Analysis of Japanese Government Bond and Swap Markets under Negative Interest Rate Policy

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Abstract

Market segmentation is observed in the Japanese government bond (JGB) and swap markets of two-, three-, four-, five-, seven- and 10-year maturities under the negative interest rate policy regime. This also means that the arbitrage between the JGB and swap markets does not work in these maturities. After the Bank of Japan (BOJ) introduces a yield curve control (YCC) policy under the negative interest rate policy, market segmentation is observed only in the JGB and swap markets of seven- and 10-year maturities. In the maturities of two, three, four, and five years, the JGB yield and the swap rate co-move. The market function recovers in these maturities. The degree of integration is especially strong in the maturities of four years and five years. A 1% increase in JGB yield leads to a 1% increase in swap rate. In other words, the swap spread is considered to be constant.

Keywords: Japanese Government Bond, Interest Rate Swap, Market Segmentation, Negative Interest Rate Policy

1. Introduction

The Bank of Japan (BOJ) introduces a quantitative and qualitative easing policy with a negative interest rate on January 29, 2016. It also introduces a negative interest rate while maintaining the framework of the quantitative and qualitative easing policy. The operating target is both the interest rate and the monetary base. The BOJ applies a negative interest rate of -0.1% to the policy-rate balances in current accounts held by financial institutions at the Bank. It introduces a yield curve control (YCC) policy on September 20, 2016. In addition to maintaining a -0.1% to the

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policy-rate balances, it purchases Japanese government bonds (JGBs) so that the 10-year JGB yields remains more or less at the current level (around 0%).

This paper focuses on the co-movement between the JGB and interest rate swap (hereinafter swap) markets in Japan in the negative interest rate period. In the analysis, the whole sample period is divided into two depending on monetary policy regimes. By doing this, it might be possible to ascertain the asymmetrical impact of different monetary policy regimes.

A swap is an agreement between two parties to exchange cash flows in the future. In a typical agreement, two counterparties exchange streams of fixed and floating interest payments. Thus, a fixed interest rate payment can be transformed into a floating payment and vice versa. The amount of each floating rate payment is based on a variable rate that has been mutually agreed upon by both counterparties: for example, the floating rate payment could be based on the six-month London Interbank Offered Rate (LIBOR).

Market participants in charge of long-term interest rates closely check the JGB and swap markets for speculative, arbitrage, and hedge transactions. The swap market in Japan was originally expanded for the risk management of commercial banks and long-term credit banks. This is different from the US swap market, which was developed for transactions related to US government securities.

For example, commercial banks depend on funding from short-term deposits used swap market to fund long-term borrowing; on the other hand, long-term credit banks depend on funding from long-term financial bonds used swap market to fund short-term borrowing. Thus, the analysis of the co-movement between the two markets is considered to be significant both in academia and practice.

So far, the relationship between government bond yield and swap rate has mainly been analyzed in the framework of swap spreads. As for the analysis of swap spreads in the US dollar market, previous studies such as Lekkos and Milas (2001) and Ito (2010a) for US market, and Ito (2007) and Ito (2010b) for Japanese market.

The approach of this paper differs from the previous studies mentioned above. In this paper, the cointegration approach is used to analyze the co-movement between JGB yield and swap rate. This approach has never been used in the analysis of JGB and swap markets except for in Ito (2008). Morris et al. (1998) use it to analyze the relationship between US government securities and corporate bonds. This approach enables us to know not only if swap rates are in long-run equilibrium with JGB yields in the corresponding term but also if a rise or decline in JGB yield is associated with a rise or decline in the swap spread.

Ito (2009) uses this method for an analysis of JGB and swap markets. In Ito's (2009) study, the whole sample is divided into two subperiods: Sample A is from January 4, 1994 through to February 12, 1999; Sample B is from February 15, 1999 through to February 27, 2009. In Sample A, Japanese swap rates are in long-run equilibrium with JGB yields in all maturities. In Sample B, Japanese swap rates are in long-run equilibrium with JGB yields only in the maturities of four years, five years, and seven years and market segmentation between the JGB and Japanese swap markets is observed in the maturities of two years, three years, and 10 years.

Related studies, such as Andresen (2015), Jackson (2015), Arteta et al. (2016), Bech and Malkhozov (2016), Turk (2016), and Ito (2017), analyze negative interest rate policy, but they also analyze short-term interest rates in the money market.

