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Financial Market Linkage between Japan and US : Investigation of Short and Long Term Interest Rates

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Abstract

This paper examines the international linkage of interest rates between Japan and US from 1 month through 10 year in the framework of Uncovered Interest Rate Parity (UIP). 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 October 2, 1990 through May 17, 1993. In Sample A the monetary policy regimes both in Japan and US are easing. We find that UIP holds true in the term structure from 2 year through 10 year. The second sub period, named Sample B, is from May 18, 1993 through August 11, 2000. In Sample B the monetary policy regime in Japan is easing, but in US it's tightening. We find no evidence of UIP in the entire term structure.

JEL Classification : C32, E43, F39, G15

Keywords : Interest Rate Linkage, Cointegration, Granger Causality
Monetary Policy Regime, Uncovered Interest Rate Parity (UIP)

1. Introduction

This paper analyzes the relationship of interest rates between Japan and US from October 2, 1990 through August 11, 2000 in the framework of uncovered interest rate parity relationship (UIP). Under floating exchange rate, interest rates differ across countries because the existing

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pressures on financial markets are absorbed by movements in the exchange rates or expected exchange rate development.

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 international financial integration 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.

Bank for International Settlements (1989) provides wide range of surveys and empirical results 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) reports that the increase of international integration in financial markets doesn't necessarily lead to the convergence of nominal interest rates.

Throop (1994) and Christiansen/Pigott (1997) apply non-stationary time series methods such as unit root test and cointegration. Throop (1994) finds that in the 1980's there was no measurable tendency for real short and long-term interest rates between US and the major industrial counties 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 US.

Berk (2001) provides extensive studies on international co-movement of long term bonds from international business cycles and inflation expectations to find that there seems no to be any convincing evidence toward a particular direction of causality among major 6 industrialized nations. McCallum (1994) concludes that there are reasons for reviewing UIP relationship as more important than the unbiasedness of forward rates as predictors of future spot exchange rates.

In view of these previous studies, the following features characterize this paper. First, this paper uses the whole term structure of JP yen and US dollar interest rates from (1 month through 10 year). In this way, whether the whole term structure between JP and US has a long

[1] Blundell-Wignall/Browne (1991), Frankel (1992), Goldstein/Mussa (1993) and Pigott (1993) show that the globalization of financial markets increased markedly.

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 can be possible.

2. Framework of the Analysis

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 KPSS (Kwiatowski/ Phillips/Schmidt/Shin) test is used. The KPSS test defines null hypothesis as 'unit roots don't exist' and alternative hypothesis as 'unit roots exist'[2]. The KPSS test is considered to have more statistical power than other unit root tests such as the ADF (Augumented Dickey/Fuller) and the PP (Phillips Perron) tests[3].

2. 2 *Cointegration Test*

The effects of exchange rate movements on interest rate relations can be described in terms of uncovered interest rate parity relation(UIP). According to Blundell-Wignall and Brown (1991), UIP defines that the difference between any two countries' nominal interest rate equals the expected depreciation of the first country's currency against second's (over the life of the instrument).

$$i(k)_t - i(k)_t^* = E_t(S_{t+j})/k \tag{1}$$

where $i(k)_t$ and $i(k)_t^*$ are respectively the interest rates on foreign currency and home currency denominated assets of a given maturity, $E_t(S_{t+j})/k$ is the expected (annualized) rate of home currency depreciation to maturity.

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 the coefficient of determination and t-statistics do not follow the simple distribution.

Granger/Newbold (1974) called this problem 'Spurious Regression'. Phillips (1986) pointed

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[2] See Kwiatowski/Phillips/Scmidt/Shin (1992).

