論　説

Long-Term Interest Rates in Japan - Analysis of Japanese Government Bond and Interest Rate Swap

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ABSTRACT

This paper analyzes the relationship between Japanese Government Bond and Japanese Yen Interest Rate Swap markets. The whole sample is divided into two sub periods. Sample A is from January 4, 1994 through February 12, 1999. Sample B is from February 15, 1999 through June 30, 2006. In Sample A, Japanese Yen Interest Rate Swap rates are in the long run equilibrium with Japanese Government Bond yields in all maturities. In Sample B, Japanese Yen Interest Rate Swap rates are in the long run equilibrium with Japanese Government Bond yields only in the maturities from 2 years through 7 years. The market segmentation is observed in 10 years between Japanese Government Bond and Japanese Yen Interest Rate Swap markets in Sample B.

Key words: Japanese Long Term Interest Rate, Market Segmentation, Cointegration

JEL Classification: E43, G10

1. Introduction

An interest rate 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 fixed interest rate payment can be transformed into floating payment and vice versa. The amount of each floating rate payment is based on

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a variable rate that has been mutually agreed upon by both counterparties. For example, the floating rate payment could be based on the 6 month LIBOR (London Interbank Offered Rate).

Differences between interest rate swap rate and government bond yield of the same maturity are referred to as swap spread. If interest rate swap market and government bond market are efficiently priced, swap spreads reveal something about the perception of the systemic risk in the banking sector. The market for interest rate swap has grown exponentially in the 1990's. According to a survey by BIS(Bank for International Settlements), the notional outstanding volume of transactions of Japanese yen interest rate derivatives amounted to 58,056 billions of US dollars at the end of June 2008[1].

In Japan before 1997 the defaults of large companies were rare. But the defaults of financial institutions such as Yamaichi Securities, one of the four largest securities firms in Japan and the Long Term Credit Bank of Japan, one of the three long term lending institutions in Japan, show that the defaults of large companies are not rare any more after 1997. In this sense, credit risk in Japanese market increased and market participants got more conscious of credit risk than before.

So far the relationship between government bond yield and interest rate swap rate has mainly been analyzed in the framework of interest rate swap spread. As for the analysis of the interest rate swap spread in US dollar market, previous studies such as Duffie and Huang(1996), Brown et al(1994), Cossin and Pirotte(1997), Lang et al.(1998), Lekkos and Milas (2001), Minton (1997), Sun et al (1993) are cited. On the other hand, previous studies analyzing the Japanese market are very limited to such as Hamano (1997), Eom et al (2000) and Ito (2007).

Hamano (1997) focuses not on credit risk but on market factors such as TED spread and finds that swap spread reflects TED spread and longer term swap spreads are less influenced by TED spread[2]. On the other hand, Eom et al (2000) focus on the credit risk and conclude that yen swap spread is significantly related to proxies for the long term credit risk factor. They also find that swap spread is also negatively related to the level and slope of the term structure. Ito (2007) investigates the determinants of interest rate swap spreads in Japan. Four determinants of swap spread — TED spread, corporate bond spread, interest rate and the slope of yield curve are chosen. The swap spreads of

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[1] Statistics are cited from OTC Derivatives Market Activity in the first half of 2008. At the end of June 1998, the notional outstanding volume of transactions of yen interest rate derivatives was 7, 164 billions of US dollars. For details, see BIS (1998) and BIS (2008).

[2] TED spread is usually defined as 6 month LIBOR minus 6 month T- bill as in Ito (2007). Hamano (1997) defines TED spread as 1 year Euro yen offer rate minus 1year JGB par rate.

2 years through 4 years are mostly influenced by TED spread, interest rate and slope. The swap spread of 5 years is mostly decided by corporate bond spread and slope. The swap spreads of 7 years and 10 years are mostly affected by corporate bond spread.

The approach of this paper differs from previous studies mentioned above. In this paper, I use a cointegration approach to analyze the relationship between government bond yield and interest rate swap rate. This approach has never been used in the analysis of Japanese Government Bond and Japanese Yen Interest Rate Swap markets. 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 Japanese Yen Interest Rate Swap rates are in the long run equilibrium with Japanese Government Bond yields in the corresponding term, but also if a rise or a decline in Japanese Government Bond yield is associated with a rise or a decline in the swap spread. In addition to cointegration tests, Granger causality tests are conducted to check whether Japanese Yen Interest Rate Swap rates affect Japanese Government Bond yields or vice versa.

