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Japanese Long-Term Interest Rates under the Quantitative and Qualitative Easing Policy- Analysis of JGB and IRS Markets

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Abstract

This paper analyzes the relationship between Japanese government bond (JGB) and interest rate swap (IRS) markets under the quantitative and qualitative easing policy. IRS rates and JGB yields on seven-, ten-, and 30-year maturities are in a long-run equilibrium. In these maturities, JGB yields propel IRS rates unilaterally. In the case of ten- and 30-year maturities, a 1% increase in JGB yield leads to a 1% increase in IRS rate. In the case of seven-year maturities, a 1% increase in JGB yields leads to an increase below 1% (0.789) in IRS rate. On the other hand, Market segmentation between JGB and IRS markets is confirmed in the case of three- and five-year maturities. The results of this paper suggest that the aggressive monetary policy introduced by the Bank of Japan (BOJ) has had flattening effects on the long-term maturities of JGB yields, propelling IRS rates into lower levels.

Keywords: Cointegration, Japanese Long-Term Interest Rate, Market Segmentation, Quantitative and Qualitative Easing Policy

1. Introduction

After the Liberal Democratic Party (LDP) won a majority in the Lower House election on December 16, 2012, Mr. Shinzo Abe was elected to a second term as Prime Minister of Japan. He advocated what has since been called Abenomics, which is based upon three pillars: fiscal stimulus, aggressive monetary easing, and structural reform. Specific policies include targeting inflation at an annual rate of 2%, correction of excessive appreciation of the yen, radical quantitative easing, and an expansion of public investment.

In addition to fiscal stimulus and structural reforms, the market expected an aggressive monetary policy immediately after the introduction of Abenomics. The Bank of Japan (BOJ), under its new governor, Mr. Kuroda, introduced a much stronger monetary policy called quantitative and

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qualitative monetary easing on April 4, 2013. The BOJ decided to double the monetary base and the amounts of Japanese government bonds (JGBs) and exchange traded funds (ETFs) outstanding in two years, and more than double the average remaining maturity of JGB purchases.

This paper examines long-term interest rates, specifically the relationship between JGB yields and interest rate swap (IRS) rates, under the regime of quantitative and qualitative easing policy. This analysis gives market practitioners insight into investment and funding in the JGB and IRS markets. For example, Japanese banks use JGB and IRS markets for asset and liability management (ALM).

Japanese long-term interest rates comprise JGB and IRS. The corporate bond market is very illiquid in Japan. IRS 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 payments can be transformed into floating payments 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, they could be based on the six-month London Interbank Offered Rate (LIBOR).

Differences between IRS rates and JGB yields of the same maturity are referred to as swap spreads. If the IRS and JGB markets are efficiently priced, swap spreads may reveal something about the perception of the systemic risk of the banking sector. The market for IRS has grown exponentially since the 1990s. According to a survey by the Bank for International Settlements (BIS), the notional outstanding volume of transactions of Japanese yen interest rate derivatives amounted to 46,127 billion US dollars at the end of December 2014.[1]

So far, with the exception of Ito (2009), the relationship between JGB yields and IRS rates has mainly been analyzed within the framework of interest rate swap spreads. 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) have analyzed IRS spreads in US dollar markets. Very few studies have analyzed Japanese yen IRS spreads: Hamano (1997), Eom et al. (2000), and Ito (2007).

Hamano (1997) focused not on credit risk but on market factors such as TED spreads, and found that swap spreads reflect TED spread and that longer-term swap spreads are less influenced by TED spread. Eom et al. (2000) focused on credit risk and concluded that yen swap spreads are significantly related to proxies for the long-term credit risk factor. They also found that swap spreads are also negatively related to the level and slope of the term structure. Ito (2007) investigated the determinants of IRS spreads in Japan, choosing four determinants of swap spreads – TED spread, corporate bond spread, interest rated and the slope of yield curve. Swap spreads of two to four years are mostly influenced by TED spread, interest rate, and slope. Five-year swap spreads are mostly decided by corporate bond spread and slope. Seven- and ten-year swap spreads are mostly affected by corporate bond spread.

