Examining Capital Market Integration in Korea and Japan Using a Threshold Cointegration Model

STEFAN C. NORRBIN
Department of Economics
Florida State University
Tallahassee, FL 32306
USA

JOANNE LI,
Department of Finance
Sellinger School of Business and Management
Loyola College in Maryland
4501 N. Charles Street
Baltimore MD 21210
USA

And

EDWARD E. FLAHERTY,
Edward Flaherty
School of Business & Economics
College of Charleston
Charleston, SC 29424
USA

Abstract: This paper models the real interest rate connection between Korea and Japan as a non-linear process that reacts stronger at the tails of the distribution. The model is tested using a threshold cointegration model, and some support is found for the existence of a non-linear response. If the Korean real interest rate exceeds the Japanese one by more than approximately 8%, and when the Japanese real interest rate exceed the Korean one by more than approximately 3% then a large capital movement exists.

Key-Words: Cointegration, Threshold Cointegration, Non-linearity, Real interest Rate Parity

1 Introduction

Real interest rates are theoretically linked through financial arbitrage conditions. Assuming that capital is perfectly mobile and that different countries' assets are perfect substitutes (implying no risk premium exists) one would expect to see real interest rate convergence between countries through capital flows to the country with a higher return.

This paper studies how closely linked the real interest rates are in Korea and Japan. Specifically, we assume that small interest rate deviations between the countries are possible without any arbitrage activity taking place. Such a range would not lead to any co-movement among interest rates, as risk averse agents do not see a sufficient return to move their capital to the other country. In contrast, once the interest deviations become large enough to go beyond some threshold level, we would expect capital to start flowing to eliminate the deviations above this critical level. This research will identify these critical levels and model a range within which no capital flows exist, and outside of which substantial flows will take place.

2 Prior Research

The integration of interest rates between Asian economies and the US has been the focus of much research. However, the research has focused on testing whether or not the financial capital is highly mobile across international borders. A change in the level of interest rates in one country can cause movements of funds, affecting both exchange rates and interest rates in other countries. Faruqee [5] examines the degree of capital mobility. He investigates interest rate differentials between selected Pacific Basin developing countries and Japan. His empirical evidence indicates an increased capital mobility. Argy and Hodjera [1] study the period 1961-1966 using data on the US, Japan, and eight European countries. Their findings indicate an increase in financial integration. Using nominal interest rate data from eleven European countries for 1961 through 1977, Fase [4] concludes that a substantial degree of market integration exists. Similarly, Bhoocha-Oom and Stansell [3] study the integration among four financial markets: U.S., Hong Kong, Singapore, and Asian dollar markets. They find a high degree of co-variability between nominal interest rates in the four markets.

Other studies use real interest rates to examine the level of integration in Asia (see Hodrick [6], or Mark [8]). For instance, Mishkin [9] uses data on real interest rates from U.S., Canada, the UK, West Germany, Netherlands, and Switzerland and rejects the equality of real interest rates among European countries. Phylaktis [10] investigates the extent to which financial markets in the Pacific Basin Region have become more integrated, by analyzing the co-movement of real interest rates. She looks at the speed of adjustment of real interest rates following a shock. Her empirical evidence indicates an increase in capital market integration with both U.S. and Japan during the 1980s. She finds that capital market integration is greater in Singapore, Hong Kong, and Taiwan. These examples show that prior work has established some form of capital integration among countries. However, no one has examined the potential for different integration for low interest rate differentials, as compared to high interest rate differentials. Therefore our work will extend this literature by both testing the co-movement in a different way and by estimating the speed of adjustments to high and low interest deviations.

3 Methodology

Many times capital flows will be flowing as deviations become large enough to compensate agents for perceived risks. Whereas at other times capital flows will disappear when the interest differential is insufficient to compensate the individual for the risk. If one uses standard econometric techniques this inactive band will "mask" the true linkage among the economies, lead to mixed results, and incorrect estimates of the adjustment speeds. Therefore the solution methodology has to allow for different states and the econometric problem therefore becomes a nonlinear problem.

We employ a two-step process, similar to the one used by Balke and Fomby [2], for testing threshold cointegration beginning with a test for non-linearity and then proceeding with a test for cointegration. Assume the autoregressive order, p, and the delay parameter, d, of the threshold variable z_t is given. The threshold variable z_t is defined as the difference between the real expected interest rate of Korea less that of Japan. In the first part of the methodology, we test where the most likely breaks in the data are. In the case of real interest rates we expect that traders may react differently to a high and a low break and therefore a three-break system is assumed.

