金融学会 2002 年度秋季大会報告論文　　於　関西学院大学

Interest Rates Comovement between Japan and USA
- Considering the Difference of Economic Cycles -

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Abstract

This paper examines the international linkage of interest rates between YEN and USD from 1 month through 10 year by unit root tests, cointegration, and Granger causality test. The whole sample from October 2,1990 through August 11,2000 is divided into two sub periods. The first sub period, named Sample A, is from October2, 1990 through May 17,1993. In Sample A the monetary policy regimes both in Japan and US are easing. The second sub period, named Sample B, is from May 18,1993 through Aug 11,2000. In Sample B the monetary policy regime in Japan is easing, but in US it's tightening. We find evidence for closer long-run international linkage between YEN and USD in the term structure from 3 month through 10 year during Sample A. YEN/USD exchange rates are found to have a long run relationship with YEN and USD interest rates in the term structure of 3 month through 5 year. On the other hand, during Sample B, we find evidence for long-run international linkages from 3 month through 9 month. YEN/USD exchange rates are found to have a long run relationship with YEN and USD interest rates in the term structure of 3 month through 9 month.

Keywords: Interest Rates Comovement, Johansen Cointegration, Granger Causality
Economic Cycle, YEN/USD Exchange Rate

JEL Classification: C32, E43, E52

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1.Introduction

This paper analyzes the relationship of interest rates between YEN and USD from October 2, 1990 through August 11,2000. The whole sample from October 2,1990 through August 11,2000 is divided into two sub periods. The first sub period, named Sample A, is from October2, 1990 through May 17,1993. In Sample A the monetary policy regimes both in Japan and US are easing. The second sub period, named Sample B, is from May 18,1993 through Aug 11,2000. In Sample B the monetary policy regime in Japan is easing, but in US it's tightening.

The international integration of financial markets has increased dramatically since the beginning of 1980's.[1] The development and increase of new financial instruments such as currency and interest rate swaps have stimulated the integration of financial markets by giving investors a wider range of choices than previously available in domestic markets. However the international integration of financial markets does not necessarily work to equalize interest rates among different countries.[2]

Bank for International Settlements [1989] provides wide range of survey and empirical result to conclude generally that the correlations of long-term interest rates among the three major economies were higher on average in the 1980's than during the 1970's. Frankel [1989] supports this view by Bank for International Settlements [1989]. But Christiansen/Pigott [1997] point out that there seems to have been no further increase in the synchronization of long-term interest rates since the early 1980's. Kasman/Pigott [1988] report that the increase of international integration in financial markets doesn't necessarily lead to the convergence of nominal interest rates.

Troop [1994] and Christiansen/Pigott [1997] apply non-stationary time series methods such as unit root test and cointegration, etc. Troop [1994] finds that in the 1980's there was no measurable tendency for real short and long-term interest rates between the U.S and the major industrial counties

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1 Blundell-Wignall/Browne [1991], Frankel [1992] and Goldstein/Mussa [1993] show that the globalization of financial markets increased markedly in the 1980's. According to Frankel[1992], the Feldstein-Horioka condition,real interest parity,uncovered interest parity and covered interest parity are four distinct definitions of perfect capital mobility.

2 As for the integration of equity markets, Hirayama/Tutsui[1998] condcts empirical analysis by using cointegration and VAR to find that in the latter half of the sample, the integration of international stock markets intensified.

to converge. Christiansen/ Pigott [1997] conclude that bilateral co variation of long-term interest rates has gone up in the 1990's among some European counties but there is no evidence of any substantial increase for counties with floating exchange rates such as Japan and USA.

Berk [2001] provides extensive studies on international comovement of long term bonds from international business cycles and inflation expectations to find that there seems no to be any convincing evidence towards a particular direction of causality among major 6 industrialized nations.

In view of these previous studies, the following features characterize this paper. First, this paper uses the whole term structure of YEN and USD interest rates from 1 month through 10 year. In this way, whether the whole term structure between YEN and USD has a long run relationship or some parts of the yield curves are in long run equilibriums. Second, the whole sample period is divided into two based upon the monetary policy regimes. Thus investigating the interest rate linkages in different monetary policy regimes or economic cycles can be possible.

The remainder of the paper is organized as follows; in Section 2, the method is explained. Section 3 mentions the data used for the analysis. Section 4 presents the empirical results. Section 5 is the concluding remarks.

2. Method

2.1 *Unit Root Test*

Since the empirical analysis from mid-1980 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 and Perron) test are used.[3] The ADF test and PP test defines null hypothesis as 'unit roots exist' and alternative hypothesis as 'unit roots don't exist'.

3 For the details of methods, see Dickey/Fuller [1979],Dickey/Fuller [1981] and Phillips/Perron [1988].

2.2 *Cointegration Test*

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 comovement with long-run equilibrium.[4] This is called as cointegration. The main idea behind cointegration is a specification of models that include beliefs about the movements of variables relative to each other in the long-run, such as multivariate relationships between different interest rates.

