Real Interest Rate Linkages in the Asian-Pacific Region: A Time-Varying Parameter Approach

K. Sato

Faculty of Economics, Yokohama National University, Yokohama, Japan

Abstract: This paper attempts to evaluate the degree of financial integration in the Asian-Pacific region by analyzing the convergence of real interest rates with the quarterly data from 1980 to 2002. In marked contrast to the previous studies, a time-varying parameter model is employed to explore how financial integration evolves over time, especially before and after the Asian currency crisis, and to compare the degree of convergence with respect to Japan and to the United States. It is found that while the Asian NIEs and Thailand exhibit close linkages with the United States and Japan, the linkages with respect to Japan appear to decline after the currency crisis, implying more financial influences of the United States on the regional economies.

Keywords: *Real interest parity; Financial integration; Time-varying parameter model; Kalman Filter; Asian-Pacific region*

1. INTRODUCTION

The purpose of this paper is to investigate to what extent the financial markets of the Asian-Pacific economies are integrated into two core financial markets, the United States and Japan, by analyzing the real interest rate linkages, and to examine which market has more financial influences on the regional economies.

After the financial liberalization process started in the Asian-Pacific economies from the late 1970s and 1980s, a lot of attention has been paid to the degree of financial integration in the region. Glick and Hutchison (1990) have investigated the extent to which the liberalization process integrated the financial markets of the Pacific-Basin countries into world financial markets by testing the real interest parity (RIP) condition, and have found stronger ties of real interest rates between six Pacific-Basin economies and the United States. Phylaktis (1997, 1999) has applied the cointegration techniques and the error-correction model to the tests of RIP in the Pacific-Basin region in order to examine to which financial market, the United States or Japan, the real interest rates of Pacific-Basin countries are linked more. By also using the impulse response function analysis, Phylaktis (1999) has concluded that these countries are closely linked with the world financial markets, and far more integrated with Japan than with the United States, implying a possibility of a Yen bloc in the region.

Whereas the recent works of RIP in the Asian-Pacific region report the interesting evidence that Japan has increased financial linkages with the regional economies, the constant parameter estimation does not necessarily reveal whether financial integration has evolved over time, and whether it was affected by the Asian currency crisis. This paper differs from the previous studies in that it uses the time-varying parameter approach to reinvestigate whether there has been an increasing tendency for the real interest rates across the Asian-Pacific economies to converge. In particular, we explore whether the Asian-Pacific economies are more financially integrated into Japan than into the United States, and also whether such integrating process has been changed after the currency crisis. Deepening financial linkages between Japan and the Asian-Pacific economies will have important implications for feasibility of a regional monetary union, for the theory of optimum currency area suggests that financial integration is one of the preconditions for forming a currency area.

This paper is structured as follows. Section 2 discusses the analytical framework and Section 3 describes the data issues. Section 4 reports the preliminary results of the conventional RIP test. The time-varying parameter estimation is also conducted. Finally, section 5 concludes the paper.

2. ANALYTICAL FRAMEWORK

2.1 Real Interest Parity

The degree of financial market integration is typically measured by the conventional interest parity conditions: covered interest parity (CIP), uncovered interest parity (UIP) and real interest parity (RIP). This paper first conducts the conventional test of RIP to investigate the real interest rate linkages between the Asian-Pacific economies and the two financial markets, the

United States and Japan. The following form of a regression is generally used to test *expected* or *ex ante* RIP (see, for example, Cumby and Mishkin, 1986, and Fujii and Chinn, 2000):

$$(i_t^m - \pi_{t,t+k}^{me}) = \alpha + \beta\,(i_t^n - \pi_{t,t+k}^{ne}) + \varepsilon_t \qquad (1)$$

where i_t is the nominal k period interest rate, inflationary expectations are rationally formed so that $\pi_{t,t+k}^m \equiv \pi_{t,t+k}^{me} + \xi_{t,t+k}^m$, $\pi_{t,t+k}^n \equiv \pi_{t,t+k}^{ne} + \xi_{t,t+k}^n$, $\xi_{t,t+k}^m$ and $\xi_{t,t+k}^n$ are the k-period ahead rational inflation forecast errors for country m and n, respectively, and ε_t is an error term. RIP is supported when the joint hypothesis that $\alpha = 0$ and $\beta = 1$ is not rejected.

