The Formation of Interbank Interest Rates and Treasury Bill Yields in Japan under Different Regimes of non-Traditional Monetary Policy

Takayasu Ito

Abstract

Interbank interest rates and Treasury Bill (TB) yields of maturities of three and six months move together, but not 12 months, under "a quantitative and qualitative easing policy." On the other hand, interbank interest rates and TB yields of maturities of three, six, and 12 months move together under a "negative interest rate policy." Interbank and TB markets are partially integrated up to the six-month maturity as a short-term money market under "a quantitative and qualitative easing policy," while, interbank and TB markets are integrated up to the 12-month maturity as a short-term money market under a "negative interest rate policy." This indicates that the arbitrage of interbank and TB markets works. Practitioners of the interbank market are limited to financial institutions, but those of TB markets also include non-financial institutions.

Keywords: Interbank Interest Rate, Negative Interest Rate, Quantitative and Qualitative Easing, Treasury Bill Yield

JEL Classifications: E43, G12

1. Introduction

This paper focuses on the formation of interbank interest rates and Treasury Bill (TB) yields in Japan under different regimes of non-traditional monetary policy. It analyzes two markets to find whether they are integrated by investigating linkage and causalities.

The Bank of Japan (BOJ 2013) stated that "The BOJ (Bank of Japan) adopted a quantitative and qualitative easing policy during the period from April 4, 2013 to January 28, 2016." The pillars of a "quantitative and qualitative easing policy" are as follows: "(1) The adoption of monetary base control, (2) An increase in JGB (Japanese Government Bond) purchases and their maturity, (3) An increase in ETF (Exchange Traded Fund) and J-REIT (Real Estate Investment Fund) purchases, (4) A continuation of quantitative and qualitative monetary easing to achieve the price

stability target of 2 percent."

The BOJ adopted a "negative interest rate policy" from January 29, 2016. According to the BOJ (2016), "they apply a negative interest rate of minus 0.1 percent to the policy-rate balances in current accounts held by financial institutions at the Bank. They purchase JGBs so that 10-year JGB yield remains more or less at the current level (around zero percent)."

This paper makes several original contributions to related literatures, mentioned below. It is the first to analyze both interbank and TB markets to find whether they are integrated or not under different regimes of non-traditional monetary policy. In addition, it analyzes the two regimes comparatively to measure the impacts of non-traditional monetary policy on both interbank and TB markets.

Related studies, such as Andresen et al. (2015), Jackson (2015), Arteta et al. (2016), Bech and Malkhozov (2016), Turk (2016), Ito (2017), Ito (2019), and Ito (2023), analyze short-term money markets under "non-traditional monetary policies such as negative interest rate policy." Andresen (2015) concluded that "the reduction of the certificate of deposit (CD) rate has increased the spread between the current account rate and the CD rate and thus the scope for fluctuations in overnight money market rates in Denmark." Jackson (2015) outlined "the concerns associated with negative interest rates, provides an overview of the international experience with negative policy rates so far, and sets out some general observations based on this experience."

Arteta et al. (2016) reported that "monetary transmission channels under a negative interest rate policy are conceptually analogous to those under a conventional monetary policy, but a negative interest rate policy presents complications that could limit policy effectiveness." Bech and Malkhozov (2016) concluded that, "for the most part, modestly negative policy rates transmit through to money markets and other interest rates in the same way as positive rates do." Turk (2016) analyzed "the profitability of Danish and Swedish banks under a negative interest rate policy."

Ito (2017) concluded that "in Denmark, monetary policy expectations have some impact on the interbank interest rates in the maturities of one, three, and six months." Ito (2019) concludes that "monetary policy expectations are not fully transmitted to the yield curve end of the short-term money market under a quantitative and qualitative easing policy or a negative interest rate policy." Ito (2023) reported that the "TB yield curve under a negative interest rate policy is driven by a

single common trend with mutual causalities in all maturities. In other words, normal transmission function of TB yield curve recovered by the introduction of a 'negative interest rate policy.'"

2. Data

Daily data of interbank interest rates and TB yields with maturities of three, six, and 12 months provided by Refinitiv are used for the analyses. The sample period is from April 4, 2013 to March 30, 2023. It is divided into two sub-sample periods. The first period, from April 4, 2013 to January 28, 2016, is named Sample A. The BOJ adopted a "quantitative and qualitative easing policy." The second period, from January 29 2016 to March 30, 2023, is Sample B. They adapted a "negative interest rate policy." The movements of TB yields and interbank interest rates are shown in Figure 1. The descriptive statistics are provided in Table 1.

