University of California, Santa Cruz
Department of Economics
Working Paper # 302, February 1994
JEL: F36, C22, F32

THE RELATIVE INFLUENCE OF US AND JAPAN ON REAL INTEREST RATES AROUND THE PACIFIC RIM: 1982-1992

by

Menzie David Chinn
Department of Economics
University of California
Santa Cruz, CA 95064

Jeffrey A. Frankel
Department of Economics
University of California
Berkeley, CA 94720

November 14, 1994

Acknowledgements: We thank Yin-Wong Cheung, Hali Edison, Neil Ericsson, Joe Gagnon, Dale Henderson, Matt Pritsker, workshop participants at UCSC and the Federal Reserve Board's International Finance Division, and two anonymous referees for their helpful comments. Yunqi Li provided assistance in data collection. We also thank Carlton Strong of Morgan Guaranty and Ramon Moreno of the San Francisco Federal Reserve Bank for providing data. All remaining errors are solely the authors' responsibility.

Address for correspondence: Menzie D. Chinn, Department of Economics, Social Sciences I, University of California, Santa Cruz, CA 95064. Tel: (408) 459-2079. Fax: (408) 459-5900. E-mail: chinn@cats.ucsc.edu.

isjapan3

ABSTRACT

The Relative Influence of US and Japan on Real Interest Rates around the Pacific Rim

This paper investigates the relative influence of US and Japanese real interest rates in the determination of local Pacific Rim rates, where influence is defined by the presence of common stochastic trends. Alternatively, we ask whether real rates are driven by the same shocks. Furthermore, the degree to which real interest parity holds is examined. Rather than searching for instantaneous real interest parity, this study searches for long run interest parity, allowing for a constant due to differing risk attributes and time invariant exchange risk premia. The cointegration testing methodology of Johansen (1988) is adopted for this analysis, which allows for multiple cointegrating vectors. The results indicate that Hong Kong, Malaysia and Taiwan are integrated with both the US and Japan (in terms of cointegration and positive covariation), while only Singapore is solely integrated with the US. On the other hand Korea, and perhaps Indonesia and Thailand appear to be more closely linked with Japan. Real interest parity holds for only the following interest rate pairs: US-Singapore, US-Taiwan and Japan-Taiwan.

JEL Codes: F36, C22, F32

Keywords: cointegration, economic integration, purchasing power parity, real interest rates

1 Introduction

This paper investigates the relative influence of US and Japanese real interest rates on local rates in several Pacific Rim countries over the decade 1982-1992. Anecdotal evidence points to increasing capital mobility in this region, and under certain conditions this phenomenon translates into an increased covariation of real interest rates, particularly over the long run. We choose to investigate whether there is a tendency toward greater comovement of real rates because, in the limiting case where real interest parity holds, such a process has a number of important macro- and microeconomic consequences, as documented for instance by Fukao and Hanazaki (1986).

Various studies have shown that the covariation in nominal interest rates have increased over the past decade and further, that covered interest parity now holds fairly well for certain Pacific Basin countries (Chinn and Frankel, 1994b). Other studies have found evidence of increasingly strong real interest rate linkages (e.g. Glick, 1987 and Glick and Hutchison, 1990), by comparing either summary statistics, such as the average real interest differential, or regression coefficients, over early and late subsamples of the data. The former approach encounters difficulties because of the possibility of differing risk attributes of the debt instruments, or the presence of nontradable goods (see Obstfeld, 1993), while the latter may yield inappropriate inferences, due to the nonstationarity of the time series data.

An issue of more recent vintage involves the question of whether Japan is gaining (or the US is maintaining) economic dominance in the region (Frankel, 1993). Frankel and Wei (1994) assess whether a trade and/or currency bloc is forming in the Pacific. Chinn and Frankel (1994a) examine the question of whether US or Japanese nominal interest rates are more influential.

In this paper, the multivariate cointegration testing methodology of Johansen (1988) and Johansen and Juselius (1990) is applied to the question of whether there are common stochastic trends in Pacific Rim real interest rates. An alternative interpretation of the question is whether common shocks drive real rates in this region. The Johansen procedure allows for the testing for multiple cointegrating vectors, and hence multiple linkages. An added benefit of this approach is that one can also test whether the estimated relationships are consistent with real interest rate parity (allowing for a constant).

The empirical results indicate the following: Hong Kong, Malaysian and Taiwanese real rates are cointegrated (with the correct sign) with both US and Japanese real rates, while only the Singapore rate is solely cointegrated with the US rate. On the other hand, Indonesian, South Korean and Thai rates appear to be more closely linked with Japanese rates. However, when the real interest parity criterion is applied, then Singapore rates appear linked with US rates, and Taiwanese rates with both US and Japanese rates.

The paper is organized as follows. Section 2 reviews the theory underlying real interest parity. Section 3 outlines the econometric methodology of the Johansen technique. Section 4 discusses the empirical results, and Section 5 concludes.

2 Theory

The empirical study of real interest parity (RIP) extends back to at least Cumby and Obstfeld (1984) and Mishkin (1986). In general, short run RIP is statistically rejected. Comovement of real rates (as opposed to equality) has also occupied some attention, as in Cumby and Mishkin (1986). In the context of the Pacific Basin, Glick and Hutchison (1990) have determined that real interest parity can often be rejected, but less frequently as financial deregulation has proceeded.

It is instructive to consider what RIP entails. Briefly, it involves the joint hypothesis of uncovered interest parity (UIP), and instantaneous relative purchasing power parity (RPPP). To see this, assume UIP:

$$i_{t,k}^{US} - i_{t,k}^{local} = E_t \Delta s_{t+k} \tag{1}$$

where

$i_{t,k}$ is a k period interest rate

s is the spot exchange rate in \$/local currency unit

E_t is the expectations operator conditional on time t information, $E(.|\Phi_t)$

RPPP is given by:

$$E_t \pi_{t,k}^{US} - E_t \pi_{t,k}^{local} = E_t \Delta s_{t+k} \qquad \textbf{(2)}$$

where

$\pi_{t,k}$ is the inflation rate from time t to t+k

Combining the two equations yields:

$$E_t r_{t,k}^{US} = E_t r_{t,k}^{local} \qquad \textbf{(3)}$$

where $E_t r_{t,k}$ is the ex ante real interest rate.

Since the ex ante real interest rate is never observed, we invoke rational expectations, so that equation (4) is the relevant one for empirical estimation:

$$r_{t,k}^{US} - r_{t,k}^{local} = \epsilon_{t+k} \quad ; \quad E(\epsilon_{t+k}|\Phi_t) = 0 \qquad \textbf{(4)}$$

where ϵ is a composite error term arising from expectational errors and Φ_t is the information set available at time t.

