correction procedure. Although both one and two steps are consistent, the latter has the advantage of being asymptotically efficient and robust to whatever patterns of heteroskedasticity.

[5] They further found that purchases of exchange-traded funds stimulate the stock and foreign exchange markets in Japan, while purchases of Japan real estate investment trusts do not have any effect.

[6] For excellent survey, see Hubbard (1994) and Bernanke and Gertler (1995).

[7] Although the results are mixed, there are numerous empirical studies examining the balance sheet channel (Bauer and Rudebusch, 2011; Gagnon et al. 2011; Gilchrist et al. 2015; Christensen and Krogstrup, 2018; Argimon et al. 2019).

[8] Bowman et al. (2015) use panel data including banks other than regional banks: city banks, trust banks, and long-term credit banks. Although they employ dummy variables for varying bank types, the estimates are not displayed in the results.

Table 1
Descriptive statistics of the variables used in GMM estimation.

Variable	Whole period				Pre-QQE period		QQE period	
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Mean	Std. Dev.
Total outstanding balance of loans; *L* (million yen)	19,49,696	17,52,862	1,19,707	1,21,00,000	16,94,526	14,59,373	23,71,299	20,84,925
Long-term JGB purchasing; *JGBL* (million yen)	2,34,00,000	1,95,00,000	27,07,900	6,01,00,000	90,42,393	47,29,127	4,72,00,000	81,06,549
Sum of long- and short-term JGB purchasing; *JGBA* (million yen)	4,46,00,000	3,03,00,000	36,12,000	10,70,00,000	2,39,00,000	98,48,578	7,88,00,000	2,01,00,000
Liquidity ratio; *LQR* (%)	7.4328	4.3888	0.8746	34.5288	6.0681	3.0293	9.6876	5.2701
Deposits outstanding; *D* (million yen)	25,80,640	21,90,395	1,60,195	1,62,00,000	22,62,276	18,49,661	31,06,658	25,75,128
Equity ratio; *EQR* (%)	5.6129	8.1629	-6.0121	100.0478	5.8039	10.2985	5.2973	1.1642
Total security-to-assets ratio; *SECR* (%)	23.3196	7.8627	0.0000	48.0732	23.3631	7.4648	23.2476	8.4812
Bad loan ratio; *BLR* (%)	4.3437	3.0237	0.0458	73.3200	5.4687	3.2420	2.3845	1.2012
Total assets; *AST* (million yen)	30,08,632	27,00,383	1,73,885	1,95,00,000	25,66,852	21,67,932	37,38,565	32,74,836
Business start-up rate; *BSR* (%)	2.1830	0.5753	0.9981	5.9788	2.1187	0.4970	2.2892	0.6722
People moving rate; *RMP* (%)	0.9222	0.1176	0.3744	1.3072	0.9282	0.1170	0.9124	0.1180
Unemployment rate; *UER* (%)	3.8192	1.3154	0.5780	8.7011	4.4695	1.1336	2.7449	0.7833
Number of observations		4416			2751		1665	

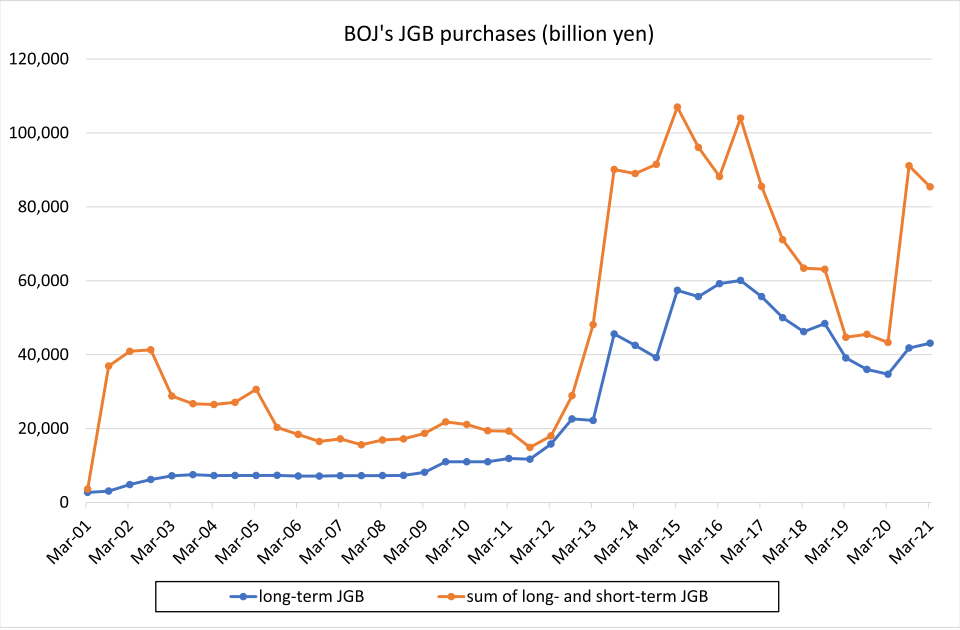

Fig. 3. BOJ's JGB purchases (billion yen).

4.2. Data

This study uses semi-annual regional bank financial data spanning from September 2001 up to September 2021. The panel data set is unbalanced because of the consolidation of the several regional banks.[9] Bank-specific data are drawn from the *Analysis of Financial Statements of All Banks*, edited by the Japanese Bankers Association. bank-level balance sheet data are obtained from the Japanese Bankers Association (JBA) website. Data on the BOJ's purchases of long/short-term government bonds are obtained from the "Bank of Japan Statistics" released on the website of the BOJ. The BOJ has released the data on JGB purchases for long- and short-term bonds. We consider two cases: long-term JGB purchase ($JGBL_t$) and the sum of long- and short-term JGB purchase ($JGBA_t$).[10] We use flow data disclosed as "Outright Purchases" of JGBs as a proxy for long-term JGB and treasury discount bills as a proxy for short-term JGB. Since the BOJ announces the amount of JGBs to be purchased per month, we aggregate the monthly data into semiannual data to match with the bank-specific data that are reported at the end of March and September. The dummy variable for the period of the QQE (DM_{QQE}) is set equal to one after September 2013 because the BOJ introduced QQE in April 2013.

Regarding the bank characteristics, we select the variables following Bowman et al. (2015) and Matousek et al. (2019). The lagged liquidity ratio ($LQR_{i,t-1}$), defined as the ratio of liquid assets to total bank assets, is used to consider the effect of financing constraints. The lagged first difference of deposits outstanding ($\Delta\ln(D_{i,t-1})$) is a measure concerning the ability to provide loans for each bank excepting excess reserves. The lagged equity ratio ($EQR_{i,t-1}$), constructed as bank equity divided by total assets, is used to capture risks associated with bank assets. The lagged total security-to-assets ratio ($SECR_{i,t-1}$) is used to capture a bank management issue concerning alternative investment strategies. Furthermore, the lagged bad loan ratio ($BLR_{i,t-1}$; bad loans/ total loan portfolio)

[9] Ashikaga bank is excluded before 2010, which went bankrupt in 2003 and has been temporarily nationalized.

[10] Saito and Hogen (2014) found that the short-term government securities purchases by the BOJ did not result in any change in financial institutions' lending activity, but the long-term government bond purchases led to an increase in lending.

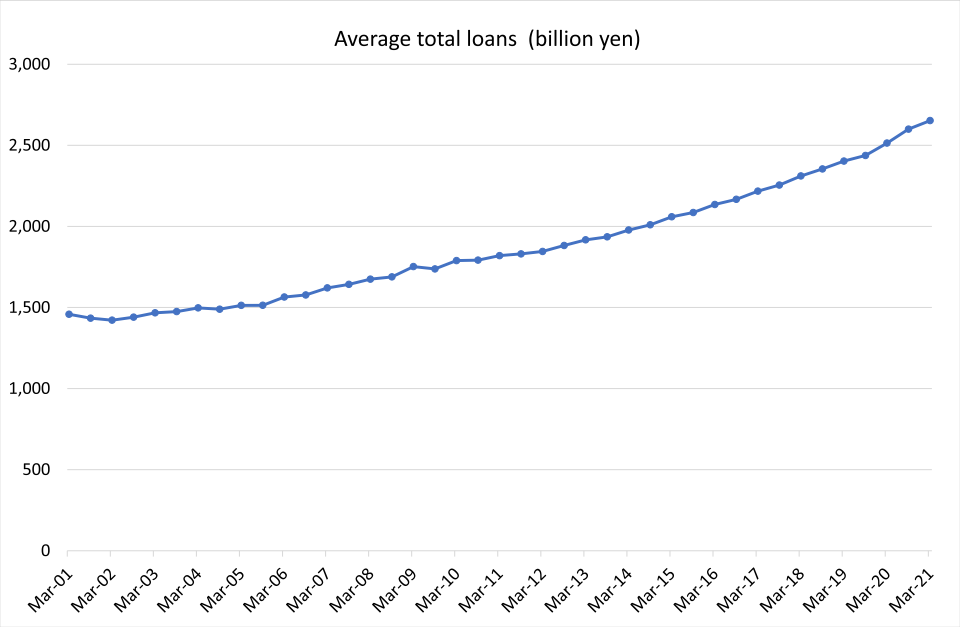

Fig. 4. Average total loans (billion yen).

is employed to investigate the impacts of bank health on loan supply, which is highlighted by Matousek et al. (2019).[11] Finally, the lagged value of total assets ($\ln(AST_{i,t-1})$) is used to as a proxy for the size of the banks.