Figure 1

Table 1

3. Methodology

3.1. Unit Root Test

The Augmented Dickey-Fuller (ADF) test and the Kwiatowski-Phillips-Schmidt-Shin (KPSS) test are used. According to Dickey and Fuller (1979, 1981), "the ADF test defines the null hypothesis as unit roots exist and the alternative hypothesis as unit roots do not exist." A table for the ADF test is provided by Fuller (1976). According to Kwiatkowski et al. (1992), "the KPSS test defines the null hypothesis as unit roots do not exist and the alternative hypothesis as unit roots exist." Following Ito (2019), "first, the original data are checked to verify whether they contain unit roots." "Next, the data with first difference are analyzed to determine whether they have unit roots to confirm that they are I (1) process."

3.2 Engle-Granger Cointegration Test

"A cointegration framework is presented to analyze the relationship between interbank interest rate and TB yield," as indicated in Ito (2015): "Non-stationary time series wander widely with their own short-run dynamics, but a linear combination of these series can sometimes be stationary

so that they show co-movement with long-run dynamics." This is called "cointegration" by Engle and Granger (1987). In the test of co-movement between interbank interest rate and TB yield by cointegration, "equation (1) is estimated by Ordinary Least Squares (OLS) to find out whether the residual contains unit roots."

$$Interbank_t = \alpha + \beta\ TB_t + u_t \qquad (1)$$

$Interbank_t$ = interbank interest rate

TB_t = Treasury Bill yield

According to Engle and Granger (1987), "when series $Interbank_t$ and TB_t are both non-stationary I (1), they are said to be in the relationship of cointegration if their linear combination is stationary I (0)." The cointegration relationship between $Interbank_t$ and TB_t implies that interbank interest rate and TB yield move together in the long-run equilibrium. In other words, interbank and TB markets are integrated.

3.3. Granger Causality Test

According to Granger (1969), "with regard to the variables $Interbank_t$ and TB_t, the Granger causality test checks whether $Interbank_t$ affects TB_t or TB_t affects $Interbank_t$ or $Interbank_t$ and TB_t mutually in a time series model." Toda and Yamamoto (1995) indicated that "original data are usually transformed into the change ratio to avoid a problem of spurious regression, but using these data causes an error." Furthermore, non-stationary data are directly used in the test of Granger causality. In this study, the null hypothesis H_0 concerning the influence of $Interbank_t$ on TB_t and the influence of $Interbank_t$ on TB_t is tested. Following this method, "trend term *t* and *p* + 1 (original lag plus one) are added for the estimation." The original lag length is decided by the AIC standard.

$$Interbank_t = u_0 + u_t + \sum_{i=1}^{p+1} \alpha_i Interbank_{t-i} + \sum_{i=1}^{p+1} \beta_i\ TB_{t-i} + u_t \qquad (2)$$

H_0: $\beta_1 = \beta_2 = \cdots \beta_p = 0$

H_1: $Either\ \beta_i \neq 0 \quad (i = 1,2,\cdots,p)$

$$\mathrm{TB}_t = v_0 + v_t + \sum_{i=1}^{p+1} \gamma_i TB_{t-i} + \sum_{i=1}^{p+1} \delta_i Interbank_{t-i} + u_t \quad (3)$$

$$H_0\colon\ \gamma_1 = \gamma_2 = \cdots \gamma_p = 0$$

$$H_1\colon\ Either\ \gamma_i \neq 0 \quad (i = 1,2,\cdots,p)$$

As described in Ito (2015), "the F test is conducted by estimating equations (2) and (3) through OLS and summing the squared error." "If the null hypothesis of H_0 in equation (2) is rejected, the interbank interest rate is considered to explain TB yield. "If the null hypothesis of H_0 in the equation (3) is rejected, TB yield is considered to explain interbank interest rate." Pair-wise analyses on interbank interest rate and TB yield at maturities of three, six, and 12 months are conducted.

4. Result

4.1 Unit Root Test

The results of the ADF and KPSS tests show that the original series have unit roots except for ADF test with trend (TB of Sample A; interbank interest rates and TB of Sample B). The results are shown in Tables 2 and 3.

Table 2

Table3

Next, all results of the ADF and KPSS tests, except for the KPPS test of interbank interest rates for Sample B, indicate that the first-differenced series do not have unit roots. Taking into account the results of both ADF and KPSS tests, I can conclude that all data used for the analyses are non-stationary I (1) variables. The results are shown in Tables 4 and 5.