This paper covers the sample periods of almost 13 years from January 4, 1994 through June 30, 2006. After the Bank of Japan (BOJ) introduced zero interest rate policy in February 15 1999, interest rates market is considered to be structurally changed since there is little room for the Bank of Japan to change the level of unsecured overnight call rate as before. Especially after the Bank of Japan introduced quantitative easing policy in March 21, 2001, swap spreads of 7 years and 10 years sometimes became negative[3].

In this paper the entire sample period is divided in half at the time when the Bank of Japan introduced zero interest rate policy in February 15, 1999. Thus it's possible to know the characteristics of interest rates movement and swap spreads movement in both sample periods.

The remainder of this paper is as follows. Section 2 describes the data and provides summary statistics. Section 3 discusses the framework of the analysis. Section 4 presents the results. Section 5 concludes.

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[3] Starting in March 21, 2001, BOJ changed their operating target from unsecured overnight call rate to current account balance held by financial institutions with the introduction of quantitative easing.

2. Data

2.1 *Japanese Government Bond Yield*

Par rates of Japanese Government Bond yields are used on a daily basis from January 4, 1994 through June 30, 2006[4]. These par rates for the maturities of 2 years, 3years, 4 years, 5 years, 7 years and 10 years are calculated by cubic spline as mentioned in McCulloch (1975). Japanese Government Bond data of 10 years and 20 years are used for the calculation of par rates[5].

2.2 *Japanese Yen Interest Rate Swap Rate*

Japanese Yen Interest Rate Swap rates (2 years, 3 years, 4 years, 5 years, 7 years and 10years) as of 3 pm at Tokyo time are used on a daily basis from January 4, 1994 through June 30, 2006[6].

2.3 *Sample Period*

The whole sample is divided into two sub periods. The first sub period, named Sample A, is from January 4, 1994 through February 12, 1999. Sample A covers the period just before the introduction of zero interest rate policy. The second sub period, named Sample B, is from February 15, 1999 through June 30, 2006[7]. Sample B covers the period of zero interest rate policy and quantitative easing. As for the Japanese Government Bond and Interest Rate Swap data of 2 years and 10 years, Figure 1 shows the data in Sample A. Figure 2 shows the data in Sample B.

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[4] Japanese Government Bonds are traded on a simple yield basis. Par rates are compounded yield.

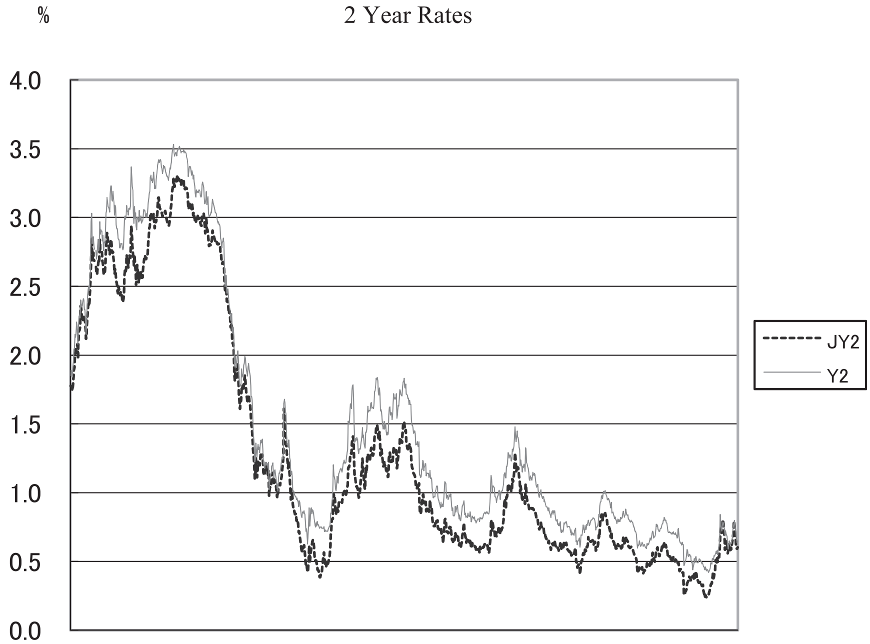
[5] By the end of November in 1998, JGB closing prices listed on the Tokyo Stock Exchange are used. After December in 1999, JGB closing prices provided by a major security house in Tokyo is tilized.