Moreover, we use three prefectural variables to consider regional differences: business start-up rate (*BSR*), the relative ratio of number of people moving in from other prefectures to those moving out to other prefectures (*RMP*), and the unemployment rate (*UER*). To avoid simultaneity bias, these prefectural demographic variables are also lagged by one period (half-year). The business start-up rate is calculated from the Monthly Report on Employment Insurance Programs, published by the Ministry of Health, Labor, and Welfare. The data for the migration population, which are used to calculate *RMP*, are obtained from the Basic Resident Register Network System released on the website of the Ministry of Internal Affairs and Communications. The unemployment rate is calculated from the Labor Force Survey released at the website of the Statistics Bureau, Ministry of Internal Affairs and Communications.

The summary statistics of all variables are presented in Table 1. They are calculated for three periods, the whole period, the pre-QQE period, and the QQE period, for the sake of comparison. The mean value of the sum of the long- and short-term JGB purchases ($JGBA_t$) is about twice as large as that of long-term JGB purchases ($JGBL_t$) in the whole period. Reflecting the shift in monetary policy, their mean value increased in the QQE period. In particular, the mean value of a long-term JGB purchase increased drastically. This is confirmed in Fig. 3. Particularly, the values surged immediately following the implementation of QQE. Although they tend to decrease in the late 2010 s, the values still exceed their maximum values in the pre-QQE period.

As shown in the minimum and maximum values of the total outstanding balance of loans in Table 1, regional banks vary greatly in size. Similar to the BOJ's JGB purchase amount, the average value of bank loans increased by about 40 % between the pre-QQE and QQE periods. Fig. 4 depicts the mean value of a bank loans over time. Though the figure does not show any distinctive change around 2013, the average semiannual growth rate increases significantly after 2013: from 1.1 % in the pre-QQE period to 1.8 % in the QQE period.

5. Empirical results

5.1. Baseline regression

To confirm the viridity of using two-step GMM estimators, we conducted standard panel-data analysis and one-step GMM estimation. In the panel-data analysis, Hausman test reject the null hypothesis of the random effect model at the 1 % level for both cases. The estimates of ln ($JGBL_t$) and ln ($JGBA_t$) are negative and statistically significant at the 10 % level, but their interaction terms with the QQE dummy are not statistically significant in both cases. In the one-step GMM estimation, the results of the Sargan test of over-identifying restrictions, which tests the overall validity of the instruments, show that the null hypothesis that all instruments are uncorrelated with the error term can be strongly rejected for both cases. We use lagged loan growth, lagged variables of the BOJ's JGB purchase amount growth, and liquidity ratios as endogenous variables in our regressions. The lagged values of the other dependent variables are used as instruments.[12] Although we have tested alternative models that use other bank characteristic variables as endogenous variables and others, the results have not improved. Thus, one-step GMM estimation is not sufficient in terms of model specification.

The results of two-step GMM estimation are shown in Table 2. The endogenous variables and instruments are the same as those of the one-step GMM estimation. As for the result of empirical model using long-term JGB ($JGBL_t$) in column (1), the Sargan test accepts the instrument validity and the Arellano–Bond test of second-order autocorrelation on first-differences of the idiosyncratic disturbances presents no significant evidence of serial correlation in the residual. As for the main findings, the estimates of two lags of the difference of logarithmic of the BOJ's long-term JGB purchase amount have opposite signs. The first difference value, $\Delta\ln(JGBL_{i,t-1})$, has negative and statistically significant

[11] Bad loans are defined as defaulted loans due to bankruptcy, loans that are doubtful or requires special attention (past due 3 months and restructured loans) as defined under Financial Reconstruction Act, enacted in October 1998.

[12] Bowman et al. (2015) used control variables as follows: total assets; equity ratio, measured by net assets as a percentage of total assets; bad loan ratio; lags of deposit growth, and lags of loan growth. In the system GMM estimation, lags 1 and 2 of loan growth variable and liquidity ratio are used as instruments.

Table 2
Effect of QQE on regional bank lending.

	Whole period						Pre-QQE period						QQE period					
	(1)			(2)			(3)			(4)			(5)			(6)		
	Coef.		Std. Err.	Coef.		Std. Err.	Coef.		Std. Err.	Coef.		Std. Err.	Coef.		Std. Err.	Coef.		Std. Err.
$\Delta\ln(L_{i,\ t\text{-}1})$	-0.6550	***	0.0200	-0.6533	***	0.0218	-0.6594	***	0.0178	-0.6684	***	0.0190	-0.5216	*	0.3091	-0.5500	*	0.2947
$\Delta\ln(L_{i,\ t\text{-}2})$	-0.3249	***	0.0099	-0.3221	***	0.0117	-0.3274	***	0.0111	-0.3307	***	0.0114	-0.5633	**	0.2549	-0.5792	**	0.2484
$\Delta\ln(JGBL_{t\text{-}1})$	-0.0530	***	0.0131				-0.0446	***	0.0128				0.0194	***	0.0057			
$\Delta\ln(JGBL_{t\text{-}2})$	0.0008		0.0060				-0.0727	***	0.0195				0.0284	***	0.0049			
$\Delta\ln(JGBL_{t\text{-}1})*DM_{QQE}$	0.0794	***	0.0122															
$\Delta\ln(JGBA_{t\text{-}1})$				-0.0107		0.0077				-0.0048		0.0097				0.0028		0.0064
$\Delta\ln(JGBA_{t\text{-}2})$				0.0144	***	0.0032				-0.0115	*	0.0070				0.0276	***	0.0068
$\Delta\ln(JGBA_{t\text{-}1})*DM_{QQE}$				0.0312	***	0.0061												
DM_{QQE}	-0.0352	***	0.0064	-0.0313	***	0.0066												
$LQR_{i,\ t\text{-}1}$	0.0004		0.0012	0.0001		0.0013	0.0042		0.0038	0.0017		0.0034	-0.0105	***	0.0025	-0.0122	***	0.0024
$LQR_{i,\ t\text{-}2}$	-0.0126	***	0.0033	-0.0109	***	0.0034	-0.0096	***	0.0035	-0.0085	**	0.0035	-0.0158	***	0.0027	-0.0166	***	0.0028
$\Delta\ln(D_{i,\ t\text{-}1})$	0.3818	***	0.0504	0.3809	***	0.0487	0.2878	***	0.0375	0.3586	***	0.0393	0.0870		0.3320	0.0947		0.3068
$\Delta\ln(D_{i,\ t\text{-}2})$	0.2622	***	0.0728	0.2820	***	0.0712	0.2247	***	0.0680	0.3512	***	0.0752	0.1080		0.2418	0.1148		0.2324
$EQR_{i,\ t\text{-}1}$	0.0002	***	0.0001	0.0003	***	0.0001	0.0002	***	0.0001	0.0002	***	0.0001	-0.0315	***	0.0107	-0.0291	***	0.0108
$SECR_{i,\ t\text{-}1}$	-0.0029	*	0.0015	-0.0016		0.0015	-0.0033		0.0022	-0.0011		0.0020	-0.0093	***	0.0019	-0.0093	***	0.0021
$BLR_{i,\ t\text{-}1}$	0.0003		0.0011	0.0004		0.0012	0.0007		0.0013	-0.0005		0.0012	0.0102		0.0117	0.0108		0.0111
$\ln(AST_{i,\ t\text{-}1})$	0.1209	***	0.0293	0.1005	***	0.0303	0.1598	***	0.0379	0.0901	**	0.0355	0.5462	***	0.1019	0.5910	***	0.0922
$BSR_{i,\ t\text{-}1}$	0.0176	***	0.0028	0.0198	***	0.0027	0.0135	***	0.0038	0.0151	***	0.0039	0.0101	***	0.0036	0.0082	**	0.0037
$RMP_{i,\ t\text{-}1}$	0.0226		0.0209	0.0141		0.0192	-0.0170		0.0354	-0.0283		0.0352	0.0822	***	0.0261	0.0641	**	0.0261
$UER_{i,\ t\text{-}1}$	-0.0091	***	0.0030	-0.0125	***	0.0034	-0.0192	***	0.0042	-0.0201	***	0.0046	0.0348	***	0.0091	0.0346	***	0.0086
Sargan test	0.2456			0.2407			0.0002			0.0002			0.0005			0.0006		
Arellano-Bond test [AR(2)]	0.7296			0.9610			0.4077			0.9423			0.0246			0.0439		
Observations	3936						2272						1664					