A difficulty in estimating Eq. (1) is that expected inflation rates, and hence *ex ante* real interest rates are unobservable. Assuming the Fisher condition, we define the *ex post* real interest rate as: $r_t^m = i_t^m - \pi_{t,t+k}^m$ and $r_t^n = i_t^n - \pi_{t,t+k}^n$. By imposing the rational expectations hypothesis, we can reformulate Eq. (1) into:

$$r_t^m = \alpha + \beta\, r_t^n + \omega_t, \qquad (2)$$

where $\omega_t = \varepsilon_t + \beta\xi_{t+k}^n - \xi_{t+k}^m$. We estimate Eq. (2) by the Two-Stage Least Squares (TSLS) method to allow for a possible correlation between r_t^n and the inflation forecast error terms.

2.2 The Time-Varying Parameter Model

The constant parameter model does not necessarily consider whether financial integration has evolved over time. We estimate the following time-varying parameter model to analyze whether the financial markets have converged between the East Asian economies and two core financial centers:

$$(i_t^m - \pi_{t,t+k}^{me}) = \alpha_t + \beta_t (i_t^n - \pi_{t,t+k}^{ne}) + \varepsilon_t \qquad (3)$$

$$\alpha_t = \alpha_{t-1} + \mu_t, \qquad (4)$$

$$\beta_t = \beta_{t-1} + \eta_t, \qquad (5)$$

where ε_t is an independently and normally distributed error term with zero mean and a constant variance, σ_ε^2; μ_t and η_t are random error terms with zero mean and variances, σ_μ^2 and σ_η^2, respectively. α_t and β_t are calculated using the Kalman filter techniques. See Hamilton (1994) for details of the Kalman filter estimation. The α_t parameter is a stochastic constant that partials out all systematic influences upon $(i_t^m - \pi_{t,t+k}^{me})$ other than those resulting from $(i_t^n - \pi_{t,t+k}^{ne})$. The β_t parameter measures the degree of real interest rate linkages between country *m* and *n*.

Since *ex ante* real interest rates are unobservable, we again use the *ex post* real interest rates. However, r_t^n is not orthogonal to the error-term as discussed in the previous sub-section. Accordingly, some adjustment to r_t^n should be made so that we can apply the Kalman filter techniques. Following McNelis and Neftci (1982), we replace r_t^n by $\hat{r}_t^n$ that is obtained from the first stage estimation of Eq. (2) by TSLS, and then perform the Kalman filter estimation.

2.3 The Haldane and Hall (1991) Test

We also attempt to examine to which market, the US or Japanese one, the Asian-Pacific economies are more financially integrated, using the Haldane and Hall (1991) approach. Manning (2002) has applied the Haldane and Hall approach to the test of convergence among Asian stock markets. Following Haldane and Hall (1991) and Manning (2002), we formulate the following equation:

$$(r_t^{US} - r_t^{AP}) = \alpha_t + \beta_t (r_t^{US} - r_t^{Jp}) + \varepsilon_t, \qquad (6)$$

where α_t and β_t follow the same process as Eq. (4) and (5). We estimate the time-varying β_t coefficient in Eq. (6) by using the Kalman filter techniques. Unlike Eq. (1) and (3), we directly incorporate r_t into the model, which means that Eq. (6) is to analyze the *ex post* real interest rate linkages, and hence, it does not necessarily reveal the linkages of *ex ante* real interest rates.

As shown by Haldane and Hall (1991), the time-varying parameter β_t measures the temporal relationship of the Asian-Pacific (AP) country's real interest rate with respect to the US and Japanese ones, respectively. We assume the United States and Japan as the common external and regional base market, respectively. If the AP country's real interest rate is correlated more with the US one (or the former is independent of the Japanese interest rate), the parameter β_t tends to be zero. Conversely, if the AP country's real interest rate is correlated more with Japan (or the former is independent of the US rate), we expect the parameter β_t to approach to one. Although Eq. (6) detaches ourselves from the conventional RIP condition, this approach may provide additional evidence for or against the financial integration in the Asian-Pacific region.