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

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 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/Granger (1987). In the test of cointegration, Eq. (2) is estimated by OLS to find if residual contains unit root.

$$i(k)_t - i(k)_t^* = \alpha + \beta E_t(S_{t+k})/k + \varepsilon_t \tag{2}$$

When series $i(k)_t - i(k)_t^*$ and $E_t(S_{t+k})/k$ are both non-stationary $I(1)$, they are called to be in a relationship of cointegration if their linear combination is stationary $I(0)$.

2．3 *Granger Causality Test*

The Granger causality test checks whether $i(k)_t$ affects $i(k)_t^*$ or $i(k)_t^*$ affects $i(k)_t$ or $i(k)_t$ and $i(k)_t^*$ affect mutually in the time series model with regard to variables $i(k)_t$ and $i(k)_t^*$. 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/Yamamoto (1995) developed the Granger causality test in which non-stationary data are directly used.

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

$$y_t = k_0 + \lambda t + \sum_{i=1}^{P+1} \alpha_i i(k)_{t-i}^* + \sum_{i=1}^{P+1} \beta_i i(k)_{t-i} + u_t \tag{3}$$

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

$$x_t = \zeta_0 + \eta t + \sum_{i=1}^{P+1} \gamma_i i(k)_{t-i} + \sum_{i=1}^{P+1} \delta_i i(k)_{t-i}^* + v_t \tag{4}$$

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

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 formula(3)is rejected, $i(k)_t$ is considered to explain. $i(k)_t^*$. If the null hypothesis of H_0 in the formula(4)is rejected, $i(k)_t^*$ is considered to explain $i(k)_t$.

3. Data

3. 1 *JPY Interest Rates*

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[4] (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 through August 11, 2000.

3. 2 *US Interest Rates*

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[4] (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 August 11, 2000.

3. 3 *Foreign Exchange Rate Expectation*

If realized values of foreign exchange rate change are I (1), the innovation will influence the future change of foreign exchange rates. When the expected values of foreign exchange rate change, $E_t(S_{t+j})$, defined as j term forward expectation of foreign exchange rate based on the period of t are random walk, it follows that $S_{t+1}=S_t+\varepsilon_{t+1}$ (ε_{t+1} is an innovation of value of foreign exchange rate change).

Accordingly as for the expected value of foreign exchange rate change at the future time of j, equation (5) holds true. Thus realized values of foreign exchange rate at the time of t indicate the future expectation of foreign exchange rates.

$$E_t(S_{t+j})=S_t \tag{5}$$

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[4] So far the issuances of JGB (Japanese Government Bond) are centered on 10 year. The most of trading activities are made on 10 year JGB. Therefore it's very difficult to draw a proper yield curve by using the actual JGB data. On the other hand, actual transactions of interest rate swaps are conducted on the yield curve of 2 year through 10 year. Since swap data are used for Japanese yen, swap data are also used for US market.

In this paper, the realized values of foreign exchange rate changes are calculated for the periods of 1 month, 3 month, 6 month, 9 month and 12 month. For the actual analysis, realized rates are used to match the maturities of interest rates. But for the maturities longer than 2 year, the realized data for the period of 12 month are used.

3．4 *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.[5] In Sample B the monetary policy regime in Japan is easing, but in US it's tightening. In figure 1 the comparison of 4 series (3 month, 12 month, 5 year, 10 year) in Sample A is shown. In figure 2 the comparison of 4 series (3 month, 12 month, 5 year, 10 year) in Sample B is indicated.

4．Result

4．1 *Unit Root Test*

The KPSS test is conducted both for trend stationarity and level statinarity. The critical point of 5 % is 0.463 (trend stationary) and 0.146 (level stationary) respectively. The results are shown on Table 1. There is no denying that all the variables are no stationary in Samples A and B.