Notes: Standard errors are clustered at bank level. Asterisks denote significance levels (***1 %, **5 %, and *10 %).
Sargan test (based on homoskedasticity) is the p-value of the J-statistic for over-identifying restrictions (distributed chi-square).
Arellano-Bond test [AR(2)] is the p-value of the autocorrelation test of second order.

impact on regional bank loan growth. The estimate of the second difference value, $\Delta\ln(JGBL_{i,t\text{-}2})$, has become positive, though smaller in absolute value and not statistically significant. The estimated coefficient for the QQE dummy is negative and that on the interaction term is positive, and both are statistically significant. Thus, the BOJ's long-term JGB purchase appears to have a significant negative impact on the regional banks' lending, but it is improved during the QQE period. The estimates of the lagged liquidity ratio, the second lagged value, $LQR_{i,t\text{-}2}$, seem to have a negative impact on regional bank loan growth. By contrast, both estimates of the lagged deposit growth are positive and statistically significant. The estimate of the lagged equity ratio is also positive and statistically significant. Regarding the three prefectural variables, the estimated coefficient for $BSR_{i,t\text{-}1}$ is positive and statistically significant, indicating that regional banks located in the areas where business start-up rate is increasing tend to increase bank loan. It is considered very reasonable result. The estimated $UER_{i,t\text{-}1}$ has significant negative impact, implying that regional banks located in economically depressed areas tend to decrease bank loan. Both are considered reasonable results.

For the specification using the BOJ's total JGB purchase ($JGBA_t$) in column (2), the results are largely in line with the results using $JGBL_t$. The Sargan test accepts the instrument validity and the Arellano–Bond test for AR (2) also supports that there is no serial correlation in the second order residual. As in the specification using $JGBL_t$, the estimates of $\Delta\ln(JGBA_{i,t\text{-}1})$ and $\Delta\ln(JGBA_{i,t\text{-}2})$ are negative and positive respectively. Although the former is statistically insignificant, the latter has become significant and larger in absolute value. Here too, the estimated coefficient for the QQE dummy is negative and that on the interaction term is positive. Thus, although the BOJ's total JGB purchase appears to have a significant negative impact on the regional banks' lending, it is improved during the QQE period. As for the other control variables, all the coefficients remain the same signs and are almost unchanged in significance, compared with the specification using $JGBL_t$. The estimates of $LQR_{i,t\text{-}1}$, $BLR_{i,t\text{-}1}$ and $RMP_{i,t\text{-}1}$ are not statistically significant here too.

Thus, the results indicate that the impact of the BOJ's JGB purchase amount on the regional banks' lending has changed after the introduction of the QQE policy. To confirm these findings, we divide the sample period before and after 2013 and estimate the same models. Columns (3) and (4) of Table 2 show the results for the pre-QQE period. The two-lag estimates of the logarithmic difference of the BOJ's long-term JGB purchase amount are negative and statistically significant. Those of the total JGB purchase amount are also negative, although the first difference value is not statistically significant. Thus, the results suggest that the BOJ's JGB purchase appears to have a negative impact on the regional banks' lending in the pre-QQE period. However, the results of the Sargan test show strong evidence against the null hypothesis that the overidentifying restrictions is valid for both cases.[13]

Columns (5) and (6) of Table 2 present the results for the QQE period. In sharp contrast to the results for the pre-QQE period, the two-lag estimates of the logarithmic difference of the BOJ's total JGB purchase amount are positive and statistically significant. Those of the total JGB purchase amount are also positive, although the first difference value is not statistically significant. These results are consistent with the estimated coefficient for the interaction term in the case of a full sample, suggesting that the BOJ's JGB purchase has a positive impact on the regional banks' lending in the QQE period. However, the results of the Sargan test reject the null hypothesis that no model misspecification exists. Moreover, the Arellano–Bond test for AR (2) provides evidence for the existence of serial correlation in the residual for both cases. Thus, deriving a plausible explanation based on these results is difficult.

[13] While we have tested alternative models that using the other bank characteristics variables such as deposits outstanding, the results were not drastically improved.

5.2. Robustness check: differences in bank characteristics

5.2.1. Differences in the loan market share

Even though the Japanese economy has stagnated for long years, there have been significant disparities among the regions.[14] In particular, the local areas have severely lost populations and their economies have tended to stagnate substantially. On the other hand, the urban areas have barely lost populations and mildly stagnated. Corresponding to those situations, many banks opened new branches in the urban areas while those in local areas are closed. As a result, the lending market in urban areas has become extremely competitive. First, we examine the differences in loan market competition and estimate the same models to confirm the robustness of the results. There are many empirical findings that greater competition may improve bank efficiency, leading to more lending (e.g., Jayaratne and Strahan, 1996; Rajan and Zingales, 1998; Bertrand et al., 2007). According to these results, the impact of QQE on bank lending might be considered weak for regional banks located in less competitive areas. We split the sample of banks into two groups based on the loan market share in each prefecture.[15] Regional banks whose market share are larger than 20 % at the end of March 2020 are classified as 'higher market share,' and other regional banks are classified as 'lower market share'.[16]

The results for regional banks with higher market share are displayed in Table 3.1. The results for the whole period are shown in columns (1) and (2). The Sargan test rejects the null hypothesis of overidentifying restrictions in both cases. The Arellano–Bond test for AR (2) also presents no significant evidence of serial correlation. In accordance with the results in Table 2, the estimates of two lags of the difference of logarithmic of the BOJ's JGB purchase amount have opposite signs. Moreover, the estimates of the interaction term between the BOJ's JGB purchases and the QQE dummy are positive and statistically significant for both cases.

Columns (3) and (4) of Table 3.1 show the results for the pre-QQE period. Unlike the results based on the entire sample in Table 2, the results of the Sargan test accept the instrument validity for both cases. Although the estimates of the logarithmic difference of the BOJ's long-term JGB purchase amount are negative and statistically significant, those of the total JGB purchase amount have opposite signs and are insignificant. Columns (5) and (6) of Table 3.1 present the results for the QQE period. In this case, the Sargan test also accepts the instrument validity, and the Arellano–Bond test for AR (2) also presents no significant evidence of serial correlation. The two-lag estimates of the logarithmic difference of the BOJ's long-term JGB purchase amount are positive, although the first difference value is not statistically significant. By contrast, those of the total JGB purchase amount have opposite signs and are insignificant.

Table 3.2 shows the results for regional banks with lower market share. In the results for the whole period shown in columns (1) and (2) of Table 3.2, the Sargan test accepts the instrument validity, and the Arellano–Bond test for AR (2) presents no significant evidence of serial correlation. Similar to the results in Table 3.1, the estimates of the interaction term between the BOJ's JGB purchases and the QQE dummy are positive and statistically significant for both cases. Moreover, they become larger than those in Table 3.1, indicating that the BOJ's JGB purchase has greater positive impact on lending growth of regional banks with lower market share in the QQE period.

[14] There are some studies showing that the impact of monetary policy could vary across banks depending on bank characteristics (e.g., Kashyap and Stein, 2000; Hosono, 2006; Kobayashi et al., 2006).

[15] Data on the loans of regional banks and all financial institutions in each prefecture used to calculate loan market share are derived from Financial Map, edited by the Japan Financial News Co., Ltd.

[16] The mean value of prefectural loan market share is 24.4 % at the end of March 2020 (100 observations), and the median value of that is 20.9 %.

Table 3.1
Effect of QQE on regional bank lending (differences in loan market share: higher market share).