[1] Statistics are cited from OTC derivatives market activity in the first half of 2003. At the end of June 1998, the notional outstanding volume of transactions of yen interest rate derivatives was 7,164 billion US dollars. For details, see BIS (1998) and BIS (2015).

The approach of this paper differs from the studies mentioned above. I use a cointegration approach to analyze the relationship between JGB yields and IRS rates. Morris et al. (1998) used this approach to analyze the relationship between US government securities and corporate bonds markets. Ito (2009) used it to analyze the relationship between JGB and IRS markets in data covering the period January 4, 1994 to February 27, 2009. In the latter part of Ito's sample, starting from February 15, 1999, the long-run equilibrium of JGB yields with IRS rates was found only in four-year, five-year, and seven-year maturities. The latter part of the sample includes the period of zero interest rate policy and quantitative easing policy. After the BOJ introduced its zero interest rate policy in February 15 1999, the interest rate market was considered to be structurally changed because there was little room for the BOJ to change the unsecured overnight call rate as before. After the BOJ introduced quantitative easing in March 2001, swap spreads of seven years and ten years sometimes became negative.

This approach enables us to know not only whether JGB yields are in a long-run equilibrium with IRS rates in the corresponding term, but also whether a rise or decline in JGB yield is associated with a rise or a decline in swap spread. In addition to cointegration tests, Granger causality tests are conducted to check whether IRS rates (y_t) propel JGB yields (jy_t), jy_t propels y_t, or y_t and jy_t propel each other mutually.

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

2. Data

JGB yields and IRS rates for three-, five-, seven-, ten- and 30-year maturities are used. The daily data are provided by Bloomberg. The sample period of approximately two years and eight months runs from January 4, 2013 to August 24, 2015. Four series of data are shown in Figure 1. Though the quantitative and qualitative monetary easing policy was introduced on April 4, 2013, the financial market had been anticipating a strong easing policy for a few months. Thus the start of the sample period is set as January 4, 2013.