Next, the data with first difference from original data are analyzed by the KPSS test. There is no denying that all the variables are I (1) in Sample A. But in Sample B, Δ(USM3-JPM3), Δ(USM6-JPM6) and Δ(USM9-JPM9) are considered to contain unit roots. Results are shown on the Table 2

4．2 *Cointegration Test*

Even though (USM3-JPM3), (USM6-JPM6) and (USM9-JPM9) are possibly to be I (2) in Sample B, Engle / Granger cointegration test is conducted in accordance with Lukepohl (1991)[6]. In Sample A, UIP holds true in the term structure from 2 year through 10 year. In other words, we find evidence for closer long-run international linkage between JP and US in the term structure over 3 month from October 2, 1990 through May 17, 1993. The results are shown

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[5] The Federal Open Market Committee (FOMC) changed monetary policy bias from neutral to tightening on May18, 1993. The Bank of Japan lifted zero interest rate policy on August 11, 2000.

[6] Lukepohl (1991) avoids distinguishing between variables with different order of integration.

on Table 3.

On the other hand, in Sample B, we find no evidence of UIP in the entire term structure. Thus we find weak evidence for long-run international linkages between JP and US from May 18, 1993 and August 11, 2000. The results are shown on Table 3.

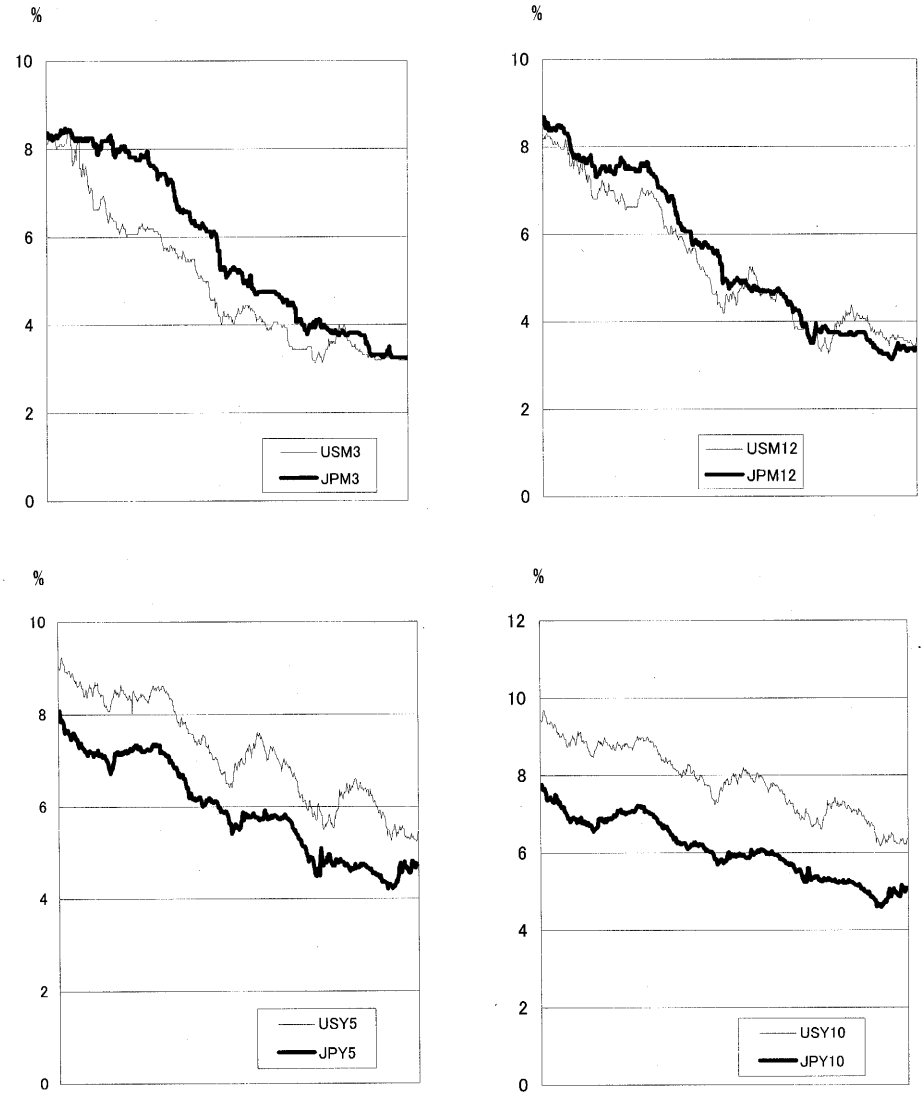

Figure 1 The Movement of 4 Series (90.10. 2 ~93. 5 .17)

