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The Reversal of BoJ's Balance Sheet Policy and Liquidity Dependence

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Abstract

This paper empirically examines the Liquidity Dependence in Japanese banking system. Acharya and Rajan (2024) and Acharya et al. (2024) pointed out this phenomenon of Liquidity Dependence observed during the quantitative easing and quantitative tightening policies in the United States, which is regarded as one possible factor of the Silicon Valley Bank (SVB) bankruptcy in 2023. Since the introduction of quantitative easing in March 2001, the Japanese economy has experienced a longer period of quantitative easing than the United States, lasting more than 20 years. Our macro and micro analysis, using more than 20 years of macroeconomic and bank-level accounting data, we found that the same phenomenon is observed in the Japanese economy as well. The Japanese economy has a more sufficient deposit insurance system than the United States, so a phenomenon like the SVB bankruptcy is unlikely to occur. However, we would suggest the Japanese economy is necessary to prepare for the coming major quantitative tightening, so-called the exit from the long-term quantitative easing policy that has lasted for more than 20 years.

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Introduction

Developed market central banks that conducted quantitative easing have positioned the reduction of their balance sheets as merely an adjustment with no policy intent. Therefore, they also state that the tightening effect of such QT is far less than the easing effect of QE. That said, the history of central banks embarking on balance sheet reductions with such intentions showed that when they reduce their expanding balance sheets, the markets unwind portfolio rebalancing, causing to change bond prices. While this in itself is natural, there were several disruptive events in the US market and financial system, as liquidity dried up. For example, after the Federal Reserve Board (Fed) started the quantitative tightening (QT) in 2017, a repo rate spike occurred in September 2019, and after it restarted QT in 2022, the Silicon-Valley Bank (SVB) and Signature Bank went bankruptcy in March 2023 due to a massive outflow of non-insured deposits reflecting its huge losses in security investment[3]. Acharya et al. (2024) empirically showed that when the Fed expanded its balance sheet via quantitative easing, the US banks financed their reserve holdings with demandable deposits and issued credit lines to corporations. Since these bank-issued claims on liquidity did not shrink even when the Fed halted its balance-sheet expansion and turned to reduce its balance sheet, banks became highly vulnerable to liquidity turbulence. In the case of SVB, when the bank announced in March 2023 that it had incurred significant losses on its bond investments caused by a sharp rise in interest rates and its recapitalization program, start-ups with deposits in the SBV withdrew their deposits at a great scale and speed, driving it into bankruptcy in just a few days. The fact that large deposits were concentrated on demandable deposits backfired.

Acharya and Rajan (2024) and Acharya et al. (2024) called this phenomenon, whereby QE leaves the banking system with more demandable claims that are not simply reversed with QT, as “Liquidity Dependence”, since it would necessitate an even greater central bank balance sheet support in the future[4]. The standard analysis focuses on changes in the asset side of banks and examines how these affect the real economy

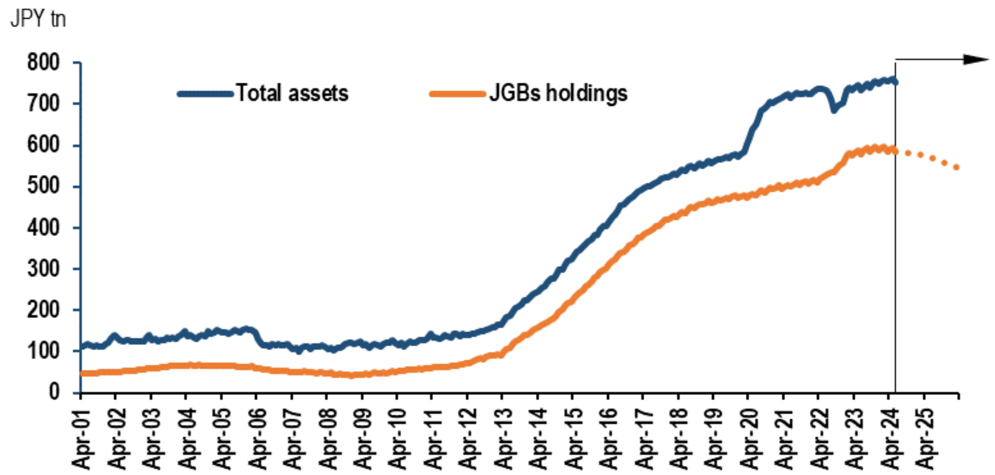
[3] Jiang et al. (2024) also examine monetary tightening and US bank fragility in 2023. They provide a conceptual framework and an empirical methodology to analyze all U.S. banks’ exposure to raising interest rates and uninsured depositors runs, with implications for financial stability.
[4] While Acharya and Rajan (2024) theoretically examine this phenomenon, Acharya et al. (2024) empirically do it. The former does not emphasize this word “liquidity dependence” as much as the latter.

through price changes, but it does not look at changes in the liability side of banks. The key to inspecting the fragility of the financial system is to look specifically at the liability side, and in particular, at changes in liquidities.

Before going into details of Liquidity Dependence, let us clarify that when the central bank supplies the reserves, liquidity demand is no more determined exogenously. This is because when the central bank supplies reserves by purchasing securities from nonbanks, nonbanks deposit the payment in the banks, thereby expanding the balance sheets of the banks and changing their capital structure. Then the banks newly increase their liquidity demand. At the same time, all the short-term interest rates are going into zero territory when the central bank conducts the QE, thus it may be natural that the banks increase the demandable deposits reflecting the needs of depositors. Then even if the central bank turns its policy to the QT and the banks do not reduce the demandable deposits and increase the time deposits symmetrically, they have reasons not to do that. Acharya et al. (2024) assumed that the reason of such asymmetric bank behavior between QE and QT is that they feel confident they will retain their access to liquidity during QT if they substitute lost reserves with bonds that are eligible collateral for repo transactions.

Turning to Japan, the Bank of Japan (BoJ) abolished its Yield Curve Control (YCC) framework and negative interest rate policy in March 2024 after quite a long period of the quantitative easing for more than 20 years. The BoJ decided to start reducing the amount of JGB purchases from August 2024 from 6 trillion yen per month to around 3 trillion yen per month in January-March 2026, thereby reducing the size of its balance sheet gradually (Figure 1). Since the Japanese economy experienced the longest period and the largest size (as of the BoJ's balance sheet-to-GDP ratio) of the quantitative easing, and has just completed such framework, this asymmetric behavior of banks should be worth being addressed. In this paper, we refer to this phenomenon as the Quantitative Tightening (QT) period, following the U.S. Fed's terminology. During the QT period, to examine the vulnerabilities of Japanese banks in the event of liquidity turbulence and how bank behavior affects the effectiveness of monetary tightening, we analyze how the balance sheets of Japanese banks change as the BoJ expanded and then will shrink its balance sheet by applying the method of Acharya et al. (2024).