Thus a common stochastic trend (s) in a system of interest rates can be interpreted to mean that the stochastic trend in one individual interest rate is related to the stochastic trend in some other interest rates. There are more than one method of conducting cointegration tests. In this paper, the method developed by Johansen (1988) and Johansen/Juselius (1990) is uesed. The Johansen maximum likelihood approach sets up the non-stationary time series as vector autoregressive (VAR).

$$\Delta X_t = c + \sum_{i=1}^{N} \Gamma_i \Delta X_{t-i} + \Pi X_{t-1} + \eta_t, \qquad (1)$$

where $X_t = (YEN\ Rate_t, USD\ Rate_t)$ $\qquad \eta_t \sim niid(0, \delta)$

where X_t is a vector of non-stationary (in levels) variables, Δ implies first difference and C is the constant term. The information on the coefficient matrix between the levels of the series Π is decomposed as $\Pi = \alpha \beta'$ where the relevant elements of the α matrix are the adjustment coefficients and β matrix contains the cointegrating vectors. The Johansen method provides two different tests, the trace test and the maximal eigenvalue test to determine the number of cointegration vector(s). Osterwald-Lenum(1992) provides the table for critical values.

In this paper, first each pair of interest rates (for example, 2 year interest rates of YEN and USD)

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4 Generally OLS method is used to analyze the relationships among the variables. However when the non-stationary variables are included, ordinary hypothesis test tends to draw the mistaken results since coefficient of determination and t-statistics do not follow the simple distribution.

Granger/Newbold [1974] called this problem 'Spurious Regression'. Phillips [1986] pointed out two points as to the analysis of non-stationary data—(1) the coefficient of determination tend not to measure the relationship among variables,(2)estimated equation with low Drubin-Watson ratio can possibly have a problem of spurious regression. Nelson/Plosser [1982] got a conclusion that there is no denying the existence of unit root in the macro economic variables of USA.

from 11 series of the yield curves is tested if they are in a relationship of cointegration. Next in addition to a pair of interest rates, YEN/USD exchange rate is included to conduct the cointegration test of three variables. Thus the relationship of interest rates with YEN/USD exchange rate can be investigated.

2.3 *Granger Causality*

The Granger causality test checks whether x_t affects y_t or y_t affects x_t or x_t and y_t affect mutually in the time series model with regard to variables x_t and y_t. The original data are transformed into the change ratio to avoid a problem of spurious regression. But using these data are considered to cause an error. Toda/Yamamoto [1995] develop the Granger causality test in which non-stationary data are directly used.

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

$$y_t = \kappa_0 + \lambda t + \sum_{i=1}^{p+1} \alpha_i y_{t-i} + \sum_{i=1}^{p+1} \beta_i x_{t-i} + u_t \qquad (2)$$

$$H_0 : \beta_1 = \beta_2 = \cdots \beta_p = 0$$
$$H_1 : \text{Either } \beta_i \neq 0 \quad (i = 1,2,\cdots, p)$$

$$x_t = \varsigma_0 + \eta t + \sum_{i=1}^{p+1} \gamma_i x_{t-i} + \sum_{i=1}^{p+1} \delta_i y_{t-i} + v_t \qquad (3)$$

$$H_0 : \gamma_1 = \gamma_2 = \cdots \gamma_p = 0$$
$$H_1 : \text{ Either } \gamma_i \neq 0 \quad (i = 1,2,\cdots, p)$$

The F test is conducted by estimating (2) and (3) through OLS and summing the squared error. If the null hypothesis of H_0 in the formula (2) is rejected, y is considered to explain x. If the null hypothesis of H_0 in the formula (3) is rejected, x is considered to explain y. In this paper, with the

method by Toda/Yamamoto[1995], two variables VAR is used to test each pair of interest rates (for example, 2 year interest rates of YEN and USD) from 11 series of the yield curves.

3. Data

2.1 *Japan*

The 11 series of data-LIBOR (London Interbank Offered Rate-1 month, 3 month, 6 month, 9 month, 12 month) and interest rate swap rate (2 year, 3 year, 4 year, 5 year, 7 year and 10 year) as of 5 pm in New York time are used on a daily basis from October 2,1990 through Aug 11, 200.[5,6]

2.2 *US*

The 11 series of data - LIBOR (London Interbank Offered Rate-1 month, 3 month, 6 month, 9 month, 12 month) and interest rate swap rate (2 year, 3 year, 4 year, 5 year, 7 year and 10 year) as of 5 pm New York time are used on a daily basis from October 2,1990 through December 30,2001.[7]

3.3 *Sample Period*

The whole sample is divided into two sub periods. The first sub period, named Sample A, is from October 2,1990 through May 17,1993. In Sample A the monetary policy regimes both in Japan and US are easing. The second sub period, named Sample B, is from May 18,1993 through August 11,2000.[8] In Sample B the monetary policy regime in Japan is easing, but in US it's tightening.

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5 LIBOR is interbank offered rate at 11 am London time which is officially released by the BBA (British Bankers' Association). 16 panel banks contribute the data. Fixing data are calculated by averaging the 8 remaining banks after subtracting 4 highest and 4 lowest banks. LIBOR is often used as a short term benchmark rate for interest rate swap transaction.

6 So far the issuances of JGB (Japanese Government Bond) are centered on 10 year. Thus most of trading activities are made on 10 year JGB. Therefore it's very difficult to draw a yield curve by using the actual JGB data. On the other hand, actual transactions are conducted on the yield curve of 2 year through 10 year.

7 USD LIBOR doesn't reflect a day's event in a whole since they publish the rates at 11 am in London time. Thus next business day's rates are used to incorporate all events in USD LIBOR rates.

8 The Federal Open Market Committee (FOMC) changed monetary policy bias from neutral to tightening on May18,1993. The Bank of Japan continued easing policy during 1990' s until it lifted zero interest rate policy on August 11,2000.