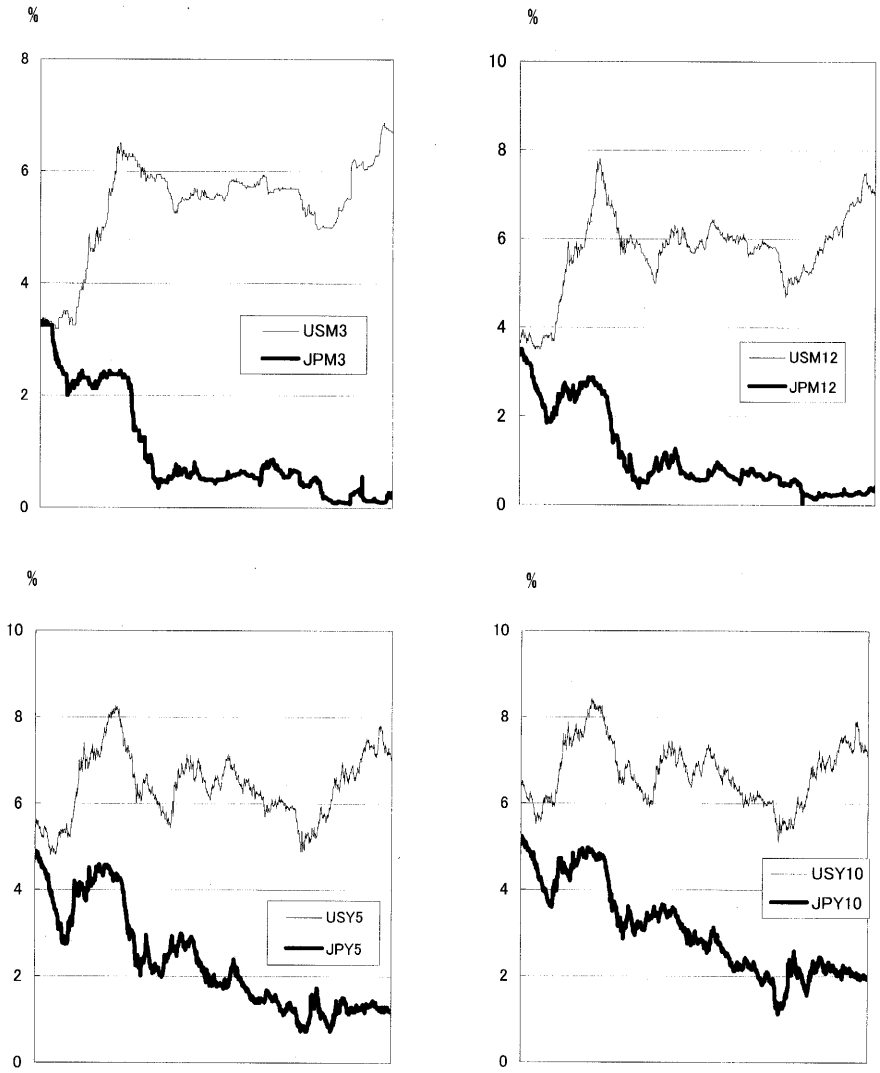

Figure 2 The Movement of 4 Series (93. 5 .18～00. 8 .11)