Figure 1：Size of the BoJ Balance Sheet



Note: Future size of JGB holdings is calculated based on the BoJ's plan for the reduction of the purchase amount of JGBs. Source: BoJ, Macrobond

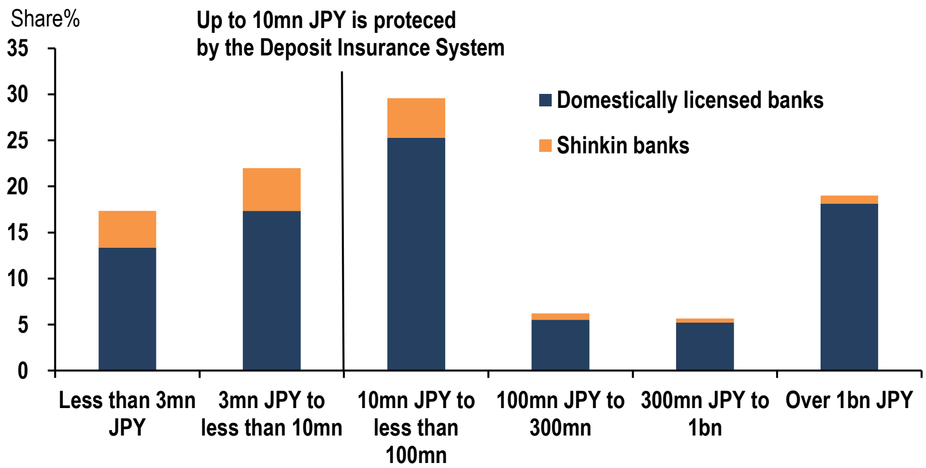
Specifically, when the demandable claims the BoJ supplies to the banks reach due when turning to QT from QE, banks may experience liquidity stress. Therefore, we will check how the BoJ's balance sheet expansion will affect the banks' demandable deposits, and how it will affect other demandable assets such as credit lines. We will also check whether the bank will turn to reduce its liquid liabilities when the BoJ turns to QT from QE in a situation that the bank's increase in demandable deposits was very large during the QE period. If the banks increased demandable deposits largely during the QE period, and if there is an asymmetry of banks' behavior between the QE and QT periods in which they do not decrease their liquid liabilities in the form of decrease in demandable deposits or increase in time deposits in the QT period, deposits might be withdrawn easily from banks when they incur losses on bond investments facing the rapid rise in long-term interest rates during the QT period, thereby increasing the liquidity risk. In addition, a change in banks' asset/liability maturity transformation behavior could also affect the spillover effects of monetary tightening.

In considering the impact of the BoJ policy and the response of Japanese banks, it is important to note the difference between the Japanese and the US financial systems. The most significant difference is that in the US, if an FDIC member bank fails, only up to USD 250,000 (approximately JPY 39 million) per account is protected[5]. In contrast, in

[5] Following the failure of SVB and Signature Bank, the FDIC published its report "Options for Deposit Insurance Reform" on 1 May 2023, The report considers the reform of the deposit insurance system in response to the increased likelihood of a bank run due to the increase in uninsured deposits

Japan, deposits for settlement purposes including current deposits and non-interest bearing ordinary deposits that meet the following three requirements are fully protected: (1) they can provide settlement services, (2) the depositor can request reimbursement at any time, and (3) they do not earn interest. Interest bearing ordinary deposits, time deposits, installment savings, money trusts with contracts for compensating the principal and financial bonds are protected up to 10 million yen in principal per depositor and their interests up to the date of bankruptcy per financial institution. To put it more simply, the big difference is that in Japan corporate deposits are protected in full, whereas in the US a large amount of corporate deposits are not protected, thereby potentially withdrawn instantly by depositor corporations, leading to the collapse of the SVB and the Signature Bank. Another characteristics of Japanese banks is that they have diversified their yen funding sources by using a variety of funding sources together, especially small, sticky retail deposits, which suggest that the amount of deposit in Japan is also diversified to uncovered deposits to some extent (Figure 2), which can lead to the stability during the normal period, but could lead to the instability with the withdrawal by households during the crisis period.

Figure 2：Distribution of Deposit Amounts per Account



Note: At the end of September 2023. Shares of all deposits of domestically licensed banks and Shikin banks (amount basis). Excluding financial institutions' deposits. Source: BoJ, JST

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and increased speed of deposit withdrawals associated with technological advances, and proposes options for increased deposit insurance coverage: (i) maintaining the current deposit insurance framework with increasing the deposit insurance limit, (ii) introducing full protection, and (iii) applying preferential protection to certain deposits.

In this paper, since the BoJ first started QE in March 2001, we regard the period from February 2002 to February 2024, just before the removal of the YCC framework and negative interest rate policy (March 2024) as the estimation period of QE, considering the constraints of reliable data, and the period from the BoJ's change in the operating target from outstanding amount of current account balances at the BoJ (hereafter called "reserves") to uncollateralized overnight call rate until its resumption of the QE (March 2006 to September 2010) as the QT period. We consider the QE period to be the period immediately prior to the elimination of QQE with YCC for the purpose of inspecting the debt side of the banks, because even though the BoJ converted from QQE to YCC in September 2016 (hereafter called "QQE with YCC"), it continued the large amount of JGB purchases (often called the period from QQE to YCC as unprecedented monetary easing). That said, since the BoJ's financial support operations in response to the COVID-19 ended except for SMEs at the end of March 2022 (operations for SMEs ended in September 2022), the reserves began to decline. Thus we will also examine by assuming the period from then until the elimination of the YCC framework and the negative interest rate policy in March 2024 as the QT period.

Through these periods, we examine how the domestic banks have increased or decreased demandable deposits, which have extremely high liquidity and can be withdrawn at any time, and time deposits, whose liquidity is fixed for a certain period of time. We have two key findings: First, the BoJ's QE creates demandable deposits significantly in Japan's banking system, and the behavior of the time deposits is unclear. Second, when the BoJ turns from QE to QT, the behavior of demandable deposits seems not to be asymmetric, but its sensitivity to QT is quite small, and the behavior of the time deposits are quite uncertain, sometimes symmetric and sometimes asymmetric. At least we cannot say that banks may have behaved to eliminate the liquidity mismatch between assets and liabilities. Overall, the same phenomenon as that of the US financial system is observed in Japan's financial system as well. The BoJ is not trying to move forward with QT too rapidly. In fact, while the Fed has stopped bond purchases just three months after it started raising interest rates in March 2022 and allowed maturing bonds to expire at or below the cut-off rate, the BoJ has only reduced its JGB purchases amount and has not gone as far as to stop buying. Thus, Japanese banks have plenty of liquidities. So isn't this situation matter? The real problem is not in normal times, but when there is a sudden need for large amounts of cash (Acharya et al. 2024 refer to this as a "dash for cash"). If liquidity is insufficient at that time, Japanese banks will not only run to secure reserves to avoid a bank run, but will also concentrate demand for funding from the market, causing interest rates to spike and being forced to conduct fire sales if the BoJ cannot address them with appropriate market operations.

The rest of this paper consists as follows. Section 2 analyses aggregate time-series data by linking reserve amounts, various type of deposits, and credit lines. Section 3 analyses further the banks' behavior by using bank-level panel data. Section 4 concludes by telling the ratcheting-up of bank liquidity risk and the following financial fragility and some monetary policy issues with some directions for future research.