	Whole period						Pre-QQE period						QQE period					
		(1)			(2)			(3)			(4)			(5)			(6)	
	Coef.		Std. Err.	Coef.		Std. Err.	Coef.		Std. Err.	Coef.		Std. Err.	Coef.		Std. Err.	Coef.		Std. Err.
$\Delta\ln(L_{i,\ t\text{-}1})$	-0.6182	***	0.0342	-0.6089	***	0.0591	-0.6306	***	0.0309	-0.6370	***	0.0314	-0.2639	*	0.1401	-0.2801	**	0.1415
$\Delta\ln(L_{i,\ t\text{-}2})$	-0.2892	***	0.0336	-0.2787	***	0.0405	-0.3020	***	0.0298	-0.3025	***	0.0290	-0.0765		0.1795	-0.1130		0.1472
$\Delta\ln(JGBL_{t\text{-}1})$	-0.0226	**	0.0115				-0.0218	*	0.0119				0.0052		0.0051			
$\Delta\ln(JGBL_{t\text{-}2})$	0.0045		0.0057				-0.0477	**	0.0198				0.0120	***	0.0047			
$\Delta\ln(JGBL_{t\text{-}1})*DM_{QQE}$	0.0463	***	0.0120															
$\Delta\ln(JGBA_{t\text{-}1})$				-0.0019		0.0076				0.0094		0.0078				0.0014		0.0057
$\Delta\ln(JGBA_{t\text{-}2})$				0.0134	**	0.0054				-0.0088		0.0102				-0.0023		0.0071
$\Delta\ln(JGBA_{t\text{-}1})*DM_{QQE}$				0.0199	***	0.0076												
DM_{QQE}	-0.0291	***	0.0060	-0.0251	***	0.0064												
$LQR_{i,\ t\text{-}1}$	-0.0004		0.0013	-0.0008		0.0015	-0.0025		0.0032	-0.0038		0.0033	-0.0041	***	0.0015	-0.0034	*	0.0016
$LQR_{i,\ t\text{-}2}$	-0.0087	***	0.0027	-0.0080	***	0.0029	-0.0093	***	0.0027	-0.0098	***	0.0030	-0.0102	***	0.0023	-0.0097	***	0.0028
$\Delta\ln(D_{i,\ t\text{-}1})$	0.4116	***	0.0610	0.3744	***	0.0726	0.2257	***	0.0582	0.2631	***	0.0614	0.1854	**	0.0860	0.2023	**	0.0983
$\Delta\ln(D_{i,\ t\text{-}2})$	0.3598	***	0.0851	0.3368	***	0.0899	0.2537	**	0.1043	0.3292	***	0.1092	0.0349		0.0730	0.0421		0.0671
$EQR_{i,\ t\text{-}1}$	0.0002	**	0.0001	0.0002	**	0.0001	0.0002	**	0.0001	0.0002	**	0.0001	-0.0126	**	0.0055	-0.0107		0.0070
$SECR_{i,\ t\text{-}1}$	-0.0020		0.0014	-0.0014		0.0014	-0.0023		0.0014	-0.0013		0.0017	-0.0064	***	0.0019	-0.0060	***	0.0021
$BLR_{i,\ t\text{-}1}$	0.0021		0.0021	0.0023		0.0026	0.0032		0.0024	0.0020		0.0019	0.0343	***	0.0113	0.0370	***	0.0119
$\ln(AST_{i,\ t\text{-}1})$	0.1110	***	0.0298	0.1018	***	0.0364	0.1664	***	0.0361	0.1175	***	0.0348	0.3580	***	0.1102	0.3564	***	0.1095
$BSR_{i,\ t\text{-}1}$	0.0152	***	0.0039	0.0170	***	0.0036	0.0111	**	0.0050	0.0113	**	0.0057	0.0073	***	0.0026	0.0073	**	0.0032
$RMP_{i,\ t\text{-}1}$	-0.0054		0.0268	-0.0066		0.0271	-0.0441		0.0446	-0.0411		0.0458	0.0802	***	0.0240	0.0841	***	0.0250
$UER_{i,\ t\text{-}1}$	-0.0163	***	0.0045	-0.0169	***	0.0048	-0.0232	***	0.0046	-0.0217	***	0.0051	0.0103	*	0.0061	0.0153	**	0.0064
Sargan test	1.0000			1.0000			0.7290			0.7328			0.3831			0.2933		
Arellano-Bond test [AR(2)]	0.6587			0.6969			0.4613			0.7542			0.7662			0.7995		
Observations	1942						1095						847					

Notes: Standard errors are clustered at bank level. Asterisks denote significance levels (***1 %, **5 %, and *10 %).
Sargan test (based on homoskedasticity) is the p-value of the J-statistic for over-identifying restrictions (distributed chi-square).
Arellano-Bond test [AR(2)] is the p-value of the autocorrelation test of second order.

Table 3.2
Effect of QQE on regional bank lending (differences in loan market share: lower market share).

	Whole period						Pre-QQE period						QQE period					
	(1)			(2)			(3)			(4)			(5)			(6)		
	Coef.		Std. Err.	Coef.		Std. Err.	Coef.		Std. Err.	Coef.		Std. Err.	Coef.		Std. Err.	Coef.		Std. Err.
$\Delta\ln(L_{i,\ t\text{-}1})$	-0.6599	***	0.0301	-0.6618	***	0.0287	-0.6568	***	0.0263	-0.6727	***	0.0226	-0.5244		0.4439	-0.4867		0.4646
$\Delta\ln(L_{i,\ t\text{-}2})$	-0.3290	***	0.0135	-0.3308	***	0.0149	-0.3255	***	0.0141	-0.3347	***	0.0122	-0.7704	**	0.3142	-0.7281	**	0.3514
$\Delta\ln(JGBL_{t\text{-}1})$	-0.0859	***	0.0244				-0.0673	***	0.0214				0.0267	***	0.0076			
$\Delta\ln(JGBL_{t\text{-}2})$	-0.0030		0.0105				-0.0992	***	0.0323				0.0354	***	0.0070			
$\Delta\ln(JGBL_{t\text{-}1})*DM_{QQE}$	0.1176	***	0.0220							-0.0165		0.0142				0.0062		0.0116
$\Delta\ln(JGBA_{t\text{-}1})$				-0.0232	*	0.0119				-0.0080		0.0081				0.0312	**	0.0123
$\Delta\ln(JGBA_{t\text{-}2})$				0.0145	***	0.0046												
$\Delta\ln(JGBA_{t\text{-}1})*DM_{QQE}$				0.0539	***	0.0088												
DM_{QQE}	-0.0513	***	0.0127	-0.0486	***	0.0127												
$LQR_{i,\ t\text{-}1}$	-0.0003		0.0015	-0.0008		0.0015	0.0026		0.0044	-0.0002		0.0042	-0.0138	***	0.0039	-0.0151	***	0.0033
$LQR_{i,\ t\text{-}2}$	-0.0133	**	0.0052	-0.0098	*	0.0052	-0.0088		0.0054	-0.0060		0.0048	-0.0200	***	0.0049	-0.0188	***	0.0063
$\Delta\ln(D_{i,\ t\text{-}1})$	0.3462	***	0.0684	0.3645	***	0.0562	0.2649	***	0.0467	0.3699	***	0.0513	-0.0106		0.5007	-0.0656		0.5074
$\Delta\ln(D_{i,\ t\text{-}2})$	0.2147	**	0.1004	0.2571	***	0.0921	0.1800	**	0.0811	0.3413	***	0.0958	0.2664		0.3175	0.2353		0.3682
$EQR_{i,\ t\text{-}1}$	0.0002		0.0001	0.0002	*	0.0001	0.0002	*	0.0001	0.0002	**	0.0001	-0.0307	*	0.0174	-0.0310	*	0.0188
$SECR_{i,\ t\text{-}1}$	-0.0023		0.0024	0.0001		0.0024	-0.0029		0.0032	0.0003		0.0028	-0.0119	***	0.0035	-0.0094	**	0.0039
$BLR_{i,\ t\text{-}1}$	0.0000		0.0018	0.0000		0.0017	0.0009		0.0019	-0.0005		0.0016	0.0026		0.0074	0.0028		0.0064
$\ln(AST_{i,\ t\text{-}1})$	0.1288	**	0.0521	0.1029	**	0.0506	0.1795	***	0.0573	0.0899		0.0577	0.6392	***	0.1273	0.6502	***	0.1065
$BSR_{i,\ t\text{-}1}$	0.0170	***	0.0048	0.0203	***	0.0047	0.0158	***	0.0052	0.0180	***	0.0069	0.0131		0.0086	0.0119		0.0087
$RMP_{i,\ t\text{-}1}$	0.0502		0.0315	0.0425		0.0307	0.0081		0.0397	0.0027		0.0322	0.0883	**	0.0414	0.0673	*	0.0403
$UER_{i,\ t\text{-}1}$	-0.0024		0.0052	-0.0083		0.0054	-0.0132	**	0.0064	-0.0177	***	0.0068	0.0583	***	0.0127	0.0533	***	0.0135
Sargan test	0.9995			0.9996			0.4250			0.3516			0.3504			0.2747		
Arellano-Bond test [AR(2)]	0.3156			0.5512			0.8461			0.3724			0.018			0.0402		
Observations	1994						1177						817					

Notes: Standard errors are clustered at bank level. Asterisks denote significance levels (***1%, **5%, and *10%).
Sargan test (based on homoskedasticity) is the p-value of the J-statistic for over-identifying restrictions (distributed chi-square).
Arellano-Bond test [AR(2)] is the p-value of the autocorrelation test of second order.