Table 1. KPSS Test-Original Series

Sample A

	Lag=4		Lag=12	
Variable	$\eta\mu$	$\eta\tau$	$\eta\mu$	$\eta\tau$
USM1-JPM1	3.070*	1.636*	1.244*	0.669*
USM3-JPM3	4.789*	1.663*	1.098*	0.671*
USM6-JPM6	5.890*	1.499*	2.356*	0.613*
USM9-JPM9	6.399*	1.322*	2.590*	0.553*
USM12-JPM12	6.834*	1.059*	2.771*	0.447*
USY2-JPY2	4.139*	0.901*	1.718*	0.383*
USY3-JPY3	2.390*	0.670*	1.008*	0.287*
USY4-JPY4	0.987*	0.538*	0.418*	0.229*
USY5-JPY5	0.523*	0.364*	0.224*	0.156*
USY7-JPY7	1.646*	0.517*	0.702*	0.223*
USY10-JPY10	1.323*	0.269*	0.571*	0.117*
E1	0.616*	0.169*	0.116*	0.076*
E3	0.623*	0.576*	0.252*	0.233*
E6	1.704*	1.160*	0.677*	0.461*
E9	2.456*	1.462*	0.969*	0.579*
E12	2.158*	0.980*	0.877*	0.403*

Sample B

	Lag=4		Lag=12	
Variable	$\eta\mu$	$\eta\tau$	$\eta\mu$	$\eta\tau$
USM1-JPM1	23.804*	7.549*	9.218*	2.919*
USM3-JPM3	23.306*	7.281*	9.031*	2.817*
USM6-JPM6	22.994*	6.994*	8.916*	2.709*
USM9-JPM9	22.712*	6.685*	8.812*	2.591*
USM12-JPM12	23.539*	5.837*	9.149*	2.273*
USY2-JPY2	24.910*	5.338*	9.688*	2.085*
USY3-JPY3	25.909*	4.931*	10.077*	1.931*
USY4-JPY4	26.494*	4.525*	10.305*	1.775*
USY5-JPY5	27.242*	3.793*	10.598*	1.495*
USY7-JPY7	25.790*	3.233*	10.050*	1.278*
USY10-JPY10	247.158*	7.788*	9.356*	3.015*
E1	24.158*	0.639*	0.282*	0.281*
E3	0.639*	1.735*	0.700*	0.690*
E6	1.760*	3.932*	1.303*	1.250*
E9	3.328*	4.898*	2.281*	1.911*
E12	5.849*	5.577*	2.992*	2.170*

* indicates significance at the 5 % level.
5 % critical values are 0.463 (trend stationary), 0.146 (level stationary).
$\eta\mu$ indicates trend stationarity. $\eta\tau$ indicates level stationarity.
E is expectation of foreign exchange rates.
For example, E1 is expectation of 1 month ahead.

Table 2. KPSS Test-Series with a First Difference

Sample A

	Lag=4		Lag=12	
Variable	$\eta\mu$	$\eta\tau$	$\eta\mu$	$\eta\tau$
⊿(USM1-JPM1)	0.151	0.038	0.230	0.060
⊿(USM3-JPM3)	0.182	0.048	0.205	0.055
⊿(USM6-JPM6)	0.099	0.034	0.111	0.038
⊿(USM9-JPM9)	0.047	0.022	0.051	0.026
⊿(USM12-JPM12)	0.028	0.022	0.032	0.024
⊿(USY2-JPY2)	0.022	0.023	0.026	0.028
⊿(USY3-JPY3)	0.031	0.027	0.039	0.033
⊿(USY4-JPY4)	0.045	0.034	0.048	0.037
⊿(USY5-JPY5)	0.056	0.034	0.064	0.038
⊿(USY7-JPY7)	0.045	0.030	0.056	0.037
⊿(USY10-JPY10)	0.049	0.027	0.059	0.032
⊿E1	0.087	0.082	0.100	0.094
⊿E3	0.093	0.076	0.100	0.076
⊿E6	0.147	0.070	0.148	0.072
⊿E9	0.151	0.056	0.157	0.059
⊿E12	0.032	0.022	0.037	0.025