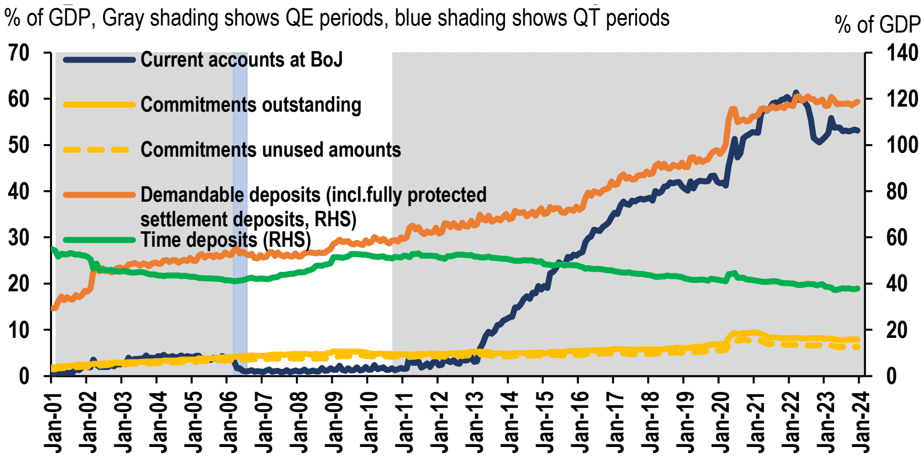
1. The aggregate time-series analysis

Before conducting the time-series analysis, let us look at developments of domestic bank deposits and credit lines of Japanese banks during the QE period (Figure 3). The reserves increased through the entire periods of QE, and in particular, the pace of increase accelerated when the BoJ launched QQE in 2013. Domestic banks' demandable deposits at domestic banks have been increasing for almost the entire period, and their growth accelerated since the BoJ implemented QQE. On the other hand, time deposits appear to have continued to decline throughout the QE period. Credit lines are smaller than those of US banks in the US. Since credit lines are hardly used by firms, the contract amount and unused amount have moved almost in a same way. In any case, they appear to have increased moderately during the QE period.

Looking at the QT period, the Reserves decreased slightly in 2006 and remained flat until the next resumption of QE; demandable deposits actually declined slightly during the period when such Reserves declined, but appear to have resumed growth thereafter. Time deposits appear to have increased throughout the QT period, while they appear to have declined after the suspension of operations in response to the COVID-19. Credit lines appear to have at least stopped increasing.

Overall, it appears that demandable deposits generally increased during the QE period, but appear not to have decreased during the QT period. In addition, time deposits appear to have continued to decline during the QE period and to have conversely increased during the QT period, but it is not clear whether they increased or decreased after the suspension of operations in response to the COVID-19. It is still necessary to conduct an empirical analysis to rigorously determine whether the deposits increased or decreased during the QT period. In the following, we will first conduct the aggregate the time serios analysis using the macro data.

Figure 3: Current Account Balances at the BoJ, Deposits, and Credit Lines



Note: Covers domestically licensed banks. As current accounts at BoJ before 2005 do not have the data for domestically licensed banks, those data are estimated by using the shares of such banks in Jan. 2005. Source: BoJ, Cabinet Office

Specifically, in accordance with Acharya et al. (2024), we estimate the following ordinary least square (OLS) regression.

$$\Delta Y_t = \alpha \Delta X_t + \beta X_{t-12} + \varepsilon_t \tag{1}$$

Where, $\Delta Y_t = Y_t - Y_{t-12}$ is the change in Ln(*Deposits*) or Ln(*Credit lines*), or the change in *Deposits or Credit lines* to control the seasonality. Also, $\Delta X_t = X_t - X_{t-12}$ is change in Ln(*Reserves*) or the change in *Reserves*. The *Deposits* are then split into *Demandable deposits* and *Time deposits*, and the same analysis is performed for each. Furthermore, to allow for a lagged impact of *Reserves* production, we include a 12-month lag in Ln(*Reserves*) or *Reserves*. In order to deal with heterogeneity of variance and serial correlation, Newey-West's HAC estimator is applied.

The data used are the data of reserves and of monthly data on deposits and commitment lines of domestic banks. The sample period is from January 2002, close to the initial period of QE in consideration of data reliability restraint, to February 2024, just before the removal of YCC framework and the negative interest rate policy.

2.1. Whole periods

We estimate model (1) for the whole periods. Columns (1) to (4) of Table 1 show the correlation between the quarterly changes of the neutral logarithm of Deposits/ Demandable deposits/ Time deposits/ or Credit lines (contract amount) and those of

Reserves. The results show that changes in Deposits and Demandable Deposits are strongly positively affected by changes in reserves, where changes in Time deposits have a negative correlation in some cases but not in others, and changes in Credit lines have no correlation. According to our point estimates, a 10% increase in Reserves is associated with a 0.17% increase in Deposits and a 0.6% increase in Demandable deposits, while being associated with a 0.3% decrease in Time deposits. The correlations appear to be smaller than those of the US banks estimated by Acharya et al. (2024), positive or negative signs of each deposits are the same except for that of Credit lines. Demandable deposits and time deposits show opposite movements, as expected from Figure 1. This suggests that when the BoJ increased reserves, domestic banks not only increased Deposits but also shifted from Time deposits to Demandable deposits.

Columns (5) to (8) are not log-transformed, but instead use arithmetic changes in *Deposits* and their breakdown as well as changes in C*redit lines* as dependent variables. The results are generally similar to the log-transformed results, with changes in Deposits responding to changes in Reserves in the same direction by about its 40% share, and changes in Demandable deposits also responding in the same direction by almost the same share of the shift. On the other hand, the coefficient for changes in Time deposits is negative but not statistically significant. Overall, in the case of the US banks as measured by Acharya et al. (2024), when the Fed increased the supply of reserves, almost all of it was shifted to deposits. On the other hand, in Japan when the BoJ supplies Reserves, about 40% of them flow into non-banks as funds, which in turn flow back to the banks as Demandable deposits. Since at least this portion has zero risk weights, there is no need for domestic banks to increase their capitals or rebalance the portfolios to meet liquidity regulations. We do not know how much of the demandable deposits are uninsured from those macro data.