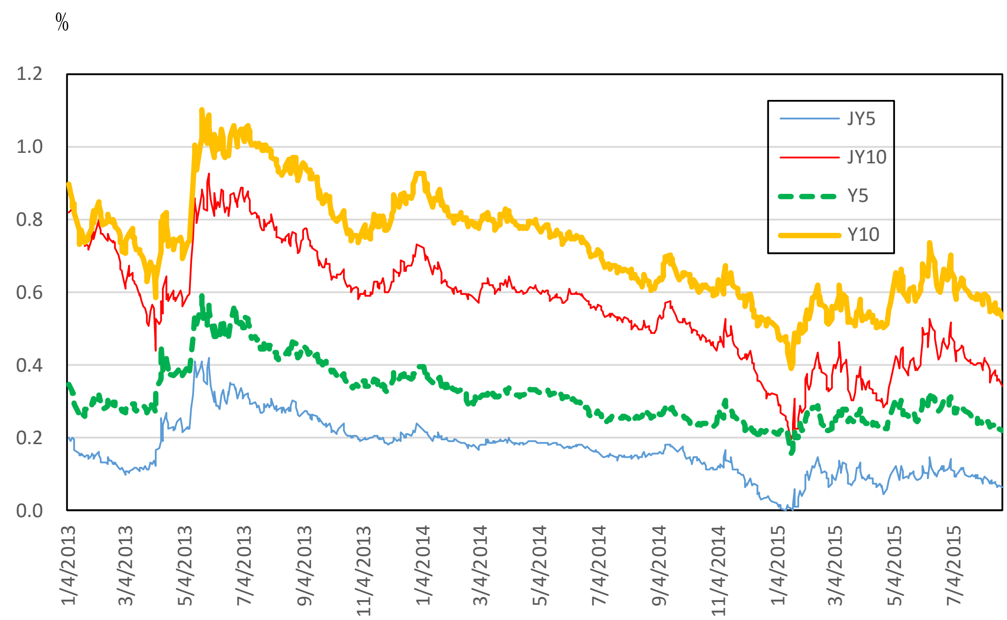

Figure 1 Movement of Four Series

Notes: Four data series from Januray 4, 2013 to August 24. 2015 are shown.
JY5 is 5-year Japanese government bond yield.
Y5 is 5-year Japanese interes rate swap rate.
JY10 is 10-year Japanese government bond yield.
Y10 is 10-year Japanese interest rate swap rate. Data soure is Bloomberg.

3. Methodology

3.1 Unit Root Test

Because empirical analysis from the mid-1980s through the mid-1990s shows that such data as interest rates, foreign exchange, 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[2] and the Phillips-Perron (PP) test are used.[3] Both tests define the null hypothesis as "unit roots exist" and the alternative hypothesis as "unit roots do not exist." Fuller (1976) provided a table for the ADF and PP tests.

3.2 Cointegration Test and Market Segmentation

A cointegration framework is presented to analyze the relationship between swap rate and JGB yield. Ordinary least squares (OLS) is the method generally used to analyze the relationships among the variables. However, when non-stationary variables are included, the ordinary hypothesis test tends to draw inaccurate results since the coefficients of determination and *t*-statistics do not follow a simple distribution.

Granger and Newbold (1974) called this problem "spurious regression." Phillips (1986) pointed out two facts about the analysis of non-stationary data: (1) the coefficient of determination tends

[2] See Dickey and Fuller (1979) and Dickey and Fuller (1981).
[3] See Phillips and Perron (1988).

not to measure the relationships among variables, and (2) estimated equations with a low Durbin-Watson ratio can present the problem of spurious regression.

Non-stationary time series wander widely in terms of 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 relationship was called "cointegration" by Engle and Granger (1987). In the test for cointegration, equation (1) is estimated by OLS to determine whether the residual contains unit roots.

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

y_t = IRS 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 IRS rate and JGB yield move together in the long-run equilibrium. In testing a cointegration relationship, a pair of IRS rate and JGB yield of the same maturity is used. When no cointegration relationship is found in a maturity, market segmentation between two markets is considered to be observed.

In addition to testing whether IRS rate and JGB yield are in a relationship of cointegration, the cointegration vector, β in equation (1), is checked with the dynamic OLS method developed by Stock and Watson (1993). Equation (2) is used to test whether β = 1 can be rejected. Δjy_{t-i} is lead and lag variables of JGB yield.[4] This test is conducted only for pairs of IRS rates and JGB yields found to be in a relationship of cointegration.

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

When β is equal to 1, a 1% increase in JGB yield leads to a 1% increase in IRS rate. When β is less than 1, a 1% increase in JGB yield leads to an increase below 1% in IRS rate. In other words, a rise (a decline) in JGB yield is associated with a decline (an increase) in IRS spread.

On the other hand, when β is greater than 1, a 1% increase in JGB yield leads to an increase greater than 1% in IRS rate. In other words, an increase (a decrease) in JGB yield is associated with an increase (a decrease) in the IRS spread.

3.3 Granger Causality Test

The Granger causality test checks whether IRS rates (y_t) propel JGB yields (jy_t), jy_t propels y_t, or y_t and jy_t propel each other mutually in the time series model with regard to variables y_t and jy_t. The original data are usually transformed into a change ratio to avoid the problem of spurious regression. But using these data is considered to cause errors. Toda and Yamamoto (1995) developed the Granger causality test in which non-stationary data are used directly. According to their method, the null hypothesis H_0 is tested as for the influence of jy_t to y_t and

[4] Twelve lead and lag terms are used. The results are the same when six and nine terms are used.

for the influence of y_t to jy_t. But trend term *t* and *p + 1* (original lag plus one) are added for the estimation.