Sample B

	Lag=4		Lag=12	
Variable	$\eta\mu$	$\eta\tau$	$\eta\mu$	$\eta\tau$
⊿(USM1-JPM1)	0.352	0.092	0.671*	0.124
⊿(USM3-JPM3)	0.911*	0.202*	0.882*	0.199*
⊿(USM6-JPM6)	0.807*	0.213*	0.756*	0.203*
⊿(USM9-JPM9)	0.563*	0.183*	0.540*	0.175*
⊿(USM12-JPM12)	0.415	0.155*	0.408	0.154*
⊿(USY2-JPY2)	0.194	0.097	0.200	0.100
⊿(USY3-JPY3)	0.130	0.075	0.138	0.080
⊿(USY4-JPY4)	0.094	0.059	0.103	0.064
⊿(USY5-JPY5)	0.073	0.049	0.081	0.054
⊿(USY7-JPY7)	0.043	0.034	0.050	0.039
⊿(USY10-JPY10)	0.038	0.033	0.044	0.038
⊿E1	0.120	0.045	0.120	0.045
⊿E3	0.090	0.038	0.100	0.042
⊿E6	0.049	0.039	0.047	0.037
⊿E9	0.027	0.026	0.028	0.027
⊿E12	0.009	0.008	0.009	0.008

* indicates significance at the 5 % level.
5 % critical values are 0.463 (trend stationary), 0.146 (level stationary).
$\eta\mu$ indicates trend stationarity. $\eta\tau$ indicates level stationarity.
E is expectation of foreign exchange rates.
For example, E1 is expectation of 1 month ahead.

Table 3 . Cointegration Test

Sample A

Variable	Test Statistics
(USM1-JPM1), E1	-2.8280
(USM3-JPM3), E3	-2.2490
(USM6-JPM6), E6	-2.1860
(USM9-JPM9), E9	-2.3870
(USM12-JPM12), E12	-2.3940
(USY2-JPY2), E12	-3.494*
(USY3-JPY3), E12	-4.106*
(USY4-JPY4), E12	-4.052*
(USY5-JPY5), E12	-4.214*
(USY7-JPY7), E12	-3.441*
(USY10-JPY10), E12	-4.031*

Sample B

Variable	Test Statistics
(USM1-JPM1), E1	-2.476
(USM3-JPM3), E3	-2.297
(USM6-JPM6), E6	-2.390
(USM9-JPM9), E9	-1.936
(USM12-JPM12), E12	-1.799
(USY2-JPY2), E12	-1.724
(USY3-JPY3), E12	-1.653
(USY4-JPY4), E12	-1.594
(USY5-JPY5), E12	-1.591
(USY7-JPY7), E12	-1.529
(USY10-JPY10), E12	-1.772

Critical value is-3.3377 (5 %) MacKinnon (1991).
* indicates significant 5 %.
E is expectation of foreign exchange rates.
For example, E1 is expectation of 1 month ahead.

4．3 *Granger Causality Test*

In Sample A the influences of JP interest rates on US interest are confirmed in the entire structure except for 3 month and 6 month. The influences of US interest rates on JP interest rates are not confirmed in the entire term structure. The results are shown on Table 4.

On the other hands, in Sample B the influences of JP interest rates on US interest rates are confirmed in the entire term structure except for 6 month, 9 month and 12 month. The influences of US interest rates on JP interest rates are confirmed in the entire term structure. The results are shown on Table 5. Thus it can be concluded that during Sample B, JP interest rates and US interest rates influenced mutually.