Table 1: Effects of reserves on aggregate deposits and credit lines (since 2000s)

This table reports the results from OLS regression of changes in deposits or credit lines on changes in reserves. Sample period: April 2001 to February 2024 for deposits, demandable deposits, and time deposits. January 2002 to February 2024 for credit lines. Demandable deposits consist of current deposits, ordinary deposits, savings deposits, and notice deposits. Time deposits consist of time deposits and installment savings. t-statistics are reported in parentheses. ***, **, * are significant at the 1%, 5%, 10% level respectively. Newey-West's HAC estimator is applied.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ΔLn (Deposits)	ΔLn (Demandable deposits)	ΔLn (Time deposits)	ΔLn (Credit lines)	ΔDeposits	ΔDemandable deposits	ΔTime deposits	ΔCredit lines
ΔLn (Reserves)	0.0168 ***	0.0660 ***	-0.0303 **	-0.0056				
	(7.2280)	(3.2356)	(-2.2491)	(-0.2714)				
Ln $(Reserves)_{t-12}$	0.0071 ***	0.0042	-0.0027	0.0007				
	(4.6871)	(0.9102)	(-0.7753)	(0.9373)				
ΔReserves					0.3707 ***	0.3959 ***	-0.0412	0.0146
					(5.0641)	(5.2635)	(-1.3728)	(0.7078)
$Reserves_{t-12}$					0.0765 ***	0.0721 ***	-0.0005	0.0026
					(5.5120)	(4.5827)	(-0.0503)	(0.6445)
Constant	-0.0637 ***	-0.0027	0.0289	0.0559	87542.2820 ***	112257.2400 ***	-24295.8540	11371.9185 ***
	(-3.4761)	(-0.0443)	(0.5956)	(0.5292)	(7.5060)	(4.1257)	(-0.9600)	(3.0736)
Number of Samples	275	275	275	266	275	275	275	266
Adj. R-sq	0.390	0.241	0.114	-0.006	0.624	0.455	0.001	0.019
Type of regression	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS

1.2. QQE period

Even if we say the BoJ's QE in one word, the scale of the Reserves expansion differs significantly between the initial QE and the QQE period since 2013. This may have different effects on bank behavior. Therefore, let us examine only the QQE period, when the scale of the BoJ's QE increased significantly, to see how the portfolios of domestic banks have changed.

First, we conduct the same estimations as (1) through (8) above from the start of QQE in April 2013 to February 2024, just before the QQE with YCC was abolished in March 2024. The results in Table 2 show that changes in both Deposits and Demandable deposits are positively affected by Reserves in both logarithmic and arithmetic terms, as in Table 1, but the coefficients are larger in both cases. Changes in Time deposits no longer have the negative correlation as seen in Table 1, and the coefficients is statistically insignificant. The coefficients for changes in Credit lines are also statistically insignificant, as in Table 1. The QQE can be seen to have characteristics that domestic banks shifted more of the increase in Reserves to Demandable deposits than in the previous QE, but did not go that far to reduce Time deposits.

Table 2: Effects of reserves on aggregate deposits and credit lines (since QQE)

This table reports the results from OLS regression of changes in deposits or credit lines on changes in reserves. Sample period: April 2013 to February 2024 for deposits, demandable deposits, time deposits, and credit lines. Demandable deposits consist of current deposits, ordinary deposits, savings deposits, and notice deposits. Time deposits consist of time deposits and installment savings. t-statistics are reported in parentheses. ***, **, * are significant at the 1%, 5%, 10% level respectively. Newey-West's HAC estimator is applied.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ΔLn (Deposits)	ΔLn (Demandable deposits)	ΔLn (Time deposits)	ΔLn (Credit lines)	ΔDeposits	ΔDemandable deposits	ΔTime deposits	ΔCredit lines
ΔLn (Reserves)	0.0748 **	0.0940 **	0.0210	-0.1376				
	(2.2916)	(2.0586)	(1.2814)	(-0.7466)				
Ln (Reserves)$_{t-12}$	0.0297 **	0.0351 *	0.0030	-0.0424				
	(2.2810)	(1.9145)	(0.4366)	(-0.5364)				
ΔReserves					0.4200 ***	0.4641 ***	-0.0240	0.0193
					(3.1337)	(3.9343)	(-0.8688)	(0.4325)
Reserves$_{t-12}$					0.0937 ***	0.1046 ***	-0.0060	0.0029
					(3.3860)	(3.9013)	(-0.9453)	(0.2778)
Constant	-0.3989 **	-0.4539 *	-0.0616	0.6969	36509.0447	20635.8713	-14867.9623	9280.7789
	(-2.0832)	(-1.6808)	(-0.6067)	(0.6013)	(0.4964)	(0.3072)	(-0.8790)	(0.3581)
Number of Samples	131	131	131	131	131	131	131	131
Adj. R-sq	0.132	0.067	0.090	0.014	0.334	0.374	0.011	-0.005
Type of regression	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS

However, the absence of a negative correlation in Time deposits, for example, may be due to the fact that there was a period during the QQE period when the supply of Reserves was reduced. In fact, during the QQE period, when the COVID-19 occurred in 2020, the BoJ started to strengthen monetary easing in March 2020, including financial support operations, so that more liquidity were available to companies suffering from the COVID-19. They were terminated in March 2022 except for the extension of operations for SMEs until September 2022. As a result, the amount of Reserves supplied by the BoJ decreased since March 2022. Thus, we use similar estimations to measure how domestic banks shift their portfolios during the QQE period, treating the period up only to February 2022 as a QQE period.

Table 3 shows that the positive response of changes in Deposits and Demandable deposits to an increase in Reserves is even greater, with Deposits increasing by 0.84% and Demandable deposits by 1.1% for a 10% increase in Reserves. It can be seen that about 60% of the increase in Reserves went to the increase in Deposits or Demandable deposits. Changes in Time deposits in arithmetic terms are positively but weakly affected by changes in Reserves. The fact that none of the credit lines are significant is in common with the previous analysis. Thus, no major trends were found to change whether the QQE period was defined as narrowly or broadly except for the size of the coefficients.

Table 3: Effects of reserves on aggregate deposits and credit lines (when amount of JGB holdings by the BoJ increased under QQE)

This table reports the results from OLS regression of changes in deposits or credit lines on changes in reserves. Sample period: April 2013 to March 2022 for deposits, demandable deposits, time deposits, and credit lines. Demandable deposits consist of current deposits, ordinary deposits, savings deposits, and notice deposits. Time deposits consist of time deposits and installment savings. t-statistics are reported in parentheses. ***, **, * are significant at the 1%, 5%, 10% level respectively. Newey-West's HAC estimator is applied.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ΔLn (Deposits)	ΔLn (Demandable deposits)	ΔLn (Time deposits)	ΔLn (Credit lines)	ΔDeposits	ΔDemandable deposits	ΔTime deposits	ΔCredit lines
ΔLn (Reserves)	0.0838 **	0.1063 **	0.0200	-0.1231				
	(2.4272)	(2.2761)	(1.2318)	(-0.6212)				
$Ln (Reserves)_{t-12}$	0.0357 **	0.0468 **	-0.0024	-0.0223				
	(2.4938)	(2.3918)	(-0.3752)	(-0.2454)				
ΔReserves					0.6096 ***	0.5493 ***	0.0607 ***	0.0013
					(3.8827)	(3.5809)	(3.3141)	(0.0226)
$Reserves_{t-12}$					0.0928 ***	0.1177 ***	-0.0192 ***	0.0082
					(2.6759)	(3.4597)	(-4.7568)	(0.6285)
Constant	-0.4838 **	-0.6164 **	0.0108	0.4207	-29569.3242	-23670.2959	-30455.4409 ***	9854.9187
	(-2.3060)	(-2.1462)	(0.1126)	(0.3181)	(-0.3624)	(-0.3014)	(-2.9179)	(0.3228)
Number of Samples	108	108	108	108	108	108	108	108
Adj. R-sq	0.181	0.124	0.455	0.045	0.427	0.425	0.425	0.008
Type of regression	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS

2.3. QT period

Now, the main concern in this paper is whether bank behavior is asymmetric when the BoJ turns from QE to QT. In other words, if domestic banks rapidly increase demandable deposits during the QE period and then do not reduce demand deposits to the same extent during the QT period, liquidity risk may increase. From this perspective, we estimate bank behavior during the QT period using macro time series data (Table 4).

