論　説

Linkage of Long Term Interest Rates between Japan and Euro Zone: Investigation of Uncovered Interest Rate Parity

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Abstract

This paper analyzes the relationship of long term interest rates between Japan and Euro zone in the framework of uncovered interest rate parity relationship (UIP) from June 1, 2000 through May 24, 2004. Engle and Granger cointegration test is conducted. We find no evidence of UIP in the entire term structure. Thus we find little evidence for long-run international linkages of long term interest rates between Japanese Yen and Euro from June 1, 2000 through May 24, 2004. The Granger causalities of Japanese interest rates on Euro interest are confirmed in the entire term structure. The Granger causalities of Euro interest rate on Japanese interest rate are confirmed only in 10 year.

Keyword : Interest Rates Linkage, Cointegration, Granger Causality,
Uncovered Interest Rate Parity

JEL Classification : E43, F39, G15

1. Introduction

This paper analyzes the relationship of long term interest rates between Japan and Euro zone in the framework of uncovered interest rate parity relationship (UIP). Under floating exchange rate, interest rates differ across countries because the existing pressures on financial markets are absorbed by movements in the exchange rates or expected exchange rate development.

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The research for this paper is supported by Grant-in-Aid for Scientific Research (KAKENHI 19530271) from JSPS.

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't necessarily work to equalize interest rates among different countries.

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 and 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 and Pigott (1988) report that the increase of international integration in financial markets doesn't necessarily lead to the convergence of nominal interest rates.

Throop (1994) and Christiansen and 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 countries to converge. Christiansen and 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. Ito (2006) investigates the linkage between JP yen and US dollar interest rates to find that UIP holds true in the term structure from 2 year through 10 year when the monetary policy regimes both in Japan and US were easing.

In view of these previous studies, this paper has a feature in that it analyzes the long term interest rates between Japan and Euro zone. Since the introduction of Euro in the beginning of 2000, the accumulation of historical data is not enough.

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

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

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 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) indicates 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

[2] For the details of methods, see Dickey and Fuller (1979) and Dickey and Fuller (1981).
[3] See Kwiatowski et ai. (1992).

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, 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 $E_t(S_{t+j})/k$ 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 and 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 for the influence from $i(k)_t^*$ on $i(k)_t$ and for the influence from $i(k)_t$ on $i(k)_t^*$. But trend term t and $p+1$ (original lag plus one) are added for the estimation.

$$i(k)_t^* = \kappa_0 + \lambda t + \sum_{i=1}^{p+1} \alpha_i i(k)_{t-i}^* + \sum_{i=1}^{p+1} \beta_i i(k)_{t-i} + u_t \tag{3}$$

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

$$i(k)_t^* = \varsigma_0 + \eta t + \sum_{i=1}^{p+1} \gamma_i i(k)_{t-i} + \sum_{i=1}^{p+1} \delta_i i(k)_{t-i}^* + v_t \tag{4}$$

$$H_0 : \delta_1 = \delta_2 = \cdots \delta_p = 0$$
$$H_1 : \text{ Either } \gamma_i \neq 0 \quad (i = 1,2,\cdots,p)$$

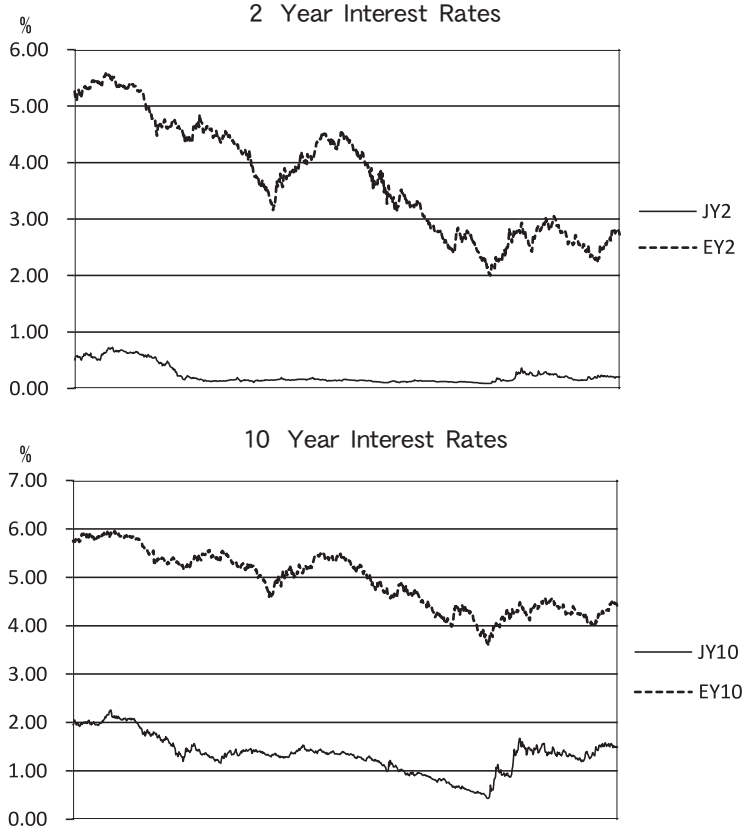
The F test is conducted by estimating (3) and (4) through OLS and summing the squared error. If the null hypothesis of H_0 in the formula (3) is rejected, $i(k)_t$ is considered to explain $i(k)_t^*$. If the null hypothesis of H_0 in the formula (4) is rejected, $i(k)_t^*$ is considered to explain $i(k)_t$.