This paper makes two contributions to the literature. First, it is the first paper to analyze long-term interest rates in Japan under the monetary policy regime of negative interest rate. Second, it divides the negative interest rate regime into two. Thus, it is possible to analyze the impact of different negative interest policy regimes on long-term interest rates.

2. Data

JGB yields and swap rates are used on a daily basis from January 29, 2016 to November 14, 2018. The maturities are two years, three years, four years, five years, seven years, and 10 years. These data are provided by Thomson Reuters Data Stream. The movements of two-year and 10-year JGBs and swaps are shown in Figure 1, and the descriptive statistics are provided in Table 1.

The entire sample period is divided into two. The first period, Sample A, runs from January 29, 2016 to September 20, 2016. The BOJ introduces quantitative and qualitative monetary easing with a negative interest rate policy on January 29, 2016. It adopts a quantitative and qualitative easing policy from April 4, 2013 to January 28, 2016. The pillars of a quantitative and qualitative easing policy are as follows: (1) the adoption of the monetary base control, (2) an increase in JGB purchases and their maturity, (3) an increase in exchange traded fund (ETF) and J-REIT (real estate investment trust) purchases, and (4) the continuation of the quantitative and qualitative monetary easing to achieve the price stability target of 2%[2].

The second period, Sample B, runs from September 21, 2016 to November 14, 2018. The BOJ applies a negative interest rate of -0.1% to the policy-rate balances in current accounts held by financial institutions at the Bank. It introduces a yield curve control (YCC) policy. In addition to maintaining a -0.1% interest rate to the policy-rate balances, it purchases JGBs so that the 10-year JGB yields remains more or less at the current level (around 0%). Even though it introduces the YCC, there is a consensus in the market that the BOJ would permit JGBs to move from -0.1% to 0.1%. Mr. Haruhiko Kuroda, Governor of the BOJ, indicates at a press conference on July 31, 2018 that the 10-year JGB yield would move within the range of -0.2% to 0.2%.

3. Methodology

3.1 Unit Root Test

Because empirical analysis from the mid-1980s through to the mid-1990s shows that such data as interest rates, foreign exchanges, and stocks are non-stationary, it is necessary to check whether the data used in this paper contain unit roots. The Augmented Dickey-Fuller (ADF) test and the Kwiatowski-Phillips-Schmidt-Shin (KPSS) test are used[3]. The ADF test defines the null hypothesis as "unit roots exist" and the alternative hypothesis as "unit roots do not exist." Fuller (1976) provides a table for the ADF test. The KPSS test defines the null hypothesis as "unit roots do not exist" and the alternative hypothesis as "unit roots exist." 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 Cointegration Test and Market Segmentation

Non-stationary time series wander widely with their own short-run dynamics, but a linear combination of the 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 cointegration, equation (1) is estimated by OLS to find if the residual contains a unit root.

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[2] There are two kinds of REITs in Japan, one is a Public REIT which is listed on the Tokyo Stock Exchange (TSE), and the other is a Private REIT. In this paper, REIT represents a Public REIT. It is also called J-REIT.

[3] See Dickey and Fuller (1979), Dickey and Fuller (1981), and Kwiatkowski et al. (1992).

$$y_t = \alpha + \beta \; jy_t + u_t \qquad (1)$$

y_t = swap rate

jy_t = JGB yield

When series y_t and jy_t are both non-stationary *I* (1), they are said to be in a relationship of cointegration if their linear combination is stationary *I* (0). The cointegration relationship between y_t and jy_t implies that swap rate and JGB yield move together in the long-run equilibrium. In testing a cointegration relationship, a swap rate and JGB yield pair in the same maturity is used. When cointegration is found in a maturity, arbitrage between two markets works. When a cointegration relationship is not found in a maturity, market segmentation between two markets is considered to be observed. In other words, the arbitrage does not work.

In addition to testing if swap rate and JGB yield are in a relationship of cointegration, the cointegration vector *(1,-1)*, β in equation (1), is checked with the method of dynamic OLS developed by Stock and Watson (1993). The cointegration vector test is only conducted on a pair of samples when they have a cointegration relationship.