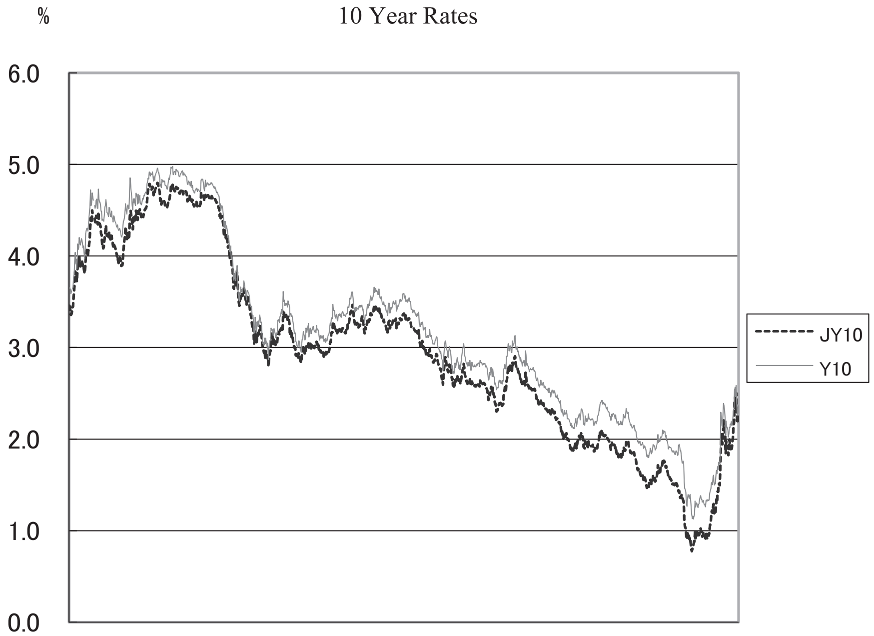
[6] The data used in this paper are mid rates provided by a major bank in Japan. Mid rates are averages of offer and bid rates.

[7] The Bank of Japan lifted quantitative easing policy to adopt zero interest rate policy on March 9, 2006.

Figure 1 Data in Sample A

Daily data from January 4, 1994 through Feburary 12, 1999. The number of sample is 1263.