Columns (3) and (4) of Table 3.2 show the results for the pre-QQE period. In accordance with the results in Table 3.1, the results of the Sargan test and the Arellano–Bond test for AR (2) show the model's validity. The estimates of the logarithmic difference of the BOJ's long-term JGB purchase amount are negative and statistically significant. Moreover, those of the total JGB purchase amount have negative signs but are insignificant. Columns (5) and (6) of Table 3.2 show the results for the QQE period. In sharp contrast to the results in Table 3.1, most of the estimates of the BOJ's JGB purchases are positive and statistically significant. Considering that lower market share may reflect highly competitive environment, these results indicate that greater competition leads to higher lending growth. However, the Arellano–Bond test for AR (2) show evidence for the existence of serial correlation in the residual for both cases.

5.2.2. Differences in bank size

Next, we examine the influences of the bank size. As for the effect of the BOJ's QE policy, Matousek et al. (2019) found that the degree of leverage is increased for banks, especially for small-sized regional banks. We estimate the same models for the larger and smaller regional bank groups. Regional banks with total assets more than 3 billion yen at the end of March 2020 are classified as 'larger regional banks,' and other regional banks are as 'smaller regional banks'.[17]

Table 4.1 presents the results for larger regional banks. The results for the whole period are shown in columns (1) and (2). The results of the Sargan test and the Arellano–Bond test for AR (2) show the validity of the model. In accordance with the results in Table 3.1 and Table 3.2, the estimates of the interaction term between the BOJ's JGB purchases and the QQE dummy are positive and statistically significant for both cases.

The results for the pre-QQE period are shown in in columns (3) and (4). Although the model specification tests are clear, the estimates of the difference of logarithmic of the BOJ's JGB purchase amount are negative and not statistically significant for both cases. The results for the QQE period are shown in columns (5) and (6). The Sargan test accepts the instrument validity, but the p-values of the Arellano–Bond test for AR (2) are less than 0.1 for both cases. By contrast to the results for the pre-QQE period, the two-lag estimates of the logarithmic difference of the BOJ's long-term JGB purchase amount are positive and statistically significant. Those of the total JGB purchase amount are also positive, although the first difference value is not statistically significant.

Table 4.2 presents the results for smaller regional banks. The model specification tests are clear for the results of the whole period in columns (1) and (2) of Table 4.2. In this case, the estimates of the interaction term between the BOJ's JGB purchases and the QQE dummy are also positive and statistically significant for both cases.

Columns (3) and (4) of Table 4.2 present the results for the pre-QQE period. The model specification tests are clear for both cases, and the estimates of the logarithmic difference of the BOJ's long-term JGB purchase amount are negative and statistically significant. Those of the total JGB purchase amount are also negative but are not statistically significant. Columns (5) and (6) of Table 4.2 present the results for the QQE period. The results of the Sargan test and the Arellano–Bond test for AR (2) show the model's validity. Moreover, the estimates of the logarithmic difference of the BOJ's JGB purchase amount are all positive and statistically significant for the second difference values. The estimates are smaller than those in Table 4.1, indicating that the BOJ's JGB purchase has a less positive impact on lending growth for smaller regional banks in the QQE period. These results are inconsistent with the findings of Matousek et al. (2019) that small-sized regional banks increase the degree of leverage more in response to the BOJ's QE policy.

[17] The mean value of total assets at the end of March 2020 is 4.05 billion yen, and the median value of that is 2.96 billion yen.

5.2.3. Differences in bank health

Matousek et al. (2019) found that the effectiveness of the BOJ's QE policy is larger for small-sized regional banks with high NPLs. Bowman et al. (2015) also argued that weak banks benefited more from the QE policy than stronger banks. Therefore, we finally examine the influences of the NPL holdings and we estimate the same models for the high and low NPLs groups separately. Regional banks with NPL ratio less than 1.8 % at the end of March 2020 are classified as 'lower NPL ratio,' and the other regional banks are as 'higher NPL ratio'.[18]

The 5.1 presents the results for regional banks with lower NPL ratio. The model specification tests are clear for all results. For the results for the whole period in columns (1) and (2), the estimates of the interaction term between the BOJ's JGB purchases and the QQE dummy are positive and statistically significant for both cases. Columns (3) and (4) of Table 5.1 show the results for the pre-QQE period. The two-lag estimates of the logarithmic difference of the BOJ's long-term JGB purchase amount are negative and statistically significant. Columns (5) and (6) of Table 5.1 present the results for the QQE period. Moreover, most estimates of the logarithmic difference of the BOJ's JGB purchase amount are not statistically significant.

The results for regional banks with higher NPL ratio are displayed in Table 5.2. The model specification tests are clear for the results for the whole period in columns (1) and (2). Here too, the estimates of the interaction term between the BOJ's JGB purchases and the QQE dummy are positive and statistically significant for both cases. Columns (3) and (4) of Table 5.2 present the results for the pre-QQE period. Similar to the results in Table 5.1, the two-lag estimates of the logarithmic difference of the BOJ's long-term JGB purchase amount are negative and statistically significant. Columns (5) and (6) of Table 5.2 present the results for the QQE period. Interestingly, in sharp contrast to the results in Table 5.1, all the estimates of the logarithmic difference of the BOJ's JGB purchase amount are positive and statistically significant. Thus, there is strong evidence that weak banks benefited more from the BOJ's JGB purchase in the QQE period.

In addition, to enhance the robustness of the results, we estimated the same model excluding 15 regional banks involved in consolidation during the sample period. In addition, we have additionally eliminated four outlier banks and estimated the same model.[19] As a result, we could confirm that the results matched those obtained from the full sample. Since the introduction of QQE, we find that the BOJ's purchase of JGBs has had a positive and significant impact on the lending of regional banks. Regarding differences in bank characteristics, the magnitude of the positive impact is greater for regional banks with a smaller market share, a larger asset size, and a higher NPL ratio.

5.3. Granger causality tests

Overall, the BOJ's JGB purchases have a positive impact on regional banks' lending during the QQE period even when considering the differences in bank characteristics. In particular, for the regional banks with higher NPL ratio, they have a smaller but significantly positive impact. On the other hand, it is popular to run Granger causality tests to investigate the relationship between monetary policy and bank lending. For instance, as for the reverse causality, Wang (2016) showed that increases in bank lending leads to increases in the BOJ's long-term government bonds purchase based on the standard VAR methodology. Therefore, we also apply panel Granger causality test to confirm the

[18] The mean value of NPL ratio at the end of March 2020 is 2.03 %, and the median value of that is 1.80 %.

[19] The outlier banks are those with particularly large variations in the outstanding loan balance. Based on the semiannual rate of change in the outstanding loan balance for each bank, we used their coefficient of variation to find outliers. In addition, Suruga Bank, which has received administrative actions by Japan's financial regulator in 2018, was designated as an outlier.

Table 4.1
Effect of QQE on regional bank lending (differences in bank size: larger regional banks).