Table 4

Table5

4.2 Engle-Granger Cointegration Test

The cointegration relationship is confirmed in the pairs of interbank interest rates and TB yields of three and six months in Sample A, and in all three pairs in Sample B. Interbank interest rates and TB yields in the maturities of three, six, and 12 months thus move together under a regime of a "negative interest rate policy."

4.3 Granger Causality Test

Causalities from interbank interest rate to TB yield are confirmed in all maturities, not vice versa in Sample A, while causalities from TB yield to interbank interest rate are found in the maturities of six and 12 months in Sample B.

5. Conclusion

This paper investigates whether interbank and TB markets are integrated in Japan by analyzing the formation of interbank interest rates and TB yields under different monetary policy regimes. Interbank interest rates and TB yields in the maturities of three and six months move together, but not in the maturity of 12 months, under "a quantitative and qualitative easing policy." However, interbank interest rates and TB yields in the maturities of three, six, and 12 months move together under a "negative interest rate policy."

Interbank and TB markets are partially integrated up to the maturity of six months as a short-term money market under a "a quantitative and qualitative easing policy." On the other hand, interbank and TB markets are integrated up to the maturity of 12 months as a short-term money market under a "negative interest rate policy." This indicates that the arbitrage of interbank and TB markets works. The practitioners of the interbank market are limited to financial institutions, but those of TB markets include non-financial institutions too.

The market practitioners considered that there would be little room for short-term interest on interbank and TB to be lowered because of the zero lower bound restriction before the introduction of a "negative interest rate policy." In addition to this point, the BOJ changed an operating target from monetary base to interest rate. These changes have led to recognition that short-term interest rates move into negative territory. The market function of the short-term money market therefore recovered after the BOJ introduced a "negative interest rate policy."

The causalities of interbank interest rates to TB yields are observed under a "a quantitative and qualitative easing policy," while causalities of TB yields to interbank interest rates, with the exception of three months, are observed under a "negative interest rate policy." The TB market propelled the interbank market after the BOJ introduced a "negative interest rate policy" because practitioners of the TB market are open to non-financial institutions with differing views on

interest rate paths in the future.

This paper has analyzed only the interbank and TB markets in Japan. There is room to expand research to other countries that have adopted "a negative interest rate policy."

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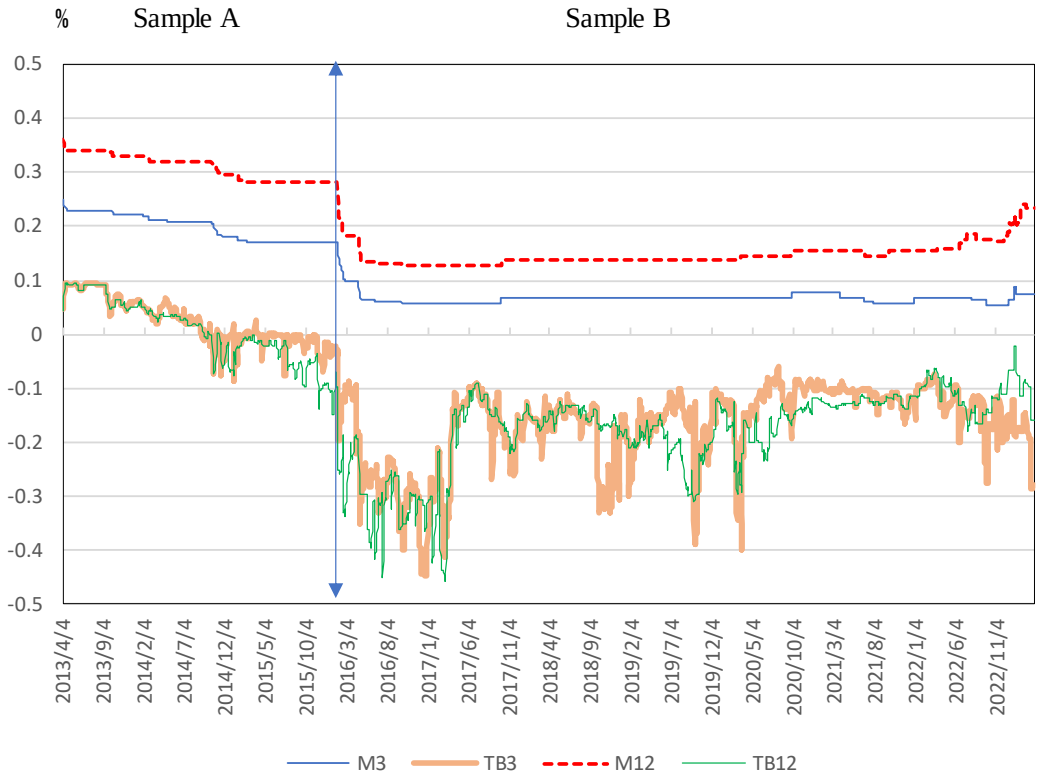
Figure 1 Movement of Interbank Interest Rate and Treasury Bill