In Cumby and Obstfeld (1984), the source of the rejection of RIP was primarily located in the failure of RPPP, rather than UIP, to hold. If the failure is due to sticky prices, then the deviations from RIP should no longer be considered white noise, and one can write:

$$r^{US}_{t,k} - r^{local}_{t,k} = \Delta q_{t+k} + \tilde{e}_{t+k} \quad ; \quad E(\tilde{e}_{t+k}|\Phi_t) = 0 \qquad \textbf{(5)}$$

where q is the log real exchange rate and $\tilde{e}_{t+k}$ is a composite expectational error for real interest rates and real exchange rate depreciation. In the discussion that follow below, we will allow for a constant in equation (5), due to differences in default risk attributes of the debt instruments, and a time invariant exchange risk premium. Hence, as long as the expected real depreciation is stationary, then the two real interest rate series should move together over long periods.[1]

3 Testing for Cointegration

3.1 Overview

In this study real interest rates are modeled as integrated processes of order 1 [I(1)], mainly on the basis of empirical evidence.[2] Real interest parity then implies (i) cointegration and (ii) a cointegrating vector with coefficients of equal and opposite signs. If only the first condition applies, then the two real interest rates are subject to the same stochastic trend, but real

[1] This statement actually holds under less restrictive assumptions regarding the exchange risk premium. As long as the risk premium is stationary, then the two interest rate series will move together.

[2] Gagnon and Unferth (1993) model developed country real interest rates as I(0) series, and use a principal components approach to obtaining a measure of the real world rate of interest. Their study differs from this one in terms of time span (1977-1992) and countries covered.

interest parity fails to hold even in the long run.

At this juncture, there are several ways in which to proceed. The first is the original Engle-Granger two-step methodology, which may be appropriate if the choice is between the null hypothesis of no cointegrating vectors and the alternative of one cointegrating vector. In this paper we adopt the Johansen (1988) and Johansen and Juselius (1990) multivariate maximum likelihood approach for a number of reasons. First, on technical grounds this approach is more efficient than the Engle-Granger approach (assuming that the lag order is chosen correctly so that the errors are serially uncorrelated). There is also an economic reason: we wish to test whether local interest rates are linked to the US, to Japan, or to both. This implies that in a system of three variables there exists the possibility of <u>two</u> cointegrating vectors. The Johansen technique allows for the testing for, and estimation of, more than one vector.

3.2 Technical Description

Let x_t be a $m \times 1$ vector of I(1) variables. Then one can estimate the VAR(p):

$$\ldots + \Gamma_1 \Delta x_{t-1} + \Gamma_2 \Delta x_{t-2} + \ldots \Gamma_{p-1} \Delta x_{t-p+1} + \Pi x_{t-p} + B \ldots \qquad \textbf{(6)}$$

where Γ_1, Γ_2, ... Γ_{p-1}, $\prod$ are $m \times m$ matrices of unknown parameters, B is an $m \times s$ matrix, and u is distributed $N(0,\Sigma)$. The matrix $\prod$ is estimated by the Johansen maximum likelihood procedure subject to the hypothesis that $\prod$ has reduced rank (i.e., $r < m$). This hypothesis is written:

$$H(r): \Pi = \alpha\beta' \tag{7}$$

where α and ß are $m \times r$ matrices. If $r < m$ then under certain conditions $ß'x_t$ is stationary (the $ß'x_t$ are the cointegrating relationships).

There are two tests for reduced rank based, respectively, on the trace and the maximal eigenvalues of the $\prod$ matrix. In each case, the Johansen procedure allows one to test the hypothesis of the number of cointegrating vectors being 0 vs. 1, or 1 vs. 2, etc.

In the analysis below, a number of systems will be estimated. In the bivariate system, the vector $x_t' = (r_t^{US}\ r_t^{\ell})$, or $x_t' = (r_t^{JP}\ r_t^{\ell})$. In a more general multivariate framework, where the possibility of more than one cointegrating vector is allowed for, $x_t' = (r_t^{US}\ \ r_t^{JP}\ r_t^{\ell})$.

In this framework, it is possible to test whether <u>individual</u> series are stationary; i.e., whether a "trivial" cointegrating vector involving a single variable exists. Consider the bivariate US-local example above. A test for stationarity of the local series is equivalent to a test that the vector (0 1) is contained in the cointegrating space.

Once the number of cointegrating vectors is determined, one can investigate whether the values of the estimated cointegrating vectors are consistent with real interest parity. For instance in the simple bivariate US-local system, the implied cointegrating vector is (-1 1), indicating that in the long run a permanent unit innovation in US real rates is matched by a unit change in the local real rate. One can then calculate a likelihood ratio test statistic for the restriction, which is asymptotically distributed χ^2 .

It is also be possible to determine the rate of reversion towards real interest parity. In the Johansen framework, the α matrix summarizes this movement. Rather than focus on the α matrix, consider the more intuitive case of one equation from a bivariate system of (x_{1t}, x_{2t}):

$$\begin{aligned}\Delta x_{1,t} &= \mu + \gamma_1 \Delta x_{1,t-1} + \ldots + \gamma_{p-1} \Delta x_{1,t-p+1} \\ &\quad + \theta_1 \Delta x_{2,t-1} + \ldots + \theta_{p-1} \Delta x_{2,t-p+1} \\ &\quad + \alpha_1 (\beta_1 x_{1,t-p} + \beta_2 x_{2,t-p}) + u_t\end{aligned} \tag{8}$$

Consider $ß_1$ = -1 and $ß_2$ = 1; then α_1 is the rate of reversion of x_1 toward RIP. If α_1 is not statistically significant, then x_1 is weakly exogenous with respect to the cointegrating vector, i.e., x_1 is not caused by the real interest rate deviation. On the other hand, if α_1 is statistically significant, then x_1 does respond to the deviation.[3]

4 Empirical Results

[3] This approach could be interpreted as an alternative means of testing for cointegration. See Kremers, Ericsson and Dolado (1992).

4.1 Data

The data are of quarterly frequency and cover the US, Australia, Canada, Hong Kong, Indonesia, Japan, South Korea (henceforth, Korea), Malaysia, New Zealand, Singapore, Thailand and Taiwan over the 1982Q3-1992Q1 period. The nominal interest rates (usually three month interbank rates)[4] are drawn from the Morgan Guaranty and Data Resources, Inc. Financial and Credit Statistics (DRI FACS) databases, and pertain to rates at the end of the quarter.[5] The inflation rates used to generate the ex post real interest rates are calculated by taking log-differences of the monthly local consumer price indices (CPIs), seasonally unadjusted. Using end-of-quarter data minimizes the amount of serial correlation due to time averaging of data. The average real interest rate differentials are reported in Table 1. The ex post real interest rates are graphed in Figures 1-11.[6]

[4] The corporate bond series is used as the Korean interest rate series. Of the two alternative series, the 3 month interbank rate is highly regulated and shows little time variation, while the Monetary Stabilization Bond series mimics the movements in the corporate bond series, but spans a much shorter period (1987Q2-1991Q3).