First, for the narrowly defined QT period from March 2006 to October 2010, we estimate the same measurements as in columns (1)-(8) above. The results show that the coefficient of changes in Demand deposits is positive as before, but on log-transformed basis, the size of the decrease in Demandable deposits for a 10% decrease in Reserves is about 1/3 of that in the QQE period, while on a arithmetic basis, the amount of the decrease in Reserves is about 2-3 times that of the decrease in demand deposits. Notably, the coefficients of changes in Time deposits are also statistically significant, with Time deposits increasing only 0.2% relative to the 10% decrease in Reserves, or about 60% of the decrease in Reserves. This suggests that domestic banks are making risk-averse portfolio choices in the QT period by reducing demandable deposits and increasing time deposits. Changes in Credit lines are also statistically significant, with domestic banks increasing their credit lines when reserves decline. Although this appears to be a myopic risk aversion behavior of banks, it is likely to indicate that the demand for credit line contracts from firms increases when the financial environment tightens during the QT period.

Table 4: Effects of reserves on aggregate deposits and credit lines (from QT through the restart of QE)

This table reports the results from OLS regression of changes in deposits or credit lines on changes in reserves. Sample period: March 2006 to September 2010 for deposits, demandable deposits, time deposits, and credit lines. Demandable deposits consist of current deposits, ordinary deposits, savings deposits, and notice deposits. Time deposits consist of time deposits and installment savings. t-statistics are reported in parentheses. ***, **, * are significant at the 1%, 5%, 10% level respectively. Newey-West's HAC estimator is applied.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ΔLn (Deposits)	ΔLn (Demandable deposits)	ΔLn (Time deposits)	ΔLn (Credit lines)	ΔDeposits	ΔDemandable deposits	ΔTime deposits	ΔCredit lines
ΔLn (Reserves)	0.0073 ***	0.0397 ***	-0.0207 **	-0.1000 **				
	(4.8001)	(5.4927)	(-2.2362)	(-2.4420)				
$Ln (Reserves)_{t-12}$	-0.0056 ***	0.0400 ***	-0.0493 ***	-0.0313				
	(-2.9955)	(5.7514)	(-5.6153)	(-0.7633)				
ΔReserves					0.4798 ***	1.3843 ***	-0.5828 **	-0.2548 **
					(5.9983)	(6.1521)	(-2.6224)	(-2.1225)
$Reserves_{t-12}$					-0.1731 *	1.3633 ***	-1.1988 ***	-0.1160
					(-1.9523)	(7.8098)	(-7.6804)	(-0.9800)
Constant	0.0843 ***	-0.4323 ***	0.5858 ***	0.3687	135890.0601 ***	-59862.8839 ***	179004.1438 ***	12261.9379
	(3.9400)	(-5.6777)	(6.0926)	(0.8172)	(14.3899)	(-4.3287)	(16.1542)	(1.5202)
Number of Samples	55	55	55	55	55	55	55	55
Adj. R-sq	0.763	0.299	0.546	0.389	0.806	0.281	0.562	0.343
Type of regression	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS

However, since this period is very short as the QT period, the sample size may not be large enough for the estimation to be stable. On the other hand, Reserves have been decreasing since the end of the COVID-19 in the second half of the QQE period, when the BoJ terminated its financial support operations, leaving only operations for SMEs at the end of March 2022. We may therefore be able to consider this period as a QT period and estimate by combining this period together to the first Q'T period (Table 5).

Then, Demandable deposits decrease by only 0.1%, although this is statistically significant, in response to a 10% decrease for Reserves. In arithmetic terms, the decrease of demandable deposits is also statistically significant, but only by 10% of Reserves. Furthermore, although the coefficients of time deposits are statistically significant at the 10% level on a log-transformed basis, the sign of the coefficient is negative, which is opposite to that of Table 3, suggesting their asymmetric behavior (Liquidity Dependence). That said, it is no longer statistically significant on an arithmetic basis. Changes in Credit lines respond to the decrease in Reserves in an increasing direction, as in the narrowly defined QT period.

Table 5: Effects of reserves on aggregate deposits and credit lines (from QT through the restart of QE and recent reduction in QE)

This table reports the results from OLS regression of changes in deposits or credit lines on changes in reserves. Sample period: March 2006 to September 2010 and from April 2022 to February 2024 for deposits, demandable deposits, time deposits, and credit lines. Demandable deposits consist of current deposits, ordinary deposits, savings deposits, and notice deposits. Time deposits consist of time deposits and installment savings. t-statistics are reported in parentheses. ***, **, * are significant at the 1%, 5%, 10% level respectively. Newey-West's HAC estimator is applied.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ΔLn (Deposits)	ΔLn (Demandable deposits)	ΔLn (Time deposits)	ΔLn (Credit lines)	ΔDeposits	ΔDemandable deposits	ΔTime deposits	ΔCredit lines
ΔLn (Reserves)	0.0149 ***	0.0125 **	0.0135 *	-0.0757 ***				
	(13.6396)	(2.1018)	(1.6996)	(-5.2484)				
Ln (Reserves)$_{t-12}$	0.0032 ***	0.0089 ***	-0.0101 ***	-0.0034				
	(8.1980)	(9.0886)	(-6.2275)	(-0.8501)				
ΔReserves					0.1193 **	0.1081 ***	0.0490	-0.0329 *
					(2.1507)	(3.8394)	(0.9994)	(-1.8490)
Reserves$_{t-12}$					0.0705 ***	0.0878 ***	-0.0251 ***	-0.0014
					(12.6695)	(21.5146)	(-4.2209)	(-0.7482)
Constant	-0.0134 **	-0.0870 ***	0.1506 ***	0.0591	102981.3737 ***	26980.5199	84441.4395 ***	7440.5010 **
	(-2.6317)	(-5.9594)	(7.2070)	(1.0452)	(10.2973)	(2.1930)	(6.2883)	(2.0045)
Number of Samples	78	78	78	78	78	78	78	78
Adj. R-sq	0.818	0.537	0.538	0.389	0.856	0.875	0.362	0.088
Type of regression	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS

In this way, banking behavior in response to the decline in reserves during the QT period is quite uncertain, if not asymmetric. This requires to be measured more rigorously using micro data and panel tests because the OLS analysis of time series data is not conducive to infer about the causal impact of reserves and may pick up a false correlation. We, therefore, turn to panel tests with cross-sectional micro data of banks in the next chapter.

2. BoJ Reserves and bank deposits: bank-level analyses

In this chapter, using bank accounting data of this century, we will conduct micro-econometrics analysis. A micro-analysis can take into account confounding factors causing biases which are difficult to be removed in a macro-analysis. By using 2-stage least squares (2-SLS) regression, we cope with this difficulty.