Notes: Sample A is from April 4, 2013 to January 28, 2016.
Sample B is from Januray 29, 2016 to March 30, 2023.
M3 is interbank interest rate 3 month. TB3 is Treasury Bill 3 month.
M6 is interbank interest rate 6 month. TB6 is Treasury Bill 6 month.
M12 is interbank interest rate 12 month. TB3 is Treasury Bill 12 month.
Data sourece:Datastream for interbank interest rates.
major Japanese security company for Treasury Bills.

Table 1

Descriptive Statistics of Data for Analysis

Variable	Average	SD	Min	Max	Median
Sample A					
M3	0.199	0.024	0.171	0.250	0.210
M6	0.290	0.029	0.257	0.349	0.300
M12	0.310	0.022	0.284	0.360	0.320
TB3	0.023	0.043	-0.087	0.095	0.020
TB6	0.008	0.060	-0.159	0.095	0.015
TB12	0.007	0.058	-0.150	0.095	0.016
Sample B					
M3	0.067	0.010	0.054	0.171	0.067
M6	0.126	0.014	0.106	0.257	0.126
M12	0.148	0.022	0.126	0.284	0.136
TB3	-0.169	0.075	-0.448	-0.061	-0.145
TB6	-0.177	0.071	-0.436	-0.075	-0.158
TB12	-0.178	0.076	-0.458	-0.020	-0.158

Notes:

Sample A is from April 4, 2013 to January 28, 2016.

Sample B is from Januray 29, 2016 to March 30, 2023.

M3 is interbank interest rate 3 month. TB3 is Treasury Bill 3 month.

M6 is interbank interest rate 6 month. TB6 is Treasury Bill 6 month.

M12 is interbank interest rate 12 month. TB12 is Treasury Bill 12 month.

Table 2

ADF unit root test (Original Series)

Variable	Without Trend	With Trend
Sample A		
M3	-2.027	-2.071
M6	-2.353	-1.493
M12	-2.924	-1.436
TB3	-1.872	-4.509*
TB6	-1.200	-4.777*
TB12	-0.486	-3.162
Sample B		
M3	-1.005	-4.627*
M6	-0.464	-4.893*
M12	0.191	-3.466*
TB3	-1.688	-5.375*
TB6	-1.135	-4.008*
TB12	-1.329	-4.6723*

Notes:

* indicates significance at the 5% level.

5% critical values are −2.86 (without trend) and −3.41 (with trend).

Sample A is from April 4, 2013 to January 28, 2016.

Sample B is from Januray 29, 2016 to March 30, 2023.

M3 is interbank interest rate 3 month. TB3 is Treasury Bill 3 month.

M6 is interbank interest rate 6 month. TB6 is Treasury Bill 6 month.

M12 is interbank interest rate 12 month. TB12 is Treasury Bill 12 month.

Table 3

KPSS unit root test (Original Series)

Variable	Lag = 4		Lag = 12	
	Level Stationary	Trend Stationary	Level Stationary	Trend Stationary
Sample A				
M3	13.359*	1.082*	5.190*	0.428*
M6	13.482*	1.204*	5.234*	0.476*
M12	13.358*	1.015*	5.192*	0.403*
TB3	11.727*	1.048*	4.703*	0.500*
TB6	11.695*	0.517*	4.639*	0.231*
TB12	12.374*	0.274*	4.914*	0.135
Sample B				
M3	0.926*	0.978*	0.381*	0.402*
M6	7.929*	0.879*	3.202*	0.362*
M12	14.631*	3.333*	5.812*	1.351*
TB3	9.294*	0.937*	3.835*	0.397*
TB6	10.695*	1.038*	4.279*	0.429*
TB12	15.123*	1.323*	6.036*	0.544*

Notes:

* indicates significance at the 5% level.

5% critical values are 0.463 (level stationary) and 0.146 (trend stationary).