Table 1. The Real Interest Parity Results: Comparisons with the United States and Japan

	Panel A: Comparisons with the United States					Panel B: Comparisons with Japan				
Country:	α	β	β=1	α=0 and β=1	Adj.R^2	α	β	β=1	α=0 and β=1	Adj.R^2
Japan										
1980Q1-1996Q4	0.015 *	0.516 **	6.760 **	7.068 *	0.20	–	–	–	–	–
1980Q1-2002Q2	0.005	0.658 **	2.635	4.215 **	0.07	–	–	–	–	–
Korea										
1980Q1-1996Q4	0.065 **	0.847 *	0.180	127.151 **	0.25	0.055 **	1.138 **	0.141	106.089 **	0.15
1980Q1-2002Q2	0.054 **	1.101 **	0.086	145.326 **	0.25	0.063 **	0.868 **	0.222	132.799 **	0.07
Taiwan 1										
1980Q4-1996Q4	0.016	1.034 #	0.003	4.130	0.15	0.008	1.256 *	0.199	3.334	0.07
1980Q4-2002Q2	0.021	0.909 #	0.033	7.190 *	0.12	0.026 *	0.832 *	0.202	10.224 **	0.10
Taiwan 2										
1980Q1-1996Q4	0.169 **	0.583	0.482	309.280 **	0.11	0.158 **	0.904	0.027	296.585 **	0.09
1980Q1-2002Q2	0.172 **	0.444	1.101	480.520 **	0.08	0.169 **	0.672 #	0.744	521.601 **	0.11
Hong Kong										
1982Q1-1996Q4	-0.047 **	1.590 **	2.637	35.001 **	0.24	-0.037 **	1.124 **	0.098	27.310 **	-0.07
1982Q1-2002Q2	0.005	0.409	1.396	3.634	0.08	0.029 *	-0.614	17.630 **	18.584 **	-0.05
Singapore										
1980Q1-1996Q4	0.002	0.977 **	0.010	0.138	0.22	0.006	0.776 **	0.993	1.000	0.19
1980Q1-2002Q2	0.007	0.796 **	0.847	1.274	0.20	0.018 **	0.468 **	9.973 **	13.118 **	0.13
Malaysia										
1980Q1-1996Q4	0.036 **	-0.239	16.606 **	16.650 **	-0.08	0.032 **	-0.090	14.626 **	14.643 **	-0.04
1980Q1-2001Q4	0.032 **	-0.178	15.873 **	15.874 **	-0.05	0.024 **	0.130	18.069 **	18.969 **	-0.01
Indonesia										
1986Q2-1996Q4	0.056 **	1.386	0.186	61.038 **	0.06	0.066 **	0.612	0.446	42.871 **	-0.09
1986Q2-2002Q2	0.035	1.391	0.031	4.721 #	-0.07	0.035 **	1.588	0.241	5.564 #	-0.06
Thailand										
1980Q1-1996Q4	0.025 *	1.173 **	0.208	27.993 **	0.22	0.017	1.371 **	0.828	20.714 **	0.02
1980Q1-2002Q2	0.019 #	1.257 **	0.499	28.068 **	0.25	0.024 **	1.219 **	0.497	26.635 **	-0.02
Philippines										
1980Q1-1996Q4	0.102 **	-1.991 #	7.684 **	8.702 *	-0.04	0.075 *	-0.988	3.624 #	4.437	-0.07
1980Q1-2002Q2	0.090 **	-1.702 #	9.262 **	11.604 **	-0.04	0.054 **	-0.385	4.636 *	4.014 *	-0.03
Australia										
1980Q1-1996Q4	0.054 **	-0.176	21.767 **	50.768 **	0.04	0.046 **	0.097	13.086 **	36.178 **	-0.03
1980Q1-2002Q2	0.035 **	0.278	6.941 **	24.132 **	-0.09	0.030 **	0.532 *	5.257 *	30.290 **	-0.13

