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DOES REAL INTEREST PARITY HOLD? EMPIRICAL EVIDENCE FROM ASIA

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Abstract: This paper presents some evidence on the real interest parity (RIP) hypothesis for six Asian countries *vis-à-vis* Japan. Testing RIP is carried out by examining the behaviour of *ex ante* real interest differentials, employing conventional and more sophisticated unit root tests. The results strongly reject the null hypothesis that the *ex ante* real interest differential follows a random walk in all cases when less conventional tests are employed. The results are interpreted to indicate that Asian markets have become highly integrated and that capital has become *potentially* highly mobile over the period under consideration.

1. INTRODUCTION

In the 1980s, Asian countries embarked on measures to deregulate and liberalise their national financial markets, including the relaxation of capital controls and the policy shift towards more flexible exchange rate arrangements. These developments are thought to have resulted in a high degree of financial integration and enhanced capital mobility among these countries. The integration of national financial markets stimulates capital flows by facilitating commodity and financial arbitrage, which in turn eliminate the differential between these countries' rates of return. Thus, testing real interest parity (RIP) among these countries will provide some evidence on the effectiveness (or otherwise) of financial deregulation in enhancing market integration and *potential* capital mobility.

The objective of this paper is to test the real interest parity hypothesis between six Asian countries—Hong Kong, Korea, Malaysia, the Philippines, Singapore, and Taiwan—and Japan over the period 1980–1994. This hypothesis is tested by

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detecting whether or not there is zero mean reversion in real interest differentials. For this purpose we employ the conventional Dickey-Fuller (1979, 1981) tests as well as the more sophisticated Sims (1988) Bayesian test and the variance ratio test.

2. THE RIP HYPOTHESIS

The real interest parity (RIP) hypothesis postulates that if the world markets for goods, capital and foreign exchange are integrated, real interest rates on perfectly comparable financial assets tend to be equalised across countries over time. This hypothesis predicts that the nominal interest rate differential adjusts fully to the inflation differential, maintaining the constancy and equality of real interest rates across countries. In essence, the hypothesis relies on the stability of the Fisher closed condition. The RIP condition is derived by assuming the validity of CIP (efficiency of domestic and foreign financial markets), *ex ante* purchasing power parity (PPP) and the unbiasedness of the forward rate as a forecaster of the market's expectations of the future spot rate.[1] These conditions are given respectively by

$$f_t - s_t = i_t - i_t^* \tag{1}$$

$$s_{t+1}^{e} - s_t = \Delta p_{t+1}^{e} - \Delta p_{t+1}^{*e} \tag{2}$$

$$s_{t+1}^{e} = f_t \tag{3}$$

where s_t is (the logarithm of) the current spot exchange rate (defined as the domestic currency price of one unit of the foreign currency), s_{t+1}^{e} is (the logarithm of) the spot exchange rate expected to prevail at time $t+1$, f_t is (the logarithm of) the forward exchange rate (also defined as the domestic currency price of one unit of the foreign currency) set at time t for delivery at time $t+1$, i_t (i_t^*) is the domestic (foreign) nominal interest rate, and Δp_{t+1}^{e} (Δp_{t+1}^{*e}) is the expected change in the logarithm of the domestic (foreign) price index from t to $t+1$. Substituting equation (3) into equation (1) we obtain the UIP condition which is given by

$$s_{t+1}^{e} - s_t = i_t - i_t^* \, . \tag{4}$$

By substituting equation (2) into equation (4) and rearranging the resulting expression, we obtain

$$\Delta p_{t+1}^{e} - \Delta p_{t+1}^{*e} = i_t - i_t^* \, . \tag{5}$$

Equation (5) shows that if the Fisher closed condition is valid both at home and abroad, then the nominal interest rate differential adjusts fully to the expected inflation differential, maintaining the constancy within and equality across countries of *ex ante* real interest rates. The RIP hypothesis represented by equation (5) can be tested in a univariate framework by examining the hypothesis that the

[1] See Roll (1979, pp. 356–57).

ex ante real interest differential is mean reverting over time.

