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Abstract

In this paper, we investigate the financial linkages between the East Asian economies with Japan and the US using the real interest rate parity (RIP) condition. We test for long-run RIP using an array of panel unit root tests, including a recent technique developed by Breuer et al. (2002). This study offers two important results: first, we found strong (robust) evidence that the parity condition holds in all the Asian countries, except for China. For China, there is no evidence of RIP when Japan is used as based country. Real interest differential between China and the US exhibits a tendency towards stationary equilibrium over the period 1987-2006. Second, the analysis drawn on half-life suggests that the US-Asian link has been getting stronger than the Japan-Asian one in the post-liberalization era.

Keywords: RIP, panel unit root tests, half-lives
JEL Classification: F36, F32, F02

1.0 Introduction

The extent to which rates of real interest are connected across countries, and how these linkages have progressed over time, especially in the last two decades, have gained considerable attention in the literature (Holmes, 2002; Anoruo, 2002). From the perspective of the East Asian countries, the interest has been fueled by the emerging consensus that their joint development agreements are best served through close economic cooperation among member countries. Real interest rate parity (RIP) requires both good and financial market arbitrage and its confirmation is viewed as an indication of macroeconomic convergence. Although a considerable amount of literature exists on market integration and the long-run relationship between the various Asian capital markets (Bhoocha-Oom and Stansell, 1990; Chinn and Frankel, 1995; Phylaktis, 1997, 1999; Chan *et al.*, 2003; Sun, 2004; among others), the empirical evidence on the interaction of these countries with Japan and the US is by no means a settled question. Additionally, very little research to date has examined the impact of the 1997 financial crisis on the long term dynamics of Asian financial markets. The degree of financial integration achieved by the influx of foreign capital flows in the last two decades, especially with Japan and the newly industrialized economies (NIEs), is notably lacking[1]. This investigation is also warranted as there has been much debate about economic cooperation among the ASEAN+3 member countries in the post-crisis era. To this end, we included China in the group of East Asian countries and examined the extent to which China is integrated with Japan and the US. To the best of our knowledge, China's integration with the global markets has yet to be revealed[2].

[1] Chinn and Frankel (1995), for instance, found that although Indonesia and Thailand were integrated with Japan, RIP holds only for US-Singapore, US-Taiwan and Japan-Taiwan. On the other hand, Phylaktis (1997, 1999) found that Asia-Pacific capital markets are considerably integrated but that the results regarding the US' and Japan's leading roles in the regional market are contradictory.

[2] We note that interest rates were under strict control of the People's Bank of China (PBC). It was only recently that the PBC affirmed its commitments to pursue market-based rate reforms.

The main goal of this paper is to examine one of the building blocs of international finance - real interest rate parity (RIP). The notion of RIP - that is, arbitrage should force real interest rate towards parity—provided an indication of whether countries are financially integrated wit other financial markets. In this study, we examined the international parity condition between the East Asian countries and their two major trading partners, namely the US and Japan[3]. Specifically, this paper investigates the following questions: first, has financial integration in these countries increased in the post-liberalization period that started in the mid-1980s? Second, how has the recent Asian financial crisis affected the parity condition in these countries? Third, has economic integration with Japan increased over time, that is, is there any evidence to suggest that Japan has overtaken the US in recent years? To answer all of these questions, we used monthly frequency data and applied an array of panel unit root tests. In addition, the sampling period is truncated into four sub-periods to account for the effect of institutional changes as well as the impact of the Asian financial crisis on the international parity condition in the region.

The present study differs from those in the existing literature in several aspects. First, East Asia is a region of growing importance in the global economy but the financial linkages among its members have yet to be systematically investigated. We believe that a different perspective may be gained by looking at the East Asian economies, including China, and the emerging market economies of ASEAN that have removed their regulatory measures at different stages of their economic development. Additionally, the deregulation process in these countries are varied in

[3] Japan and the US are the most important and influential for the rest of the world in international commerce, finance and economic coordination. The importance of these large economies in terms of trade and investment are discussed in Ogawa and Kawasaki (2003) and Choudhry (2005), among others.