The methodology is largely based on Acharya et al. (2024), but differs from this pioneering study in several respects due to the difference in the data availability for Japan and the United States. For example, Acharya et al. (2024) uses quarterly data, but this paper uses annual data because, although a small portion of the data is available semi-annually, most of the variables used in the analysis are annual data. The source of our bank accounting data (unconsolidated basis) is the Nikkei Economic Electronic Databank Systems' Financial QUEST (NEEDS FQ) and that of macroeconomic data is the BoJ. All the data as of the end of March of each year, which is the fiscal year end of all banks used in this empirical analysis.

We employ 2-SLS analyses, instrumenting the change in bank-level reserves in the first stage to obtain the impact of an exogenous change in bank-level reserves on bank-level deposits to allay endogeneity concerns (Acharya et al. 2024).

The first & second stage estimates are as follows:

The first stage

$$\Delta Ln(Reserves)_{it} = \alpha_1 z_{it}^{R1} + \alpha_2 z_{it}^{R2} + \alpha_3 Ln(Reserves)_{it-1} + \gamma X_{it-1} + \epsilon_{it}, \quad (2)$$

The second stage

$$\Delta Ln(Deposits)_{it} = \beta_1 \Delta Ln(\widehat{Reserves})_{it} + \beta_2 Ln(Reserves)_{it-1} + \delta X_{it-1} + \tau_t + u_{it}, \quad (3)$$

where $\Delta Ln(Reserves)_{it}$ is an annual growth rate of bank i's reserve holdings at year *t*. we use 'Cash and Due from Banks' in balance sheets as $Reserves$. Ideally, we should and would like to use 'Deposit Paid to BoJ', but this data has not been recorded since fiscal year 2013 (March 2014). We don't know why it was no longer recorded since 2013, but it coincided with the period when Governor Kuroda's QQE led to a rapid increase in reserves at the BoJ. During the period of so-called Unconventional Monetary Policy since March 2001[6], most of 'Cash and Due from Banks' is 'Deposit Paid to BoJ', so we think that this treatment would not cause severe estimation biases.

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[6] There are two different views that the start of unconventional monetary policy was in February 1999 (the start of the Zero Interest Rate Policy) and March 2001 (the start of the first Quantitative Easing Policy). Significant increases in bank reserves start from the latter.

$\Delta Ln(Deposits)_{it}$ is an annual growth rate of bank *i*'s deposits as liabilities in the balance sheet at year *t*. We use three different deposits as dependent variables: total deposits, demandable deposits (liquid deposits) and time deposits. Bank i's total deposits are sum of current deposits, ordinary deposits, saving deposits, notice deposits, time deposits, installment savings, other deposits and negotiable certificates of deposit. Demandable deposits are sum of current deposits, ordinary deposits, saving deposits and notice deposits. Time deposits are sum of time deposits and installment savings.

z_{it}^{R1} and z_{it}^{R2} are bank-level Reserve Instruments as follows:

$$z_{it}^{R1} = ln\left(\frac{Aggregate\ bank\ reserves_t}{Aggregate\ bank\ reserves_{t-1}}\right) \times \frac{1}{2}\sum_{k=0}^{1} Bank\ i'sshare\ of\ aggregate\ bank\ reserves_{t-k}, \qquad (IV1)$$

$$z_{it}^{R2} = ln\left(\frac{Monetary\ Base_t}{Monetary\ Base_{t-1}}\right) \times \frac{1}{2}\sum_{k=0}^{1} Bank\ i'sshare\ of\ aggregate\ bank\ reserves_{t-k}, \qquad (IV2)$$

where z_{it}^{R1} is computed as the product of two components, the most recent change in aggregate bank reserves and the bank i's recent share of aggregate bank reserves. The second instrument z_{it}^{R2} uses the growth of the Monetary Base as the first component, instead of using the growth in aggregate reserves. The first components of each variable are driven in large part by the BoJ's monetary policy stance, which can be regarded to be correlated with banks' reserves but not with their deposits. The second component takes into account of the difference among in banks' propensity to use reserves.

X_{it} represents bank controls lagged by one year which are bank size (measured as *Ln*(Total Assets)), profitability (Ordinary Revenue/Total Assets), and capitalization (Net Assets / Total Assets). τ_t represents the time-fixed effect, and ϵ_{it} and u_{it} represents the error term.

Table 6 shows the descriptive statistics of variables. Our data is an unbalanced panel data of 125 banks for 24 years. Due to the missing values of *Time Deposits* and *Equity to Asset*, the number of observations used in the empirical analysis is approximately 2,000.

By focusing on the estimation results of β_1 in QE periods and QT periods, we examine whether Liquidity Dependence observed in Japan. When we observe it, estimates of demandable deposits are expected to be positive during QE periods but not during QT periods. And estimates of time deposits are expected to be negative during QE periods but not to be negative during QT periods.

Table 6: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Dependent Variables					
$\Delta Ln(Total\ Deposits)_{it}$	2,695	0.028	0.080	-0.890	1.359
$\Delta Ln(Demandable\ Deposits)_{it}$	2,526	0.061	0.083	-0.515	0.937
$\Delta Ln(Time\ Deposits)_{it}$	2,007	-0.012	0.075	-1.006	0.849
Explanatory & Instrument Variables					
z_{it}^{R1}	2,587	14.642	104.110	-653.282	2463.408
z_{it}^{R2}	2,587	5.006	31.123	-173.542	587.304
$Ln(Reserves)_{it}$	2,813	11.920	1.641	8.254	18.325
$Ln(Total\ Asset)_{it}$	2,814	14.780	1.242	9.845	19.518
ROA_{it}	2,814	0.020	0.011	0.000	0.182
$Equity\ to\ Asset_{it}$	2,063	0.051	0.024	0.004	0.640

3.1. Whole periods

Table 7 shows the estimation results of the second stage of 2-SLS using our full sample: for 24 years from March 2001 to March 2024. This sample period almost match that of Table 1, where we report the results from OLS regression using macroeconomic data[7].

It can be seen that, throughout the whole sample period, the change of demandable deposits is positively affected by changes in reserves, while total deposits and time deposits are not significant[8]. The result of demandable deposits is consistent with that of macro-economic analysis in Table 1, suggesting that when the BoJ increased (decreased) reserves, Japanese banks increased (decreased) demandable deposits.

[7] Sample periods of following five tables, Table 7, 8,9, 10 and 11 match those of tables in Section 2: Table 1, 2, 3, 4 and 5 respectively.

[8] Since we focus on the impact of the change in reserves to deposit behaviors, the R-sq of the entire models do not matter. The reason why R-sq of this table is so low is that we exclude the impact of macroeconomic variables at the first stage of this 2-SLS analyses.

Table 7: Results of Second Stage (2-SLS): Mar. 2001- 2024

This table reports the results of second stage from 2-SLS regression of changes in deposits on changes in reserves. Sample period: March 2001 to March 2024 for total deposits, demandable deposits, and time deposits. Demandable deposits consist of current deposits, ordinary deposits, savings deposits, and notice deposits. Time deposits consist of time deposits and installment savings. t-statistics are reported in parentheses. ***, **, * are significant at the 1%, 5%, 10% level respectively.