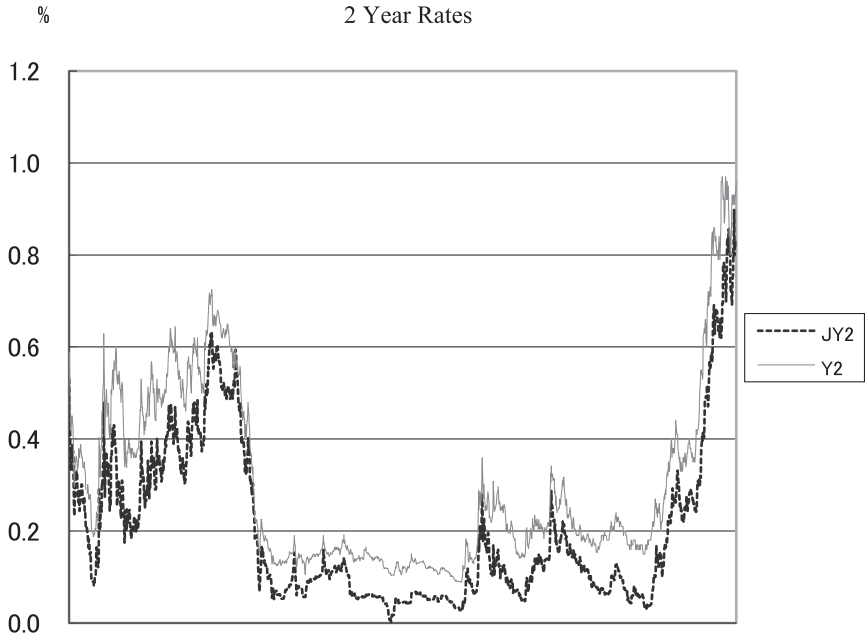


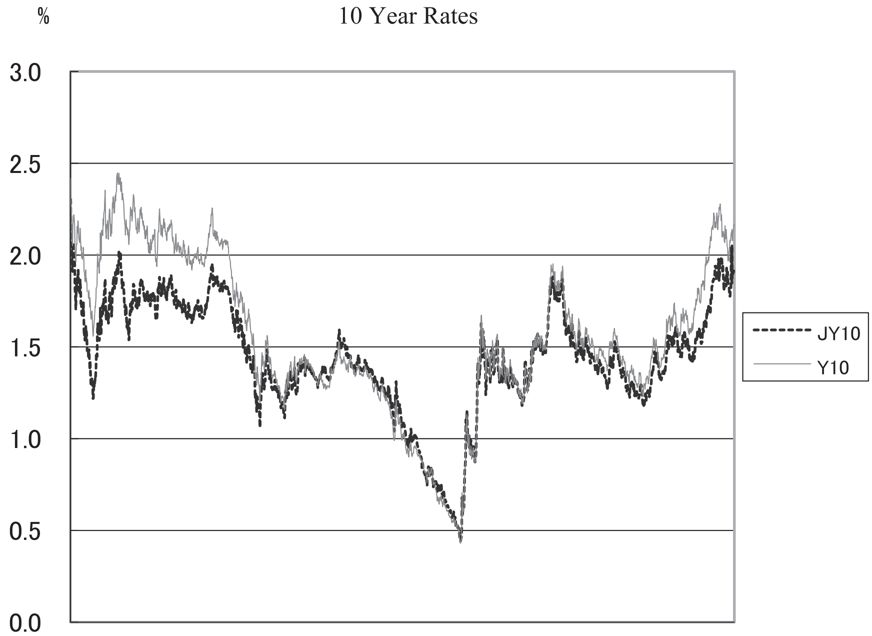
JY = Japanese Government Bond Yield

Y = Japanese Yen Interest Rate Swap Rate

Figure 2 Data in Sample B

Daily data from Feburary 15, 1999 through June 30 2006. The number of sample is 1816.





JY = Japanese Government Bond Yield
Y = Japanese Yen Interest Rate Swap Rate

3. The Framework of Analysis

3.1 *Unit Root Test*

Since the empirical analysis from mid-1980's through mid-1990's show that such data as interest rates, foreign exchange and stocks are non-stationary, it's necessary to check if the data used in this paper contain unit roots. The ADF (Augmented Dickey Fuller) test and the PP (Phillips Perron) test are used[8 9]. Both the ADF test and PP test define null hypothesis as 'unit roots exist' and alternative hypothesis as 'unit roots don't exist'. Fuller (1976) provides the table for ADF test and PP test.

3.2 *Cointegration Test and Market Segmentation*

A cointegration framework is presented to analyze the relationship between Japanese Yen Interest Rate Swap rate and Japanese Government Bond yield. Generally OLS method is used to analyze relationships among the variables. However when the non-stationary variables are included, ordinary hypothesis test tends to draw mistaken results since the coefficient of determination and t-statistics don't follow a simple distribution.

Granger and Newbold (1974) call this problem 'Spurious Regression'. Phillips (1986) points out two points as to the analysis of non-stationary data — (1) the coefficient of determination tend not to measure a relationship among variables, (2) estimated equation with low Durbin-Watson ratio can possibly have a problem of spurious regression.

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 as cointegration by Engle and Granger (1987). In the test of cointegration, the equation (1) is estimated by OLS to find if residual contains unit root.

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

y_t = Japanese Yen Interest Rate Swap rate

jy_t = Japanese Government Bond yield

When y_t and jy_t are both non-stationary $I(1)$, they are called to be in a relationship

[8] See Dickey and Fuller (1979) and Dickey and Fuller (1981).
[9] See Phillips and Perron (1988).

of cointegration if their linear combination is stationary $I(0)$. The cointegration relationship between y_t and jy_t implies that Japanese Yen Interest Rate Swap rate and Japanese Government Bond yield move together in the long run equilibrium. In testing a cointegration relationship, a pair of Japanese Yen Interest Rate Swap rate and Japanese Government Bond yield in the same maturity is used. When cointegration relationship isn't fund in a maturity, market segmentation between two markets is considered to be observed.

In addition to testing if Japanese Yen Interest Rate Swap rate and Japanese Government Bond yield are in a relationship of cointegration, cointegration vector $(1,-1)$, β in the equation (1), is checked with the method of dynamic OLS by Stock and Watson (1993). The equation (2) is used to test if $\beta = 1$ can be rejected. Δjy_{t-i} is lead and lag variables of Japanese Government Bond yield[10].

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

When β is one, a 1% increase in Japanese Government Bond yield will lead to a 1% increase in Japanese Yen Interest Rate swap rate. In other words, swap spread is considered to be constant. When β is less than one, a 1% increase in Japanese Government Bond yield will lead to a less than 1% increase in Japanese Yen Interest Rate Swap rate. In other words, a rise (a decline) in Japanese Government Bond 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 Japanese Government Bond yield will lead to a more than 1% increase in Japanese Yen Interest Rate Swap rate. In other words, a rise (a decline) in Japanese Government Bond yield is associated with a rise (a decline) in the swap spread.