[5] The US interest rate is the 3 month Eurobond rate. Since the US market is considered completely open, use of this rate yields the same results as using the onshore counterpart. The New Zealand interest rates are sampled at the end of the second month of each quarter, since New Zealand CPIs are only reported at midquarter.

[6] The series depicted in the figures are 3 quarter centered moving averages of the series used in the regressions. Because of large seasonal component in Japanese inflation, the Japanese real rate series is a moving average of the seasonally adjusted rates.

By the criterion of average interest differentials, the US appears most integrated with Canada, Japan, Malaysia, Singapore, and Taiwan, while Japan appears integrated with Malaysia, Singapore, and Taiwan. However, averages may mask sizable but offsetting positive and negative deviations. Moreover, average real interest differentials may be inappropriate measures of economic integration, given the differing risk attributes of the debt instruments, as well as the presence of nontradable goods. The Balassa-Samuelson hypothesis would predict larger real interest differentials between less developed countries and a developed country if productivity growth is very different in the tradables versus nontradables sectors (Obstfeld, 1993). Hence, a view to the covariation of rates is necessary.

4.2 Univariate Unit Root Tests

The proposed testing methodology relies upon cointegration of nonstationary series. The conventional ADF tests (with trend) were applied to all the real interest rate series. The results (for 4 lags) are reported in Table A1. All series, save the New Zealand, fail to reject the unit root null hypothesis.[7] Given the well-known low power of such univariate tests, this set of results is unsurprising. Below, a multivariate unit root test using the

[7] Gagnon and Unferth (1993) find Japanese and Canadian real interest rates to be stationary in their longer (1978-1992) time sample. However, they do corroborate our results for the US real rate.

Johansen methodology is also applied, and largely similar conclusions are obtained. Hence, the subsequent statistical analysis is conducted assuming all the rates, save New Zealand's, are I(1).

4.3 US-Local Cointegration Results

The first set of results involves testing for cointegration between US and local interest rates. Table 2 reports the results. The VAR order is set so as to make the residuals from each regression equation serially uncorrelated, according to the F version of a Lagrange Multiplier test (Godfrey, 1978a,b) of lag order 4. It appears that real rates in Australia, Canada, Hong Kong, Indonesia, Singapore and Taiwan are cointegrated with US rates, when judged using critical values adjusted for sample size (Cheung and Lai, 1993). The Thai and Malaysian rates are borderline cases; only the maximal eigenvalue test indicates cointegration for the former, and the trace for the latter. Given that the trace test appears more robust to nonnormality of errors[8], more weight is placed on the trace test; hence Malaysia is interpreted as being cointegrated with the US.

While a large number of interest rate pairs appear to be cointegrated, the <u>signs</u> of the estimated cointegrating parameters for the foreign rate are correct (positive) in only a few cases --

---

[8] See Cheung and Lai (1993) for monte carlo results on this issue.

Hong Kong, Malaysia, Singapore and Taiwan. The coefficient signs for Japan and Thailand are also correct, but these are for cases where the null of zero cointegrating vectors could not be rejected.

The estimated elasticities of local rates with respect to US rates range from 0.31 for Malaysia to a implausibly high 3.08 for Taiwan. While the Singapore point estimate of 0.98 is essentially unity, the Hong Kong (0.40) and Malaysian estimates strongly reject the restriction implied by RIP. The interpretation of point estimates both economically and statistically less than unity is somewhat problematic. Basically, this finding means that these local rates and US rates are driven by the same shocks, but can nonetheless drift apart, in levels.

The set of cases where cointegration is found, and the restriction that the cointegrating vector is (-1 1) is not rejected at the 1% level is small -- Singapore and Taiwan. Thus, real interest rate parity appears to be a rare phenomenon.[9]

One interesting result is the failure to find cointegration between the US and Japanese real interest rates.[10] This outcome implies that US and Japanese capital and goods markets are not

---

[9] One problem with the interpretation of the Taiwanese and Canadian results is that a test for a trivial cointegrating vector indicates that these interest rates are stationary, using a 10% significance level (see Table A2). Since the null hypothesis in this case is trend stationarity, this finding could be due to low power.

[10] Moreover, a multivariate test for stationarity indicates that the null hypothesis of stationarity for the Japanese real rate could not be rejected (see Table A2).

tightly linked by the criteria of UIP and RPPP.

The failure to find cointegration stands in contrast with those results obtained by Hutchison and Singh (1993). The disagreement is likely due to differences in data as well as the time period covered (they use quarterly averages of both interest rate and CPI data over the 1981Q1-1991Q1 period). Perhaps most importantly, they do not adjust for finite sample effects, as we do, thus biasing their results towards the finding of cointegration.[11]

4.4 Japan-Local Cointegration Results

The results for the Japan-local regressions reported in Table 3 indicate that the Japanese Gensaki real rate is cointegrated with the Hong Kong, Korean, Malaysian and (borderline) Taiwanese real rates. There is some evidence of cointegration between the Japanese and Thai rates, according to the maximal eigenvalue test using the adjusted critical values. However, the signs are positive only in the cases of Hong Kong, Korea, Malaysia and Taiwan (and the ambiguous case of Thailand). Furthermore, of the cases where cointegration is found, the restriction on the cointegrating vector imposed by RIP is always rejected, excepting Taiwan.

---

[11] The results also contrast with those obtained by Marston (1993). He finds a small average difference in the real cost of capital calculated using loan rates adjusted for compensating balance costs; however he finds the smallest average differences when using offshore rates and producer price indices (rather than CPI), which proxy for tradables prices.

There are also a number of cases where the null of two cointegrating vectors cannot be rejected: Australia, Canada, Indonesia and Singapore. The result implies that for these pairs, the null of stationary individual series cannot be rejected. Since these same series appear to be nonstationary according to the results in Table 2 and Table A2, there is clearly some ambiguity regarding the determination of their order of integration.

Multivariate tests for whether the null hypotheses for stationarity were applied. Among the local rates, only the Taiwanese rate appears stationary; however the Japanese rate also appears stationary in about five out of nine cases. This ratio appears high especially when recalling the univariate test results, but it is important to recall that the null hypothesis here is trend stationarity. The findings of trend stationary series could be due to the low power of the test.

There is one apparent inconsistency between the US-local and Japan-local results. The Japanese rate appears cointegrated with Hong Kong, Korean, Malaysian and Taiwanese real rates. Of these, the US appears cointegrated with all save the Korean. This inconsistency implies that the US rate should be cointegrated with the Japanese. Yet the results in Table 2 indicate that this is not the case. As partial explanation, it should be noted that the results obtained using our data set are somewhat sensitive to the lag order chosen for the VAR; if a VAR(2) is estimated, then the trace test indicates 1 cointegrating vector. Furthermore, the RIP constraint can only be rejected at the 5% level.