	$\Delta Ln(Total\ Deposits)_{it}$		$\Delta Ln(Demandable\ Deposits)_{it}$		$\Delta Ln(Time\ Deposits)_{it}$	
$Instr\ \Delta Ln(Reserves)_{it}$	0.267		0.090	***	0.021	
	(1.420)		(4.240)		(1.590)	
$Ln(Reserves)_{i\,t-1}$	0.101		0.044	***	0.012	
	(1.560)		(4.440)		(1.200)	
$Ln(Total\ Asset)_{i\,t-1}$	-0.309	*	-0.214	***	-0.126	**
	(-1.770)		(-5.530)		(-1.990)	
$ROA_{i\,t-1}$	2.755		-4.845	***	1.751	
	(0.860)		(-3.020)		(1.210)	
$Equity\ to\ Asset_{it-1}$	-2.116		-1.367	***	-0.751	*
	(-1.400)		(-3.950)		(-1.790)	
$Constant$	3.440	*	2.839	***	1.699	**
	(1.860)		(5.360)		(1.970)	
R-sq(within)	0.000		0.128		0.139	
Number of obs	1,820		1,710		1,273	
Number of banks	125		117		99	

3.2. QQE periods

Table 8 shows the estimation results of the second stage of 2-SLS using the period of "Quantitative and Qualitative Monetary Easing (QQE)" since April 2013: from the end of March 2014 to March 2024. There are no significant effects of reserves on deposits. These results are not consistent with those of Table 2, which analyses the QQE period analyses by using macro-economic data.

However, as we discussed in the subsection 2.2., during the QQE period, when the COVID-19 occurred in 2020, the BoJ started to strengthen monetary easing in March

2020, including financial support operations, so that more liquidity was available to companies suffering from the COVID-19. They were terminated in March 2022, as a result, the amount of reserves supplied by the BoJ decreased since March 2022. Thus, we use similar estimations to measure how Japanese banks shift their portfolios during the QQE period, treating the period up only to February 2022 as a QQE' period.

Table 8: Results of Second Stage (2-SLS): QQE (Mar. 2014-Mar.2024)

This table reports the results of second stage from 2-SLS regression of changes in deposits on changes in reserves. Sample period: March 2014 to March 2024 for total deposits, demandable deposits, and time deposits. Demandable deposits consist of current deposits, ordinary deposits, savings deposits, and notice deposits. Time deposits consist of time deposits and installment savings. t-statistics are reported in parentheses. ***, **, * are significant at the 1%, 5%, 10% level respectively.

	$\Delta Ln(Total\ Deposits)_{it}$	$\Delta Ln(Demandable\ Deposits)_{it}$	$\Delta Ln(Time\ Deposits)_{it}$
$Instr\ \Delta Ln(Reserves)_{it}$	0.600	0.148	0.008
	(1.200)	(1.330)	(0.160)
$Ln(Reserves)_{i\,t-1}$	0.321	0.087	-0.004
	(1.210)	(1.390)	(-0.130)
$Ln(Total\ Asset)_{i\,t-1}$	-0.612 *	-0.224 **	-0.054 **
	(-1.460)	(-2.350)	(-1.240)
$ROA_{i\,t-1}$	10.241	0.648	1.007
	(0.770)	(0.140)	(0.250)
$Equity\ to\ Asset_{it-1}$	-1.927	-0.939	-2.010 ***
	(-1.420)	(-1.360)	(-3.310)
$Constant$	5.010 *	2.343 ***	0.906 *
	(1.740)	(3.650)	(1.800)
R-sq(within)	0.000	0.000	0.139
Number of obs	1,126	1,051	738
Number of banks	119	111	84

Table 9 shows the estimation results of the second stage of 2-SLS using QQE period: from March 2014 to March 2021. While the change in demandable deposits is positively and significantly affected by changes in reserves, while total deposits and time deposits are not significant. QQE policy increased the amounts of demandable deposits. The result of demandable deposits is consistent with that of macro-econometric analysis in Table 3, suggesting that when the BoJ increased (decreased) reserves, Japanese banks increased (decreased) demandable deposits. In other words, Japanese economy also experienced a maturity-shortening of deposits at the bank level during QE periods.

Table 9: Results of Second Stage (2-SLS): QQE' (Mar. 2014-Mar.2021)

This table reports the results of second stage from 2-SLS regression of changes in deposits on changes in reserves. Sample period: March 2014 to March 2021 for total deposits, demandable deposits, and time deposits. Demandable deposits consist of current deposits, ordinary deposits, savings deposits, and notice deposits. Time deposits consist of time deposits and installment savings. t-statistics are reported in parentheses. ***, **, * are significant at the 1%, 5%, 10% level respectively.

	$\Delta Ln(Total\ Deposits)_{it}$	$\Delta Ln(Demandable\ Deposits)_{it}$	$\Delta Ln(Time\ Deposits)_{it}$
$Instr\ \Delta Ln(Reserves)_{it}$	0.447	0.086 **	-0.036
	(1.290)	(2.050)	(-0.870)
$Ln(Reserves)_{i\,t-1}$	0.286	0.053 *	-0.034
	(1.290)	(1.790)	(-1.160)
$Ln(Total\ Asset)_{i\,t-1}$	-0.933	-0.147 **	-0.073 **
	(-1.550)	(-2.100)	(-1.310)
$ROA_{i\,t-1}$	7.556	-6.590 *	-4.022
	(0.520)	(-1.710)	(-0.840)
$Equity\ to\ Asset_{i\,t-1}$	-0.699	-2.108 ***	-1.445 ***
	(-0.430)	(-3.140)	(-2.900)
$Constant$	10.243 *	1.814 ***	1.611 ***
	(1.700)	(2.590)	(2.820)
R-sq(within)	0.000	0.000	0.000
Number of obs	908	860	607
Number of banks	116	111	84

3.3. QT periods

Table 10 shows the estimation results of the second stage of 2-SLS using QT period: from March 2006 to March 2010. In contrast to the results of Table 9, while the change in time deposits is positively and significantly affected by changes in reserves, while total deposits and demandable deposits are not significant. The result of time deposits is inconsistent with that of macro-economic analysis in Table 4 but is consistent with that in Table 5, suggesting that when the BoJ decreased reserves, Japanese banks decreased time deposits. The maturity-shortening, which was shown in the previous sub-section 3.2., does not reverse when the central bank stops injecting or reduces aggregate reserves. Banks may not have behaved to eliminate the liquidity mismatch between assets and liabilities which they faced during QT periods.

Table 10: Results of Second Stage (2-SLS): QT (Mar. 2006-Mar.2010)

This table reports the results of second stage from 2-SLS regression of changes in deposits on changes in reserves. Sample period: March 2006 to March 2010 for total deposits, demandable deposits, and time deposits. Demandable deposits consist of current deposits, ordinary deposits, savings deposits, and notice deposits. Time deposits consist of time deposits and installment savings. t-statistics are reported in parentheses. ***, **, * are significant at the 1%, 5%, 10% level respectively.