3. Data

3.1 *Interest Rates*

As for Japanese interest rates, 6 series of interest rate swap rate[4] (2 year, 3 year, 4 year, 5 year, 7 year and 10 year) as of 3 pm in Tokyo time are used on a daily basis from June 1, 2000 through May 24, 2004. As for Euro interest rates, 6 series of interest rate swap rate (2 year, 3 year, 4 year, 5 year, 7 year and 10 year) as of 3 pm London time are used on a daily basis from June 1, 2000 through May 24, 2004. Figure 1 shows the movements of 2 year interest rates and 10 year interest rates.

Figure 1 The Movement of Interest Rates



The data are daily basis from June 1, 2000 through May 24, 2004.
J = Japanese Interest tates, E = Euro Interest Rates

[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 interest rate swap data are used for Japanese yen, interest rate swap data are also used for Euro market.

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 $E_t(S_{t+j})/k$, are 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. In this paper, the realized data for the period of 12 month are used.

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

4. Result

4.1 *Unit Root Test*

The ADF 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).

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

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 3. There is no denying that all the variables are non-stationary.

Next, the data with first difference from original data are analyzed by KPSS tests. There is no denying that all the variables are $I(1)$. Results are shown on the Table 4.

Table 1 ADF Test-Original Series

Variable	Lag	Without Trend	Lag	With Trend
EUR Y2 - JP Y2	0	-1.627	0	-2.190
EUR Y3 - JP Y3	11	-1.370	10	-2.343
EUR Y4 - JP Y4	10	-1.179	8	-2.489
EUR Y5 - JP Y5	5	-1.122	9	-2.617
EUR Y7 - JPY 7	5	-0.945	5	-2.493
EUR Y10 - JPY 10	5	-0.825	5	-2.655
E	0	-2.004	0	-2.027

* indicates significance at the 5 % level.

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

E is expectation of foreign exchage rates.

Table 2 ADF Test-Series With a First Difference

Variable	Lag	Without Trend	Lag	With Trend
⊿EUR Y2 - JP Y2	0	-31.717*	0	-31.574*
⊿EUR Y3 - JP Y3	0	-29.285*	0	-29.128*
⊿EUR Y4 - JP Y4	0	-29.961*	0	-29.770*
⊿EUR Y5 - JP Y5	0	-30.688*	0	-30.477*
⊿EUR Y7 - JP Y7	0	-31.035*	0	-30.823*
⊿EUR Y10 - JP Y10	4	-15.306*	4	-15.285*
⊿E	0	-30.880*	0	-30.720*

* indicates significance at the 5 % level.

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

E is expectation of foreign exchage rates.

Table 3 KPSS Test-Original Series

	Lag=4		Lag=12	
Variable	η_μ	η_τ	η_μ	η_τ
EUR Y2 - JP Y2	17.477*	0.872*	6.774*	0.346*
EUR Y3 - JP Y3	16.855*	1.2351*	6.537*	0.491*
EUR Y4 - JP Y4	16.319*	1.6804*	6.335*	0.668*
EUR Y5 - JP Y5	15.777*	2.208*	6.131*	0.878*
EUR Y7 - JP Y7	14.725*	2.883*	5.739*	1.151*
EUR Y10 - JP Y10	13.142*	2.716*	5.155*	1.092*
E	6.962*	2.967*	2.743*	1.175*

* indicates significance at the 5 % level.
5% critical values are 0.463 (trend stationary), 0.146 (level stationary).
η_μ indicates trend stationarity. η_τ indicates level stationarity.
E is expectation of foreign exchage rates.

