Impact of Negative Interest Rate Policy on the Swap Market in Japan : Comparative Analysis before and after Yield Curve Control

Takayasu Ito

Abstract

No co-movement was found among swap rates with a maturity of 10, 15, 20 and 30 years before the introduction of YCC under ZNIRP. On the other hand, they co-moved after the introduction, driven by a single common trend. No single pair of swap rates moved together before the introduction, but every pair moved together after the introduction. The function of the swap market was lost after the introduction of NIRP. Even the swap rate of 10 years declined to negative figures. This caused uncertainties regarding the formation of the yield curve among the market participants in the super long zone of the swap market. After the BOJ introduced YCC to move the yield curve upward, particularly in moving the 10-year Japanese Government Bond (JGB) yield to around zero percent, structural changes took place not only in JGB but also in swap markets. Four swap rates in the super long zone started to co-move as the swap market recovered market function.

Keywords: cointegration, negative interest rate, swap rate, yield curve control

1.Introduction

Since the Bank of Japan (BOJ) introduced the Negative Interest Rate Policy (NIRP) in 2016, long term interest rates have experienced unprecedented movement. The yield of 10-year Japanese Government Bonds declined to around -0.3% in July, 2016. The BOJ introduced yield curve control (YCC) policy to move the yield curves in a long-term upwards trend, as banks and life insurance companies had struggled to make profits with the negative long-term interest rates.

This paper focuses on the super long zone in the interest rate swap (hereinafter swap) market in Japan. The super long zone refers to maturities of over 10 years. The motive for the transaction is very specific: most of the players in the super long zone are foreign security houses and life insurance companies. Japanese banks also participate in the super zone as swap rates of mid- and long-term zones are very low.

Related studies (Andresen, 2015; Jackson, 2015; Arteta et al., 2016; Bech and Malkhozov, 2016; Turk, 2016; Ito, 2017, 2019) analyze the short-term interest rates under negative interest rate policy. Ito (2000), Wu and Xia (2000), and Kubota and Shintani (2021) analyze long term interest rates under NIRP. However, none of these focus on the super long zone in the interest rate swap market in Japan, and therefore this paper distinguishes itself from other related literature in terms of originality.

Ito (2000) concluded that "market segmentation is observed in the Japanese government bond (JGB) and swap markets of 2, 3, 4, 5, 7, and 10-year maturities under negative interest rate policy regime". Ito (2000) also mentioned that "after the Bank of Japan introduces a yield curve control policy under negative interest rate policy, market segmentation is observed only in the JGB and swap markets of 7 and 10-year maturities".

Wu and Xia (2000) found that "the four NIRP events lowered the short-term interest rate by the same amount and impact is dampened at longer maturities for the first two event dates, due to lack of forward guidance by evaluating the implications of the ECB's negative interest rate policy (NIRP) on the yield curve".

Kubota and Shintani (2021) identified monetary policy shocks in Japan during the unconventional monetary policy period including NIRP, concluding that "the responses of the longer-term yields tend to be larger than those of the shorter-term yields. The response is the largest for the 10-year government bond yield".

The remainder of this paper is structured as follows: Section 2 explains background of the BOJ's negative interest policy and YCC. Section 2 describes the data and provides summary statistics. Section 3 discusses methodology. Section 4 presents the results. Section 5 concludes.

2. Background of the BOJ's Negative Interest Policy and YCC

The BOJ adopted a negative interest rate policy on January 29, 2016. According to the BOJ (2016a), "they apply a negative interest rate of -0.1% 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)".

The BOJ introduced the YCC policy on September 21, 2016, indicated in the BOJ (2016b): "In addition to maintaining a -0.1% interest rate for policy-rate balance, they purchase JGBs so that the 10-year JGB yield remains more or less at the current level (around 0%). Even though they introduced a YCC, there was 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, said 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%", as indicated by the BOJ (2018). According to the BOJ (2021), they expanded the range to between -0.25% to 0.25% on March 19, 2021.

3.Data

Daily data of swap rates with a maturity of 10, 15, 20 and 30 years were used in this analysis. The sample period runs from January 29, 2016 to December 30, 2021, with data provided by Datastream. The descriptive statistics of the dataset are shown in Table 1. The movements of swap rates are shown in Figures 1 and 2. The descriptive statistics are shown in Table 1. The sample period is divided at the point that the BOJ introduced YCC under NIRP on September 20, 2016. The sample period from January 29, 2016 to September 20, 2016 is Sample A, and the period from September 21, 2016 to December 30, 2021 is Sample B.