	$\Delta Ln(Total\ Deposits)_{it}$		$\Delta Ln(Demandable\ Deposits)_{it}$		$\Delta Ln(Time\ Deposits)_{it}$	
$Instr\ \Delta Ln(Reserves)_{it}$	0.089		0.068		0.130	**
	(1.410)		(1.170)		(2.020)	
$Ln(Reserves)_{i\,t-1}$	0.094		0.087		0.109	*
	(1.480)		(1.410)		(1.720)	
$Ln(Total\ Asset)_{i\,t-1}$	-0.846	***	-0.741	***	-0.897	***
	(-7.640)		(-3.860)		(-7.380)	
$ROA_{i\,t-1}$	0.955		-3.138		-8.028	*
	(0.450)		(-1.320)		(-1.960)	
$Equity\ to\ Asset_{it-1}$	-0.566		-3.476	***	0.669	
	(-0.920)		(-5.200)		(0.890)	
$Constant$	11.332	***	10.085	***	11.975	***
	(8.170)		(3.740)		(6.270)	
R-sq(within)	0.420		0.399		0.000	
Number of obs	353		334		282	
Number of banks	119		113		97	

However, when we include the March 2023-2024 into the sample of QT' period, estimation results change. Table 11 shows those of the second stage of 2-SLS using the period of QT': March 2006 to March 2010 & March 2023 to March 2024. While we have a significantly positive effect of reserves on total deposits, there are no significant effects of reserves on demandable and time deposits. The shrink of reserves during QT' period decreased total deposits, but it cannot be clearly determined from these results whether this decrease is caused by the decrease of demandable deposits or time deposits. Based on the negative and positive estimates of demandable and time deposit in Table 11, though they are not significant, we might infer that the decrease of time deposits causes that of total deposits. Since these bank-level analyses are more rigorous tests to identify the causality of the supply of reserves by the central bank and the liquidity demand of the banks, we think these results describe the asymmetric behavior of the banks appropriately. If this inference is correct, it implies that Japanese economy experienced Liquidity Dependence during QT' period: there increased the liquidity mismatch between asset-side and liability-side in Japanese banking sector. In other words, although the liquidity in their asset-side was decreased by QT policy, liquidity increased in their liability-side.

Table 11: Results of Second Stage (2-SLS): QT' (Mar. 2006-2010 & Mar. 2023-2024)

This table reports the results of second stage from 2-SLS regression of changes in deposits on changes in reserves. Sample period: from March 2006 to March 2010, and from March 2023 to March 2024 for total deposits, demandable deposits, and time deposits. Demandable deposits consist of current deposits, ordinary deposits, savings deposits, and notice deposits. Time deposits consist of time deposits and installment savings. t-statistics are reported in parentheses. ***, **, * are significant at the 1%, 5%, 10% level respectively.

	$\Delta Ln(Total\ Deposits)_{it}$	$\Delta Ln(Demandable\ Deposits)_{it}$	$\Delta Ln(Time\ Deposits)_{it}$
$Instr\ \Delta Ln(Reserves)_{it}$	0.137 **	-0.030	0.134
	(2.140)	(-1.000)	(0.880)
$Ln(Reserves)_{i\,t-1}$	0.073 **	0.016	0.060
	(2.410)	(0.620)	(0.680)
$Ln(Total\ Asset)_{i\,t-1}$	-0.204 **	-0.133	-0.276
	(-2.010)	(-1.100)	(-0.960)
$ROA_{i\,t-1}$	-0.164	-3.876 **	-1.947
	(-0.180)	(-2.030)	(-0.650)
$Equity\ to\ Asset_{it-1}$	0.452	-1.991 ***	-0.141
	(0.780)	(-4.460)	(-0.230)
$Constant$	2.176 *	1.963	3.407
	(1.820)	(1.260)	(1.040)
R-sq(within)	0.000	0.127	0.000
Number of obs	462	428	346
Number of banks	125	117	97

Overall, the results in this section suggest that Japanese economy also experienced Liquidity Dependence; there is a maturity-shortening of deposits at the bank level during QE periods, however, it doesn't reverse during QT periods. A micro-analysis that takes into account of confounding factors, which are difficult to remove in a macro-analysis, revealed the existence of the phenomenon Liquidity Dependence in Japan.

3. Conclusion and Further Research

This paper empirically examines the Liquidity Dependence in Japanese banking system. Acharya and Rajan (2024) and Acharya et al. (2024) pointed out this phenomenon of Liquidity Dependence observed during the quantitative easing and quantitative tightening policies in the United States, which is regarded as one possible factor of the Silicon Valley Bank (SVB) bankruptcy in 2023. Since the introduction of quantitative easing in March 2001, the Japanese economy has experienced a longer period of quantitative easing than the United States, lasting more than 20 years. Our macro and micro analysis, using more than 20 years of macroeconomic and bank-level accounting data, we found that the same phenomenon is observed in the Japanese economy as well.

Our findings have implications for both financial and monetary stability. On the financial stability side, the main takeaway from our findings is that the BoJ's QE could incentivize an accumulation of liquidity risk in some banks, and the coming QT could not significantly alleviate such accumulation. It is interesting that central bank's reserve provision could induce banks to move to make the financial system potentially more vulnerable to liquidity risk. One may think that Japanese banks cannot change such behavior because they cannot reject the customers' demands, but we do not think so. Their ALM should signal them to change the liability structure though it may take time to actually change such structure, and the bank supervisors also should monitor and advise them. The Japanese economy has a more sufficient deposit insurance system than the United States, so a phenomenon like the SVB bankruptcy is unlikely to occur. However, we would suggest the Japanese economy is necessary to prepare for the coming major quantitative tightening, so-called the exit from the long-term quantitative easing policy that has lasted for more than 20 years. Some kind of bankruptcy might happen when the solvency of those banks are in question if the sticky retail deposits become more flexible or the large shocks occur to banks holding large amount of flexible retail deposits. What conditions could trigger such situations and what type of banks would be vulnerable appear to be fertile area for future analyses.

On the monetary policy side, one of the channels through which QE is intended to work is "portfolio rebalancing" under the preferred habitat theory (Vayanos and Vila 2021). However, our evidence shows that although the Bank of Japan compressed the long-term yields, banks are shortening the maturity of their liabilities by increasing the demandable deposits, thereby limiting the maturity-lengthening effect of the QE on their assets (loans), weakening some portion of the portfolio rebalancing channel. We may have to revisit the desirable scale, scope, and duration of the next QE with due consideration of the above financial stability issue especially if the banks naturally increase the demandable deposits during the QE and this weakening effect of the monetary policy, which also appear to be the future area of the research. Now that the BoJ is on the way to enter the significant QT process after eliminating the YCC framework and the negative interest rate policy, the symmetric but smaller behavior, or asymmetric behavior of maturity transformation of their liabilities suggests the maturity-shortening effect of the QT on their assets might be maintained. This would, ceteris paribus, at least not weaken the tightening effect of QT, contrary to the easing effect of QE.

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