$$y_t = \kappa_0 + \lambda t + \sum_{i=1}^{p+1} \alpha_i y_{t-i} + \sum_{i=1}^{p+1} \beta_i jy_{t-i} + u_t \tag{3}$$

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

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

$$jy_t = \varsigma_0 + \eta t + \sum_{i=1}^{p+1} \gamma_i y_{t-i} + \sum_{i=1}^{p+1} \delta_i jy_{t-i} + v_t \tag{4}$$

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

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

y_t = IRS rate, jy_t = JGB 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 equation (3) is rejected, jy_t is considered to explain y_t. If the null hypothesis of H_0 in equation (4) is rejected, y_t is considered to explain jy_t .

4. Results

4.1 Unit Root Test

ADF and PP tests are conducted to check for both with time trends and without time trends. The BIC standard is used for the determination of lag length in the ADF test. The critical point of 5% for the *t* type of $T = \infty$ is -2.86 (without trend) and -3.41 (with trend).[5]

The results are shown in Table 1 and Table 2.[6] 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 the original data are analyzed by ADF and PP tests. It is possible to conclude that all the variables in both Sample A and Sample B are *I* (1). The results are shown in Tables 3 and 4.

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

[6] Though the result of the PP test with trend for seven-year JGB shows significance at the 5% level, it does not show significance at the 1% level. The critical value for 1% is −3.977.

Table 1 ADF Test Original Series

Variable	Without Trend	With Trend
JY3	−1.251	−2.865
JY5	−1.183	−3.289
JY7	−1.229	−3.103
JY10	−1.351	−3.169
JY30	−1.163	−3.346
Y3	−0.852	−3.330
Y5	−0.840	−3.379
Y7	−0.903	−3.250
Y10	−1.020	−3.135
Y30	−1.123	−3.108

Notes:
* indicates significance at the 5 % level.
5% critical values are −2.89 (without trend), −3.45 (with trend).
JY = Japanese government bond yield, Y = Japanese interest rate swap rate

Table 2 PP Test Original Series

Variable	Without Trend	With Trend
JY3	−1.618	−2.824
JY5	−1.946	−3.023
JY7	−2.044	−3.687*
JY10	−1.795	−3.192
JY30	−2.183	−3.053
Y3	−1.588	−2.990
Y5	−1.922	−2.852
Y7	−1.877	−2.792
Y10	−1.749	−2.817
Y30	−1.693	−3.172

Notes:
* indicates significance at the 5 % level.
5% critical values are −2.89 (without trend), −3.45 (with trend).
JY = Japanese government bond yield, Y = Japanese interest rate swap rate

Table 3 ADF Test Series with First Difference

Variable	Without Trend	With Trend
⊿ JY3	−28.464*	−28.362*
⊿ JY5	−20.490*	−20.437*
⊿ JY7	−11.316*	−11.269*
⊿ JY10	−10.725*	−10.824*
⊿ JY30	−23.054*	−22.854*
⊿ Y3	−28.403*	−28.453*
⊿ Y5	−27.267*	−27.332*
⊿ Y7	−26.408*	−26.486*
⊿ Y10	−25.819*	−25.877*
⊿ Y30	−20.398*	−20.010*

Notes:
* indicates significance at the 5 % level.
5% critical values are −2.89 (without trend), −3.45 (with trend).
JY = Japanese government bond yield, Y = Japanese interest rate swap rate

Table 4 PP Test Series with First Difference

Variable	Without Trend	With Trend
⊿ JY3	−28.498*	−28.507*
⊿ JY5	−26.687*	−26.694*
⊿ JY7	−28.941*	−28.946*
⊿ JY10	−25.833*	−25.833*
⊿ JY30	−23.100*	−23.103*
⊿ Y3	−28.436*	−28.446*
⊿ Y5	−27.293*	−27.301*
⊿ Y7	−26.437*	−26.441*
⊿ Y10	−25.855*	−25.856*
⊿ Y30	−25.088*	−25.087*