Sample A is from April 4, 2013 to January 28, 2016.

Sample B is from Januray 29, 2016 to March 30, 2023.

M3 is interbank interest rate 3 month. TB3 is Treasury Bill 3 month.

M6 is interbank interest rate 6 month. TB6 is Treasury Bill 6 month.

M12 is interbank interest rate 12 month. TB12 is Treasury Bill 12 month.

Table 4

ADF unit root test (first differenced series)

Variable	Without Trend	With Trend
Sample A		
M3	-10.057*	-10.104*
M6	-9.305*	-9.3756*
M12	-11.587*	-11.782*
TB3	-6.891*	-13.749*
TB6	-8.453*	-15.226*
TB12	-13.531*	-17.805*
Sample B		
M3	-11.951*	-11.985*
M6	-11.826*	-11.911*
M12	-17.003*	-24.126*
TB3	-25.147*	-24.969*
TB6	-12.729*	-12.722*
TB12	-17.668*	-17.549*

Notes:

* indicates significance at the 5% level.

5% critical values are −2.86 (without trend) and −3.41 (with trend).

Sample A is from April 4, 2013 to January 28, 2016.

Sample B is from Januray 29, 2016 to March 30, 2023.

M3 is interbank interest rate 3 month. TB3 is Treasury Bill 3 month.

M6 is interbank interest rate 6 month. TB6 is Treasury Bill 6 month.

M12 is interbank interest rate 12 month. TB12 is Treasury Bill 12 month.

Table 5

KPSS unit root test (first differenced series)

Variable	Lag = 4		Lag = 12	
	Level Stationary	Trend Stationary	Level Stationary	Trend Stationary
Sample A				
M3	0.440	0.139	0.231	0.089
M6	0.378	0.137	0.249	0.091
M12	0.323	0.114	0.238	0.084
TB3	0.020	0.018	0.031	0.028
TB6	0.056	0.026	0.054	0.025
TB12	0.050	0.019	0.066	0.026
Sample B				
M3	1.060*	0.403*	0.781*	0.301*
M6	1.335*	0.463*	0.920*	0.324*
M12	1.662*	0.300*	1.220*	0.228*
TB3	0.025	0.023	0.028	0.026
TB6	0.035	0.034	0.041	0.040
TB12	0.023	0.022	0.027	0.026

Notes:

* indicates significance at the 5% level.

5% critical values are 0.463 (level stationary) and 0.146 (trend stationary).

Sample A is from April 4, 2013 to January 28, 2016.

Sample B is from Januray 29, 2016 to March 30, 2023.

M3 is interbank interest rate 3 month. TB3 is Treasury Bill 3 month.

M6 is interbank interest rate 6 month. TB6 is Treasury Bill 6 month.

M12 is interbank interest rate 12 month. TB12 is Treasury Bill 12 month.

Table 6

Engle-Granger cointegration test

Variable	Test Statistics
Sample A	
M3, TB3	-4.231*
M6, TB6	-3.439*
M12, TB12	-1.847
Sample B	
M3, TB3	-4.950*
M6, TB6	-3.666*
M12, TB12	-3.852*

Notes:

* indicates significance at the 5% level.

5% critical values are −3.3377 from MacKinnon (1991).

Sample A is from April 4, 2013 to January 28, 2016.

Sample B is from Januray 29, 2016 to March 30, 2023.

M3 is interbank interest rate 3 month. TB3 is Treasury Bill 3 month.

M6 is interbank interest rate 6 month. TB6 is Treasury Bill 6 month.

M12 is interbank interest rate 12 month. TB12 is Treasury Bill 12 month.

Table 7 Granger causality test

Variables	Test Statistics	Variables	Test Statistics
Sample A		Sample B	
M3 → TB3	5.065*	M3 → TB3	1.574
M6 → TB6	1.811**	M6 → TB6	0.951
M12 → TB12	2.558*	M12 → TB12	1.159
TB3 → M3	1.060	TB3 → M3	1.508
TB6 →M6	1.610	TB6 →M6	1.995**
TB12 →M12	1.755	TB12 →M12	2.410*

Notes:
Sample A is from April 4, 2013 to January 28, 2016.
Sample B is from Januray 29, 2016 to March 30, 2023.
M3 is interbank interest rate 3 month. TB3 is Treasury Bill 3 month.
M6 is interbank interest rate 6 month. TB6 is Treasury Bill 6 month.
M12 is interbank interest rate 12 month. TB12 is Treasury Bill 12 month.