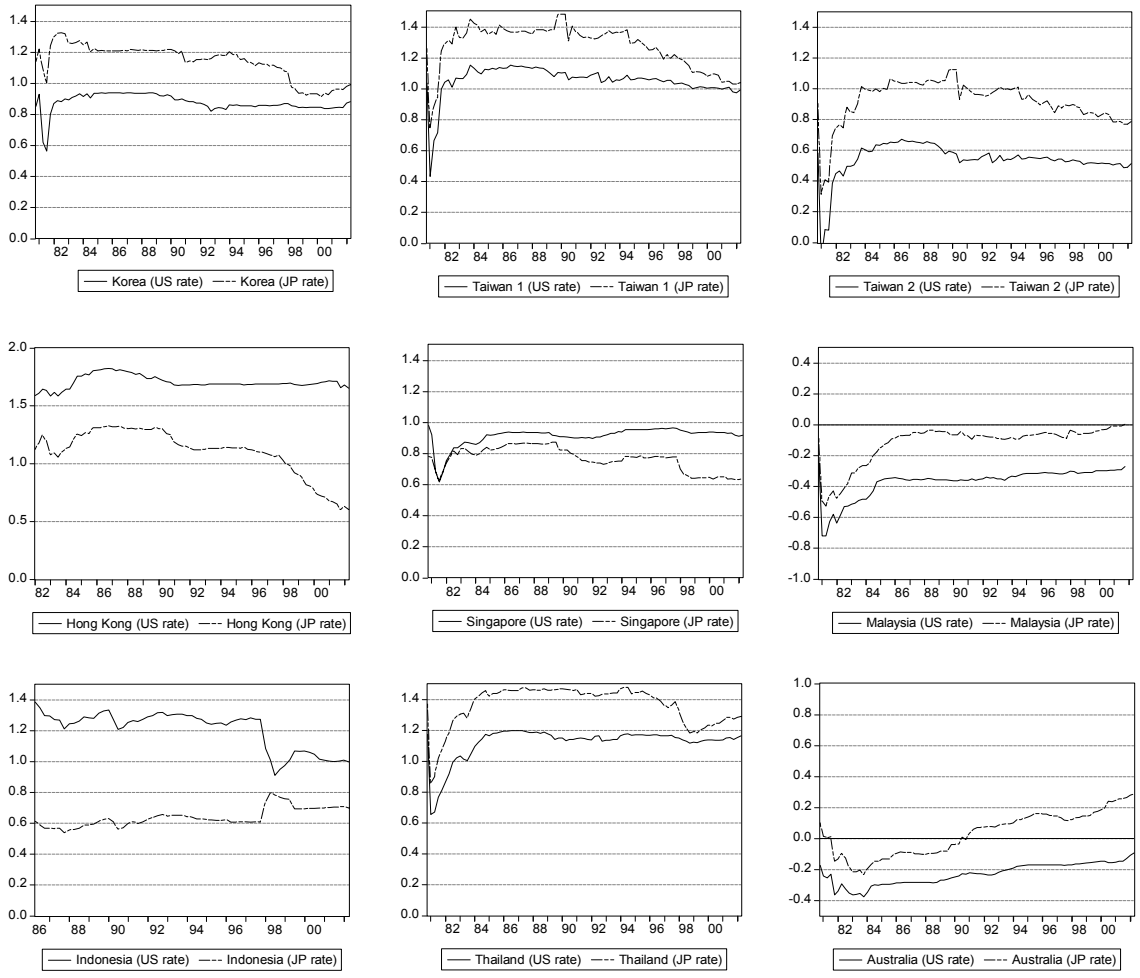
Notes: Panels A and B report the results of the TSLS estimation of equation (2) in the text. The instruments are a constant, a time trend, the nominal interest of the United States or Japan, and the inflation rates of the United States or Japan lagged by 1 through 3. Standard errors are not reported due to the space limitation. The fourth and fifth columns as well as ninth and tenth ones report the Wald test statistics for the null hypothesis indicated the second row. Double asterisk (**), single asterisk (*) and sharp (#) denote statistical significance at 1 percent, 5 percent and 10 percent levels, respectively. "Taiwan 1" denotes the commercial paper rate and "Taiwan 2" the curve market rate.

3. DATA

The United States and ten Asian-Pacific economies are taken up in this paper: Japan, Korea, Taiwan, Hong Kong, Singapore, Malaysia, Indonesia, Thailand, the Philippines and Australia. We have used quarterly (end of quarter) data from 1980Q1 to 2002Q2 except for Taiwan (1980Q4-2002Q4 for money market rate), Hong Kong (1982Q1-2002Q2), Malaysia (1980Q1-2001Q4) and Indonesia (1986Q2-2002Q1).

The 3-month maturity of domestic money market interest rates are used in this paper: the 3-month Treasury Bill secondary market rate for the United States and Australia; the 3-month Gensaki rate for Japan; 31-90 day commercial paper secondary market rate for Taiwan; the 3-month inter-bank offered rate for Hong Kong and Singapore; the weighted average rate paid on 3-month deposits at commercial banks for Indonesia; the 91-day Treasury Bill rate for the Philippines. Due to the data availability, the financial instruments employed here are not strictly comparable in terms of maturity and risks. The yield of 3 year corporate bonds is alternatively used for Korea; the daily average 7-day interbank rates of ten banks (up to 1995) and average overnight interbank rate (from 1996) are used for Malaysia; the daily average of commercial banks' overnight rates for interbank lending is alternatively used for Thailand. Although the maturity periods of the last three interest rates differ from others, we include the former in our analysis and treat them as a 3-month maturity for the sake of completeness. For Taiwan, we use the curve market interest rate (the unorganized money market rate on loans against post-dated checks in Taipei) as well, for the curve rate was more important in Taiwan during the 1980s when the domestic money market rates were highly regulated. For the price series, we use the consumer price index (CPI). As is the case in the previous studies, all interest rates and inflation rates are annualized, continuously compounded.