Equation (2) is used to test if $\beta = 1$ can be rejected. Δjy_{t-i} is the lead and lag variables of JGB yield[4].

$$y_t = \alpha + \beta jy_t + \sum_{i=-p}^{p} b_i \Delta jy_{t-i} + u_t \qquad (2)$$

When β is one, a 1% increase in JGB yield will lead to a 1% increase in swap rate. In other words, swap spread is considered to be constant. This also means that the integration between the two markets is strong. When β is less than one, a 1% increase in JGB yield will lead to a less than 1% increase in swap rate. In other words, a rise (a decline) in JGB yield is associated with a decline (a rise) in the swap spread.

On the other hand, when β is more than one, a 1% increase in JGB yield will lead to a more than 1% increase in swap rate. In other words, a rise (a decline) in JGB yield is associated with a rise (a decline) in the swap spread.

[4] As regards the number of lead and lag terms, six are used.

4. Results

4.1 Unit Root Test

First, ADF and KPSS tests are conducted on the original series. The results do not eliminate the doubt that the original data have unit roots because the results of both tests show non-stationarity. The results are shown in Table 2 and Table 3.

Table 2

Table 3

Next, ADF and KPSS tests are conducted for the data with a first difference. The results show that all data with a first difference are stationary, with some exceptions in the KPSS test. But it is appropriate to think that all of the variables used for the analysis are non-stationary I (1) variables, taking into account the results of both the ADF and KPSS tests, and to judge that non-stationary time series can be used. The results are shown in Table 4 and Table 5.

Table 4

Table 5

4.2 Cointegration Test

Engle and Granger's (1987) cointegration tests are conducted. For the critical values, numbers provided by MacKinnon (1991) are used. The results are shown in Table 5. In Sample A, none of the swap rates or JGB yields are in a relationship of cointegration in the maturities of two years to 10 years.

On the other hand, in Sample B, swap rates are cointegrated with JGB yields in the maturities of two, three, four, and five years. In the maturities of seven years and 10 years, no cointegration relationship is found. This result indicates that the market segmentation between the JGB and swap markets is confirmed in all the maturities in Sample A and in the maturities of seven and 10 years in Sample B.

5. Concluding remarks

This paper focuses on the co-movement between the JGB and swap markets in Japan for the negative interest rate period. The 10-year JGB yield and swap rate yield declines to about -0.3% and -0.1% respectively in July 2016. In the analysis, the whole sample period is divided into two depending on monetary policy regimes. By doing this, it might be possible to ascertain the asymmetrical impact of different monetary policy regimes. The BOJ applies a negative interest rate policy in the whole sample period, but it applies a YCC policy in the latter half of the sample period.

Market segmentation is observed in the JGB and swap markets of two-, three-, four-, five-, seven-, and 10-year maturities. The arbitrage between the JGB and swap markets does not work in these maturities. This also means that the market function does not work under the negative interest rate policy regime.

After the BOJ introduces the YCC policy, market segmentation is observed only in the JGB and swap markets of seven- and 10-year maturities. In the maturities of two, three, four, and five years, the JGB yield and the swap rate co-move. The JGB and swap markets are integrated in these maturities. This means that the arbitrage between the two markets works in these maturities.

The degree of integration is especially strong in the maturities of four years and five years. A 1% increase in JGB yield leads to a 1% increase in swap rate. In other words, swap spread is considered to be constant. In the maturities of two years and three years, a 1% increase in JGB yield leads to a less than 1% increase in swap rate. In other words, a rise (a decline) in JGB yield is associated with a decline (a rise) in the swap spread. The market function gradually recovers with the introduction of the YCC policy because market participants assume that the long-term interest rates will move above the level of 0%.

This paper analyzes the relationship between the JGB and swap markets. It is necessary to analyze swap spreads (swap rate minus JGB yield) in terms of the factors influencing them. I would like to point out them as further research.

References

Andresen, M.M., Kristoffersen, M.S, and Risbjerg, L. (2015), “The Money Market at Pressure on the Danish Krone and Negative Interest Rates,” *Danmarks National Bank Monetary Review* 4th Quarter 2015.

Arteta, C., Kose, A. Stocker, M., and Taskin, T. (2016), “Negative Interest Rate Policies: Sources and Implications,” *Centre for Economic Policy Research* DP11433.