From a view point of economic cycles, in Sample A, both Japan and US are downtrend. On the other hand ,in Sample B, Japan is downtrend, but US is uptrend. In figure 1 the comparison of 4 series (3 month, 12 month, 5 year, 10 year) during Sample A is shown. In figure 2 the comparison of 4 series (3 month, 12 month, 5 year, 10 year) during Sample B is indicated.

4. Result

4.1 *Unit Root Tests*

ADF and PP Tests 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 $T = \infty$ is –2.86 (without trend) and –3.41 (with trend). [9]

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

4.2 *Cointegration Test (two variables)*[10]

During Sample A, the term structure from 3 month through 10 year is in a relationship of cointegration. But 1 month is not in a relationship of cointegraion. In other words, we find evidence for closer long-run international linkage between YEN and USD in the term structure over 3 month from October 2,1990 through May 18,1993. The results are shown on Table 5.

On the other hand, during Sample B, only the term structure from 3 month through 9 month is in a relationship of cointegration. But 1 month and 12 month through 10 year are not in a relationship of cointegration. Thus we find weaker evidence for long –run international linkages between YEN and

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9 Fuller [1976] provides table for critical values.

10 Engle/Granger[1987] method is also conducted. Results are slightly different during Sample A, the term structure from 9 month through 10 year is in a relationship of cointegration. But the structure from 1 month through 6 month is not in a relationship of cointegraion. On the other hand, during Sample B, the entire term structure is not in a relationship of cointegration. Thus we find little evidence for long –run international linkages between JP and US from May 19,1993 through February 8,2001. The results are shown on Table 5.

USD interest rates from May 19,1993 through August 11,2000 compared with the period from October 2,1990 through May 18,1993 .The results are shown on Table 6.

4.3 *Cointegration Test (three variables)*

During Sample A, the term structure from 3 month through 5 year is in a relationship of cointegration with YEN/USD exchange rate. But 1 month and 7 year through 10 year is not in a relationship of cointegraion with YEN/USD exchange rate. In other words, we find evidence for closer long-run international linkage among three variables – YEN, USD interest rates from 3 month through 5 year and YEN/USD exchange rates from October 2,1990 through May 17,1993. The results are shown on Table 7.

On the other hand, during Sample B, only the term structure from 3 month through 9 month is in a relationship of cointegration. But 1 month and 12 month through 10 year are not in a relationship of cointegration. Thus we find evidence for closer long-run international linkage among three variables – YEN, USD interest rates from 3 month through 9 month and YEN/USD exchange rates from May 17,1993 through August 11,1993. The results are shown on Table 8.

4.4 *Granger Causality*

During Sample A the influences of YEN interest rates on USD interest rates are confirmed in the term structure from 6 month through 10 year. The influences of USD interest rates on YEN interest rates are not confirmed in the entire term structure. The results are shown on Table 9.

On the other hands, during Sample B the influences of YEN interest rates on USD interest rates are confirmed in 1 month and from 2 year through 10 year. The influences of USD interest rates on YEN interest rates are confirmed in the entire term structure except 7 year. The results are shown on Table 10.

5. Concluding Remarks

This paper examines the international linkage of interest rates between YEN and USD data from 1 month through 10 year data from October 2,1990 through August 8,2000. The whole sample is divided into two sub periods. The first sub period, named Sample A, is from October2,1990 through

May 17,1993. In Sample A the monetary policy regimes both in Japan and US are easing. From a view point of economic cycles, in Sample A, both Japan and US are downtrend. The second sub period, named Sample B, is from May 18,1993 through August 8,2000. In Sample B the monetary policy regime in Japan is easing, but in US it's tightening. From a view point of economic cycles, in Sample B, Japan is downtrend, but US is uptrend.

We find evidence for closer long-run international linkage between YEN and USD interest rates in the term structure over 3 month from October 2,1990 through May 18,1993. The influences of JP interest rates on US interest are confirmed in the term structure of 1 month and from 6 month through 10 year. The influences of US interest rates on JP interest rates are not confirmed in the entire term structure.

The interest rates of YEN and USD in the term structure of 3 month through 5 year are in the relationship of cointegration with YEN/USD exchange rates. Thus it's considered that YEN/USD exchange rates are related to the comovement of YEN and USD interest rates in the term structure of 3 month through 5 year.

On the other hand, during Sample B we only find evidence for closer long-run international linkage between YEN and USD interest rates in the term structure from 3 month through 9 month from May 19,1993 and August 8,2000. The influences of JP interest rates on US interest rates are confirmed in the term structure from 1 month through 3 month and from 2 year through 10 year. The influences of US interest rates on JP interest rates are confirmed in the entire term structure.

The interest rates of YEN and USD in the term structure of 3 month through 9 month are in the relationship of cointegration with YEN/USD exchange rates. Thus it's considered that YEN/USD exchange rates are related to the movement of YEN and USD interest rates in the term structure of 3 month through 9 month.

From October 2,1990 through May 18,1993, monetary policies both in Japan and USA are in easing phase. Thus it's considered that economic cycles both in Japan and USA during that period are in downtrend. When the FRB changed monetary policy stance from neutral to tightening on May 18,1993 the divergence of JP and US interest rates from 12 month through 10 year started.

It's believed that the integration of international financial markets lead to convergence of interest rates among countries or to greater synchronization of interest rate movement than before. However from this analysis, considerable divergence existed between YEN and USD after May 19,1993,

during which time international integration of markets increased. This empirical analysis shows that the synchronization of economic cycles is one of the causes for the comovement of YEN and USD interest rates.