Let us assume that market agents across countries are able to form expectations in such a way that the actual (*ex post*) inflation rate realised at time $t+1$ differs from the expected inflation rate by a zero mean stationary error. Therefore

$$\Delta p_{t+1} = \Delta p^{e}_{t+1} + v_{t+1} \tag{6}$$

$$\Delta p^{*}_{t+1} = \Delta p^{*e}_{t+1} + v^{*}_{t+1} \tag{7}$$

where $v_{t+1} \sim I(0)$ and $v^{*}_{t+1} \sim I(0)$. Substituting equations (6) and (7) into equation (5), we obtain

$$\Delta p_{t+1} - \Delta p^{*}_{t+1} = i_t - i^{*}_t + \varepsilon_{t+1} \tag{8}$$

where $\varepsilon_{t+1} = v_{t+1} - v^{*}_{t+1}$ is a zero mean stationary inflation differential forecasting error.[2] The *ex post* real interest rate differential is given by

$$\varepsilon_{t+1} = r_{t+1} - r^{*}_{t+1} \tag{9}$$

where

$$r_{t+1} = i_t - \Delta p_{t+1} = r^{e}_{t+1} + v_{t+1} \tag{10}$$

and

$$r^{*}_{t+1} = i^{*}_t - \Delta p^{*}_{t+1} = r^{*e}_{t+1} + v^{*}_{t+1} \, . \tag{11}$$

Therefore, RIP holds as a long-run equilibrium condition if the *ex post* real interest rate differential is mean reverting over time.

3. ALTERNATIVE TESTS FOR MEAN REVERSION

This section is confined to a brief description of the Sims (1988) Bayesian test and the variance ratio test. The Sims Bayesian test is considered to be more powerful in discriminating between a true and a near random walk. This test is based on two test statistics, γ and $(1-\alpha^{*})$. To derive these test statistics, let us consider the autoregression model

$$(\varepsilon_t - \mu) = \rho(\varepsilon_{t-1} - \mu) + v_t \tag{12}$$

where μ is the long-run value to which ε_t tends to revert and $v_t \sim (0, \sigma^2_v)$ is an error term which is independent of past values of ε_t. In equation (12), the long-run behaviour of ε_t is dependent on the value of the autoregression coefficient, ρ. If $0<\rho<1$, then there is a tendency for ε_t to revert to its long-run value, μ, over time. The null hypothesis that ε_t follows a random walk is rejected if γ turns out

[2] If $v_{t+1} \sim I(0)$ and $v^{*}_{t+1} \sim I(0)$, as assumed here, it follows that $\varepsilon_{t+1} \sim I(0)$. The property of stationarity is less stringent than the rational expectations requirement of white noise. Even if the property of zero mean does not hold, as long as the condition $\varepsilon_{t+1} \sim I(0)$ is satisfied, this will imply real interest "linkages" as opposed to "equality".

to be negative, where γ is given by

$$\gamma = 2\log\left[\frac{1-\alpha}{\alpha}\right] - \log[\sigma_\rho^2] + 2\log[1-2^{-1/n}] - 2\log[\Phi(\tau)] - \log[2\pi] - \tau^2 \quad (13)$$

where $\tau = (1-\hat{\rho})/\sigma_\rho$ is the conventional t statistic for $\rho = 1$, $\sigma_\rho = \sqrt{\sigma_v^2/\sum \varepsilon_{t-1}^2}$ is the standard error, $\Phi(\tau)$ is the cumulative distribution function for the standard normal distribution evaluated at τ, $\phi(\tau)$ is its probability density function and n is the number of periods per year (e.g. 4 for quarterly data). The numerical value of the $(1-\alpha^*)$ test statistic can also be estimated from equation (13) by setting γ equal to zero, given the information about τ and σ_ρ. This is given by

$$(1-\alpha^*) = 1 - \frac{1}{1+e^{[\log(\sigma_\rho^2) - \log(1-2^{-1/n}) + \log(\Phi(\tau)) + (1/2)\log(2\pi) + (1/2)\tau^2]}}. \quad (14)$$

The null hypothesis of unit root is strongly rejected if the estimated value of $(1-\alpha^*)$ is close to 1. In contrast, the rejection of the null hypothesis of unit root will be very weak if the estimated value of $(1-\alpha^*)$ is close to zero.