Figure 1

Table 1

4.Methodology

4.1 Unit Root Test

The Augmented Dickey-Fuller (ADF) test and the Kwiatowski-Phillips-Schmidt-Shin (KPSS) test were used[1]. 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 were checked to verify whether they contained unit roots. Next, the data with first difference were analyzed to determine whether they had unit roots, to confirm

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

that they were I (1) process.

4.2 Johansen Cointegration Test

The first Johansen (1988) cointegration test was applied as detailed below after confirmation that the data used for analysis were non-stationary I (1) variables. Johansen suggests "starting an analysis with the *k* order VAR model". Here, "the vectorauto regression (VAR) model is presented with *k* order against vector X_t with *p* variables". Trace and maximal eigen value tests were conducted to analyze swap rates of 10, 15, 20 and 30 years, using critical values at the 5% level from Osterwald-Lenum (1992).

$$X_t = \Pi_1 X_{t-1} + \cdots + \Pi_k X_{t-k} + \lambda + u_t \quad (1)$$

As mentioned in Johansen (1988), "all the *p* elements of X_t are considered to be I (1) variables. u_t is an error term with a zero mean. λ is a constant term".

Stock and Watson (1988) indicated that "an alternative interpretation of the cointegration among yields of different maturities arises from the relationship between cointegration and common trends". They showed that "when there are ($n-p$) linearly independent cointegration vectors for a set of *n* I (1) variables, then each of these *n* variables can be expressed as a linear combination of *p* I (1) common trends and ($n-p$) I (0) components".

The work of Hall et al. (1992) is relevant to this part of the analysis. They found that "the entire series comprises 10 cointegration vectors and one common trend by conducting the Johansen cointegration test using the monthly data of the US Treasury bill data [11 series of 1 to 11 months] from 1970 through to 1988".

4.3 Engle-Granger Cointegration Test

Following Engle and Granger (1987), "equation (1) is estimated by Ordinary Least Squares (OLS) to find out whether the residual contains unit roots in the test of co-movement between yields". This test is conducted on every pair of swap rate in the maturities of 10, 15, 20 and 30 years. The critical values from MacKinnon (1991) are used.

$$SWAP10Y = \alpha + \beta \, SWAP15Y + u_t \quad (1)$$

$SWAP10Y$ = swap yield of 10 years

SWAP15Y = swap yield of 15 years

5. Results

5.1 Unit Root Test

The first ADF and KPSS tests were conducted on original data series. All original data contain unit roots. The results are shown in Tables 2 and 4.

Table 3

Table 4

Next, ADF and KPSS tests were conducted on first differenced data. All first differenced data did not contain unit roots. It can be concluded that all data used for analyses are non-stationary I (1). Consequently, it is correct to use a non-stationary time series model. The results are shown in Tables 4 and 5.

Table 4

Table 5

5.2 Johansen Cointegration Test

Both maximal eigen value and trace tests were conducted. No cointegration relationship was found in Sample A. However, three cointegration relationships and one common trend was found in sample B. Swap rates of 10, 15, 20 and 30 years move together driven by a single common trend following the introduction of YCC by the BOJ. The results are shown in Table 6.

Table 6

5.3 Engle-Granger Cointegration Test

Engle-Granger cointegration tests were conducted on a pair wise from swap rates of 10, 15, 20 and 30 years. No cointegration relationship was found in Sample A, but cointegration relationships were found in every pair. Swap rates of 10, 15, 20 and 30 years move together following the introduction of YCC by the BOJ. The results are shown in Table 7.

Table 7

6. Conclusion

This paper focuses on the super long zone of swap markets in Japan and makes comparative analyses before and after the introduction of YCC under NIRP. The super long zone refers to maturities of over 10 years. Daily data of swap rates with a maturity of 10, 15, 20 and 30 years were used in this analysis. No co-movement was found among four interest rates before the introduction of YCC. However, they do co-moved, driven by a single common trend. No single pair of swap rates moved together before the introduction of YCC, but every pair moved together following the introduction.

The function of the swap market was lost following the introduction of NIRP. Even the swap rate of 10 years declined into negative figures. This caused uncertainty in the formation of the yield curve among market participants in the super long zone of the swap market.

After the BOJ introduced the YCC to move the yield curve upward, including moving the 10-year Japanese Government Bond (JGB) yield to around zero percent, structural changes took place not only in the JGB but also in the swap markets. Four swap rates of the super long zone started to co-move after regaining market functions.