As for the future topics, (1) investigate the reasons why USD interest rates didn't influence YEN interest rates during Sample A, (2) estimate the error correction models and impulse response function, (3) add Euro interest rates to check the relationship of interest rates among US and Japan, EU, (4) analyze further the relationship between YEN/USD exchange rates and the comovement of interest rates from a view point of CIP (Covered Interest Parity) and UIP (Uncovered Interest Parity), (5) conduct event analysis, (6) investigate the comovement of real term interest rates by using monthly data —these six points are to be mentioned.

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Figure1　The Movement of 4 Series（90.10.2～93.5.17）

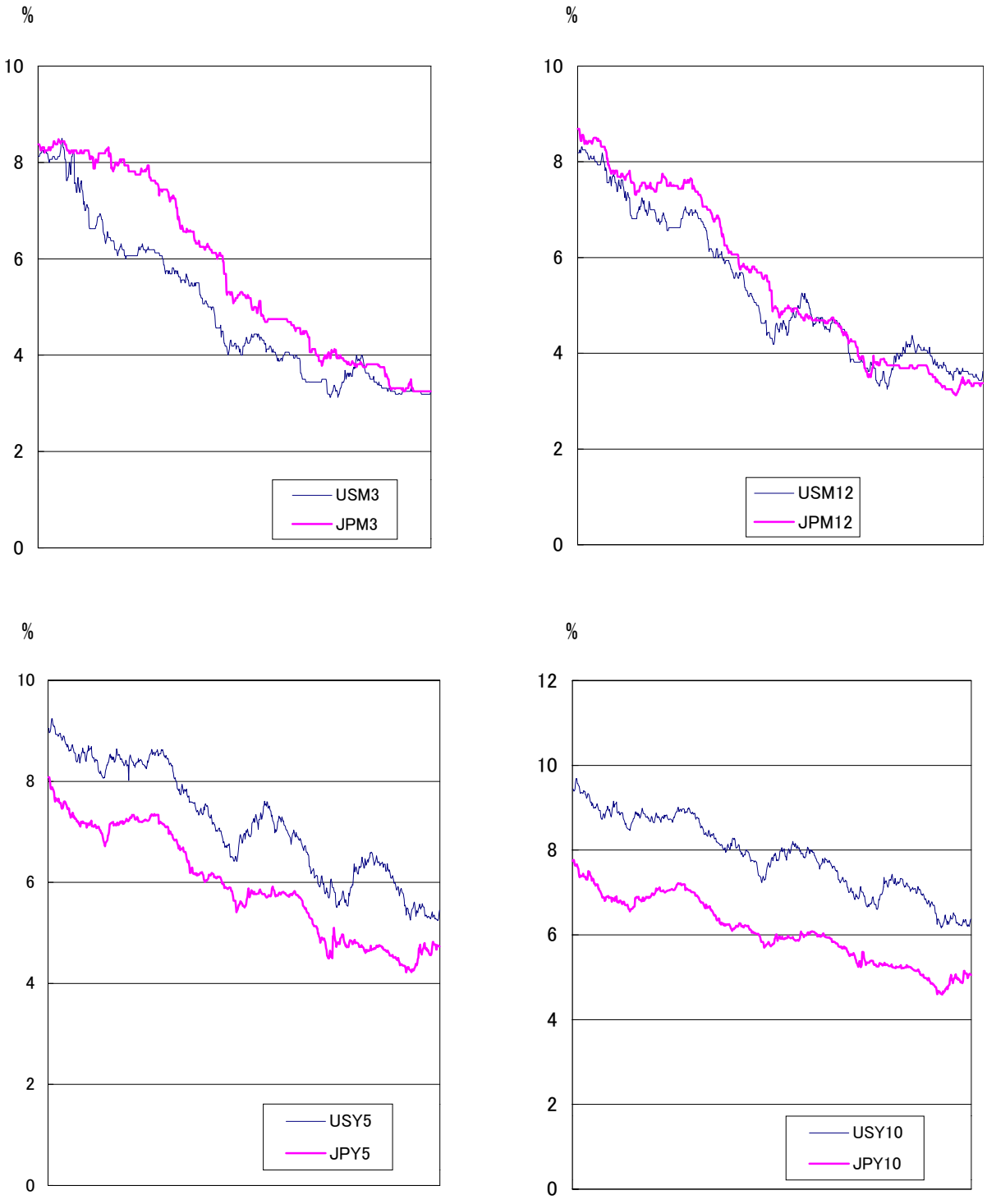

Figure2　The Movement of 4 Series(93.5.18～00.8.11)