Bech, M. and Malkhozov, A. (2016), “How Have Central Banks Implemented Negative Policy Rates?,” *BIS Quarterly Review*, March 2016, pp.31-44.

Dickey, D.A. and Fuller, W.A. (1979), "Distribution of the Estimators for Autoregressive Time Series with a Unit Root," *Journal of the American Statistical Association*, Vol.74, No.366, pp.427-431.

Dickey, D.A. and Fuller, W.A. (1981), "Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root," *Econometrica*, Vol.49, Iss.4, pp.1057-1072.

Engle, R.F. and Granger, C.W.J. (1987), "Co-integration and Error Correction: Representation, Estimation and Testing," *Econometrica*, Vol.55, No.2, pp.51-276.

Fuller, W.A. (1976), *Introduction to Statistical Time Series*, John Wiley & Sons, Inc.

Ito, T. (2007), "The Analysis of Interest Rate Swap Spreads in Japan," *Applied Financial Economics Letters*, Vol.3, No.1, pp.1-4.

Ito, T. (2009), "The Analysis of Co-movement between Government Bond and Interest Rate Swap Markets in Japan," *Asia-Pacific Journal of Economics and Business*, Vol.13, pp.14-30.

Ito, T. (2010a), "Global Financial Crisis and US Interest Rate Swap Spreads," *Applied Financial Economics*, Vol.20, No.1, pp.37-43.

Ito, T (2010b), "Japanese Interest Rate Swap Spreads under Different Monetary Policy Regimes," *IUP Journal of Applied Finance*, Vol.16, pp.57-70.

Ito, T. (2017), "Do Monetary Policy Expectations Influence the Transmission Mechanism in the Danish Interbank Market under a Negative Interest Rate Policy?," *International Journal of Bonds and Derivatives*, Vol.3, No.3, pp.223-234.

Jackson, H. (2015), "The International Experience with Negative Policy Rates," *Bank of Canada Staff Discussion Paper* 2015-13.

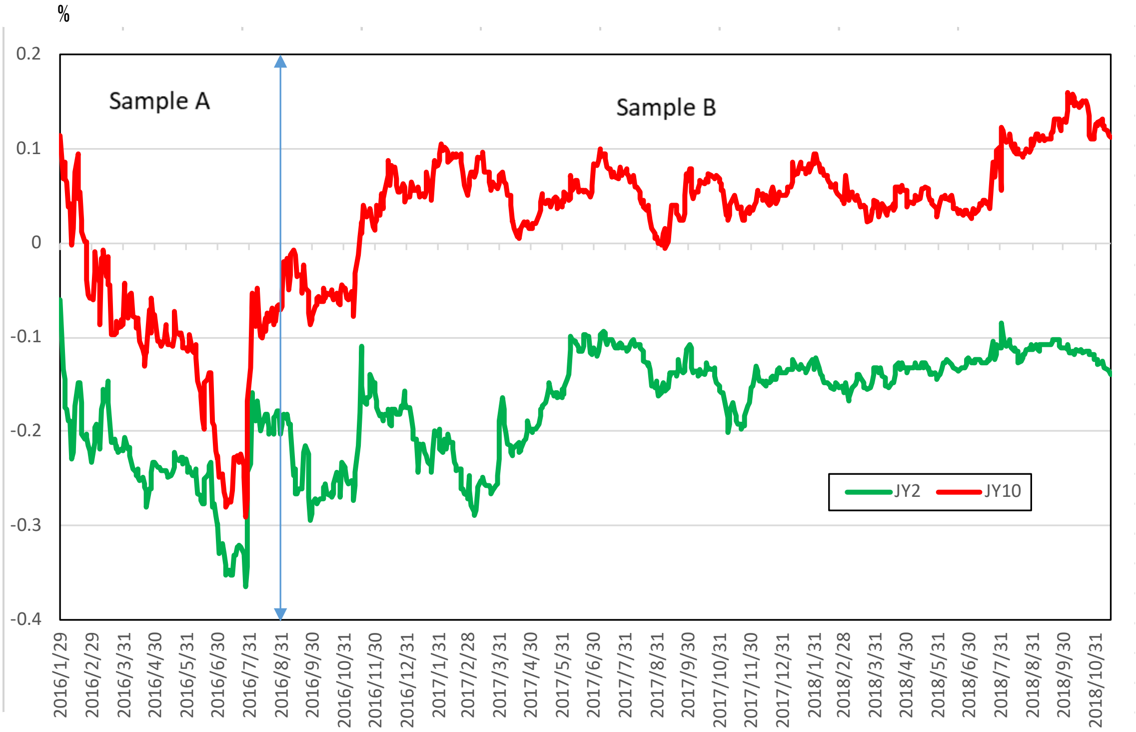
Kwiatkowski, D., Phillips, P.C.B., Schmidt, P. and Shin, Y. (1992), "Testing the Null Hypothesis of Stationarity Against the Alternative of a Unit Root," *Journal of Econometrics*, Vol.54, Nos.1-3, pp.159-178.