4.5 Trivariate Cointegration Results

In any system where there are more than two variables of interest, there could be multiple cointegrating vectors. This suggests the estimation of trivariate VARs. In this case, $x_t = (r_t^{US}\ r_t^{JP}\ r_t^{\ell})$, RIP between the US and the local market implies a cointegrating vector of (-1 0 1), and RIP between Japan and the local market, (0 -1 1). The results, reported in Table 4, are not entirely conclusive. Using the adjusted critical values, there do not appear to be any cointegrating vectors for Canada, Hong Kong, Korea, Malaysia, and Thailand. Only when using the asymptotic critical values does there appear to be more than one cointegrating vector. Since use of the asymptotic critical values does not appear justified, one can conclude that there is one cointegrating vector for Singapore, and mixed evidence for Australia, Indonesia, New Zealand, and (perhaps) Taiwan.[12]

We apply likelihood ratio tests to examine whether the restrictions implied by RIP fail to reject for the possibly cointegrated pairs. Using the 10% significance level as a cutoff, only the following pairs were in accord with the RIP hypothesis: US-Singapore, US-Taiwan and Japan-Taiwan. Using a 5% cutoff adds

---

[12] The test statistic is 21.7, while the adjusted critical value is 20.5 at the 10% level, so one could argue that there is evidence for only one cointegrating vector using a 5% critical value.

the Japan-Indonesia pair to the list.

4.6 Interpretation

The trivariate specification in Section 4.5 is the most appealing on theoretical grounds, since one would not like to rule out either the US, or alternatively the Japanese, real interest rates a priori when examining the influences on local rates. However, the difficulty in fitting adequate trivariate VARs and the sensitivity of the results to different lag specifications argues for reference to bivariate system results (i.e., whether they are cointegrated, and have the right signs).

In regard to the bivariate systems, the US rate appears to be cointegrated, and positively covarying, with Hong Kong, Malaysian, Singapore and Taiwanese rates. Japanese rates appear to be similarly linked with Hong Kong, Malaysian, Korean, Taiwanese and perhaps Thai rates.

For the trivariate systems, Japan seems linked with Taiwan (and possibly Indonesia), and the US with Singapore and Taiwan.

This suggests the following schema:

Chart 1
Common Stochastic Trends with:

Both US and Japan	US	Japan
Hong Kong Malaysia Taiwan	Singapore	Indonesia (?) Korea Thailand (?)

These results are in accord with one's intuition that several East Asian countries are closely linked with the international economy, as represented by the US and Japan. The strong linkage of Japan with Korea, and to a lesser degree Indonesia and Thailand, is supportive of the anecdotal evidence of Japanese influence in the region, in the form of trade, direct investment and financial capital flows. However, since the links with Indonesia and Thailand are tentative, these results may be taken to support Frankel's (1993) view that Japan's economic influence in the region has been overstated in some accounts.

4.7 Weak Exogeneity and Rates of Convergence

One can also test for cointegration with the cointegrating vectors given a priori, by using the following error correction model:

$$\begin{aligned} &+ \gamma_1 \Delta r^{\ell}_{t-1} + \ldots + \gamma_p \Delta r^{\ell}_{t-p+1} + \theta_1 \Delta r^{US}_{t-1} + \ldots + \theta_p \Delta \\ &\phi_1 \Delta r^{JP}_{t-1} + \ldots + \phi_p \Delta r^{JP}_{t-p+1} + \alpha_1 ECT^{US}_{t-p} + \alpha_2 ECT^{JP}_{t-p} + \end{aligned} \qquad \textbf{(9)}$$

where the ECTs (error correction terms) are the US and Japanese real interest differentials. Hence, these estimates of rates of reversion differ from those obtained from the Johansen technique in that long run unit coefficients are imposed.

The local interest rate is placed on the left-hand side implying that the foreign interest rates are weakly exogenous with respect to the local interest rate. In this case, then one does not need to model the data generating process governing the marginal processes.

The regression results for equation (9) are reported in Table 5. Both error correction terms are included in each regression. The lag order p is usually set to 2, and is selected so as to reduce the amount of error serial correlation. If the specification fails to reject the null hypothesis of no serial correlation at the 10% level, then the specification is deemed adequate.

The results indicate that the US rates dominate in Singapore, and Japanese in Korea, with statistical significance. In all other cases, the standard errors are too large to make a determination. Hence these regressions confirm two of the earlier results, but fail to shed any additional light on how strongly real interest rate parity holds, or the rate at which real interest parity is attained.

5 Conclusions

This paper has reassessed the degree of financial capital and goods market integration around the Pacific Rim, using recent data and newly developed statistical techniques. Since the statistical methodology is sensitive to various aspects of specification, including the dimension of the vectors and the lag order, a number of simple regressions are also implemented to check for the robustness of the results.

We find that there is a fairly high degree of economic integration in the region, when integration is defined as the presence of common stochastic trends in real interest rates. However, real interest parity (even allowing for a constant) does not hold, with only a few exceptions. What is surprising is that so much evidence of cointegration can be found in a mere ten years of data.

The results also appear to suggest continued US influence in various markets, including Hong Kong, Malaysia, Singapore, and Taiwan. On the other hand Japan also has a sphere of influence which encompasses Hong Kong, Korea, Malaysia, Taiwan, and perhaps Indonesia and Thailand.

Canada constitutes the one anomalous result. Given its proximity to the US, and the large amount of cross-border trade, Canada would appear to be well integrated with the US in both the goods and financial asset market sense.[13] Explanation of this result warrants further research.

---

[13] For a differing perspective, however, see Engel and Rogers (1994). Note that Glick and Hutchison (1990) also conclude, after comparing East Asian and Canadian (from Cumby and Mishkin, 1986) real interest rate regression results, that the East Asian linkages to the US are stronger.

References

Cheung, Yin-Wong and Kon. S. Lai, 1993, "Finite-Sample Sizes of Johansen's Likelihood Ratio Tests for Cointegration," Oxford Bulletin of Economics and Statistics 55(3), 313-328

Chinn, Menzie and Jeffrey Frankel, 1994a, "Financial Linkages around the Pacific Rim: 1982-1992," in Reuven Glick and Michael Hutchison (editors) Exchange Rate Policy and Interdependence: Perspectives from the Pacific Basin (Cambridge University Press): 17-47.

____________ and __________, 1994b, "Capital Barriers in the Pacific Basin: 1982-1992," Journal of Economic Integration 9, 62-80.

Cumby, Robert and Frederick Mishkin, 1986, "The International Linkage of Real Interest Rates: The European-US Connection," Journal of International Money and Finance 5, 5-23.

Cumby, Robert and Maurice Obstfeld, 1984, "International Interest-Rate and Price-Linkages under Flexible Exchange Rates," in John Bilson and Richard Marston (editors) Exchange Rates Theory and Practice (University of Chicago Press for NBER, Chicago).

Engel, Charles, and John H. Rogers, 1994, "How Wide Is the Border?" Mimeo (University of Washington, and Federal Reserve Board) (August).