To search for the appropriate break we try every possible break by increasing the threshold parameter, θ_i, from the smallest θ in the sample to the largest. A TAR(p,d) model with three regimes as divided by the θ_i can then be constructed as:

$$(1)\quad z_{1,t} = \mu_1 + \rho_{1,1} z_{1,t-1} + \phi_{1,1}\Delta z_{1,t-1} + \ldots + \phi_{1,p-1} \Delta z_{1,t-p+1} + \varepsilon_{1,t},$$

for $| z_{t-d} | < \theta_i$ resulting in the interior section, and

$$(2)\quad z_{2,t} = \mu_2 + \rho_{2,1} z_{2,t-1} + \phi_{2,1}\Delta z_{2,t-1} + \ldots + \phi_{2,p-1} \Delta z_{2,t-p+1} + \varepsilon_{2,t},$$

for $z_{t-d} \le \theta_i$, which represents the lower section, and

$$(3)\quad z_{3,t} = \mu_3 + \rho_{3,1} z_{3,t-1} + \phi_{3,1}\Delta z_{3,t-1} + \ldots + \phi_{3,p-1} \Delta z_{3,t-p+1} + \varepsilon_{3,t},$$

for $z_{t-d} \ge \theta_i$, representing the upper section, for i={1,...,N}, with the entire data set sorted by $|z_{t-d}|$ in descending order. The critical threshold is defined as the one that minimizes the total SSE within the search space.

Then the second step models the process as a threshold autoregression and tests for cointegration. Cointegration is tested by examining the AR coefficients, using an augmented Dickey-Fuller (ADF) test. If cointegration is found, then the dynamics of the adjustment process may be examined with a vector error-correction model (VECM). Modifying Johansen [7], a process z_t with threshold cointegration properties can be represented as:

$$(4)\quad \Delta x_t = \delta + \Sigma_{m=1}^{p-1} \phi_m \Delta x_{t-m} + \beta_i{}' z_{t-d} + \nu_t,$$

where $\Delta \boldsymbol{x}_t = [\Delta i_{Korea,t}, \Delta i_{Japan,t}]'$, with i_t being the real expected interest rate in a country, $\beta_i = [\beta_1, \beta_2, \beta_3]$, and ν_t is a white noise disturbance term. Recall that z_{t-d} is the difference between the real expected interest rates for Korea and Japan. Note that the value of β_i depends on whether if z_{t-d} is above or below the threshold θ.

The change in a countries real interest rate can be disaggregated, using equation (4), into the part that comes from inside the country and the part that is inherited from the conditions in the rest of the world. Thus monetary authorities would be able to examine the part of the real interest rate that they can affect, and would also be able to better forecast what would happen to the domestic interest rate if foreign real interest conditions change.

4 Results

We use monthly data from 1977-1994 for Korea and Japan. The real interest rate is calculated as the nominal one-month interest rate less the expected inflation rate proxied by the inflation during a 6-month centered moving average period around the nominal interest rate. The data is available from the authors by request.

Using the difference between the real rates as the reaction variable we proceed to test if a threshold process provides more information than a standard analysis. In Table 1 we report the full Vector Error Correction Model (VECM).

Table 1

Estimation of Full Sample Vector Error Correction Model (N=214)

	ΔKorea$_{t-1}$	ΔJapan$_{t-1}$	ECV$_{t-1}$
ΔKorea$_t$	0.329*	0.088	-0.120*
	(4.792)	(0.804)	(-3.757)
ΔJapan$_t$	0.072	-0.066	0.030
	(1.618)	(-0.933)	(1.433)

Note: t-statistics in parentheses, * indicates significance at the 95% confidence interval.

In this table we can see that the Korean real interest rate responds to its own past as well as to the gap between the Korean rate and the Japanese rate. For every 1% gap between the Korean rate and the Japanese rate, the Korean rate will fall by 0.12% to approach the Japanese rate. This error correction pattern will be investigated closer using the threshold procedure.

First we examine the data to find the highest probability of a break. The data shows a clear threshold behavior, and the most likely place for this break is at 8.040% for the upper break and –2.877% for the lower break. This means that the process changes when the Korean real interest rate exceeds the Japanese real interest rate by more than 8.040%. At this point Japanese funds would start to move to Korea, and the gap between the interest rates should close. The lower break indicates that as soon as the Japanese real rates exceed the Korean by more than 2.877% then the process changes. The upper regime consists of 24 data points above the break with an AR coefficient of 0.8401 and a lower regime with 29 data points and an AR coefficient of 0.849. Both of these coefficients are significantly different from unity at a 90% confidence interval, indicating that these sections of the data are stationary and thus the real interest rates are cointegrated. In contrast, the interior regime appears to be non-stationary with an AR coefficient of 0.974. To calculate the speed of adjustment in the different groupings of the data we proceed to estimate the VECM model for each sub-section of the data.