MacKinnon, J.(1991), "Critical Values for Cointegration Tests," R.F. Engle and C.W.J. Granger eds, *Long-run economic relationships: readings in cointegration*, Oxford University Press, pp.267-276.

Stock, J.H. and Watson, M.W. (1993), "A Simple Estimator of Cointegrating Vectors in Higher Order Integrated Systems," *Econometrica*, Vol.61, Iss.4, pp.783-820.

Turk, R.A. (2016), "Negative Interest Rates: How Big a Challenge for Large Danish and Swedish

Banks?," *IMF Working Paper* WP/16/198.



Fgure 1 Movement of Two Series

Notes : Data Source is Thomson Reuters Data Stream

Sample A is from January29, 2016 to October 20, 2016.

Sample B is from October 21, 2016 to November 14, 2018.

JY2= two years Japanese Government Bond Yield, JY10=ten years Japanese Government Bond Yield

Table 1 Descriptive statistics

Sample A

Variable	Average	SD	Min	Max	Median
JY2	-0.232	0.052	-0.364	-0.060	-0.232
JY3	-0.233	0.052	-0.370	-0.049	-0.234
JY4	-0.222	0.057	-0.370	-0.057	-0.220
JY5	-0.217	0.060	-0.372	-0.050	-0.216
JY7	-0.21	0.07	-0.41	-0.04	-0.20
JY10	-0.093	0.083	-0.291	0.114	-0.087
Y2	-0.116	0.035	-0.183	-0.010	-0.123
Y3	-0.132	0.042	-0.230	-0.013	-0.138
Y4	-0.120	0.044	-0.230	0.003	-0.119
Y5	-0.09	0.05	-0.21	0.03	-0.09
Y7	-0.025	0.056	-0.173	0.118	-0.009
Y10	0.090	0.075	-0.093	0.275	0.110

Notes: Sample A is from January29, 2016 to October 20, 2016.

Sample B

Variable	Average	SD	Min	Max	Median
JY2	-0.159	0.049	-0.294	-0.085	-0.142
JY3	-0.133	0.041	-0.271	-0.064	-0.125
JY4	-0.117	0.037	-0.251	-0.048	-0.110
JY5	-0.105	0.037	-0.241	-0.030	-0.100
JY7	-0.05	0.05	-0.22	0.04	-0.04
JY10	0.054	0.043	-0.087	0.159	0.054
Y2	0.037	0.027	-0.098	0.065	0.043
Y3	0.052	0.036	-0.115	0.093	0.060
Y4	0.073	0.043	-0.113	0.125	0.080
Y5	0.10	0.05	-0.10	0.16	0.11
Y7	0.161	0.059	-0.055	0.255	0.170
Y10	0.276	0.072	0.040	0.405	0.285

Notes: Sample B is from October 21, 2016 to November 14, 2018.

Table 2 ADF Test Original Series

Sample A

Variable	Without Trend	With Trend
JY2	-0.268	-2.806
JY3	0.319	-2.505
JY4	-0.382	-2.692
JY5	-0.395	-2.649
JY7	-0.338	-1.998
JY10	-1.083	-1.943
Y2	-0.814	-3.252
Y3	-0.832	-3.076
Y4	-0.893	-2.834
Y5	-0.108	-2.635
Y7	-2.566	-2.467
Y10	-2.173	-2.362

Notes:* indicates significant at the 5 % level.
5% critical values are -2.89 (without trend), -3.45 (with trend).
JY=Japanese Government Bond Yield ,Y=Japanese Swap Rate
Sample A is from January29, 2016 to September 20, 2016.