It is has been shown on the basis of Monte Carlo investigations that the variance ratio test is generally more powerful than the conventional Dickey-Fuller test (see Lo and MacKinlay, 1988; Ardeni and Lubian, 1989). This is because, unlike standard unit root tests, the variance ratio test is able to detect the importance of the stationary component, which is likely to be dominant over the random walk component if the latter tends to die out after few lags. For the purpose of this test, an economic time series is generally decomposed into permanent and transitory components to examine its properties at different frequencies. If ε_t follows a pure random walk, it will be represented by the equation

$$\varepsilon_t = \varepsilon_{t-1} + u_t \quad (15)$$

such that

$$u_t \sim N(0, \sigma_u^2) \quad (16)$$

where μ_t is an error term which is serially uncorrelated. In this case, the variance of the kth difference, $\varepsilon_t - \varepsilon_{t-k}$, will be k times the variance of the first difference, $\varepsilon_t - \varepsilon_{t-1}$. If, on the other hand, ε_t is a combination of a temporary (stationary) component and a permanent (random-walk) component, the variance of the kth difference will be less than k times the variance of the first difference. Therefore, to test the hypothesis that ε_t follows a random walk, the variance ratio statistic is calculated as

$$VR = \frac{1}{k}\left[\frac{k\sigma_u^2}{\sigma_u^2}\right]. \quad (17)$$

If $VR = 1$, then the series will follow a random walk. Conversely if $VR < 1$, the series will follow a stationary process.

Some bias is likely to exist in the measurement of the variance of the kth difference.[3] First, the sum of squared deviations in small samples is a biased estimate of the variances of long differences. This bias can be avoided by setting the maximum value for k to be roughly equal to $N/2$, where N is the sample size.[4] Second, if the mean of a variable is unknown and has to be estimated, the estimator of the variance of the kth difference will be biased (Fuller, 1976, pp. 236–244). In order to avoid this bias the variance of the kth difference must be multiplied by a factor, λ, which is given by

$$\lambda=(N-k)/[(N-k)-k+(k^2-1)/3(N-k)]\ . \quad (18)$$

This correction generates unbiased estimates of the variance when the true process is a random walk.[5]

4. EMPIRICAL RESULTS

The empirical results presented in this section are based on quarterly data on consumer prices and relevant short-term interest rates over the period 1980:1–1994:4.[6] All data were obtained from Datastream.

Table 1 reports the results of testing for mean reversion in the *ex ante* real interest rate differentials using three unit root tests: the Dickey-Fuller, Phillips-Ouliaris and the Sims tests. The results indicate that the null hypothesis that the *ex ante* real interest differential follows a random walk can be rejected consistently in three cases (the Philippines, Singapore and Taiwan) when the Dickey-Fuller τ_μ,

TABLE 1. Testing *Ex Ante* Real Interest Differentials for Random Walk (The Dickey-Fuller, Phillips-Ouliaris and Sims Tests)

Country	Dickey-Fuller			Phillips-Ouliaris		Sims	
	τ_μ	Φ_2	Φ_3	$\hat{Z}_\alpha$	$\hat{Z}_t$	$1-\alpha^*$	γ
Hong Kong	−2.581	4.929*	7.327*	−86.331*	−7.688*	1.000	−62.952
Korea	−5.845*	4.379	6.517*	−53.408*	−6.230*	1.000	−68.665
Malaysia	−2.697	2.377	3.565	−79.977*	−8.048*	1.000	−68.644
Philippines	−3.977*	5.727*	8.560*	−34.862*	−4.846*	1.000	−25.811
Singapore	−3.015*	5.964*	8.802*	−90.902*	−8.587*	1.000	−78.655
Taiwan	−6.904*	5.906*	8.858*	−61.115*	−7.042*	1.000	−51.931

* Significant at the 5% level.

[3] See Kaminsky (1987, p. 9).

[4] See Ardeni and Lubian (1989) and Lo and MacKinlay (1988).

[5] The critical values for the variance ratio test statistic under the null hypothesis that the time series is an integrated process can be found in Kaminsky (1987, Table 1).

[6] The short-term interest rates are the 3-month deposit rate for Hong Kong and Malaysia and the 3-month treasury bill rate for Taiwan, the Philippines and Korea. The comparable short-term interest rates for Japan are the 3-month deposit rate and the 3-month Gensaki rate.