Notes:
* indicates significance at the 5 % level.
5% critical values are −2.89 (without trend), −3.45 (with trend).
JY = Japanese government bond yield, Y = Japanese interest rate swap rate

4.2 Cointegration Test

Engle and Granger's (1987) cointegration test is conducted on pairs of IRS rates and JGB yields of the same maturity. The numbers provided by MacKinnon (1991) are used for the critical values. The results are shown in Table 5. IRS rates and JGB yields are in a cointegration relationship for maturities of seven, ten, and 30 years, but not those of three and five years. This result indicates confirmation of market segmentation between JGB and IRS markets for three- and five-year maturities.

Table 5 Cointegration Test

Variables	Test Statistics
JY3-Y3	−2.858
JY5-Y5	−3.593
JY7-Y7	−4.550*
JY10-Y10	−4.127*
JY30-Y30	−5.488*

Notes:
Critical value is −3.7809 (5%) from MacKinnon (1991).
* indicates significance at the 5 % level.
JY = Japanese government bond yield, Y = Japanese interest rate swap rate

Next, Stock and Watson's (1993) dynamic OLS method is used to check whether β indicated in equation (1) equals 1. The tests are conducted only for the pairs of seven-, ten-, and 30-year maturities found to be in a cointegration relationship. The results are shown in Table 6. In Sample A, β = 1 cannot be rejected in the case of ten- and 30-year maturities, which means that a 1% increase in JGB yield leads to a 1% increase in IRS rate. In the case of seven-year maturities, β equals 0.789, which means that a 1% increase in JGB yields leads to an increase of less than 1% (0.789) in IRS rate.

Table 6 Test on the Cointegration Vector

Variables	β	Modified SE	Test Statistics
JY7-Y7	0.789	0.054	3.907
JY10-Y10	0.934	0.061	1.082*
JY30-Y30	1.103	0.087	1.184*

Notes:
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 cannot be rejected.
JY = Japanese government bond yield, Y = Japanese interest rate swap rate

4.3 Granger Causality Test

The Granger causality test is conducted using the method developed by Toda and Yamamoto (1995). The results are shown in Tables 7. JGB yield Granger-causes IRS rates in all maturities. On the other hand, IRS rates Granger-cause JGB yields only in the case of three- and five-year maturities. These mutual Granger-causalities between IRS rates and JGB yields are considered to be one of the reasons why there is no cointegration relationship in maturities of three and five years.

Table 7 Granger Causality Test

From JY to Y

Variables	Test Statistics
JY3 → Y3	3.938*
JY5 → Y5	3.961*
JY7 → Y7	13.143*
JY10 → Y10	7.329*
JY30 → Y30	14.573*

From Y to JY

Variables	Test Statistics
Y3 → JY3	5.217*
Y5 → JY5	3.896*
Y7 → JY7	0.995
Y10 → JY10	2.045
Y30 → JY30	0.897

Notes:
* indicates significance at the 5 % level.
Original lag is chosen by BIC standard.
The method by Toda and Yamamoto (1995) is used.
JY = Japanese government bond yield, Y = Japanese interest rate swap rate

5. Concluding Remarks

This paper has examined long-term interest rates, and specifically the relationship between JGB yields and IRS rates, under the regime of quantitative and qualitative easing policy. JGB yields and IRS rates are in a relationship of equilibrium in the case of seven-, ten-, and 30-year maturities, but not three- or five-year maturities. Market segmentation between JGB and IRS markets is confirmed in the case of three- and five-year maturities. In the case of ten- and 30-year maturities, a 1% increase in JGB yield leads to a 1% increase in IRS rate. In seven-year maturities, a 1% increase in JGB yields leads to an increase below 1% (0.789) in IRS rate. In other words, a rise (a decline) in JGB yield is associated with a decline (a rise) in the swap spread of seven-year maturities.