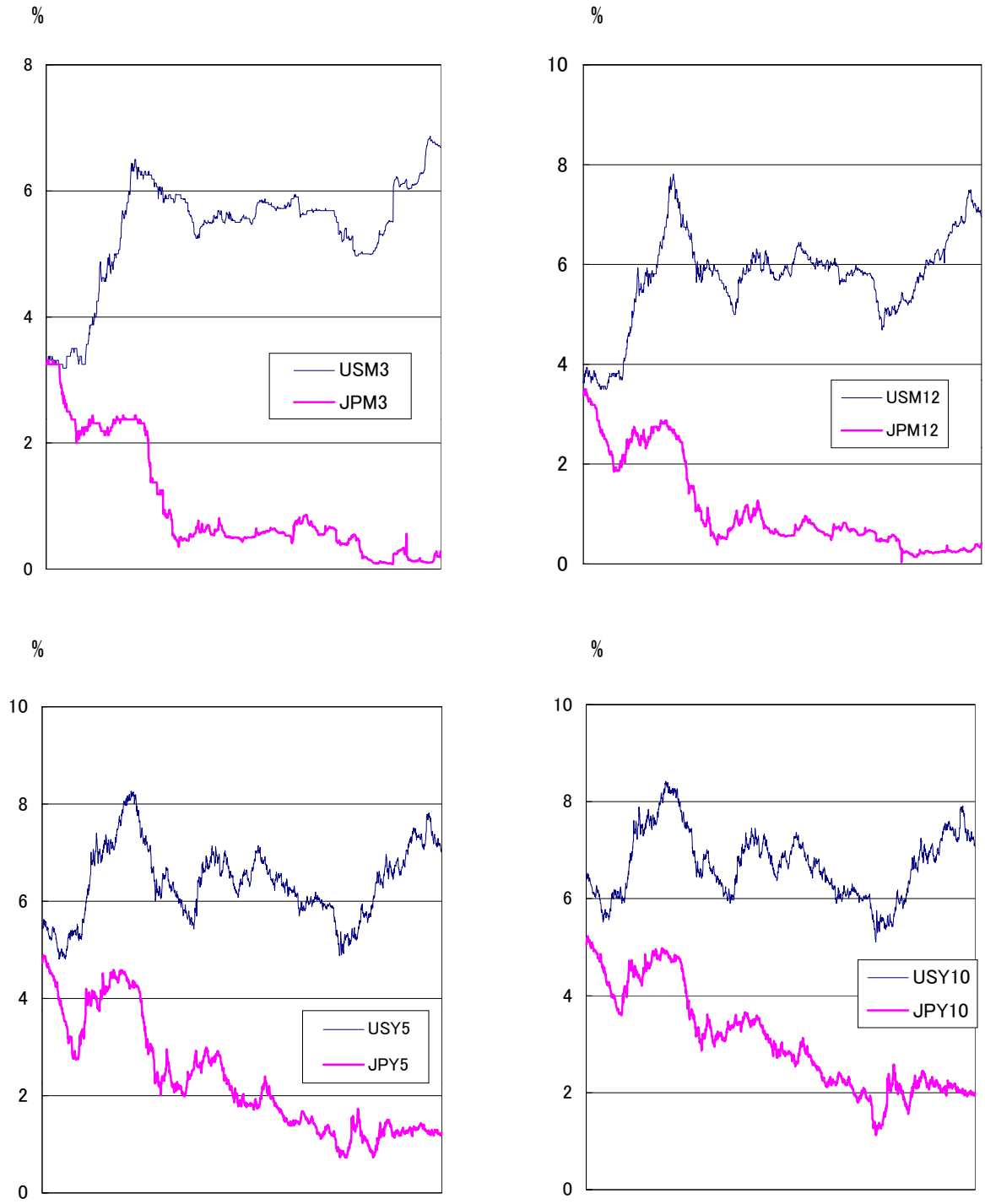

Table 1 .ADF Test -Original Series

Sample A

Variables	Without Trend	With Trend	Variables	Without Trend	With Trend
JP M1	-0.0782	-3.1322	US M1	-1.9719	-1.6916
JP M3	-0.4086	-1.7275	US M3	-2.5958	-1.1314
JP M6	-0.9487	-1.2220	US M6	-2.3898	-1.2988
JP M9	-1.3132	-1.0148	US M9	-1.8236	-1.654
JP M12	-1.5835	-0.9876	US M12	-1.6216	-1.8057
JP Y2	-1.6394	-1.6144	US Y2	-1.3707	-2.2164
JP Y3	-1.5914	-1.8613	US Y3	-1.1178	-2.4141
JP Y4	-1.6336	-1.7891	US Y4	-1.0533	-2.4508
JP Y5	-1.4888	-1.7107	US Y5	-0.902	-2.413
JP Y7	-1.7696	-1.7019	US Y7	-0.9388	-3.0851
JP Y10	-1.6698	-2.1320	US Y10	-0.976	-3.1948
FX	-0.6003	-2.6259			

Sample B

Variables	Without Trend	With Trend	Variables	Without Trend	With Trend
JP M1	-2.6788	-1.9095	US M1	-2.4321	-1.7025
JP M3	-3.0177*	-1.7843	US M3	-2.5332	-1.4114
JP M6	-3.1583*	-2.0330	US M6	-2.3152	-1.5076
JP M9	-2.9952*	-2.1263	US M9	-2.2183	-1.5533
JP M12	-2.7681	-2.1411	US M12	-2.1449	-1.5651
JP Y2	-2.3481	-2.4267	US Y2	-2.0741	-1.6703
JP Y3	-2.1308	-2.4594	US Y3	-1.9935	-1.7226
JP Y4	-2.0231	-2.4432	US Y4	-1.9283	-1.7527
JP Y5	-1.9352	-2.4965	US Y5	-1.8728	-1.7741
JP Y7	-1.7230	-2.4773	US Y7	-1.7613	-1.7378
JP Y10	-1.6838	-2.5580	US Y10	-1.7674	-1.8544
FX	-1.5884	-1.6674			

5% critical values are -2.89(Without Trend),-3.45（with Trend）.

* indicates significant at 5%.