Table 4 KPSS Test-Series With a First Difference

	Lag=4		Lag=12	
Variable	η_μ	η_τ	η_μ	η_τ
⊿EUR Y2 - JP Y2	0.099	0.067	0.098	0.066
⊿EUR Y3 - JP Y3	0.094	0.063	0.093	0.063
⊿EUR Y4 - JP Y4	0.091	0.061	0.091	0.061
⊿EUR Y5 - JP Y5	0.087	0.059	0.088	0.060
⊿EUR Y7 - JP Y7	0.081	0.059	0.083	0.061
⊿EUR Y10- JP Y10	0.070	0.054	0.074	0.058
⊿E	0.269	0.023	0.308	0.027

* indicates significance at the 5 % level.
5% critical values are 0.463 (trend stationary), 0.146 (level stationary).
η_μ indicates trend stationarity. η_τ indicates level stationarity.
E is expectation of foreign exchage rates.

4.2 *Cointegration Test*

Engle and Granger cointegration test is conducted. The results are shown on Table 5. We find no evidence of UIP in the entire term structure since no cointegration relationship was found in all maturities of interest rates. Thus we find little evidence for long-run international linkages of long term interest rates (2 year, 3 year, 4 year, 5year, 7 year and 10 year) between Japanese Yen and Euro from June 1, 2000 through May 24, 2004.

Table 5 Cointegration Test

Variables	Test Statistics
EUR Y2 - JP Y2, E	-0.9106
EUR Y3 - JP Y3, E	-0.9439
EUR Y4 - JP Y4, E	-0.9824
EUR Y5 - JP Y5, E	-0.7861
EUR Y7 - JP Y7, E	-0.8421
EUR Y10 - JP Y10, E	-1.1007

Critical value is -3.3377 (5%) from MacKinnon (1991).
Critical value is -3.0462 (10%) from MacKinnon (1991).
* indicates significance at the 5% level.
E is expectation of foreign exchage rates.

4.3 *Granger Causality*

The Granger causalities of Japanese interest rates on Euro interest are confirmed in the entire term structure. The Granger causalities of Euro interest rate on Japanese interest rate are confirmed only in 10 year. The results are shown on Table 6. Thus it's considered that interest rates moved only by the influences from Japanese on Euro rates except for 10 year interest rates. Two years rates are considered to be moving from mutual influences in 10 year.

Table 6 Granger Causality Test

From JP on EUR

Variables	Lag	Test Statistics
JP Y2 →EUR Y2	2	3.404*
JP Y3 → EUR Y3	6	3.253*
JP Y4 → EUR Y4	3	4.016*
JP Y5 → EUR Y5	6	3.777*
JP Y7 → EUR Y7	6	4.370*
JP Y10 → EUR Y10	6	4.146*

From EUR on JP

Variables	Lag	Test Statistics
EUR Y2 → JP Y2	2	0.654
EUR Y3 →JP Y3	6	1.348
EUR Y4 →JP Y4	3	0.867
EUR Y5 →JP Y5	6	1.667
EUR Y7 →JP Y7	6	1.981
EUR Y10 → JP Y10	6	2.255*

* indicates significance at the 5% level.
Original lag is chosen by AIC standard.
The method by Toda and Yamamoto (1995) is used.

5. Concluding Remarks

This paper analyzes the relationship of long term interest rates between Japan and Euro zone in the framework of uncovered interest rate parity relationship (UIP) from June 1, 2000 through May 24, 2004.

Engle and Granger cointegration test is conducted. We find no evidence of UIP in the entire term structure. Thus we find little evidence for long-run international linkages of long term interest rates between Japanese Yen and Euro from June 1, 2000 through May 24, 2004.

The Granger causalities of Japanese interest rates on Euro interest are confirmed in the entire term structure. The Granger causalities of Euro interest rate on Japanese interest rate are confirmed only in 10 year. Thus it's considered that interest rates moved only by the influences from Japanese on Euro rates except for 10 year interest rates. Two interest rates are considered to be moving from mutual influences in 10 year.

As for the remaining topics, (1) to investigate the reasons why Euro interest rates didn't

Granger cause Japanese interest rates except for the term structure of 10 year, (2) to estimate the error correction models and impulse response function, --these two points are pointed out.

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