TABLE 2. Testing *Ex Ante* Real Interest Differentials for Random Walk (The Variance Ratio Test)

Lag	Hong Kong	Korea	Malaysia	Philippines	Singapore	Taiwan
1	1.000	1.000	1.000	1.000	1.000	1.000
2	0.519*	0.520*	0.522*	0.519*	0.519*	0.520*
4	0.281*	0.283*	0.286*	0.281*	0.281*	0.283*
6	0.205*	0.208*	0.2125*	0.204*	0.204*	0.208*
8	0.170*	0.174*	0.181*	0.169*	0.169*	0.174*
10	0.154*	0.159*	0.167*	0.152*	0.152*	0.159*
12	0.147*	0.155*	0.168*	0.145*	0.145*	0.155*
14	0.150*	0.162*	0.184*	0.147*	0.146*	0.162*
16	0.163*	0.183*	0.222*	0.158*	0.158*	0.183*
18	0.192*	0.227*	0.296*	0.183*	0.183*	0.227*
20	0.246*	0.294*	0.281*	0.231*	0.231*	0.294*
22	0.283*	0.221*	0.067*	0.281*	0.281*	0.221*
24	0.133*	0.048*	0.005*	0.169*	0.169*	0.048*
26	0.023*	0.004*	0.000*	0.035*	0.035*	0.004*

* Significantly less than 1 at the 5% level.

Φ_2 and Φ_3 tests are used. In contrast, the results based on the Phillips-Ouliaris $\hat{Z}_\alpha$ and $\hat{Z}_t$ tests and the Sims test consistently reject the null hypothesis of random walk in all cases. These results are strongly supported by those obtained from the variance ratio test which are presented in Table 2. These results in turn show that even at short lags the estimated values of the variance ratio are smaller than 1 at the 5% significance level in all cases, indicating strong mean reversion in real interest differentials.

5. INTERPRETATION OF THE RESULTS AND CONCLUDING REMARKS

The empirical results presented in Section 4, verifying that RIP holds as a long-run equilibrium condition, have three implications for market integration, capital mobility and monetary policy. First of all, a finding that real interest parity holds as a long-run relationship may be interpreted to imply a greater degree of (financial and goods) market integration amongst Asian countries. The connection between real interest parity and market integration is that the latter enhances capital mobility by facilitating commodity and financial arbitrage which in turn eliminate the differential between these countries' rates of return. Moreover, Frankel and McArthur (1988) have shown that it is possible to split the real interest differential in such a way as to obtain measures of financial market integration (covered interest differential) and goods market integration (real forward discount). The same conclusion can be reached by considering the derivation of the real interest parity relationship by combining uncovered interest parity (which is a measure of financial market integration) and *ex ante* PPP (which is a measure of goods market integration) since the equilibrium conditions implied by these relationships are maintained via financial arbitrage and commodity arbitrage respectively.

The second implication of real interest parity pertains to capital mobility. The concepts of (financial) market integration and capital mobility are connected to the extent that some economists use them interchangeably. Some economists, on the other hand, use the scale of capital flows to measure the degree of market integration. However, a high degree of integration can be present even without a large volume of capital flows, since the latter are likely to occur only if participants in the different markets have conflicting views on the effects of unanticipated events (Goldstein *et al.*, 1991, p. 7). Our interpretation of these issues boils down to the following propositions: (i) capital mobility is not a necessary condition for market integration, (ii) market integration is conducive to capital mobility, and (iii) capital mobility is a sufficient condition for market integration in the sense that a high level of capital mobility should indicate a high level of market integration. The connection between real interest parity, market integration and capital mobility can thus be stated as follows: if national financial markets are highly integrated, potentially infinite capital flows will tend to eliminate real interest differentials.[7] Thus, the implication of our finding that real interest parity holds is that *potential* capital mobility has become very high.

The third implication of our results pertains to monetary policy. If capital is capable of moving freely to equalise domestic and foreign real interest rates, then currency denomination would become largely irrelevant to borrowing and lending decisions, and hence domestic monetary policy would have no effect on the expected real interest rate faced by borrowers and lenders. Thus, the extent to which these countries can pursue independent monetary policies must become very limited.

Whether the findings of this study represent good news or bad news can be judged in terms of the associated costs and benefits. While the benefits are realised from easier access to capital markets across the national frontiers, implying the relaxation of the constraint imposed by domestic savings, the costs are represented by the failure of domestic monetary policy.

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[7] The distinction between actual capital mobility and potential capital mobility resulting from market integration is relevant to the distinction between conventional and Fisherian CIP. While the former postulates that actual capital flows triggered by covered arbitrage restore and maintain the equilibrium condition, the latter presents market integration (and therefore potential capital flows) as the means whereby equilibrium is achieved. For a further discussion, see Moosa and Bhatti (1995).

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