Most of the players in the super long zone were foreign security houses and life insurance companies before the introduction of NIRP. Japanese banks also participated in the super zone to make profits following the introduction due to the low swap rates of mid- and long-term zones.

The results of this study coincide with Ito (2020), stating that market function gradually recovers in JGB and swap markets under the maturities of 10 years with the introduction of YCC policy, because market participants assume that long-term interest rates will move above zero percent.

This paper analyzes the super long zone of swap markets. There is a room to analyze the relationship of JGB and swap markets in the super long zone under the NIRP, an area that I would like to study further.

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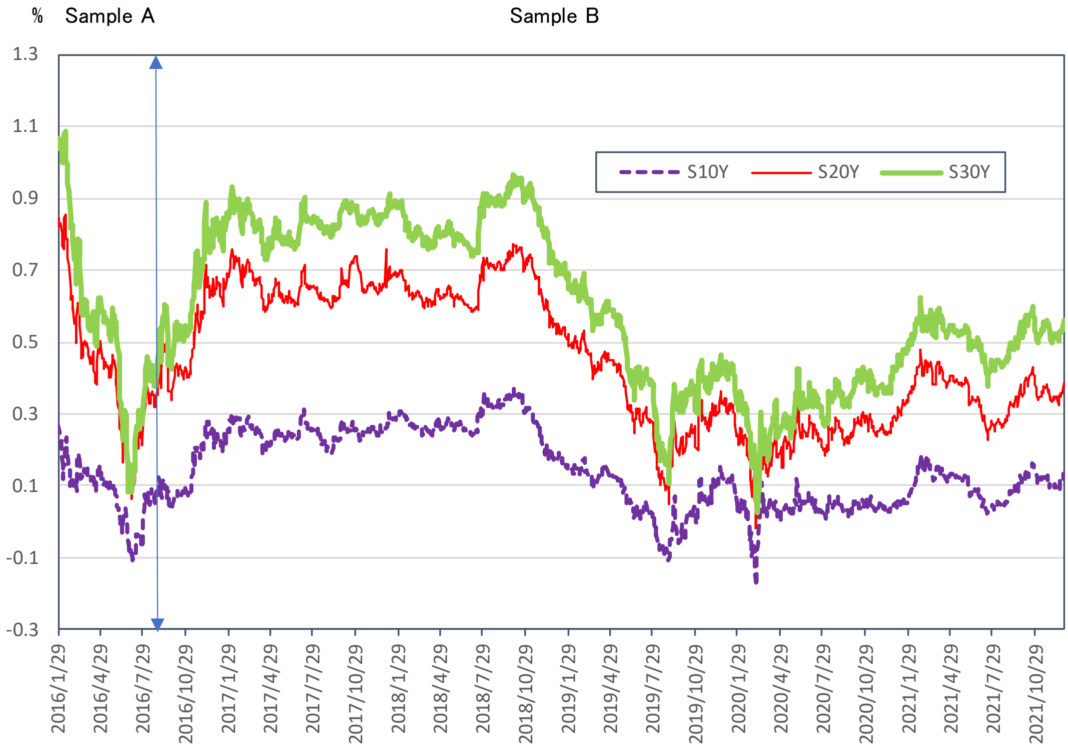
Figure 1 Swap Rate



Note:
Sample A is from January 29, 2016 to September 20, 2016.
Sample B is from September 21, 2020 to December 30, 2021.
Data source is Datastream.

Table 1 Descriptive statistics

Variable	Average	SD	Min	Max	Median
Sample A					
S10Y	0.080	0.079	-0.109	0.270	0.095
S15Y	0.274	0.130	0.003	0.585	0.280
S20Y	0.423	0.181	0.065	0.855	0.432
S30Y	0.534	0.235	0.081	1.084	0.541
Sample B					
S10Y	0.15	0.11	-0.18	0.37	0.13
S15Y	0.31	0.15	-0.08	0.59	0.29
S20Y	0.452	0.187	-0.016	0.771	0.423
S30Y	0.596	0.219	0.025	0.965	0.558

Note: Sample A is from January 29, 2016 to September 20, 2016.
Sample B is from September 21, 2020 to December 30, 2021.