3.3 *Granger Causality Test*

The Granger causality test checks whether Japanese Yen Interest Rate Swap rate(y_t) affects Japanese Government Bond yields (jy_t) or jy_t affects y_t or y_t and jy_t affect mutually. The original data are usually transformed into the change ratio to avoid a problem of spurious regression. But using these data is considered to cause an error. Toda and Yamamoto (1995) develop the Granger causality test in which non-stationary data are directly used.

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[10] As for the number of lead and lag terms, 12 is used. In the case of 6 and 9, the results are the same.

According to their method, the null hypothesis H_0 is tested as for the influence from jy_t on y_t and for the influence from y_t on jy_t. But trend term t and $p+1$ (original lag plus one) are added for the estimation.

$$y_t = \kappa_0 + \lambda t + \sum_{i=1}^{p+1} \alpha_i y_{t-i} + \sum_{i=1}^{p+1} \beta_i jy_{t-i} + u_t$$

$$H_0 : \beta_1 = \beta_2 = \cdots \beta_p = 0 \qquad (3)$$

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

$$jy_t = \varsigma_0 + \eta t + \sum_{i=1}^{p+1} \gamma_i y_{t-i} + \sum_{i=1}^{p+1} \delta_i jy_{t-i} + v_t$$

$$H_0 : \gamma_1 = \gamma_2 = \cdots \gamma_p = 0 \qquad (4)$$

$$H_1 : \text{Either } \gamma_i \neq 0 \quad (i = 1,2,\cdots,p)$$

y_t = Japanese Yen Interest Rate Swap rate

jy_t = Japanese Government Bond yield

The F test is conducted by estimating (3) and (4) through OLS and summing the squared error. If the null hypothesis of H_0 in the equation (3) is rejected, jy_t is considered to explain y_t. If the null hypothesis of H_0 in the equation (4) is rejected, y_t is considered to explain jy_t.

4. Result

4.1 *Unit Root Test*

ADF test and PP test are conducted both for with time trend and without time trend. AIC standard is used for the determination of lag length in the ADF Test. The critical point of 5% for the t type of T = ∞ is – 2.86 (without trend) and – 3.41 (with trend)[11].

The results are shown on Table 1 and Table 2. There is no denying that all the variables for both Sample A and Sample B are non-stationary. Next, the data with first difference from original data are analyzed by ADFtest and PP test. It's possible to conclude that all the variables in both Sample A and Sample B are I (1). The results are shown on the Table 3 and Table 4.

[11] Fuller (1976) provides table for critical values.

Table 1 ADF Test Original Series

Sample A

Variable	Without Trend	With Trend
JY2	-0.873	-1.603
JY3	-0.879	-1.832
JY4	-0.840	-2.051
JY5	-0.716	-2.365
JY7	-0.757	-2.409
JY10	-0.680	-1.970
Y2	-0.805	-1.843
Y3	-0.793	-2.063
Y4	-0.644	-2.045
Y5	-0.640	-2.242
Y7	-0.669	-2.410
Y10	-0.777	-2.547

* 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 Yen Interest Rate Swap Rate

Sample B

Variable	Without Trend	With Trend
JY2	-0.284	-0.002
JY3	-0.706	-0.437
JY4	-1.063	-0.772
JY5	-1.327	-1.033
JY7	-1.825	-1.590
JY10	-2.342	-2.104
Y2	-0.188	-0.072
Y3	-0.538	-0.310
Y4	-0.853	-0.589
Y5	-1.097	-0.795
Y7	-1.448	-1.123
Y10	-1.645	-1.312

* 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 Yen Interest Rate Swap Rate

Table 2 PP Test Original Series

Sample A

Variable	Without Trend	With Trend
JY2	-0.725	-1.624
JY3	-0.755	-1.969
JY4	-0.737	-2.322
JY5	-0.716	-2.782
JY7	-0.758	-2.908
JY10	-0.681	-2.466
Y2	-0.667	-1.988
Y3	-0.678	-2.270
Y4	-0.645	-2.495
Y5	-0.640	-2.705
Y7	-0.669	-2.962
Y10	-0.778	-2.940

* 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 Yen Interest Rate Swap Rate