terms of timing and intensity (Phylaktis, 1999), with China being the last to enter the race following the country's accession to the World Trade Organization (WTO)[4]. Despite these developments and the increasing importance of China in the world economy, very few studies have looked at China's connection with the other countries. Second, previous studies have relied on a number single-equation test to examine the unit root null of RIP (exceptions are Wu and Chen, 1998; Holmes, 2002). Unlike these earlier works, we relied on recent advancements in the nonstationary panel unit root tests that allow for greater flexibility in modeling differences in the behavior across individual countries, and which has been proven quite satisfactorily in improving the power of the unit root tests[5]. The low power of standard unit root tests is one of the main motivations for the use of panel unit root tests in recent work (see Im *et al.*, 1997, on this issue). With the liberalization of interest rates due to the open market policy and deregulation of financial markets, interest rates in the East Asian countries are expected to rise in the long term and are expected to be closely connected with the global markets.

The outline of the remainder of this paper is as follows. Section 2 provides an overview of the East Asian financial development. In Section 3, the theoretical framework applied in this study is elaborated. Section 4 then deals with the methodological issues and data description. In Section 5, we report and discuss the empirical results. Finally, the last section summarizes the main findings and offers some concluding remarks.

[4] The US and Japan are China's main trading partners and foreign investors. In 2002, total trade (imports plus exports) between China and the US and Japan was recorded at US$ 100 billion. FDI flows into China from the US were US$ 5.4 billion in 2002, while those from Japan were about US$ 4.2 billion.

[5] It is well known that the power of unit root tests for a given sample size can be increased by exploiting cross-sectional information (Levin and Lin, 1993). As such, panel unit root tests have found wide application in testing purchasing power parity. For some application of the various panel unit root tests, see Taylor and Sarno (1998), Wu (1996) and O'Connell (1998). Some serious drawbacks of these panel tests were also investigated in O'Connell (1998), Taylor and Sarno (1998) and Breuer *et al.* (2002).

2.0 Overview of the East Asian Financial Development

Financial development in the East Asia followed almost the same pattern and took place primarily in three stages. In the first stage, foreign exchange controls and the ceilings on deposits and lending rates were removed at different pace during 1975-1986[6]. The second stage witnessed the capital accounts liberalization during 1987-1994. The third stage of financial reformation which provide better platform for regional cooperation has taken place in the post-crisis era.

Oil shock during the late 1970s was entailed with world recession and price instability. Many of the Asian economies have adopted restrictive monetary policy to reduce inflation. This was followed by the common practice of tax cut, marked expansion of public deficit and financial deregulation that aimed to increase external competitiveness. It was thereby during the first stage of financial liberalization, the regional authorities viewed interest rate stability as an important policy variable in promoting a stable financial system and contributing to a more effective monetary policy transmission mechanism. With considerable low inflation in the 1980s, such strategies had resulted in the commonly high rate of voluntary savings among many East Asian economies. High levels of domestic savings, to great extent, sustained high investments in the region. In 1990, East Asian averagely saved 34% of GDP, compared to only half that in Latin America, and slightly more in South Asia. The policies were reflected in the positive and stable real interest in Asia, with only occasionally turned negative (see Figure 1). [Insert figure 1]

[6] Singapore (1975) and Malaysia (1978) were among the first countries to liberalize their interest rate controls. In Indonesia and Philippines, interest rates were fully deregulated in the early 1980s. Thailand did not abolish their interest ceilings until mid to late 1980s. In Korea, the prospect of becoming an OECD and GATT-member country was instrumental in the move towards liberalizing its financial market since late 1980s. For Taiwan, the interest controls were gradually liberalized when the money market was established in 1976 and fully phased out in 1989.

Capital inflows were most evident in the episode of capital accounts liberalization. Restrictions on foreign asset holding by residents were relaxed and the private sectors were allowed to have access to external finance. The widespread liberalization of financial markets as well as external factors like the sustained decline in world interest rates and recession in the industrial economies led to a surge in foreign capital into the region[7]. Between 1994 and 1996, US$210 billions flowed to ASEAN-5, which was about 20% of their GDP (Radelet and Sachs, 1998). Asia is among the high-growth region with an accumulated foreign direct investment stock of US$ 657 billion in 1996, which is half of the total amount (US$ 1.2 trillion) received by all the developing countries. Hong Kong, South Korea, Taiwan and the ASEAN-5 were in fact the major holdings of foreign capitals in the region during that episode[8].