Table 4. Granger Causality Test-Sample A

From JP on US

Variables	Lag	Test Statistics
JP M1 → US M1	11	3.051*
JP M3 → US M3	11	1.456
JP M6 → US M6	2	1.605
JP M9 → US M9	2	8.235*
JP M12 → US M12	2	10.000*
JP Y2 → US Y2	2	7.379*
JP Y3 → US Y3	3	5.146*
JP Y4 → US Y4	2	15.065*
JP Y5 → US Y5	2	13.253*
JP Y7 → US Y7	2	15.043*
JP Y10 → US Y10	6	8.247*

From US on JP

Variables	Lag	Test Statistics
US M1 → JP M1	11	0.593
US M3 → JP M3	11	0.819
US M6 → JP M6	2	2.795
US M9 → JP M9	2	0.853
US M12 → JP M12	2	0.783
US Y2 → JP Y2	2	0.358
US Y3 → JP Y3	3	0.801
US Y4 → JP Y4	2	0.553
US Y5 → JP Y5	2	0.540
US Y7 → JP Y7	2	0.712
US Y10 → JP Y10	6	0.522

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

Table 5. Granger Causality Test-Sample B

From JP on US

Variables	Lag	Test Statistics
JP M1 → US M1	3	8.749*
JP M3 → US M3	12	4.266*
JP M6 → US M6	12	0.876
JP M9 → US M9	12	1.388
JP M12 → US M12	12	1.570
JP Y2 → US Y2	13	3.497*
JP Y3 → US Y3	13	3.712*
JP Y4 → US Y4	13	4.226*
JP Y5 → US Y5	13	4.405*
JP Y7 → US Y7	5	9.576*
JP Y10 → US Y10	13	3.756*

From US on JP

Variables	Lag	Test Statistics
US M1 → JP M1	3	6.589*
US M3 → JP M3	10	2.255*
US M6 → JP M6	12	2.571*
US M9 → JP M9	12	3.065*
US M12 → JP M12	12	2.643*
US Y2 → JP Y2	13	2.934*
US Y3 → JP Y3	13	2.577*
US Y4 → JP Y4	13	2.128*
US Y5 → JP Y5	13	2.386*
US Y7 → JP Y7	5	2.152*
US Y10 → JP Y10	13	1.876*

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

5. Concluding Remarks

This paper examines the international linkage of interest rates between JP and US in the framework of UIP by using the data from 1 month through 10 year. The whole sample from October 2, 1990 through August 8, 2000 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. 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 17, 1993 through August 11, 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.

In Sample A, UIP holds true in the term structure from 2 year through 10 year. In other words, we find evidence for closer long-run international linkage between JP and US in the term structure from 2 year through 10 year in the period from October 2, 1990 through May 17, 1993. The influences of JP interest rates on US interest rates are confirmed in the entire structure except for 3 month and 6 month. The influences of US interest rates on JP interest rates are not confirmed in the entire term structure.

On the other hand, in Sample B, we find no evidence of UIP in the entire term structure.

Thus we find little evidence for long-run international linkages between JP and US in the entire term structure from May 18, 1993 and August 11, 2000.

From October 2, 1990 through May 17, 1993, monetary policies both in Japan and US are in easing phase. Thus it's considered that economic cycles both in Japan and US during that period are in downtrend. When the FRB changed monetary policy stance from neutral to tightening on May18, 1993, the divergence of JP and US interest rates over 2 year started.

The influences of JP interest rates on US interest rates are confirmed in the entire term structure except for 6 month, 9 month and 12 month. The influences of US interest rates on JP interest rates are confirmed in the entire term structure.

Our results show that only when economic cycles are generally coincided between Japan and US, long term interest rates (from 2 year through 10 year) were in the long term equilibrium through the expectation of foreign exchange rates. Thus domestic factors are considered to exert an important influence on short and long term interest rates.

As for the future topics, (1) to investigate the reasons why US interest rates didn't influence JP interest rates in Sample A, (2) to estimate the error correction models and impulse response function, (3) to add Euro interest rates to check the relationship of interest rates among US, Japan, and EU——these three points are to be pointed out.

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