Sample B

Variable	Without Trend	With Trend
JY2	-0.712	-0.408
JY3	-1.728	-1.469
JY4	-2.095	-1.791
JY5	-2.274	-1.945
JY7	-2.618	-2.317
JY10	-2.966	-2.671
Y2	-0.207	-0.086
Y3	-0.716	-0.432
Y4	-1.171	-0.812
Y5	-1.412	-0.979
Y7	-1.787	-1.307
Y10	1.976	-1.465

* 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 Yen Interest Rate Swap Rate

Table 3 ADF Test Series with First Difference

Sample A

Variable	Without Trend	With Trend
⊿JY2	-30.388*	-30.336*
⊿JY3	-31.396*	-31.374*
⊿JY4	-32.166*	-32.147*
⊿JY5	-32.949*	-33.002*
⊿JY7	-35.248*	-35.667*
⊿JY10	-32.878*	-33.147*
⊿Y2	-31.653*	-31.535*
⊿Y3	-32.126*	-32.058*
⊿Y4	-33.047*	-32.970*
⊿Y5	-33.619*	-33.553*
⊿Y7	-34.640*	-34.831*
⊿Y10	-27.092*	-27.335*

* 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 Yen Interest Rate Swap Rate

Sample B

Variable	Without Trend	With Trend
⊿JY2	-8.962*	-8.952*
⊿JY3	-22.212*	-21.853*
⊿JY4	-8.892*	-8.888*
⊿JY5	-9.182*	-9.188*
⊿JY7	-9.109*	-9.122*
⊿JY10	-9.084*	-9.096*
⊿Y2	-22.75*	-22.200*
⊿Y3	-9.517*	-9.500*
⊿Y4	-10.056*	-10.041*
⊿Y5	-11.175*	-11.166*
⊿Y7	-9.817*	-9.812*
⊿Y10	-10.556*	-10.560*

* 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 Yen Interest Rate Swap Rate

Table 4 PP Test Series with First Difference

Sample A

Variable	Without Trend	With Trend
⊿JY2	-30.412*	-31.424*
⊿JY3	-31.421*	-31.424*
⊿JY4	-32.191*	-32.197*
⊿JY5	-32.975*	-32.984*
⊿JY7	-32.276*	-35.280*
⊿JY10	-32.904*	-32.951*
⊿Y2	-31.678*	-31.684*
⊿Y3	-32.152*	-32.159*
⊿Y4	-33.073*	-33.082*
⊿Y5	-33.646*	-33.654*
⊿Y7	-34.667*	-34.673*
⊿Y10	-35.516*	-35.519*

* 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 Yen Interest Rate Swap Rate

Sample B

Variable	Without Trend	With Trend
⊿JY2	-38.429*	-38.533*
⊿JY3	-41.423*	-41.507*
⊿JY4	-41.662*	-41.736*
⊿JY5	-42.516*	-42.586*
⊿JY7	-43.595*	-43.586*
⊿JY10	-43.718*	-43.647*
⊿Y2	-36.983*	-43.766*
⊿Y3	-37.146*	-37.087*
⊿Y4	-38.343*	-37.245*
⊿Y5	-39.250*	-38.435*
⊿Y7	-41.300*	-39.338*
⊿Y10	-41.314*	-41.373*

* 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 Yen Interest Rate Swap Rate

4.2 *Cointegration Test*

Cointegration tests by Engle and Granger (1987) are conducted. For the critical values, numbers provided by MacKinnon (1991) are used. The results are shown on the Table 5. In Sample A, Japanese Yen Interest Rate Swap rates and Japanese Government Bond yields are in the relationship of cointegration from 2 years through 10 years.

On the other hand, in Sample B, Japanese Yen Interest Rate Swap rates are cointegrated with Japanese Government Bond yields from 2 years through 7 years. In the term structure of 10 years, no cointegration relationship is found. This result indicates that the market segmentation was confirmed between Japanese Government Bond and Japanese Interest Rate Swap in the zone of 10 years in Sample B.

Table 5 Cointegration Test

Sample A

Variables	Test Statistics
JY2-Y2	-3.966*
JY3-Y3	-3.568*
JY4-Y4	-3.336**
JY5-Y5	-3.317**
JY7-Y7	-3.662*
JY10-Y10	-5.192*

Sample B

Variables	Test Statistics
JY2-Y2	-4.851*
JY3-Y3	-3.820*
JY4-Y4	-3.505*
JY5-Y5	-3.336**
JY7-Y7	-3.323**
JY10-Y10	-2.788

Critical value is -3.338(5%) , -3.046(10%) from MacKinnon(1991).