JGB yields and IRS rates influence one another mutually in three- and five-year maturities. On the other hand, JGB yields influence IRS swap rates unilaterally in the case of seven-, ten- and 30-year maturities. Thus it is concluded that JGB yields propel IRS rates in the case of seven- , ten-, and 30-year maturities. The results of this paper suggest that the aggressive monetary policy introduced by the BOJ has had flattening effects on the long-term zone of JGB, thus propelling lower rates of IRS in maturities of seven, ten, and 30 years. The quantitative and qualitative easing policy has been successful in the sense that both yield curves of JGB and IRS have flattened as the BOJ projected.

References

Bank for International Settlements (1998). *Global OTC Derivatives Market at End-June 1998*.

Bank for International Settlements (2015). *OTC Derivatives Statistics at End-December 2014*.

Brown, K., Harlow, W., and Smith, D.J. (1994). An Empirical Analysis of Interest Rate Swap Spreads. *Journal of Fixed Income*, March, 61-78.

Cossin, D. and Pirotte, H. (1997). Swap Credit Risk: An Empirical Investigation on Transaction Data. *Journal of Banking & Finance*, 21, 1351-1373.

Dickey, D.A. and Fuller, W. (1979). Distribution of the Estimators for Autoregressive Time Series with a Unit Root, *Journal of the American Statistical Association*,74, 427-431 .

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

Duffie, D. and Huang, M. (1996). Swap Rates and Credit Quality. *Journal of Finance*, 51,921-949.

Engle, R.F. and Granger, C.W.J. (1987). Co-Integration and Error Correction: Representation, and Testing. *Econometrica*, 55, 251-276.

Eom, Y.H., Subrahmanyam, M.G., and Uno, J. (2000). Credit Risk and the Yen Interest Rate Swap Market. *Unpublished manuscript, Stern Business School*, New York.

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

Granger, C.W.J. and Newbold, P. (1974). Spurious Regressions in Econometrics. *Journal of Econometrics*, 2,111-120.

Hamano, M. (1997). Empirical Study of the Yen Interest Rate Swap Spread. *Gendai Finance (Modern Finance)*, 1, 55-67.

Ito, T. (2007). The Analysis of Interest Rate Swap Spreads in Japan. *Applied Financial Economics Letters*, 3, 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*, 13, 14-30.

Lang, L.H.P., Litzenberger, R.H., and Liu, L.A. (1998). Determinants of Interest Rate Swap Spreads. *Journal of Banking and Finance*, 22, 1507-1532.

Lekkos, I. and Milas, C. (2001). Identifying the Factors that Affect Interest Rate Swap Spreads: Some Evidence from the United States and the United Kingdom. *Journal of Futures Markets*, 21, 737-768.

MacKinnon, J. (1991). Critical Values for Cointegration Tests. R.F. Engle and C.W.J. Granger (ed.), *Long-Run Economic Relationships: Readings in Cointegration*, Oxford University Press, 267-276.

Minton, B.A. (1997). An Empirical Examination of Basic Valuation Models for Plain Vanilla U.S. Interest Rate Swaps. *Journal of Financial Economics*, 44, 251-277.

Morris, C., Neal, R., and Rolph, D. (1998). Credit Spreads and Interest Rates: A Cointegration Approach," *Federal Reserve Bank of Kansas City Research Working Paper*, RWP 98-08.
Phillips, P.C.B. (1986). Understanding Spurious Regressions in Econometrics. *Journal of Econometrics*, 33, 311-340.
Phillips, P.C.B. and Perron, P. (1988). Testing for a Unit Root in Time Series Regression. *Biometrica*, 75, 335-346.
Sun, T., Sundaresan, S., and Wang, C. (1993). Interest Rate Swaps: An Empirical Investigation. *Journal of Financial Economics*, 34, 77-99.
Toda, H.Y. and Yamamoto, T. (1995). Statistical Inference in Vector Autoregressions with Possibly Integrated Processes. *Journal of Econometrics*, 66, 225-250.