Sample B

Variable	Without Trend	With Trend
JY2	-1.572	-3.491
JY3	-1.183	-3.682*
JY4	-1.228	-3.843*
JY5	-1.389	-3.987*
JY7	-2.370	-3.583*
JY10	-0.942	-3.259
Y2	-1.579	-4.749*
Y3	-1.173	-4.538*
Y4	-0.818	-4.345*
Y5	-0.515	-4.062*
Y7	-0.056	-3.69*
Y10	0.366	-3.292

Notes :* indicates significant at the 5 % level.
5% critical values are -2.89 (without trend), -3.45(with trend).
JY=Japanese Government Bond Yield ,Y=Japanese Swap Rate
Sample B is from September 21, 2016 to November 14, 2018.

Table 3 KPSS test - original series

Sample A

	Lag=2		Lag=12	
Variable	η_μ	η_τ	η_μ	η_τ
JY2	1.192*	0.571*	0.361*	0.175*
JY3	0.865*	0.570*	0.270*	0.179*
JY4	0.933*	0.908*	0.284*	0.192*
JY5	1.051*	0.655*	0.315*	0.198*
JY7	1.486*	0.698*	0.425*	0.205*
JY10	1.993*	0.829*	0.541*	0.234*
Y2	0.891*	0.460*	0.289*	0.160*
Y3	0.850*	0.429*	0.282*	0.151*
Y4	0.502*	0.437*	0.186*	0.142*
Y5	0.505*	0.449*	0.165*	0.146*
Y7	1.567*	0.481*	0.457*	0.146*
Y10	2.738*	0.569*	0.740*	0.165*

Notes: * indicates significance at the 5 % level.
5% critical values are 0.463(level stationary), 0.146 (trend stationary).
η_μ indicates level stationarity. η_τ indicates trend stationarity.
Sample A is from January29, 2016 to September 20, 2016.

	Lag=2		Lag=12	
Variable	η_μ	η_τ	η_μ	η_τ
JY2	10.038*	1.148*	2.477*	0.301*
JY3	8.161*	0.972*	2.063*	0.259*
JY4	6.179*	0.632*	1.587*	0.169*
JY5	4.606*	0.685*	1.203*	0.184*
JY7	4.241*	0.650*	1.091*	0.170*
JY10	5.300*	0.996*	1.336*	0.254*
Y2	6.325*	1.116*	1.609*	0.289*
Y3	7.772*	1.130*	1.966*	0.294*
Y4	8.320*	1.108*	2.097*	0.288*
Y5	8.870*	1.057*	2.204*	0.275*
Y7	10.202*	0.963*	2.536*	0.251*
Y10	11.635*	0.923*	2.861*	0.240*

Notes: * indicates significance at the 5 % level.
5% critical values are 0.463(level stationary), 0.146 (trend stationary).
η_μ indicates level stationarity. η_τ indicates trend stationarity.
Sample B is from October 21, 2016 to November 14, 2018.

Table 4 ADF Test Series with First Difference

Sample A

Variable	Without Trend	With Trend
⊿JY2	-7.507*	-7.520*
⊿JY3	-7.613*	-7.260*
⊿JY4	-7.320*	-7.274*
⊿JY5	-7.551*	-7.620*
⊿JY7	-8.064*	-8.162*
⊿JY10	-8.206*	-8.299*
⊿Y2	-12.618*	-10.140*
⊿Y3	-11.515*	-10.199*
⊿Y4	-10.949*	-10.429*
⊿Y5	-10.719*	-10.466*
⊿Y7	-7.409*	-7.795*
⊿Y10	-7.262*	-7.262*

Notes:* indicates significant at the 5 % level.
5% critical values are -2.89 (without trend), -3.45 (with trend).
JY=Japanese Government Bond Yield ,Y=Japanese Swap Rate
Sample A is from January29, 2016 to September 20, 2016.