* indicates significant 5% and ** indicates significant 10%.

JY=Japanese Government Bond Yield ,Y=Japanese Yen Interest Rate Swap Rate

Next, dynamic OLS by Stock and Watson (1993) are used to check if β indicated in the equation (1) is one. The results are shown on the Table 6. In Sample A $\beta = 1$ can't be rejected from 2 years through 7 years, which means that a 1% rise (decline) in Japanese Government Bond yield lead to a 1% rise (decline) in Japanese Yen Interest Rate Swap rate. In other words, swap spreads are considered to be constant. In 10 years β is 0.952 ,which means that a 1% rise (decline) in Japanese Government Bond yield lead to a less than 1% rise (decline) in Japanese Yen Interest Rate Swap rate. In other words, a rise (a decline) in Japanese Government Bond yield is associated with a decline (a rise) in the swap spread.

On the other hand, in Sample B β is larger than one from 2 years through 10 years, which means that a 1% rise(decline) in Japanese Government Bond yield lead to a more than 1% rise(decline) in Japanese Yen Interest Rate Swap rate. In other words, a rise (a decline) in Japanese Government Bond yield is associated with a rise (a decline) in the swap spread. As maturity gets longer, β becomes larger. This fact indicates that Interest Rate Swap rates get more volatile in longer terms.

Table 6 Test on the Cointegration Vector

Sample A

Variables	β	Modified SE	Test Statistics
JY2-Y2	1.026	0.021	1.235*
JY3-Y3	1.055	0.032	1.732*
JY4-Y4	1.067	0.035	1.901*
JY5-Y5	1.046	0.030	1.546*
JY7-Y7	0.983	0.016	1.096*
JY10-Y10	0.952	0.013	3.692

Sample B

Variables	β	Modified SE	Test Statistics
JY2-Y2	1.119	0.031	3.823
JY3-Y3	1.182	0.035	5.150
JY4-Y4	1.199	0.031	6.420
JY5-Y5	1.219	0.033	6.636
JY7-Y7	1.253	0.046	5.000
JY10-Y10	1.359	0.099	3.626

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 Yen Interest Rate Swap Rate

4.3 *Granger Causality Test*

Granger causality tests are conducted by using the method developed by Toda and Yamamoto (1995). The results are shown on the Table 7 and Table 8. In Sample A, Japanese Yen Interest Rate Swap rate and Japanese Government Bond yield affect mutually except for 5 years. In 5 years the causality from Japanese Yen Interest Rate Swap rate on Japanese Government Bond yield isn't observed. In Sample B, Japanese Yen Interest Rate Swap rate and Japanese Government Bond yield affect mutually.

As for the comparison of causality impacts between Sample A and Sample B, in Sample B mutual causality between Japanese Yen Interest Rate Swap rate and Japanese Government Bond yield is stronger than in Sample A.

Table 7 Granger Causality -Sample A

From JY on Y

Variables	Lag	Test Statistics
JY2 → Y2	13	2.173*
JY3 → Y3	7	2.463*
JY4 → Y4	11	2.202*
JY5 → Y5	4	2.680*
JY7 → Y7	9	3.684*
JY10 → Y10	10	1.964*

From Y on JY

Variables	Lag	Test Statistics
Y2 → JY2	13	1.868*
Y3 → JY3	7	2.270*
Y4 → JY4	11	2.048*
Y5 → JY5	4	1.566
Y7 → JY7	9	2.365*
Y10 → JY10	10	2.035*

* indicates significant at 5%.
Original lag is chosen by AIC standard. Test Statistics are *F* statistics.
The method by Toda and Yamamoto (1995) is used.
JY=Japanese Government Bond Yield ,Y=Japanese Yen Interest Rate Swap Rate

Table 8 Granger Causality -Sample B

From JY on Y

Variables	Lag	Test Statistics
JY2 → Y2	11	14.870*
JY3 → Y3	13	15.262*
JY4 → Y4	13	18.475*
JY5 → Y5	10	18.360*
JY7 → Y7	10	13.573*
JY10 → Y10	11	9.329*

From Y on JY

Variables	Lag	Test Statistics
Y2 → JY2	11	2.566*
Y3 → JY3	13	2.645*
Y4 → JY4	13	3.718*
Y5 → JY5	10	4.117*
Y7 → JY7	10	3.901*
Y10 → JY10	11	2.245*

* indicates significant at 5%.
Original lag is chosen by AIC standard. Test Statistics are F statistics.
The method by Toda and Yamamoto (1995) is used.
JY=Japanese Government Bond Yield ,Y=Japanese Yen Interest Rate Swap Rate

There seems to be three factors to support the phenomenon that in Sample B mutual causality between Japanese Yen Interest Rate Swap rate and Japanese Government Bond yield is stronger than in Sample A.