Engle, Robert and C.W.J Granger, 1987, "Cointegration and Error Correction: Representation, Estimation, and Testing," Econometrica 55, 251-267.

Frankel, Jeffrey, 1991, "Quantifying International Capital Mobility." in D. Bernheim and J. Shoven (editors), National Saving and Economic Performance. (University of Chicago Press: Chicago): 227-260.

__________, 1993, "Is Japan Creating a Yen Bloc in East Asia and the Pacific?" NBER Working Paper No. 4050, April; In Regionalism and Rivalry: Japan and the U.S. in Pacific Asia," edited by Jeff Frankel and Miles Kahler (University of Chicago Press: Chicago).

Frankel, Jeffrey, and Shang-Jin Wei, 1994, "Yen Bloc or Dollar Bloc: Exchange Rate Policies of the East Asian Economies," Third Annual East Asian Seminar on Economics, organized by Takatoshi Ito and Anne Krueger, held in Sapporo, Japan, June 17-19, 1992, and

sponsored by the National Bureau of Economic Research.

Fukao, Mitsuhiro and Masaharu Hanazaki, 1986, "Internationalization of Financial Markets: Some Implications for Macroeconomic Policy and for the Allocation of Capital," OECD Working Papers #37 (November).

Gagnon, Joseph and Mark Unferth, 1993, "Is There a World Real Interest Rate?" International Finance Discussion Paper 454.

Glick, Reuven, 1987, "Interest Rate Linkages in the Pacific Basin," SF FRB Economic Review, (Summer), 31-42.

Glick, Reuven, and Michael Hutchison, 1990, "Financial Liberalization in the Pacific Basin: Implications for Real Interest Rate Linkages," Journal of the Japanese and International Economies 4, 36-48.

Hutchison, Michael and Nirvikar Singh, 1993, "Long-Term International Capital Mobility: New Evidence from Equilibrium Real Interest Rate Linkages," Mimeo (Department of Economics, UC: Santa Cruz).

Godfrey, L.G., 1978a, "Testing against General Autoregressive and Moving Average Error Models When the Regressions Include Lagged Dependent Variables," Econometrica 46, 1293-1302.

_________, 1978b, "Testing for Higher Order Serial Correlation in Regresion Equations When the Regressors Include Lagged Dependent Variables," Econometrica 46, 1303-1310.

Johansen, Søren, 1988, "Statistical Analysis of Cointegrating Vectors," Journal of Economic Dynamics and Control 12, 231-254.

__________ and Katerina Juselius, 1990, "Maximum Likelihood Estimation and Inference on Cointegration - With Applications to the Demand for Money," Oxford Bulletin of Economics and Statistics 52, 169-210.

Kremers, Jeroen, Neil Ericsson and Juan Dolado, 1992, "The Power of Cointegration Tests," Oxford Bulletin of Economics and Statistics 54, 325-348.

Marston, Richard, 1993, "Determination of Short Term Real Interest Differentials between Japan and the United States," NBER Working Paper #4167.

Mishkin, Frederick, 1984, "Are Real Interest Rates Equal across countries: A Multicountry Empirical Study," Journal of Finance 39, 1345-1357.

Obstfeld, Maurice, 1993, "Model Trending Real Exchange Rates," Center for International and Development Economics Research Working Paper C93-011 (University of California: Berkeley) (February).

Osterwald-Lenum, M., 1992, "A Note with Quantiles of the Asymptotic Distribution of the Maximum Likelihood Cointegration Rank Test Statistics," Oxford Bulletin of Economics and Statistics 54: 461-472.

Table 1
Average Real Interest Differentials

	US - local	Japan - local
Australia	-3.35 (0.52)	-3.92 (0.56)
Canada	-0.99 (0.29)	-1.51 (0.42)
Hong Kong	3.57 (0.50)	2.99 (0.66)
Indonesia	-6.39 (0.63)	-6.96 (0.66)
Japan	0.52 (0.35)	na
Korea	-5.43 (0.40)	-6.00 (0.55)
Malaysia	-0.23 (0.42)	-0.82 (0.46)
New Zealand	-4.06 (1.20)	-4.54 (1.07)
Singapore	0.06 (0.30)	-0.47 (0.42)
Taiwan	-0.22 (0.63)	-0.81 (0.77)
Thailand	-3.53 (0.54)	-4.01 (0.62)

Notes: Average ex post real interest differentials in percent per annum, monthly basis. Standard errors in parentheses. Country indicates local country.

Table 2
Johansen Cointegration Results for Bivariate US-Local Systems

Country	lag	#Vec Mx.Eigen	#Vec Trace	Point Est.	RIP (-1 1)
AU	1	1[1]	1[1]	(-1 -0.64)	Reject 1%
CN	3	1[1]	1[1]	(-1 -2.63)	Reject 1%
HK	2	1[1]	1[1]	(-1 0.40)	Reject 1%
IN	2	1[1]	1[1]	(-1 -0.90)	Reject 1%
JP	2	0[0]	0[0]	(-1 8.37)	Reject 1%
KO	1	2[2]	2[2]	(-1 0.45)	Reject 5%
MA	2	0[1]	1[1]	(-1 0.31)	Reject 5%
SI	1	1[1]	1[1]	(-1 0.98)	Accept
TI	1	1[1]	1[1]	(-1 3.08)	Accept
TH	3	1[1]	0[0]	(-1 0.24)	Reject 1%

Notes: Country indicates local real interest rate; see the Data Appendix for Country Codes. Lag indicates the lag order of the VAR. #Vec indicates the number of cointegrating vectors indicated by either the maximal eigenvalue test (Mx. eigen.) or trace test, using the 10% critical values adjusted for sample size as per Cheung and Lai (1993). The numbers in brackets [.] are the implied number of vectors using the asymptotic critical values from Osterwald-Lenum (1992). The vectors in the "Point Est." column are the estimated cointegrating vectors, normalized on the US real interest rate; under RIP the vector should be (-1 1). If zero or two vectors are indicated, the estimated cointegrating vector is calculated assuming only one cointegrating vector. "RIP" indicates whether the null hypothesis of a (-1 1) vector is rejected according to a likelihood ratio test. All results are for specifications including seasonal dummies.