In Japan, though the real rates of interest remained stable and positive until the outbreak of Asia crisis, the nominal rates have actually declined to near-zero level in the 1990s. The event was mainly attributed to the collapse of real estate prices since the late 1980s which entailed with the fall of stock prices and the bankruptcy of leading banks and securities corporations burdened by huge non-performing loans. Economic recovery was dawdling as the authority put a high priority on reducing the large fiscal deficits (e.g. contractionary Fiscal Restructuring Policy, 1997) rather

[7] The Plaza Accord 1985 that witnessed the appreciation of Japanese Yen against US dollar was followed by the decline of interest rates in both the US and Japanese markets. Positive and high interest differences between the Asia-US and Asia-Japan have further accelerated the accumulation of foreign capitals.

[8] Of all, Thailand and Malaysia are particularly open to FDI. In the decade up to the Asia crisis, Thailand was a huge capital importer, in some years running a current account deficit of more than 8% of GDP. While FDI increased to record levels, the portfolio and other short-term capital also increased. The Government's objective to promote Bangkok as a regional capital market center in competition with Hong Kong, China and Singapore was a factor here, as virtually all restrictions on capital flows were removed. Following the capital flight in 1998 and consequent collapse of the Thai baht, the Government maintained its open posture toward FDI.

than correcting the weaknesses in financial sectors. Continued deflationary pressure in the 1990s has further convinced the Bank of Japan to continue the near-zero interest rate policies. Yet, in race with the US, Japan has tried to expand its influences in East Asia through the indirect means such as FDI, overseas development assistance, and other financial flows to the rest of the region.

On the other hand, China was characterized by the expansion of the central-planning system and the dominance of state-owned enterprises in the economy during 1949-1978, with a large number of previously active financial institutions being truncated into virtually one hierarchical organization - the People's Bank of China (PBC). The process of financial liberalizing in China started late during 1986-88 and halt temporary, due to inflationary pressure that resulted in negative real interest rates (see Figure 1). During that time, state-owned financial institutions were allowed to be commercialized. By early 1990s, deposits rates were gradually liberalized within pre-specified margins. In June 1996, the ceiling rates of inter-bank loans were removed and the interest rates have expanded twice within 1998-99. By September 2000, the controls on large fixed deposits and foreign currency loans were lifted and the China Banking Association took over the responsibility of interest rates decision on small foreign currency deposits. In recent years, China has been the world largest recipient of direct overseas investment, with US$ 52.7 billion of foreign capital being utilized in 2002. However, the liberalization process of the Chinese capital account is still slow and restricted as compared to other East Asian economies.

For many East Asia countries including China, the third stage of market liberalization is aligned with the major reforms in the wake of the Asia crisis 1998. The post-crisis stage constituted a period of macroeconomic instability and a regime of greater volatility among the Asian

currencies. Malaysia, instead of seeking IMF rescue financing, decided to reverse its liberalization policy by imposing capital controls and exchange rate pegging with US dollar (US$1 = RM3.8) during October 1998 to July 2005. South Korea, on the other hand, followed the IMF programme and substantially liberalized the capital account regime. Thailand has made some progress in broadening the scope of financial liberalization but still maintain a relatively large number of capital account restrictions as compared to Singapore, Hong Kong and South Korea. Indonesia has also requested IMF's assistance package of US$43 billion, mainly to restore the confidence of international financial markets in the short term by stabilizing the exchange rate through a combination of macroeconomic discipline (e.g. fiscal surplus, high interest and tight monetary policy), availability of sufficient foreign reserves and the reforms towards good corporate governance and market transparency. However, the economic recovery and financial reforms in Indonesia are more sluggish among the crisis-affected countries.

At the same time, the importance of increasing intraregional trade and financial cooperation to prevent regional shocks are well understood. Notably, some of the region's economies have, in recent years, placed larger emphasis on concluding bilateral and regional trade agreements, instead of multilateralism. Japan and Singapore have been particularly active in this respect, with Thailand, Korea, Malaysia, the Philippines, and Indonesia becoming increasingly involved as well[9]. China also continued to follow up on proposals for regional arrangements involving large numbers of East Asian economies, e.g. the ASEAN+3 (China, South Korea and Japan). Such policy preferences are expected to have enhanced the process of regional integration.