(1) Because of the commitment by the BOJ (Bank of Japan) to continue zero interest policy and quantitative easing policy for the time being, Japanese mid and long term interest rates decreased. But when the monetary policy change was anticipated, players were hurry in selling Japanese Government Bond market and paying in Japanese Yen Interest Rate Swap market.

(2) Japanese banks activated receiving in Japanese Yen Interest Rate Swap market to increase profit[12] in especially from 2001 through 2002. Thus Japanese Interest Rate Swap rates decreased sharply and swap spreads in 7 years and 10 years became negative.

[12] The extension of abolishing macro hedge accounting for another year promoted receiving activity. It was abolished on March 31, 2003.

⑶ The credit rating of Japanese Government Bond was downgraded a couple times from 2001 through 2003. This increased the risk premium of Japanese interest rates especially in the long term.

5. Concluding Remarks

The purpose of this paper is to analyze the relationship between Japanese Government Bond yields and Japanese Yen Interest Rate Swap rates by cointegration test and Granger causality test. Cointegration test enables us to know not only if Japanese Yen Interest Rate Swap rates are in the long run equilibrium with Japanese Government Bond yields in the corresponding term, but also if a rise or a decline in Japanese Government Bond yields is associated with a rise or a decline in the swap spreads. In addition to cointegration tests, Granger causality tests are conducted to check whether Japanese Yen Interest Rate Swap rates affects Japanese Government Bond yields or vice versa.

The whole sample is divided into two sub periods. The first sub period, named Sample A, is from January 4, 1994 through February 12, 1999. The second sub period, named Sample B, is from February 15, 1999 through June 30, 2006. Thus it's possible to know the characteristics of interest rates movement and swap spreads movement in both sample periods.

The cointegration tests reveal the following results. In Sample A, Japanese Yen Interest Rate Swap rates are in the long run equilibrium with Japanese Government Bond yields in the structure from 2 years through 10 years. On the other hand, in Sample B, Japanese Yen Interest Rate Swap rates are in the long run equilibrium with Japanese Government Bond yields only in the structure from 2 years through 7 years. Thus it's considered that market segmentation is observed in the structure of 10 years between Japanese Government Bond and Japanese Yen Interest Rate Swap in Sample B.

The cointegration vector tests reveal the following results. In Sample A, a 1% rise (decline) in Japanese Government Bond yields lead to a 1% rise (decline) in Japanese Yen Interest Rate Swap rates in the structure of 2 years, 3 years, 4 years, 5 years, and 7 years. In other words, swap spreads are considered to be constant. A 1% increase in Japanese Government Bond yield leads to a less than 1% increase in Japanese Yen Interest Rate swap rate in 10 years. In other words, a rise (a decline) in Japanese Government Bond yield is associated with a decline (a rise) in the swap spread in 10 years.

On the other hand, in Sample B, a 1% increase in Japanese Government Bond yields lead to a more than 1% increase in Japanese Yen Interest Rate swap rates in the structure of 2 years, 3 years, 4 years, 5 years, 7 years and 10 years. In other words, a rise (a decline) in Japanese Government Bond yield is associated with a rise (a decline) in the swap spread.

The Granger causality tests reveal the following results. In Sample A except for 5 years, Japanese Yen Interest Rate Swap rates and Japanese Government Bond yields affect mutually. In 5 years the causality from Japanese Yen Interest Rate swap rate on Japanese Government Bond yield isn't observed. In Sample B, Japanese Yen Interest Rate swap rates and Japanese Government Bond yields affect mutually in all maturities.

As for the comparison of causality impacts between Sample A and Sample B, in Sample B mutual causality between Japanese Yen Interest Rate Swap rates and Japanese Government Bond yields is stronger than in Sample A. Especially the impacts of Japanese Government Bond yields on Japanese Yen Interest Rate Swap rates are much stronger in Sample B than in Sample A. Thus it's considered that both in Sample A and in Sample B, Japanese Government Bond market possibly lead Japanese Yen Interest rate Swap market.

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