Figure 1. Time-varying Parameter Estimate of β_t in Eq. (3)



The major data sources are IMF, *International Financial Statistics*, CD-ROM; the web sites of the Board of Governors of the Federal Reserve System, the Bank of Korea, the National Statistics of Taiwan, the Hong Kong Monetary Authority, the Bank of Thailand, and the Reserve Bank of Australia; the Bank of Japan, *Economic Statistics Monthly* and *Financial and Economic Statistics Monthly*; the Securities Dealers Association of Japan; *Hong Kong Monthly Digest of Statistics*; and the Taiwan Economic Data Center.

4. EMPIRICAL RESULTS

4.1 Results of the Conventional Test of RIP

We estimate Eq. (2) by the TSLS and the results of estimation are reported in Table 1.[1] Following Cumby and Mishkin (1986) and Glick and Hutchison (1990), we employ as the instruments a constant, a time trend, the nominal interest of the United States (or Japan), and the inflation rates of the United States (or Japan) lagged by 1 through 3. We present the result for sub-period (1980Q1-1996Q4) as well to allow for possible structural breaks caused by the Asian currency crisis in 1997.

As a preliminary information, we report the results of RIP between the United States and Japan. Although the β coefficient is significantly different from zero and not significantly different from unity for the whole sample period, the joint hypothesis of $\alpha = 0$ and $\beta = 1$ is rejected for both sample periods. Turning to the results for Asian-Pacific economies, before the currency crisis, the

[1] We tested the stationarity of real interest rate series using the augmented Dickey-Fuller (ADF) test and the Phillips-Perron test. While the unit-root hypothesis cannot be rejected in a few cases by the ADF test, the null hypothesis of unit-root is rejected in all cases by the Phillips-Perron test (the results of unit root tests are available upon request). We therefore treat all real interest rates as stationary series in the following empirical analysis.

β coefficient is positive and significantly different from zero at least at the 10 percent level and also not significantly different from unity in five cases (the Asian NIEs and Thailand) of both Panels A and B. For Taiwan 1 and Singapore, the joint hypothesis of $\alpha = 0$ and $\beta = 1$ is not rejected in Panels A and B, implying that RIP holds in these cases. When including the post-crisis period, the β coefficient becomes significantly positive for Taiwan 2 and Australia in Panel B. Accordingly, our estimated results suggest that the *ex ante* 3-month real interest rates of the Asian NIEs and Thailand have closely linked with those of both the United States and Japan, and also that RIP holds with respect to the United States and Japan for Taiwan 1 and Singapore before the currency crisis. However, the above analysis does not necessarily reveal whether the linkages have increased over time and which market has more financial influences on the Asian-Pacific economies. These issues are investigated in the next section.

4.2 Results of the Time-varying Parameter Model

We estimate Eq. (3) using the Kalman filter techniques. As the starting values of coefficients for the Kalman filter estimation, we use the TSLS estimates obtained in the previous sub-section. The estimates before the crisis are used as the starting values, because the estimates for the whole sample period are likely affected by the currency crisis. The results for Asian-Pacific economies except the Philippines are reported in Figure 1.[2]

Our primary interest is in the results of the Asian NIEs and Thailand that exhibit the positive and significant β coefficient in Table 1. First, in these five economies, β_t is quite stable with respect to the US rate over the sample period. Second, the β_t coefficient with respect to the Japanese rate becomes unstable and moves downward from around the mid-1990s, especially in Hong Kong. These observations indicate that the degree of financial linkages between Japan and the Asian-Pacific economies might start to decline from around the mid-1990s.

McNelis and Neftci (1982) have proposed the test for the significance of the variation in the time-varying parameters. They calculated the normalized estimates as follows:

$$T_\beta = \frac{\hat{\beta}_t - \hat{\beta}_0}{\hat{\sigma}(\beta_0)}, \qquad (7)$$

where $\hat{\beta}_t$ is the Kalman filter estimate, $\hat{\beta}_0$ is the starting value of the Kalman filter estimation that is obtained by the TSLS estimation of the constant parameter model, and $\hat{\sigma}(\beta_0)$ is the standard error of the TSLS estimates. Normalized estimates T_β in Eq. (7) can be interpreted as a time-varying version of the standard *t*-test. If (the change of) T_β exceed the critical level 1.96, the variation in parameters concerned is significant at the 5 percent level in terms of the initial standard error.