	Whole period						Pre-QQE period						QQE period					
	(1)			(2)			(3)			(4)			(5)			(6)		
	Coef.		Std. Err.	Coef.		Std. Err.	Coef.		Std. Err.	Coef.		Std. Err.	Coef.		Std. Err.	Coef.		Std. Err.
$\Delta\ln(L_{i,\ t\text{-}1})$	-0.5776	***	0.0400	-0.5627	***	0.0474	-0.5941	***	0.0360	-0.6083	***	0.0345	-0.5016		0.3595	-0.5686		0.3734
$\Delta\ln(L_{i,\ t\text{-}2})$	-0.3008	***	0.0203	-0.2883	***	0.0270	-0.2974	***	0.0209	-0.3017	***	0.0201	-0.7250	***	0.2146	-0.7731	***	0.2218
$\Delta\ln(JGBL_{t\text{-}1})$	-0.0339		0.0218				-0.0226		0.0222				0.0227	***	0.0070			
$\Delta\ln(JGBL_{t\text{-}2})$	-0.0009		0.0106				-0.0454		0.0311				0.0267	***	0.0076			
$\Delta\ln(JGBL_{t\text{-}1})*DM_{QQE}$	0.0535	***	0.0188							-0.0129		0.0150				0.0091		0.0089
$\Delta\ln(JGBA_{t\text{-}1})$				-0.0249	*	0.0136				-0.0101		0.0092				0.0270	***	0.0089
$\Delta\ln(JGBA_{t\text{-}2})$				0.0112	**	0.0053												
$\Delta\ln(JGBA_{t\text{-}1})*DM_{QQE}$				0.0401	***	0.0113												
DM_{QQE}	-0.0376	***	0.0114	-0.0415	***	0.0123												
$LQR_{i,\ t\text{-}1}$	-0.0001		0.0016	-0.0006		0.0015	0.0029		0.0050	0.0027		0.0051	-0.0151	***	0.0030	-0.0164	***	0.0027
$LQR_{i,\ t\text{-}2}$	-0.0107	***	0.0032	-0.0104	***	0.0031	-0.0103	**	0.0044	-0.0102	***	0.0039	-0.0122	***	0.0039	-0.0123	***	0.0039
$\Delta\ln(D_{i,\ t\text{-}1})$	0.2279	***	0.0796	0.2083	**	0.0817	0.1807	***	0.0615	0.2190	***	0.0666	0.0194		0.4187	0.0704		0.4386
$\Delta\ln(D_{i,\ t\text{-}2})$	0.1653		0.1005	0.1366		0.0996	0.1563	*	0.0850	0.2071	**	0.0926	0.3020		0.2043	0.3450		0.2166
$EQR_{i,\ t\text{-}1}$	0.0002	**	0.0001	0.0002	**	0.0001	0.0002	*	0.0001	0.0002	*	0.0001	-0.0367	***	0.0143	-0.0291	**	0.0129
$SECR_{i,\ t\text{-}1}$	-0.0020		0.0013	-0.0012		0.0015	-0.0027		0.0018	-0.0015		0.0018	-0.0052		0.0036	-0.0047		0.0035
$BLR_{i,\ t\text{-}1}$	0.0047	*	0.0025	0.0055	*	0.0028	0.0040	*	0.0021	0.0028		0.0020	0.0050		0.0089	0.0055		0.0085
$\ln(AST_{i,\ t\text{-}1})$	0.1476	***	0.0457	0.1573	***	0.0470	0.1468	***	0.0409	0.1287	***	0.0350	0.7153	***	0.1192	0.7514	***	0.1114
$BSR_{i,\ t\text{-}1}$	0.0119	***	0.0032	0.0151	***	0.0036	0.0143	**	0.0059	0.0146	**	0.0069	0.0011		0.0052	-0.0004		0.0050
$RMP_{i,\ t\text{-}1}$	0.0139		0.0350	0.0096		0.0437	-0.0560		0.0612	-0.0874		0.0838	0.0644		0.0526	0.0547		0.0524
$UER_{i,\ t\text{-}1}$	-0.0156	***	0.0043	-0.0176	***	0.0049	-0.0222	***	0.0051	-0.0232	***	0.0054	0.0298	***	0.0089	0.0238	***	0.0091
Sargan test	1.0000			1.0000			0.8329			0.8381			0.4280			0.4625		
Arellano-Bond test [AR(2)]	0.6569			0.5317			0.2358			0.2867			0.0537			0.0875		
Observations	1794						1011						783					

Notes: Standard errors are clustered at bank level. Asterisks denote significance levels (***1 %, **5 %, and *10 %).
Sargan test (based on homoskedasticity) is the p-value of the J-statistic for over-identifying restrictions (distributed chi-square).
Arellano-Bond test [AR(2)] is the p-value of the autocorrelation test of second order.

Table 4.2
Effect of QQE on regional bank lending (differences in bank size: smaller regional banks).

	Whole period						Pre-QQE period						QQE period					
	(1)			(2)			(3)			(4)			(5)			(6)		
	Coef.		Std. Err.	Coef.		Std. Err.	Coef.		Std. Err.	Coef.		Std. Err.	Coef.		Std. Err.	Coef.		Std. Err.
$\Delta\ln(L_{i,\ t\text{-}1})$	-0.6892	***	0.0160	-0.6943	***	0.0178	-0.6752	***	0.0160	-0.6962	***	0.0158	-0.2923	***	0.1051	-0.3346	***	0.0987
$\Delta\ln(L_{i,\ t\text{-}2})$	-0.3184	***	0.0154	-0.3297	***	0.0172	-0.3167	***	0.0136	-0.3322	***	0.0161	-0.1803		0.1109	-0.2071	*	0.1069
$\Delta\ln(JGBL_{t\text{-}1})$	-0.0683	***	0.0159				-0.0676	***	0.0161				0.0069		0.0052			
$\Delta\ln(JGBL_{t\text{-}2})$	0.0044		0.0052				-0.1024	***	0.0208				0.0226	***	0.0039			
$\Delta\ln(JGBL_{t\text{-}1})*DM_{QQE}$	0.1036	***	0.0186															
$\Delta\ln(JGBA_{t\text{-}1})$				-0.0052		0.0082				-0.0029		0.0103				0.0024		0.0068
$\Delta\ln(JGBA_{t\text{-}2})$				0.0183	***	0.0047				-0.0126		0.0106				0.0130	*	0.0072
$\Delta\ln(JGBA_{t\text{-}1})*DM_{QQE}$				0.0341	***	0.0082												
DM_{QQE}	-0.0412	***	0.0098	-0.0302	***	0.0098												
$LQR_{i,\ t\text{-}1}$	-0.0011		0.0015	-0.0018		0.0017	-0.0003		0.0042	-0.0024		0.0041	-0.0047	**	0.0021	-0.0051	**	0.0021
$LQR_{i,\ t\text{-}2}$	-0.0106	***	0.0034	-0.0095	***	0.0037	-0.0108	**	0.0046	-0.0097	**	0.0047	-0.0148	***	0.0038	-0.0139	***	0.0043
$\Delta\ln(D_{i,\ t\text{-}1})$	0.5108	***	0.0710	0.5244	***	0.0688	0.3293	***	0.0390	0.4584	***	0.0477	0.1385		0.1329	0.0963		0.1162
$\Delta\ln(D_{i,\ t\text{-}2})$	0.4108	***	0.0997	0.4515	***	0.0989	0.2438	***	0.0913	0.4493	***	0.1175	-0.1082		0.0971	-0.1143		0.0957
$EQR_{i,\ t\text{-}1}$	0.0003	***	0.0001	0.0003	***	0.0001	0.0003	***	0.0001	0.0003	***	0.0001	-0.0117		0.0080	-0.0101		0.0075
$SECR_{i,\ t\text{-}1}$	-0.0027		0.0021	-0.0020		0.0022	-0.0053		0.0038	-0.0035		0.0036	-0.0104	***	0.0029	-0.0094	***	0.0033
$BLR_{i,\ t\text{-}1}$	0.0013		0.0014	0.0017		0.0015	0.0021		0.0016	0.0012		0.0019	0.0271	***	0.0080	0.0293	***	0.0085
$\ln(AST_{i,\ t\text{-}1})$	0.1192	***	0.0416	0.0934	**	0.0408	0.2249	***	0.0629	0.1189	*	0.0682	0.3641	***	0.1121	0.3851	***	0.1204
$BSR_{i,\ t\text{-}1}$	0.0179	***	0.0046	0.0216	***	0.0047	0.0145	***	0.0051	0.0182	***	0.0062	0.0145	***	0.0039	0.0133	***	0.0041
$RMP_{i,\ t\text{-}1}$	0.0142		0.0200	0.0076		0.0207	0.0221		0.0325	0.0092		0.0307	0.0545	**	0.0247	0.0485	*	0.0256
$UER_{i,\ t\text{-}1}$	-0.0056		0.0046	-0.0093	*	0.0048	-0.0173	***	0.0057	-0.0216	***	0.0071	0.0293	***	0.0070	0.0324	***	0.0078
Sargan test	0.9988			0.9988			0.2156			0.2302			0.3431			0.2538		
Arellano-Bond test [AR(2)]	0.2669			0.2378			0.6886			0.3359			0.3854			0.4550		
Observations	2142						1261						881					

Notes: Standard errors are clustered at bank level. Asterisks denote significance levels (***1 %, **5 %, and *10 %).
Sargan test (based on homoskedasticity) is the p-value of the J-statistic for over-identifying restrictions (distributed chi-square).
Arellano-Bond test [AR(2)] is the p-value of the autocorrelation test of second order.

Table 5.1
Effect of QQE on regional bank lending (differences in NPL ratio: lower NPL banks).