Table 2 ADF test - original series

Variable	Without Trend	With Trend
Sample A		
S10Y	-2.361	-2.001
S15Y	-1.982	-1.830
S20Y	-2.017	-1.906
S30Y	-2.156	-1.811
Sample B		
S10Y	-1.091	-3.019
S15Y	-0.620	-2.643
S20Y	-0.506	-2.643
S30Y	-0.314	-2.260

Notes : * indicates significance at the 5 % level.
5% critical values are -2.86(Without Trend) and -3.41(With Trend）.
Sample A is from January 29, 2016 to September 20, 2016.
Sample B is from September 21, 2020 to December 30, 2021.

Table 3 KPSS test - original series

	Lag=3		Lag=12	
Variable	η_μ	η_τ	η_μ	η_τ
Sample A				
S10Y	2.188*	0.516*	0.762*	0.192*
S15Y	2.571*	0.680*	0.872*	0.246*
S20Y	2.588*	0.696*	0.875*	0.250*
S30Y	2.709*	0.673*	0.911*	0.241*
Sample B				
S10Y	17.998*	2.804*	5.640*	0.896*
S15Y	21.309*	2.976*	6.637*	0.944*
S20Y	22.291*	3.201*	6.673*	1.013*
S30Y	20.570*	3.460*	6.391*	1.092*

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 January 29, 2016 to September 20, 2016.
Sample B is from September 21, 2020 to December 30, 2021.

Table 4 ADF test - first differenced series

Variable	Without Trend	With Trend
Sample A		
ΔS10Y	-12.620*	-12.863*
ΔS15Y	-11.795*	-11.957*
ΔS20Y	-11.804*	-12.038*
ΔS30Y	-11.022*	-11.215*
Sample B		
ΔS10Y	-40.095*	-39.989*
ΔS15Y	-23.989*	-23.979*
ΔS20Y	-24.902*	-24.916*
ΔS30Y	-25.309*	-25.388*

Notes : * indicates significance at the 5 % level.
5% critical values are -2.86(Without Trend) and -3.41(With Trend）.
Sample A is from January 29, 2016 to September 20, 2016.
Sample B is from September 21, 2020 to December 30, 2021.

Table 5 KPSS test - first differenced series

	Lag=3		Lag=12	
Variable	η_μ	η_τ	η_μ	η_τ
Sample A				
ΔS10Y	0.173	0.044	0.232	0.066
ΔS15Y	0.146	0.043	0.400	0.062
ΔS20Y	0.420	0.045	0.406	0.057
ΔS30Y	0.424	0.049	0.381	0.057
Sample B				
ΔS10Y	0.082	0.076	0.097	0.895
ΔS15Y	0.089	0.085	0.106	0.101
ΔS20Y	0.104	0.101	0.125	0.121
ΔS30Y	0.133	0.128	0.161	0.156

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 January 29, 2016 to September 20, 2016.
Sample B is from September 21, 2020 to December 30, 2021.

Table 6 Johansen cointegration test

Null	Alternative	Test Statistics	5% Value	Test Statistics	5% Value
		Maximal Eigenvalue Test		Trace Test	
Sample A					
r = 0	r = 1	26.256	28.14	48.226	53.12
r ≦1	r = 2	11.792	22.00	21.970	34.91
r ≦2	r = 3	7.272	15.67	10.178	19.96
r ≦3	r = 4	2.906	9.24	2.906	9.24
Sample B					
r = 0	r = 1	57.294*	28.14	104.303*	53.12
r ≦1	r = 2	25.566*	22.00	47.009*	34.91
r ≦2	r = 3	18.900*	15.67	21.443*	19.96
r ≦3	r = 4	2.542	9.24	2.542	9.24

Notes: *,** indicates significance at 5 % and 10% levels respectively.
Critical values are quoted from Osterwald-Lenum (1992).
Sample A is from January 29, 2016 to September 20, 2016.
Sample B is from September 21, 2020 to December 30, 2021.

Table 7 Engle-Granger Cointegration Test

Variable	Test Statistics	Variable	Test Statistics
Sample A		Sample B	
S10Y,S15Y	-2.198	S10Y,S15Y	-4.571*
S10Y,S20Y	-2.426	S10Y,S20Y	-4.553*
S10Y,S30Y	-2.369	S10Y,S30Y	-4.897*
S15Y,S20Y	-2.936	S15Y,S20Y	-5.139*
S15Y,S30Y	-3.168	S15Y,S30Y	-4.629*
S20Y,S30Y	-3.311	S20Y,S30Y	-5.064*

Notes:
* indicates significance at the 5% level.
5% critical value is −3.3377 from MacKinnon (1991).
Sample A is from January 29, 2016 to September 20, 2016.
Sample B is from September 21, 2020 to December 30, 2021.