[9] For instance, Japan and Singapore has signed an FTA which called the Japanese Singapore Economic Partnership Agreement (JSEPA), whereas the ASEAN members have constituted the ASEAN Free Trade Area (AFTA).

3.0 Theoretical Framework

Financial integration refers to the ease with which assets are traded across borders and currency denominations. Notably, three strands of international finance theory, the Uncovered Interest Parity (UIP), the Relative Purchasing Power Parity (RPPP) and the Fisher condition, form the basis of the RIP hypothesis. From the theoretical perspective, it has been shown that the degree to which RIP holds depends on the extent to which UIP and RPPP apply. UIP anticipates expected depreciation ($\Delta s^{e}_{t,t+k}$) as being explained by interest rate differentials ($i^{k}_{t} - i^{k*}_{t}$) while RPPP holds in expectation that expected depreciation equals the expected inflation differential ($\pi^{e}_{t,t+k} - \pi^{e*}_{,t+kt}$)[10]. The following state these together:

UIP condition: $$\Delta s^{e}_{t,t+k} = i^{k}_{t} - i^{k*}_{t} \quad (1)$$

and, RPPP condition: $$\Delta s^{e}_{t,t+k} = \pi^{e}_{t,t+k} - \pi^{e*}_{,t+kt} \quad (2)$$

Equations (1) and (2) yield, $$i^{k}_{t} - \pi^{e}_{t,t+k} = i^{k*}_{t} - \pi^{e*}_{,t+kt} \quad (3)$$

and, ex ante RIP condition: $$E_{t}(r_{t+k}) = E_{t}(r^{*}_{t+k}) \quad (4)$$

When rational expectations are considered, ex post RIP also implies ex ante RIP[11]. To test for weak form of RIP when the real interest rates are I*(1)*, the following standard cointegrating regression is estimated:

$$r_{t} = \beta_{0} + \beta_{1} r^{*}_{t} + \varepsilon_{t} \quad (5)$$

[10] UIP assumes the absence of exchange risk premium and country premium.

[11] The condition when RIP holds is sometimes referred to as capital mobility. Real interests are equalized when 'real' capital is free to move.

where r_t represents the domestic ex post or observed real rate of interest and r_t* the ex post or observed real rates in the base country (e.g. US or Japan). Hence, by imposing the restriction (β_0, β_1) = (0, 1) in Eq. (5), we obtained a model for the Real Interest Differential (RID) model:

$$r_t - r_t^* = \varepsilon_t \tag{6}$$

Given the specification in (6), a strong form of RIP is said to hold in the long-run if the residuals ε_t is mean reverting. Suppose that the deviations of the RID series (ε_t) from its long run value (ε_0) follows an AR (1) process, then:

$$\varepsilon_t - \varepsilon_0 = \alpha(\varepsilon_{t-1} - \varepsilon_0) + \mu_t \tag{7}$$

where μ_t is white noise. Hence, the half-life (h) is defined as the horizon at which the percentage deviation from the long run equilibrium of RID is one-half, that is, $\alpha^h = \frac{1}{2}$ and $h = \frac{\ln(1/2)}{\ln(\alpha)}$. The two-sided 95% confidence intervals of the half-life which are based on normal sampling distributions is then defined as $\hat{h} \pm 1.96\hat{\sigma}_{\hat{\alpha}}\left(\frac{\ln(0.5)}{\hat{\alpha}}[\ln(\hat{\alpha})]^{-2}\right)$, where $\hat{\sigma}_{\hat{\alpha}}$ is an estimate of the standard deviation of α (see the article by Rossi, 2005 for more details). For series that follow the AR(ρ) process, the model can be re-parameterized as

$$\varepsilon_t - \varepsilon_0 = \rho(\varepsilon_{t-1} - \varepsilon_0) + \sum_{i=1}^{p-1} a_i \Delta(\varepsilon_{t-i} - \varepsilon_0) + \mu_t \tag{8}$$

with $\rho = \sum_{j=i}^{p} \alpha_j$ and $a_i = -\sum_{j=i+1}^{p} \alpha_j, i = 1, \ldots, p-1$