Table 2. PP Test- Original Series

Sample A

Variables	Without Trend	With Trend	Variables	Without Trend	With Trend
JP M1	-0.0212	-2.7744	US M1	-1.6606	-2.7498
JP M3	-0.4086	-1.7305	US M3	-1.8563	-1.5014
JP M6	-0.9131	-2.3019	US M6	-1.82348	-1.4884
JP M9	-1.2011	-2.1411	US M9	-1.8038	-1.4883
JP M12	-1.3346	-2.1856	US M12	-1.6326	-1.5809
JP Y2	-1.6273	-1.8098	US Y2	-1.4633	-3.0992
JP Y3	-1.6815	-2.1786	US Y3	-1.3706	-3.4600
JP Y4	-1.6828	-2.2647	US Y4	-1.0021	-2.2483
JP Y5	-1.8047	-1.8170	US Y5	-0.902	-2.4373
JP Y7	-1.7937	-2.0690	US Y7	-0.9388	-3.1068
JP Y10	-1.6824	-2.4572	US Y10	-0.8977	-2.9242
FX	-0.6003	-1.9266			

Sample B

Variables	Without Trend	With Trend	Variables	Without Trend	With Trend
JP M1	-2.4201	-2.5889	US M1	-2.4612	-1.6708
JP M3	-3.0269*	-1.5735	US M3	-2.6988	-1.2671
JP M6	-3.3123*	-1.7113	US M6	-2.6959	-1.2348
JP M9	-3.0802*	-1.7121	US M9	-2.3829	-1.2455
JP M12	-2.7966	-1.7323	US M12	-2.2811	-1.3621
JP Y2	-2.2471	-1.9545	US Y2	-2.1276	-1.658
JP Y3	-1.9521	-1.9703	US Y3	-2.0254	-1.7274
JP Y4	-1.8933	-2.0271	US Y4	-1.9627	-1.7789
JP Y5	-1.7716	-2.0674	US Y5	-1.9357	-1.8387
JP Y7	-1.5786	-2.1558	US Y7	-2.1131	-2.1092
JP Y10	-1.5213	-2.3233	US Y10	-1.8577	-1.9442
FX	-1.5400	-1.1074			

5% critical values are -2.89(Without Trend),-3.45（with Trend）.

* indicates significant at 5%.

Table 3 .ADF Test - Series with a First Difference

Sample A

Variables	Without Trend	With Trend	Variables	Without Trend	With Trend
ΔJP M1	-23.4720*	-23.2485*	ΔUS M1	-11.4284*	-11.5355*
ΔJP M3	-25.9972*	-25.8442*	ΔUS M3	-9.7474*	-10.0634*
ΔJP M6	-22.7521*	-22.6274*	ΔUS M6	-9.0153*	-9.2699*
ΔJP M9	-6.9098*	-6.9623*	ΔUS M9	-18.8364*	-18.8368*
ΔJP M12	-23.0093*	-23.0608*	ΔUS M12	-24.5882*	-24.5399*
ΔJP Y2	-16.7711*	-16.6886*	ΔUS Y2	-35.6184*	-35.5429*
ΔJP Y3	-16.7232*	-16.6274*	ΔUS Y3	-22.4867*	-22.3985*
ΔJP Y4	-16.2652*	-16.1263*	ΔUS Y4	-23.8243*	-23.0760*
ΔJP Y5	-11.7513*	-11.7086*	ΔUS Y5	-24.8133*	-24.7392*
ΔJP Y7	-17.5234*	-17.2781*	ΔUS Y7	-27.3511*	-27.3508*
ΔJP Y10	-16.9762*	-16.8399*	ΔUS Y10	-23.8639*	-23.8181*
ΔFX	-24.7147*	-25.1303*			

Sample B

Variables	Without Trend	With Trend	Variables	Without Trend	With Trend
ΔJP M1	-17.6421*	-17.4430*	ΔUS M1	-41.1816*	-41.1413*
ΔJP M3	-25.1789*	-25.2868*	ΔUS M3	-22.3446*	-22.4214*
ΔJP M6	-17.5609*	-17.6821*	ΔUS M6	-10.9883*	-11.1733*
ΔJP M9	-15.0552*	-15.1941*	ΔUS M9	-10.0151*	-10.1818*
ΔJP M12	-20.0287*	-20.1446*	ΔUS M12	-10.2841*	-10.4220*
ΔJP Y2	-11.6956*	-11.7602*	ΔUS Y2	-11.0965*	-11.1884*
ΔJP Y3	-11.8655*	-11.9060*	ΔUS Y3	-11.4669*	-11.5395*
ΔJP Y4	14.3424*	-14.3600*	ΔUS Y4	-11.6450*	-11.0778*
ΔJP Y5	-13.3482*	-13.3593*	ΔUS Y5	-11.8069*	-11.8598*
ΔJP Y7	-13.2446*	-13.2508*	ΔUS Y7	-25.1702*	-25.1346*
ΔJP Y10	-13.3898*	-13.3857*	ΔUS Y10	12.9168*	-12.9418*
ΔFX	-12.9230*	-12.9190*			

5% critical values are -2.89(Without Trend),-3.45（with Trend）.

* indicates significant at 5%.