	Whole period						Pre-QQE period						QQE period					
		(1)			(2)			(3)			(4)			(5)			(6)	
	Coef.		Std. Err.	Coef.		Std. Err.	Coef.		Std. Err.	Coef.		Std. Err.	Coef.		Std. Err.	Coef.		Std. Err.
$\Delta\ln(L_{i,\ t\text{-}1})$	-0.6233	***	0.0938	-0.6836	***	0.0277	-0.6694	***	0.0241	-0.6908	***	0.0265	-0.2944		0.2172	-0.3541		0.2563
$\Delta\ln(L_{i,\ t\text{-}2})$	-0.3134	***	0.0407	-0.3499	***	0.0190	-0.3284	***	0.0159	-0.3426	***	0.0146	-0.3876		0.2385	-0.4195		0.2755
$\Delta\ln(JGBL_{t\text{-}1})$	-0.0677	***	0.0213				-0.0556	**	0.0222				0.0058		0.0077			
$\Delta\ln(JGBL_{t\text{-}2})$	-0.0138		0.0088				-0.1016	***	0.0279				0.0130	*	0.0069			
$\Delta\ln(JGBL_{t\text{-}1})*DM_{QQE}$	0.0893	***	0.0207															
$\Delta\ln(JGBA_{t\text{-}1})$				-0.0215		0.0149				-0.0085		0.0177				-0.0019		0.0073
$\Delta\ln(JGBA_{t\text{-}2})$				0.0196	***	0.0060				-0.0014		0.0105				0.0122		0.0107
$\Delta\ln(JGBA_{t\text{-}1})*DM_{QQE}$				0.0448	***	0.0130												
DM_{QQE}	-0.0534	***	0.0126	-0.0557	***	0.0140												
$LQR_{i,\ t\text{-}1}$	-0.0020		0.0014	-0.0030	**	0.0014	-0.0005		0.0038	-0.0038		0.0034	-0.0093	***	0.0036	-0.0098	**	0.0043
$LQR_{i,\ t\text{-}2}$	-0.0097	***	0.0031	-0.0086	**	0.0037	-0.0089	**	0.0040	-0.0082	**	0.0035	-0.0108	***	0.0032	-0.0116	**	0.0046
$\Delta\ln(D_{i,\ t\text{-}1})$	0.3154	***	0.1229	0.3612	***	0.0697	0.2858	***	0.0621	0.3725	***	0.0609	-0.2345		0.2461	-0.1741		0.2662
$\Delta\ln(D_{i,\ t\text{-}2})$	0.2427	**	0.1161	0.2898	***	0.0940	0.2079	**	0.0922	0.3521	***	0.0967	-0.1075		0.1868	-0.0729		0.2044
$EQR_{i,\ t\text{-}1}$	0.0001	*	0.0001	0.0002	**	0.0001	0.0001		0.0001	0.0001		0.0001	-0.0158		0.0135	-0.0166		0.0135
$SECR_{i,\ t\text{-}1}$	-0.0003		0.0014	0.0006		0.0015	-0.0021		0.0021	0.0006		0.0017	-0.0056	**	0.0022	-0.0060	**	0.0030
$BLR_{i,\ t\text{-}1}$	0.0027		0.0036	0.0025		0.0037	0.0043		0.0035	0.0020		0.0035	0.0620	***	0.0149	0.0631	***	0.0184
$\ln(AST_{i,\ t\text{-}1})$	0.1399	***	0.0475	0.1298	***	0.0497	0.1932	***	0.0532	0.1083	**	0.0523	0.6114	***	0.1714	0.6180	***	0.1974
$BSR_{i,\ t\text{-}1}$	0.0172	***	0.0032	0.0215	***	0.0036	0.0132	***	0.0049	0.0196	***	0.0052	0.0066		0.0048	0.0065		0.0057
$RMP_{i,\ t\text{-}1}$	-0.0167		0.0290	-0.0367		0.0303	-0.0910		0.0620	-0.0826		0.0520	0.0819	***	0.0315	0.0720	**	0.0338
$UER_{i,\ t\text{-}1}$	-0.0186	***	0.0052	-0.0262	***	0.0057	-0.0289	***	0.0073	-0.0301	***	0.0086	0.0210	***	0.0070	0.0184	**	0.0084
Sargan test	1.0000			1.0000			0.8520			0.8111			0.3549			0.4032		
Arellano-Bond test [AR(2)]	0.7338			0.5191			0.8564			0.5197			0.1952			0.2313		
Observations	1845						1031						814					

Notes: Standard errors are clustered at bank level. Asterisks denote significance levels (***1 %, **5 %, and *10 %).
Sargan test (based on homoskedasticity) is the p-value of the J-statistic for over-identifying restrictions (distributed chi-square).
Arellano-Bond test [AR(2)] is the p-value of the autocorrelation test of second order.

Table 5.2
Effect of QQE on regional bank lending (differences in NPL ratio: higher NPL banks).

	Whole period						Pre-QQE period						QQE period					
	(1)			(2)			(3)			(4)			(5)			(6)		
	Coef.		Std. Err.	Coef.		Std. Err.	Coef.		Std. Err.	Coef.		Std. Err.	Coef.		Std. Err.	Coef.		Std. Err.
$\Delta\ln(L_{i,\ t\text{-}1})$	-0.6484	***	0.0247	-0.6430	***	0.0238	-0.6484	***	0.0193	-0.6565	***	0.0180	-0.5978	**	0.2522	-0.6059	**	0.2523
$\Delta\ln(L_{i,\ t\text{-}2})$	-0.3213	***	0.0134	-0.3156	***	0.0138	-0.3218	***	0.0104	-0.3239	***	0.0104	-0.6525	***	0.2312	-0.6656	***	0.2445
$\Delta\ln(JGBL_{t\text{-}1})$	-0.0404	***	0.0155				-0.0328	**	0.0146				0.0302	***	0.0070			
$\Delta\ln(JGBL_{t\text{-}2})$	0.0128	*	0.0069				-0.0469	**	0.0217				0.0360	***	0.0068			
$\Delta\ln(JGBL_{t\text{-}1})*DM_{QQE}$	0.0736	***	0.0159															
$\Delta\ln(JGBA_{t\text{-}1})$				-0.0073		0.0069				0.0028		0.0068				0.0149	**	0.0070
$\Delta\ln(JGBA_{t\text{-}2})$				0.0113	***	0.0042				-0.0163	*	0.0096				0.0290	***	0.0088
$\Delta\ln(JGBA_{t\text{-}1})*DM_{QQE}$				0.0327	***	0.0074												
DM_{QQE}	-0.0284	***	0.0079	-0.0231	***	0.0077												
$LQR_{i,\ t\text{-}1}$	0.0016		0.0018	0.0009		0.0019	0.0036		0.0037	0.0032		0.0041	-0.0118	***	0.0041	-0.0133	***	0.0043
$LQR_{i,\ t\text{-}2}$	-0.0105	**	0.0042	-0.0095	**	0.0046	-0.0082	*	0.0046	-0.0082	*	0.0050	-0.0172	***	0.0034	-0.0158	***	0.0031
$\Delta\ln(D_{i,\ t\text{-}1})$	0.4060	***	0.0665	0.4122	***	0.0705	0.2959	***	0.0467	0.3609	***	0.0607	0.2816		0.2938	0.2492		0.2804
$\Delta\ln(D_{i,\ t\text{-}2})$	0.2954	***	0.0878	0.3076	***	0.0826	0.2594	***	0.0930	0.3644	***	0.0970	0.2600		0.1904	0.2709		0.1981
$EQR_{i,\ t\text{-}1}$	0.0005	***	0.0001	0.0004	***	0.0001	0.0004	***	0.0001	0.0004	***	0.0001	-0.0363	***	0.0124	-0.0293	**	0.0138
$SECR_{i,\ t\text{-}1}$	-0.0031		0.0025	-0.0025		0.0027	-0.0032		0.0032	-0.0023		0.0031	-0.0110	***	0.0027	-0.0093	***	0.0027
$BLR_{i,\ t\text{-}1}$	0.0000		0.0013	0.0003		0.0011	0.0003		0.0012	-0.0003		0.0010	0.0002		0.0046	0.0010		0.0048
$\ln(AST_{i,\ t\text{-}1})$	0.1099	**	0.0497	0.1014	**	0.0502	0.1375	**	0.0591	0.0859	**	0.0431	0.5650	***	0.1286	0.5997	***	0.1244
$BSR_{i,\ t\text{-}1}$	0.0154	***	0.0043	0.0183	***	0.0043	0.0146	***	0.0052	0.0148	***	0.0052	0.0100	*	0.0051	0.0078	*	0.0044
$RMP_{i,\ t\text{-}1}$	0.0416		0.0303	0.0475		0.0315	0.0259		0.0366	0.0243		0.0394	0.0967	***	0.0279	0.0821	***	0.0260
$UER_{i,\ t\text{-}1}$	-0.0025		0.0042	-0.0037		0.0048	-0.0105	***	0.0032	-0.0120	***	0.0031	0.0349	***	0.0083	0.0381	***	0.0084
Sargan test	0.9994			0.9995			0.2479			0.2556			0.2141			0.1992		
Arellano-Bond test [AR(2)]	0.7146			0.9131			0.7125			0.9585			0.0353			0.0657		
Observations	2091						1241						850					

Notes: Standard errors are clustered at bank level. Asterisks denote significance levels (***1 %, **5 %, and *10 %).
Sargan test (based on homoskedasticity) is the p-value of the J-statistic for over-identifying restrictions (distributed chi-square).
Arellano-Bond test [AR(2)] is the p-value of the autocorrelation test of second order.

Table 6
Granger causality tests: relationships between the BOJ's JGB purchase and regional bank lending.