Table 3
Johansen Cointegration Results for Bivariate Japan-Local Systems

Country	lag	#Vec Mx.Eigen	#Vec Trace	Point Est.	RIP (-1 1)
AU	2	2[2]	2[2]	(-1 -0.16)	Reject 1%
CN	2	2[2]	2[2]	(-1 -0.34)	Reject 1%
HK	2	1[1]	1[1]	(-1 0.12)	Reject 1%
IN	2	2[2]	2[2]	(-1 -0.20)	Reject 10%
KO	2	1[1]	1[1]	(-1 0.18)	Reject 1%
MA	2	1[1]	1[1]	(-1 0.14)	Reject 1%
SI	2	2[2]	2[2]	(-1 -0.35)	Reject 5%
TI	3	0[0]	1[a/][2]	(-1 0.15)	Accept
TH	2	1[1]	0[1]	(-1 0.02)	Reject 1%

Notes: Country indicates local real interest rate; see the Data Appendix for Country Codes. Lag indicates the lag order of the VAR. #Vec indicates the number of cointegrating vectors indicated by either the maximal eigenvalue test (Mx. eigen.) or trace test, using the 10% critical values adjusted for sample size as per Cheung and Lai (1993). The numbers in brackets [.] are the implied number of vectors using the asymptotic critical values from Osterwald-Lenum (1992). The vectors in the "Point Est." column are the estimated cointegrating vectors, normalized on the Japanese real interest rate; under RIP the vector should be (-1 1). If zero or two vectors are indicated, the estimated cointegrating vector is calculated assuming only one cointegrating vector. "RIP" indicates whether the null hypothesis of a (-1 1) vector is rejected according to a likelihood ratio test. All results are for specifications including seasonal dummies.
a/ Borderline result indicating either one or two vectors.

Table 4
Cointegration Results for Trivariate US-Japan-Local Systems

Country	lag	#Vec Mx.Eigen	#Vec Trace	Point Est.	RIP US/JP (-1 1 0)	RIP JP/loc (0 -1 1)	RIP US/loc (-1 0 1)
AU	2	0[2]	1[2]	(-1 0.91 -0.64)	Reject 1%	Reject 5%	Reject 1%
CN[a]	2	0[2]	0[2]	(-1 -20.3 -19.7)	Reject 1%	Reject 10%	Reject 1%
HK	2	0[0]	0[1]	(-1 -19.5 2.70)	Reject 5%	Reject 1%	Reject 5%
IN	2	0[2]	1[2]	(-1 0.06 0.74)	Reject 1%	Reject 10%	Reject 1%
KO	2	0[0]	0[1]	(-1 14.1 -2.91)	Reject 10%	Reject 10%	Reject 10%
MA	2	0[1]	0[1]	(-1 13.1 -1.68)	Reject 1%	Reject 1%	Reject 1%
SI	2	1[2]	1[2]	(-1 0.51 1.12)	Reject 1%	Reject 1%	Accept
TI	2	0[2]	2[3]	(-1 -0.42 2.34)	Reject 1%	Accept	Accept
TH	2	0[1]	0[1]	(-1 1.39 0.18)	Reject 5%	Reject 1%	Reject 5%

Notes: Country indicates local real interest rate; see the Data Appendix for Country Codes. Lag indicates the lag order of the VAR. #Vec indicates the number of cointegrating vectors indicated by either the maximal eigenvalue test (Mx. eigen.) or trace test, using the 10% critical values adjusted for sample size as per Cheung and Lai (1993). The numbers in brackets [.] are the implied number of vectors using the asymptotic critical values from Osterwald-Lenum (1992). The vectors in the "Point Est." column are the estimated cointegrating vectors, normalized on the US real interest rate; under RIP the vector should be (-1 1). If zero or two vectors are indicated, the estimated cointegrating vector is calculated assuming only one cointegrating vector. "RIP" indicates whether the null hypothesis of a (-1 1) vector is rejected according to a likelihood ratio test. All results are for specifications including seasonal dummies.

[a/] No adequate VAR representation.

Table 5
Regression of Local Rate on Foreign and Error Correction Terms

$$\Delta r_t^{\ell} = \mu + \gamma_1 \Delta r_t^{\ell} + \ldots + \gamma_p \Delta r_{t-p+1}^{\ell} + \theta_1 \Delta r_t^{US} + \ldots + \theta_p \Delta r_{t-p+1}^{US} + \\ + \phi_1 \Delta r_{t-1}^{JP} + \ldots + \phi_p \Delta r_{t-p+1}^{JP} + \alpha_1 ECT_{t-p}^{US} + \alpha_2 ECT_{t-p}^{JP} + u_t$$

Country	$\hat{\alpha}_1$ (s.e.)	$\hat{\alpha}_2$ (s.e.)	N	adj. R^2	p	LM(4) [p-val.]
AU	0.26 (0.90)	0.38 (1.07)	33	.02	4	0.61 [.66]
CN	0.18 (0.27)	0.33 (0.25)	36	.45	2	1.41 [.26]
HK	0.67 (0.49)	-0.12[a] (0.39)	35	.56	2	1.74 [.18]
IN	-0.13[a] (0.59)	0.99 (0.61)	36	.58	2	0.79 [.54]
KO	-0.03[a] (0.24)	0.68** (0.24)	36	.62	1	0.60 [.67]
MA	0.33 (0.33)	-0.02[a] (0.29)	35	.45	2	1.43 [.26]
SI	0.62** (0.25)	0.44 (0.26)	36	.58	2	0.68 [.61]
TI	1.34 (1.05)	-0.06[a] (0.98)	32	.68	4	0.91 [.48]
TH	0.62 (0.43)	-0.22[a] (0.40)	34	.26	2	0.54 [.71]

Notes: s.e. in parentheses (.), N is number of observations, p is the lag length. LM(4) is a F-test for serial correlation of order 4. P-values in brackets [.]. *(**)[***] indicates significance at the 10%(5%)[1%] level.
[a]/ Coefficient estimate of incorrect sign.

DATA APPENDIX

Interest rates

Eurocurrency deposit rates: The US 3 month Eurocurrency deposit rates are the arithmetic average of the bid and offer rates in London at close of market, as reported by Bank of America up to October 6, 1986, and Reuters' Information Service thereafter, and recorded by DRI in the DRIFACS database.

Local Market Rates: Where both WFM and DRI are indicated under "Source," WFM is the source until 1989:10, at which time DRIFACS becomes the source.

Ctry. Code	Country	Source	DRI FACS Variable	Description
US	US	DRI	USD03B,A	3 month Eurodollar deposit rate
AU	Australia	WFM,DRI	ADBBL90Q	90 day bank bill, quote
CN	Canada	WFM,DRI	CACP90B,A	3 month prime finance company paper
HK	Hong Kong	WFM,DRI	HKM03B,A	3 month interbank dep. rate
IN	Indonesia	WFMr		1 month interbank dep. rate
JP	Japan	WFM,DRI	JABGDS90Y	3 month Gensaki bond rate
KO	Korea	BSO		Avg. 1,3,5 yr.corp.bond, avg. of daily
MA	Malaysia	WFMr		3 month interbank dep. rate
NZ	New Zealand	WFM,WFMr		3 month commercial bills to Dec. 1987., 3 month bank bills thereafter.
SI	Singapore	WFMr		3 mo. banker's acceptances to Aug.87; 3 month commercial bills thereafter

TI	Taiwan	WFMr	90 day bankers acceptances
TH	Thailand	WFMr	call money rate

Notes: DRI indicates DRIFACS; WFM indicates World Financial Markets; WFMr indicates Morgan Guaranty's database, as provided by Carlton Strong.BSO indicates private communication from Bong Sung Oum.