Sample B

Variable	Without Trend	With Trend
⊿JY2	-12.735*	-12.197*
⊿JY3	-22.688*	-23.098*
⊿JY4	-22.564*	-22.849*
⊿JY5	-22.758*	-22.979*
⊿JY7	-25.999*	-26.323*
⊿JY10	-10.688*	-10.289*
⊿Y2	-6.541*	-8.916*
⊿Y3	-7.592*	-9.087*
⊿Y4	-7.490*	-7.863*
⊿Y5	-7.328*	-7.683*
⊿Y7	-7.384*	-7.682*
⊿Y10	-7.452*	-7.693*

Notes :* indicates significant at the 5 % level.
5% critical values are -2.89 (without trend), -3.45(with trend).
JY=Japanese Government Bond Yield ,Y=Japanese Swap Rate
Sample B is from September 21, 2016 to November 14, 2018.

Table 5 KPSS test - original series

Sample A

	Lag=2		Lag=12	
Variable	η_μ	η_τ	η_μ	η_τ
⊿JY2	0.152	0.065	0.174	0.067
⊿JY3	0.191	0.056	0.226	0.070
⊿JY4	0.167	0.044	0.222	0.062
⊿JY5	0.155	0.038	0.227	0.060
⊿JY7	0.177	0.034	0.262	0.058
⊿JY10	0.245	0.032	0.345	0.057
⊿Y2	0.150	0.055	0.202	0.076
⊿Y3	0.134	0.054	0.186	0.075
⊿Y4	0.121	0.050	0.170	0.072
⊿Y5	0.111	0.049	0.156	0.071
⊿Y7	0.104	0.047	0.144	0.068
⊿Y10	0.260	0.032	0.345	0.057

Notes: * indicates significance at the 5 % level.
5% critical values are 0.463(level stationary), 0.146 (trend stationary).
η_μ indicates level stationarity. η_τ indicates trend stationarity.
Sample A is from January29, 2016 to October 20, 2016.

	Lag=2		Lag=12	
Variable	η_μ	η_τ	η_μ	η_τ
⊿JY2	0.036	0.023	0.048	0.031
⊿JY3	0.043	0.022	0.047	0.024
⊿JY4	0.044	0.024	0.046	0.026
⊿JY5	0.038	0.024	0.043	0.027
⊿JY7	0.067	0.037	0.063	0.035
⊿JY10	0.045	0.042	0.049	0.047
⊿Y2	0.437	0.104	0.432	0.112
⊿Y3	0.425	0.097	0.415	0.102
⊿Y4	0.375	0.083	0.362	0.086
⊿Y5	0.335	0.074	0.322	0.076
⊿Y7	0.246	0.055	0.238	0.056
⊿Y10	0.169	0.041	0.166	0.041

Notes: * indicates significance at the 5 % level.
5% critical values are 0.463(level stationary), 0.146 (trend stationary).
η_μ indicates level stationarity. η_τ indicates trend stationarity.
Sample B is from September 21, 2016 to November 14, 2018.

Table 5 Cointegration Test

Sample A

Variables	Test Statistics
JY2-Y2	-2.720
JY3-Y3	-2.730
JY4-Y4	-3.092
JY5-Y5	-3.108
JY7-Y7	-2.495
JY10-Y10	-2.031

Critical value is -3.338(5%) from MacKinnon(1991).
* indicates significant at the 5% level and ** indicates significant at the 10% level.
JY=Japanese Government Bond Yield ,Y=Japanese Swap Rate
Sample A is from January29, 2016 to September 20, 2016.

Sample B

Variables	Test Statistics
JY2-Y2	-4.176*
JY3-Y3	-4.603*
JY4-Y4	-4.524*
JY5-Y5	-4.123*
JY7-Y7	-3.189
JY10-Y10	-2.507

Critical value is -3.338(5%) from MacKinnon(1991).
* indicates significant at the 5% level.
JY=Japanese Government Bond Yield ,Y=Japanese Swap Rate
Sample B is from September 21, 2016 to November 14, 2018.

Table 6 Test on the Cointegration Vector

Sample B

Variables	β	Modified SE	Test Statistics
JY2-Y2	0.288	0.093	7.656
JY3-Y3	0.655	0.137	2.518
JY4-Y4	0.900	0.188	0.532*
JY5-Y5	1.063	0.260	0.242*

Dynamic OLS by Stock and Watson (1993) is used to test if β is one.
* indicates test statistics is smaller than 5 % critical value (1.96) and β =1 can't be rejected.
JY=Japanese Government Bond Yield ,Y=Japanese Swap Rate