The threshold results are reported in Table 2.

Table 2

Estimation of Threshold Cointegration Vector Error Correction Model

	$\Delta Korea_{t-1}$	$\Delta Japan_{t-1}$	ECV_{t-1}
A. Upper Region			
$\Delta Korea_t$	0.034	-0.238	-0.053
	(0.122)	(-0.671)	(-0.090)
$\Delta Japan_t$	0.010	-0.088	0.127
	(0.047)	(-0.318)	(0.276)
B. Lower Region			
$\Delta Korea_t$	0.105	0.692*	-0.116
	(0.633)	(2.275)	(-0.704)
$\Delta Japan_t$	0.034	0.032	-0.048
	(0.307)	(0.167)	(-0.439)
C. Interior Region			
$\Delta Korea_t$	0.440*	-0.102	-0.050
	(5.441)	(0.818)	(-0.836)
$\Delta Japan_t$	0.010	-0.088	0.127
	(0.047)	(-0.318)	(0.276)

Note: t-statistics in parentheses, * indicates significance at the 95% confidence interval.

Unfortunately the small samples in the upper and lower regions lead to low significance values. Otherwise one can clearly see that the major response to the error correction variable, ECV_{t-1}, is from the lower regime. This section has a response of –0.116, which is close to the full sample value of –0.120. This means that the Korean real interest rate essentially is unaffected by the Japanese real rate until the Japanese rate exceeds the Korean rate by more than 2.877%. When this happens the Korean rate will quickly increase as money flows out of Korea into Japan. Once the rate is inside the range of –2.877 to 8.040 only past changes on the domestic Korean interest rate will matter.

5 Conclusions

The model designed in this paper allows for a non-linear response of real interest rates in Korea and Japan. The results show that a non-linear response is very likely and finds that the difference between the Korean and Japanese rate of less than –2.877 and greater than 8.040 leads to joint movements between the countries. At these extremes the changes in these rates depend on each other, but in between these boundaries the two countries ignore the actions of the other country.

In future research we want to extend this analysis to other Asian countries to verify that a similar response exists in other Asian country-pairs. Furthermore we would like to estimate the real rate in a different way to allow agents to use a rational expectations model to forecast inflation. Given the large fluctuations in some Asian inflation rates it is important to allow a flexible way of modeling inflation rates, so that the appropriate real interest rate variable can be calculated.

References:

[1] Argy, V. and Z. Hodjera, Financial Integration and Interest Rate Linkages in Industrial Countries, 1958-1971, *International Monetary Fund Staff Paper* March 1973, vol. 20, 1-77.

[2] Balke, N. S. and T. B. Fomby, *International Economic Review*, August 1997, vol. 38, No. 3, 627-646.

[3] Bhoocha-Oom, Areepong, and Stanley R. Stansell, A Study of Internatinal Financial Market Integration: An Examination the U.S., Hong Kong and Singapore Markets, *Journal of Business Finance and Accounting*, Spring 1990, vol. 17, No. 2, 193-212.

[4] Fase, M.M.F., The Interdependence of Short Term Interest Rates in the Major Financial Centers of the World: Some Evidence for 1961-1972, *Kyklos* 29,1976, 63-96.

[5] Faruqee, Hamid, Dynamic Capital Mobility in Pacific Basin Developing Countries, *International Monetary Fund Staff Paper*, September 1992, vol. 39, No. 3, 706-717.

[6] Hodrick, R.J., Some Evidence on the Equality of Expected Real Interest Rates Across Countries, Working Paper, 1979, Carnegie-Mellon University.

[7] Johansen, S., Statistical Analysis of Cointegration Vectors. *Journal of Economic Dynamics and Control*, 1988, 12, 231-254

[8] Mark, H., The International Equality of Real Rates, Working Paper, 1983, University of Chicago.

[9] Mishkin, F.S., Are Real Interest Rates Equal Across Countries? An Empirical Investigation of International Parity Conditions, Working Paper No. 1048, 1982, National Bureau of Economic Research.

[10] Phylaktis, Kate, Capital Market Integration in the Pacific-Basin Region: An Analysis of Real Interest Rate Linkages, *Pacific-Basin Finance Journal* 5, 1997, 195-213.