Eq. (8) can be further derived into the ADF regression to allow for deterministic component (constant, trend) and stochastic component such that

$$\Delta\varepsilon_t = c + bt + \beta\varepsilon_{t-1} + \sum_{i=1}^{k} a_i \Delta\varepsilon_{t-i} + \mu_t, t = k+2,...,T, \quad (9)$$

with $c + bt$ being the deterministic component while $\beta = \rho - 1$ and $\Delta\varepsilon_t = \varepsilon_t - \varepsilon_0$. As such, the AR(ρ) half-life is defined as $h = \frac{\ln(1/2)}{\ln(\beta)}$. It should be noted that the greater the degree of capital mobility the faster the adjustment to long-run equalization of real interest rates.

To sum up, RIP is a condition where real rates of return on essentially identical assets are equalized across countries. There are many reasons why real interest rates will not always be equal across countries, some of these reasons are country-specific risk, transaction costs, information asymmetries, and/or differential tax treatments. For these reasons, our focus is on long-run RIP.

4.0 ECONOMETRIC STRATEGY

We rely on the concept of mean stationarity to assess the parity condition. If the deviations of RIP are stationary then it follows that RIP holds in the long run because deviations from parity are transitory. This argument follows from the property of a stationary time series in that such a series will revert to its equilibrium value after being disturbed by external shocks. The bulk of the empirical literature that has utilized single-equation unit root tests often report evidence against equalization of real interest rates rejects. To cite a few studies, Fraser and Taylor (1990), Husted (1992), Ghosh (1995), Karfakis (1996) and, Bergin and Sheffrin (2000) failed to reject the null hypothesis of a unit root in real interest rate differentials (RID).

The advancement in the first generation panel unit root tests pioneered by Levin and Lin (1993), Levin *et al.* (2002), Im *et al*. (1997, 2003), Sarno and Taylor (1998), Harris and Tzavalis (1999), Maddala and Wu (1999) and Breitung (2000), among others, has increased the statistical power of unit root tests over the single-equation methods that were based on a limited time series dimension. These techniques exploit the benefits from cross-sectional information to produce much more favorable evidence of stationarity, particularly in the testing of purchasing power parity (PPP)[12].

In this study, we tested the mean-reverting property of the RID in eight Asian economies (China, Taiwan, South Korea, Singapore, Indonesia, Malaysia, the Philippines and Thailand). There are strong reasons to believe that there is considerable heterogeneity in the countries under investigation and thus, the standard homogenous test (e.g. Levin *et al.* 2002) and the first generation heterogeneous test (e.g. Im *et al.* 1997, 2003) employed for panel data may lead to misleading inferences.[13] It is generally known that a pitfall in the panel unit root tests mentioned above is that they maintained the null hypothesis of a unit root in all panel members. Therefore, their rejection indicates that at least one panel member is stationary, with no information about how many series or which ones are stationary. This means that when the null is rejected, it is possible that only one member of the panel had contributed to the finding. Put differently, a rejection of the joint unit root hypothesis can be driven by a few stationary series and therefore, the whole panel may erroneously be concluded as stationary (Taylor and Sarno, 1998).

[12] Motivated by the statistical power of these tests, Wu (2000) applied the Im *et al*. (1997) tests to show that for a panel of 10 OECD countries, the current account followed a mean reverting process.

[13] Taylor and Sarno (1998) demonstrated that these types of panel unit root tests are biased towards stationarity if only one series is strongly stationary.

To avoid the some of the pitfalls mentioned above, Breuer *et al.* (2002, SURADF) developed a panel unit root test that involves the estimation of the ADF regression in a SUR framework and then testing for individual unit root within the panel member. This series-specific unit root test procedure also handles heterogeneous serial correction across panel members. Importantly, the test minimized the possibility of erroneously rejecting the null hypothesis when only one panel member behaves in a stationary manner. Therefore, the method is less restrictively than the panel unit root tests mentioned above.