Table 4 .PP Test - Series with a First Difference

Sample A

Variables	Without Trend	With Trend	Variables	Without Trend	With Trend
ΔJP M1	-23.472*	-23.4676*	ΔUS M1	-25.1256*	-25.1347*
ΔJP M3	-25.9972*	-25.9784*	ΔUS M3	-24.5828*	-24.6408*
ΔJP M6	-36.4613*	-36.4524*	ΔUS M6	-25.2584*	-25.3174*
ΔJP M9	-35.9667*	-35.9868*	ΔUS M9	-24.3325*	-24.3858*
ΔJP M12	-36.0226*	-36.0613*	ΔUS M12	-24.5882*	-24.6224*
ΔJP Y2	-23.6853*	-23.7216*	ΔUS Y2	-35.6184*	-35.6134*
ΔJP Y3	-23.5904*	-23.62033*	ΔUS Y3	-34.0801*	-34.0626*
ΔJP Y4	-28.1680*	-28.2151*	ΔUS Y4	-23.8243*	-23.8104*
ΔJP Y5	-24.2970*	-24.3456*	ΔUS Y5	-24.8133*	-24.7959*
ΔJP Y7	-24.4905*	-24.5376*	ΔUS Y7	-27.3511*	-27.331*
ΔJP Y10	-24.3188*	-24.3432*	ΔUS Y10	-23.8639*	-23.8465*
Δ FX	-24.7417*	-24.7495*			

Sample B

Variables	Without Trend	With Trend	Variables	Without Trend	With Trend
ΔJP M1	-47.5554*	-47.5788*	ΔUS M1	-41.1816*	-41.2343*
ΔJP M3	-44.0717*	-44.2058*	ΔUS M3	-39.6635*	-39.7842*
ΔJP M6	-42.8231*	-42.9774*	ΔUS M6	-39.3000*	-39.4294*
ΔJP M9	-42.6448*	-42.7724*	ΔUS M9	-41.3222*	-41.4315*
ΔJP M12	-43.6435*	-43.7361*	ΔUS M12	-43.0803*	-43.4697*
ΔJP Y2	-40.5515*	-40.5791*	ΔUS Y2	-42.1689*	-42.2100*
ΔJP Y3	-40.7266*	-40.7398*	ΔUS Y3	-41.9532*	-41.9801*
ΔJP Y4	-41.3258*	-41.3365*	ΔUS Y4	-42.0255*	-42.0440*
ΔJP Y5	-42.1598*	-42.1664*	ΔUS Y5	-42.5340*	-42.5456*
ΔJP Y7	-43.8026*	-43.8024*	ΔUS Y7	-47.6591*	-47.6615*
ΔJP Y10	-44.7615*	-44.7580*	ΔUS Y10	-42.6446*	-42.6431*
Δ FX	-41.2800*	-41.2699*			

5% critical values are -2.89(Without Trend),-3.45（with Trend）.

** indicates significant at 5%.

Table 5. Cointegration Test-Sample A (two variables)

Maximal Eigen Value Test

Variables	Test Statistics for R=1
JP M1 - US M1	12.18
JP M3 - US M3	26.80**
JP M6 - US M6	21.86**
JP M9 - US M9	25.86**
JP M12 - US M12	26.18**
JP Y2 - US Y2	30.32**
JP Y3 - US Y3	19.47*
JP Y4 - US Y4	20.99**
JP Y5 - US Y5	20.96**
JP Y7 - US Y7	23.44**
JP Y10 - US Y10	17.88*

Trace Test

Variables	Test Statistics for R =1
JP M1 - US M1	22.84*
JP M3 - US M3	37.50**
JP M6 - US M6	32.69**
JP M9 - US M9	37.97**
JP M12 - US M12	37.74**
JP Y2 - US Y2	41.92**
JP Y3 - US Y3	28.39**
JP Y4 - US Y4	28.72**
JP Y5 - US Y5	28.90**
JP Y7 - US Y7	32.59**
JP Y10 - US Y10	25.89**

Critical Values for Maximal Eigen Value Test are 15.67(5%),20.20(1%).
Critical Values for Trace Test are 19.96(5%),24.60(1%) .
Osterwald-Lenum(1992) provides critical values.
**,* indicate significant at 1% and 5% respectively.

Table 6. Cointegration Test-Sample B (two variables)

Maximal Eigen Value Test

Variables	Test Statistics for R=1
JP M1 - US M1	11.18
JP M3 - US M3	26.29**
JP M6 - US M6	23.60**
JP M9 - US M9	20.19**
JP M12 - US M12	16.07
JP Y2 - US Y2	12.04
JP Y3 - US Y3	10.49
JP Y4 - US Y4	10.17
JP Y5 - US Y5	9.47
JP Y7 - US Y7	7.89
JP Y10 - US Y10	7.08

Trace Test

Variables	Test Statistics for R =1
JP M1 - US M1	14.97
JP M3 - US M3	28.34**
JP M6 - US M6	25.51**
JP M9 - US M9	22.07*
JP M12 - US M12	18.56
JP Y2 - US Y2	14.92
JP Y3 - US Y3	13.46
JP Y4 - US Y4	13.13
JP Y5 - US Y5	12.43
JP Y7 - US Y7	11.01
JP Y10 - US Y10	10.58

Critical Values for Maximal Eigen Value Test are 15.67(5%),20.20(1%).
Critical Values for Trace Test are 19.96(5%),24.60(1%) .
Osterwald-Lenum(1992) provides critical values.
**,* indicate significant at 1% and 5% respectively.