We calculated the normalized estimates to test the significance of variation in β_t. The results are not reported due to the space limitation and available upon request. The normalized estimates with respect to the US rate are quite stable at around the initial value from the mid-1980s. On the other hand, the normalized estimates with respect to the Japanese rate clearly shift downward from the initial level after the currency crisis in Korea, Taiwan, Singapore and Thailand, whereas the estimates decline by less than 1 standard deviation from the 1996 level. Even in Hong Kong, the normalized estimates decrease by 1.5 standard deviation from the 1996 level. These results suggest that the variation in β_t with respect to the Japanese rate is not statistically significant for the Asian-Pacific economies.

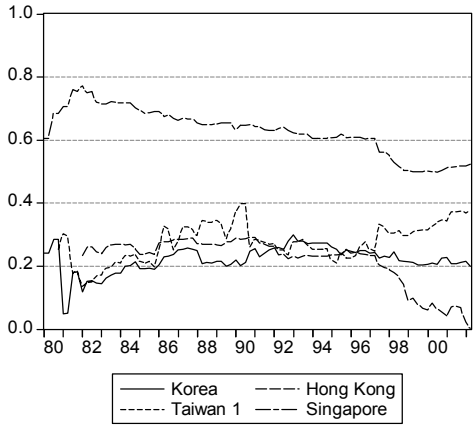
4.3 Results of the Haldane and Hall (1991) Time-varying Parameter Model

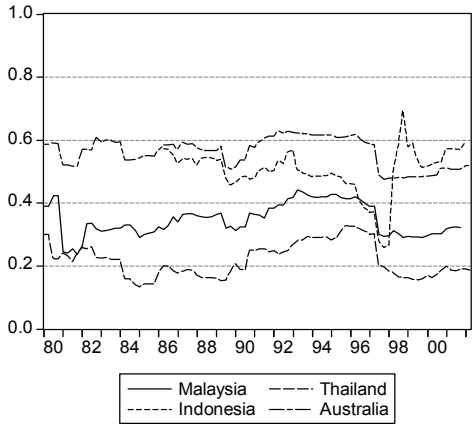
We finally present the results of Haldane and Hall (1991) estimation that are reported in Figure 2. In Korea, the value of β_t is quite stable at around 0.2, indicating the strength of the linkages with respect to the US rate. In Hong Kong, β_t fluctuates between 0.2 and 0.3 up to the currency crisis, but it declines toward zero from 1997, implying strong linkages with respect to the US rate. In Taiwan, β_t also fluctuates between 0.2 and 0.4, though it exhibits an upward trend after the crisis. Singapore shows a downward shift of β_t from the early 1980s, but it still remains at around 0.5 after the crisis. These results suggest the closer linkages to the US rate for Korea, Hong Kong, Thailand, and possibly Taiwan. Although declining steadily, Singapore still exhibits closer linkages with respect to the Japanese rate. While β_t is relatively higher in Malaysia, Indonesia and Australia, we must be careful in interpreting the results, for the estimated

[2] The results for the Philippines are not our primary concern and not reported in Figure 1, because the slope coefficients are negative and fluctuates around -2.0 with respect to the United States and around -1.0 with respect to Japan, based on the time-varying parameter estimation.

coefficients reported in Table 1 and Figure 1 are negative or not statistically significant.[3]

Figure 2. The Haldane and Hall (1991) Time-varying Parameter Estimates





5. CONCLUDING REMARKS

This paper has examined the real interest rate linkages between the Asian-Pacific economies and two financial markets, the United States and Japan, by using both the conventional test of RIP and the time-varying parameter model. The conventional RIP test shows that the Asian NIEs and Thailand have significant linkages with both the United States and Japan, whereas the test result says little about which market has more financial influence on the regional economies. The time-varying parameter estimation indicates that the real interest rate linkages with Japan declines in the Asian NIEs and Thailand. The Haldane and Hall (1991) time-varying estimation provide us with additional evidence that the real interest rate linkages are stronger for some Asian NIEs and Thailand with respect to the United States than to Japan, especially after the crisis. Contrary to the recent findings, we may say that the United States still have more financial influences on the regional economies than Japan.

[3] We also calculated the normalized estimates of the slope coefficient in Eq. (6) to test the significance of variation, but could not find any significant variation.

6. ACKNOWLEDGEMENTS

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