Price Data

The price data is the consumer price indices for the respective countries, drawn from IMF's International Financial Statistics, various issues. The Hong Kong CPI data was drawn from the Hong Kong Monthly Bulletin; the Taiwanese CPI data was provided by Ramon Moreno of the Federal Reserve Bank of San Francisco. Both the Australian and New Zealand CPI data was only available at the quarterly frequency (at midquarter). The Australian monthly PPI was used to generate a monthly Australian CPI series. For New Zealand, the interest rates were sampled at the end of the mid-quarter month, so that inflation rates and interest rates are synchronized.

Figure 1

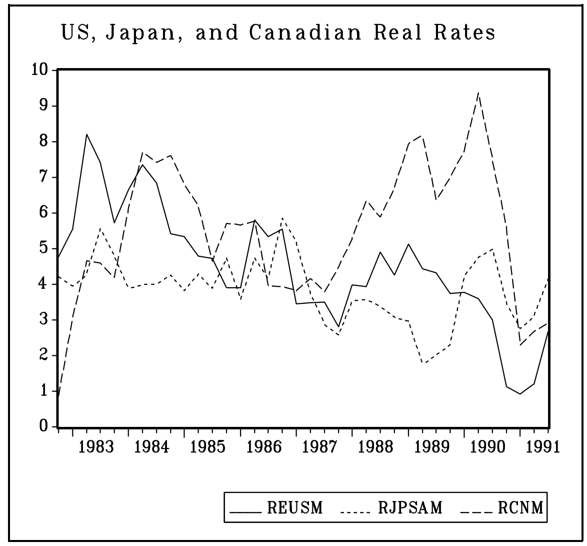

Figure 2

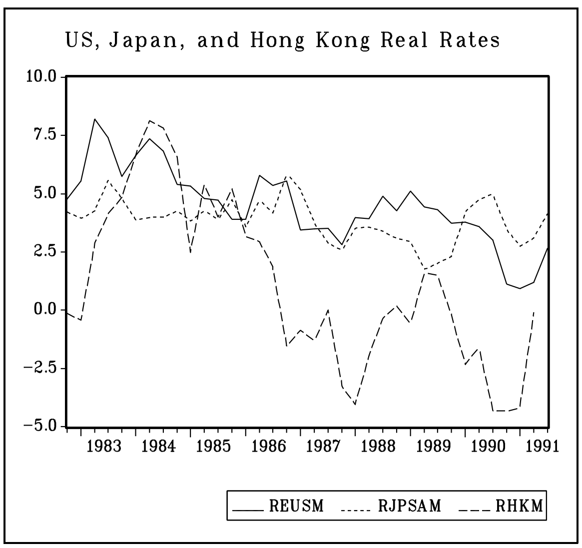

Figure 3

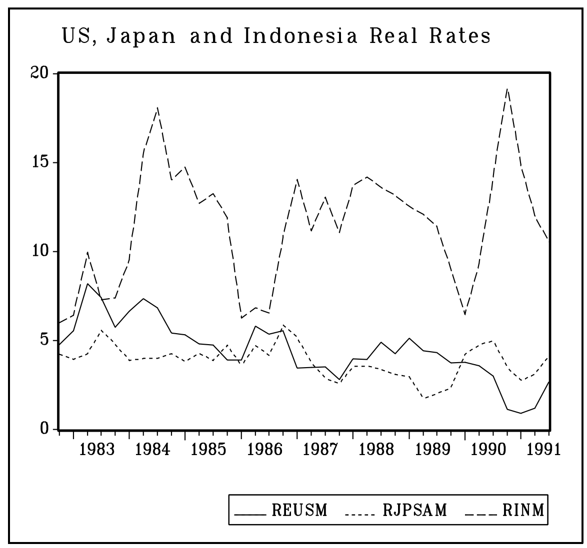

Figure 4

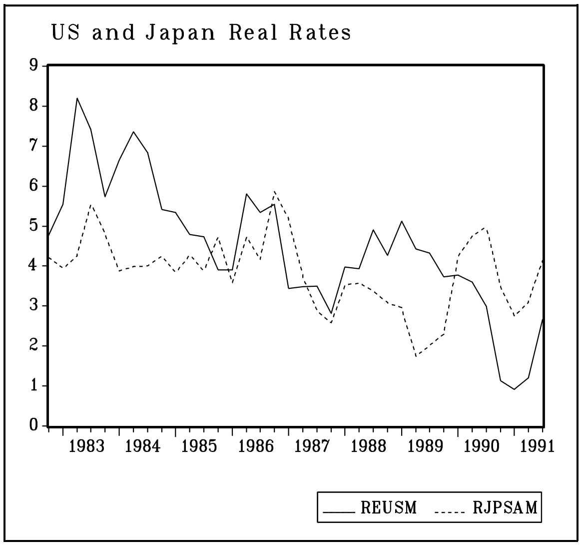

Figure 5

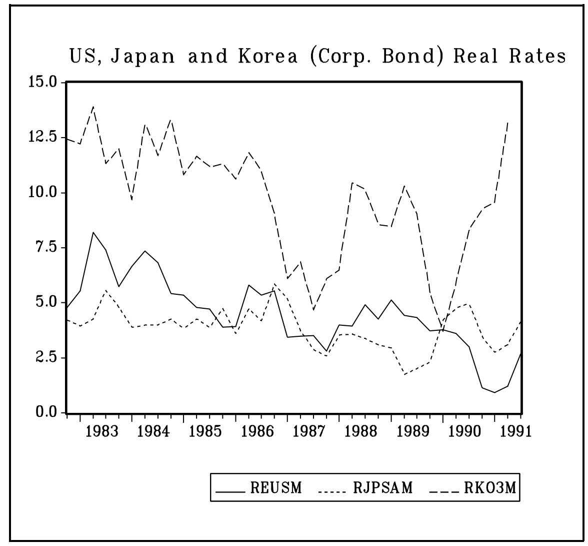

Figure 6

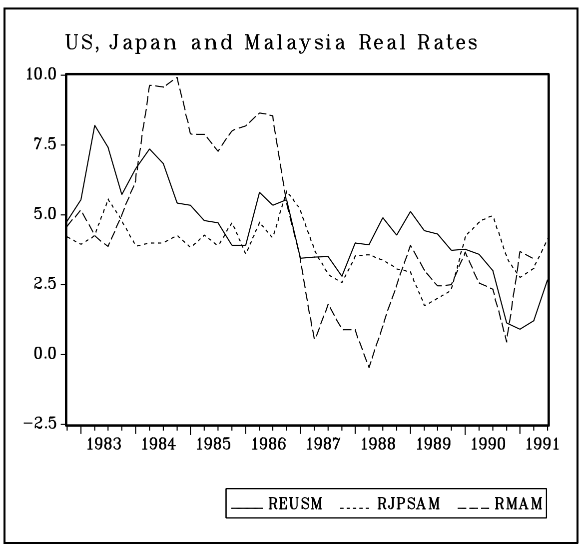

Figure 7

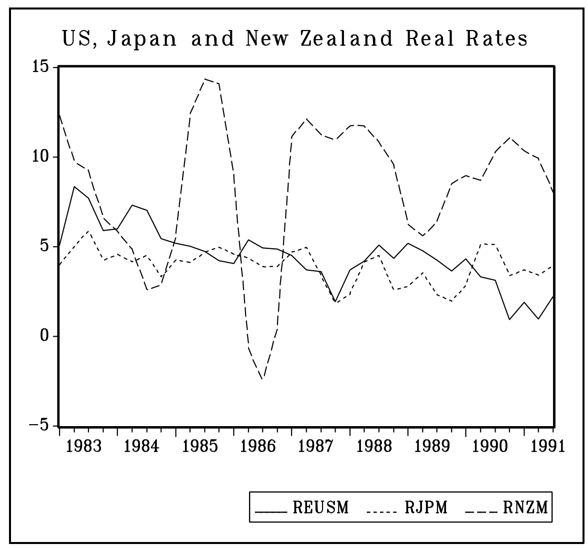

Figure 8

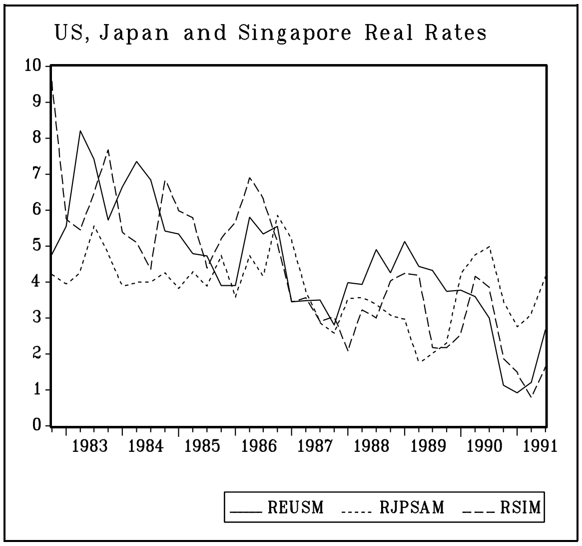

Figure 9

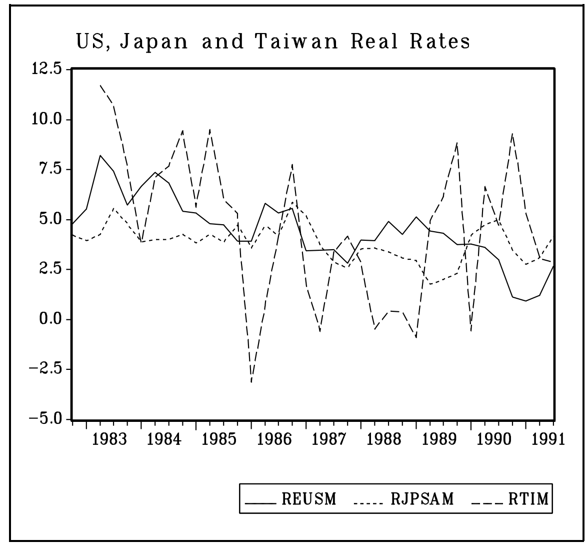

Figure 10

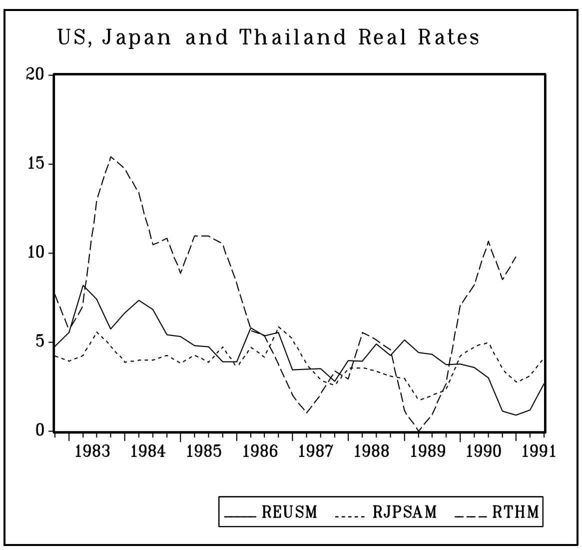

Figure 11

Table A1
Univariate Unit Root Tests: Real Interest Rates

$$\Delta y_t = \mu_1 + \phi y_{t-1} + \sum_{i=1}^{4} \Delta y_{t-i} + e_t$$

Series	τ_c (4)	τ_t (4)	N
AU	-1.67	-1.98	32
CN	-2.53	-2.26	33