		Entire sample	Higher market share	Lower market share	Larger regional banks	Smaller regional banks	Lower NPL ratio	Higher NPL ratio
Whole period	From $\Delta\ln(JGBL_{,t-1})$ to $\Delta\ln(L_t)$	0.489	0.558	0.747	0.400	0.013	0.572	0.194
	From $\Delta\ln(L_{i,t-1})$ to $\Delta\ln(JGBL_t)$	0.000	0.006	0.000	0.000	0.001	0.011	0.000
	From $\Delta\ln(JGAL_{,t-1})$ to $\Delta\ln(L_t)$	0.007	0.096	0.004	-	0.000	0.203	0.032
	From $\Delta\ln(L_{i,t-1})$ to $\Delta\ln(JGAL_t)$	0.443	0.481	0.677	-	0.000	0.765	0.464
Pre-QQE period	From $\Delta\ln(JGBL_{,t-1})$ to $\Delta\ln(L_t)$	0.001	0.039	0.254	0.046	0.000	0.000	0.584
	From $\Delta\ln(L_{i,t-1})$ to $\Delta\ln(JGBL_t)$	0.000	0.096	0.000	0.000	0.000	0.000	0.000
	From $\Delta\ln(JGAL_{,t-1})$ to $\Delta\ln(L_t)$	0.001	0.541	0.003	0.172	0.000	0.033	0.084
	From $\Delta\ln(L_{i,t-1})$ to $\Delta\ln(JGAL_t)$	0.009	0.086	0.177	0.000	0.000	0.006	0.005
QQE period	From $\Delta\ln(JGBL_{,t-1})$ to $\Delta\ln(L_t)$	0.072	0.011	0.260	0.999	0.000	0.185	0.022
	From $\Delta\ln(L_{i,t-1})$ to $\Delta\ln(JGBL_t)$	0.009	0.002	0.040	0.994	0.001	0.107	0.070
	From $\Delta\ln(JGAL_{,t-1})$ to $\Delta\ln(L_t)$	0.750	0.190	0.286	0.867	0.605	0.571	0.527
	From $\Delta\ln(L_{i,t-1})$ to $\Delta\ln(JGAL_t)$	0.412	0.396	0.351	0.987	0.580	0.002	0.702

Note: Figures mean the probability of the null hypothesis that there is no Granger causality. - indicates that the models failed to converge.

results obtained from the two-step GMM estimators.

The results for the panel unit root tests show that the hypothesis of a unit root can be rejected for the first differences of all variables.[20] According to the previous empirical models, we estimated the VAR models with three endogenous variables: lagged loan growth, the lagged variables of the BOJ's JGB purchase amount growth and liquidity ratio. The other variables are considered as exogeneous variables.[21]

The Granger causality test results are shown in Table 6. We implement the test for not only the total sample but also the three pairs of subsamples examined above. As for the results from total sample, there is a significant Granger causality from the BOJ's total JGB purchase to regional banks' lending: the p-values are less than 0.1. Moreover, in accordance with Wang (2016), a reverse Granger causality from regional banks' lending to the BOJ's long-term JGB purchase is confirmed. Notably, the results indicate the validity of using the BOJ's JGB purchase amount growth as an endogenous variable in the two-step GMM estimators. Interestingly, there is a strong evidence of Granger causality in both directions in the case of the pre-QQE period. From another aspect, a significant Granger causality in both directions can be found only between the BOJ's long-term JGB purchase and regional banks' lending.

More interesting results can be seen in the cases of subsample. First, regarding the differences in the loan market share, the results in the case of the whole period are consistent with those based on the full sample in all. For regional banks with higher market share, there is a significant Granger causality from the BOJ's long-term JGB purchase to regional banks' lending for both sub-periods. However, for regional banks with lower market share, there is a significant Granger causality from the BOJ's total JGB purchase to regional banks' lending in the case of the pre-QQE period. There is no significant evidence in the case of the QQE period, whereas the evidence of reverse causality can be observed.

Second, the results for smaller regional banks show that there is a strong evidence of Granger causality in both directions in the case of the whole period. The same results can be seen in the case of the pre-QQE period. In the case of the QQE period, a significant Granger causality in both directions can be found only between the BOJ's long-term JGB purchase and regional banks' lending.

Third, as for regional banks with higher NPL ratio, there is a strong evidence of Granger causality from the BOJ's total JGB purchase to regional banks' lending in the case of the whole period: the p-values are less than 0.05. The same results can be seen in the case of the pre-QQE period, though the p-value has become larger. Just like the results for smaller regional banks, a significant Granger causality between the BOJ's long-term JGB purchase and regional banks' lending can be found in the case of the QQE period.

Overall, as far as the case of the QQE period, these results are consistent with the results obtained from the two-step GMM estimators; the BOJ's long-term JGB purchase has a significant impact on regional banks' lending. Although there is no significant Granger causality for larger regional banks, the significant results for smaller regional banks are consistent with Matousek et al. (2019). Moreover, the results for higher NPL ratio regional banks also strongly support the findings of them.

As in the previous subsection, we have further investigated the exclusion of regional banks associated with consolidation and designated as outliers. The results are consistent; the BOJ's long-term JGB purchase has a considerable impact on regional banks' lending, particularly those with a higher NPL ratio.

6. Concluding remarks and policy implications

This study investigates the impact of the BOJ's government bonds purchase on regional banks' lending using panel data consisting of their semiannual consolidated financial statements from 2001 to 2020. Having enough samples under the QQE, we can split the sample period before and after 2013 to examine the changes since the introduction of the QQE. Most regional banks operate predominantly on lending business in each local market, in sharp contrast to the mega banks focusing on business overseas and non-interest income. The regional economy outside metropolitan areas has suffered severe economic stagnation in the last two decades, so, in this investigation, we control for the local

[20] Since the data is unbalanced, Fisher type unit root tests based on the ADF type regressions were used. By considering one and two lags with a drift term, the null hypothesis that all panels contain a unit root could be rejected at the 1% significant level in all.

[21] The estimation results of VAR models are available upon request.

economic conditions, which were ignored by some previous literature like Bowman et al. (2015) and Matousek et al. (2019). We mainly applied the two-step GMM estimation and additionally utilized the Granger causality tests to check the robustness of the findings.

Our key findings are as follows. First, we newly find that, compared with the pre-QQE period, the BOJ's JGB purchase appears to have a significantly greater impact on the regional banks' lending in the QQE period. These results remain unchanged when the short term JGB is included in the scope of the BOJ's purchase. In concrete terms, the QQE period's impacts are positive and significant, but the pre-QQE period's impacts are negative and significant. The latter may appear perplexing but it is understandable due to the QE's environment, where its impacts were muted by the decreases in the interbank lending.[22] The latter might seem puzzling but it is understandable due to the QE's environment, where its impacts were muted by the decreases in the interbank lending.

Second, the magnitude of the positive impact under the QQE is larger for regional banks with a lower market share, a higher NPL ratio, and a larger asset size. The first result is novel, the second agrees with Matousek et al. (2019), and the third disagrees with them. The difference in the sample periods might generate the different results. Their sample period contained only three years under the QQE, so, the pre-QQE period is dominant. Thus, their result might mainly reflect the financial stress situation where weaker banks faced liquidity constraints, which the QE policy tried to solve. Meanwhile, QQE began in 2013, where regional banks' liquidity conditions were no longer a pressing concern. In addition, the difference in empirical methods might influence the difference. They used a panel VAR model so that the number of variables were rather limited. They focused on macroeconomic conditions rather than local economic conditions.

Overall, our findings indicate the existence of a positive impact of QQE policy on regional banks' lending. Although almost all regional banks focus predominantly on lending business, the Japanese local areas have been losing population and their economies have been stagnated for decades. Therefore, our findings imply that the economic stagnation in the Japanese local areas would have been severer without the QQE policy.

Under the QQE policy, it is true that BOJ purchased not only those JGBs but also more riskier assets like CP, ETF, and REIT. However, the regional banks' holding of the latter assets is small so that, we consider, the impacts of their purchase on the regional banks lending would be small. Conversely, the BOJ's JGB purchase might have influenced the other components of the regional banks' investment portfolio. Regional banks have historically held substantial amounts of local government bonds, but their share in the reginal banks' portfolio has increased only moderately. Indeed, numerous regional banks have increased their investments in riskier assets, posing new threats to financial stability. In addition, the characteristics of banks' lending attitude such as a sectoral loan portfolio concentration might influence the sustainability of local economy developments. Moreover, since cooperative financial institutions also play an important role in regional finance in Japan, it would be valuable to investigate the impact of QQE policy on their lending and compare the results of regional banks. We plan to examine those sides of the QQE's impacts in future.

Data availability

The data that has been used is confidential.

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[22] So, Bowman et al. (2015) used regional banks' liquidity ratio rather than the BOJ's JGB purchase as a main explanatory variable.

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