Table 7. Cointegration Test-Sample A (three variables)

Maximal Eigen Value Test

Variables	Test Statistics for R=1	Test Statistics for R=2
JP M1 - US M1	17.16	12.73
JP M3 - US M3	28.40*	16.21
JP M6 - US M6	22.63*	11.51
JP M9 - US M9	24.00*	11.50
JP M12 - US M12	24.51*	10.62
JP Y2 - US Y2	22.65*	9.78
JP Y3 - US Y3	34.38**	11.80
JP Y4 - US Y4	24.79*	8.49
JP Y5 - US Y5	25.57*	9.64
JP Y7 - US Y7	17.28	10.88
JP Y10 - US Y10	14.19	12.41

Trace Test

Variables	Test Statistics for R =1	Test Statistics for R =2
JP M1 - US M1	37.41*	20.24
JP M3 - US M3	52.22**	23.82*
JP M6 - US M6	40.99*	18.36
JP M9 - US M9	41.53**	17.53
JP M12 - US M12	40.43*	15.92
JP Y2 - US Y2	36.67*	14.03
JP Y3 - US Y3	50.56**	14.06
JP Y4 - US Y4	37.94*	13.15
JP Y5 - US Y5	39.63*	14.06
JP Y7 - US Y7	33.47	16.20
JP Y10 - US Y10	31.85	17.66

Critical Values for Maximal Eigen Value Test (R=1) are 22.00(5%),26.81(1%).
Critical Values for Maximal Eigen Value Test (R=2) are 15.67(5%),20.20(1%).
Critical Values for Trace Test (R=1) are 34.91(5%),41.07(1%) .
Critical Values for Trace Test (R=2) are 19.96(5%),24.60(1%) .
Osterwald-Lenum(1992) provides critical values.
**,* indicate significant at 1% and 5% respectively.

Table 8. Cointegration Test-Sample B (three variables)

Maximal Eigen Value Test

Variables	Test Statistics for R=1	Test Statistics for R=2
JP M1 - US M1	12.77	11.08
JP M3 - US M3	30.54**	8.06
JP M6 - US M6	33.99**	7.65
JP M9 - US M9	28.36**	7.30
JP M12 - US M12	21.74	7.57
JP Y2 - US Y2	14.39	7.33
JP Y3 - US Y3	11.54	6.94
JP Y4 - US Y4	11.03	6.62
JP Y5 - US Y5	10.26	6.47
JP Y7 - US Y7	8.98	6.45
JP Y10 - US Y10	7.22	6.81

Trace Test

Variables	Test Statistics for R =1	Test Statistics for R =2
JP M1 - US M1	23.84	11.08
JP M3 - US M3	38.60*	8.06
JP M6 - US M6	42.89**	8.90
JP M9 - US M9	37.17*	8.81
JP M12 - US M12	31.11	9.37
JP Y2 - US Y2	24.16	9.77
JP Y3 - US Y3	21.04	9.50
JP Y4 - US Y4	20.20	9.17
JP Y5 - US Y5	19.34	9.08
JP Y7 - US Y7	18.57	9.60
JP Y10 - US Y10	16.13	8.92

Critical Values for Maximal Eigen Value Test (R=1) are 22.00(5%),26.81(1%).
Critical Values for Maximal Eigen Value Test (R=2) are 15.67(5%),20.20(1%).
Critical Values for Trace Test (R=1) are 34.91(5%),41.07(1%) .
Critical Values for Trace Test (R=2) are 19.96(5%),24.60(2%) .
Osterwald-Lenum(1992) provides critical values.
**,* indicate significant at 1% and 5% respectively.

Table 9. Granger Causality -Sample A

From JP on US

Variables	Lag	Test Statistics
JP M1 → US M1	11	3.0514**
JP M3 → US M3	11	1.4563
JP M6 → US M6	2	1.6051
JP M9 → US M9	2	8.2346**
JP M12 → US M12	2	10.000**
JP Y2 → US Y2	2	7.3785**
JP Y3 → US Y3	3	5.1463**
JP Y4 → US Y4	2	15.0647**
JP Y5 → US Y5	2	13.2527**
JP Y7 → US Y7	2	15.0434**
JP Y10 → US Y10	6	8.2469**

From US on JP

Variables	Lag	Test Statistics
US M1→JP M1	11	0.5928
US M3 →JP M3	11	0.8190
US M6 →JP M6	2	2.7946
US M9 → JP M9	2	0.8525
US M12 → JP M12	2	0.7827
US Y2 → JP Y2	2	0.3582
US Y3 →JP Y3	3	0.8011
US Y4 →JP Y4	2	0.5531
US Y5 →JP Y5	2	0.5396
US Y7 →JP Y7	2	0.7123
US Y10 → JP Y10	6	0.5218

** indicates significant at 5%.
Original Lag is chosen by AIC standard.
The method by Toda /Yamamoto(1995) is used.

Table 10. Granger Causality -Sample B

From JP on US

Variables	Lag	Test Statistics
JP M1 → US M1	3	82.7492**
JP M3 → US M3	12	4.2663**
JP M6 → US M6	12	0.8763
JP M9 → US M9	12	1.3882
JP M12 → US M12	12	1.5701
JP Y2 → US Y2	13	3.4972**
JP Y3 → US Y3	13	3.7127**
JP Y4 → US Y4	13	4.2261**
JP Y5 → US Y5	13	4.4049**
JP Y7 → US Y7	5	9.5759**
JP Y10 → US Y10	13	3.7559**

From US on JP

Variables	Lag	Test Statistics
US M1→JP M1	3	6.5893**
US M3 →JP M3	10	2.2552**
US M6 →JP M6	12	2.5711**
US M9 → JP M9	12	3.0647**
US M12 →JP M12	12	2.6428**
US Y2 → JP Y2	13	2.9336**
US Y3 →JP Y3	13	2.5771**
US Y4 →JP Y4	13	2.1275**
US Y5 →JP Y5	13	2.3862**
US Y7 →JP Y7	5	2.1518**
US Y10 → JP Y10	13	1.8755**

** indicates significant at 5%.
Original Lag is chosen by AIC standard.
The method by Toda /Yamamoto(1995) is used.