HK	-1.19	-2.62	32
IN	-2.13	-2.17	33
JP	-2.70*	-2.94	33
KO	-2.07	-1.70	32
MA	-1.18	-1.82	32
NZ	-3.73**	-4.08**	32
SI	-0.68	-2.82	33
TI	-2.08	-2.06	31
TH	-1.10	-2.78	21
US	-0.95	-2.18	33

Notes: MacKinnon 90% critical values for τ_c (τ_t): -2.61 (-3.21) for N=33. *(**) significant at 10%(5%) MSL.

Table A2
Multivariate Unit Root Tests: Real Interest Rates

	US-Local System		Japan-Local System	
Series	US	Local	Japan	Local
AU	11.76 [.001]	7.88 [.005]	**1.80** **[.180]**	7.16 [.007]
CN	8.79 [.003]	**0.93** **[.335]**	3.02 [.082]	7.25 [.007]
HK	11.40 [.001]	17.15 [.000]	**2.66** **[.103]**	18.03 [.000]
IN	14.19 [.000]	3.94 [.047]	3.89 [.049]	7.86 [.005]
JP	10.07 [.002]	**0.50** **[.479]**	--	--
KO	6.18 [.013]	15.47 [.000]	3.06 [.080]	14.57 [.000]
MA	2.85 [.091]	9.43 [.002]	4.30 [.038]	24.92 [.000]
NZ	11.09 [.001]	**1.79** **[.181]**	8.72 [.003]	4.78 [.029]
SI	23.31 [.000]	20.62 [.000]	**1.42** **[.233]**	7.93 [.005]
TI	8.08 [.004]	**0.10** **[.757]**	**0.67** **[.413]**	**2.41** **[.121]**
TH	6.82 [.009]	13.36 [.000]	**0.16** **[.690]**	14.94 [.000]

Notes: χ_1^2 statistics for the null hypothesis that the variable is I(0), and the alternative that the variable is I(1), using restrictions on the cointegrating vector from a Johansen estimation procedure, as reported in either Table 2 or 3. p-values in brackets. Failures to reject the trend stationary null at the 10% MSL in **bold face**.