The seemingly unrelated regressions of the augmented Dickey-Fuller (SURADF) test are based on the system of ADF regression of Eq. (9) which can be represented as:

$$\Delta\varepsilon_{1,t} = c_1 + bt_1 + \beta_1\varepsilon_{1,t-1} + \sum_{i=1}^{k} a_i\Delta\varepsilon_{1,t-i} + u_{1,t}$$

$$\Delta\varepsilon_{2,t} = c_2 + b_2t_2 + \beta_2\varepsilon_{2,t-1} + \sum_{i=1}^{k} a_i\Delta\varepsilon_{2,t-i} + u_{1,t}$$

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$$\Delta\varepsilon_{N,t} = c_1 + bt_1 + \beta_N\varepsilon_{N,t-1} + \sum_{i=1}^{k} a_i\Delta\varepsilon_{N,t-i} + u_{N,t} \qquad (10)$$

where $\beta_i = (\rho_i - 1)$ and ρ_i is the autoregressive coefficient for series *i*. This system is estimated by the SUR procedure and the null and the alternative hypotheses are tested individually as

$$H_0^1 : \beta_1 = 0; \qquad H_A^1 : \beta_1 < 0$$
$$H_0^2 : \beta_2 = 0; \qquad H_A^2 : \beta_2 < 0$$

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$$H_0^N : \beta_N = 0; \qquad H_A^N : \beta_N < 0$$

The test statistics computed from the (10) are to compare with the critical values that generated using the Monte Carlo simulations. This procedure yields several advantages: first, by exploiting the information from the error covariances and allowing for the autoregressive process, it produces efficient estimators over the single equation methods. Second, the estimation also allows for heterogeneity of the lag structure across the panel members. Third, the SURADF panel integration test allows us to identify how many and which members of the panel contain a unit root. The test is based on an individual rather then a joint null hypothesis as in earlier versions of the panel unit root tests.

As this test has non-standard distributions, the critical values of the SURADF test must be obtained through simulations. In the Monte Carlo simulations, the intercepts, the coefficients on the lagged values for each series, were set equal to zero. In what followed, the lagged differences and the covariances matrix were obtained from the SUR estimation on the actual current account data. The SURADF test statistic for each of the series under investigation was computed as the *t*-statistic calculated individually for the coefficient on the lagged level. To obtain the critical values, the experiments were replicated 10000 times and the critical values of 1%, 5% and 10% were tailored to each of the twelve panel members. To estimate half-life, the AR(ρ) method is applied to the SUR series that being generated and confirmed to be stationary.

4.1 Data Description

The sample includes Malaysia, Thailand, the Philippines, Singapore, South Korea, Taiwan, China, Japan and the US. Hsiao and Hsiao (2003) and Petri (2006) examined the real and financial linkages for most of these Asian economies. Their findings suggest that Asians are

increasingly becoming integrated through trade and investment. These works justify the selection of the Asian economies included in the present study.

Following the Fisher equation, real interest rates of one country will take account of the expected inflation. These are estimated from actual inflation as measured by changes in the consumer price index (CPI). In our case, the expected inflation is estimated by using the autoregressive distribution lag approach rather than by having the actual inflation as proxy. For China, the estimation of the real rates is subject to the constraint that the price series is only available since 1987 as recorded by the IFS. The nominal interest rates employed in the study are: prime lending rates for the US, Japan, China, Taiwan, Singapore, Malaysia, Philippines and Thailand; working capital loan rates for Indonesia; and the interbank call loan rates for South Korea. Only short-term interest rates (which capture monetary policy) are used due to the fact that historical data of long-term interest rates such as government bond yields are not available for the period under investigation in most the Asian countries. Furthermore, the choice of short-term rates is due to its forecast ability of future expected inflation rates (see Byun and Chen, 1996). To assure the consistency and reliability of the data, we crosschecked with various sources such as the IMF International Financial Statistics and the Central Banks of the respective countries.

The full sample period started in January 1976 and ended in June 2005. To control the various financial market reforms that were undertaken by the sample countries and to determine their impact on the data generating process, the monthly data is divided into three sub-periods, namely, 1976:M1 through 1986:M12, 1987:M1 through 1997:M6, 1987:M1 through 2005:M6[14].

[14] Since the late 1980s, the East Asian countries have been the largest recipient of capital inflows in the world (Grenville, 2000). The investment boom during 1987-1997 was primarily led by foreign capital.

The earlier sub-period allows investigating the pre-liberalization era. Importantly, the last sub-sample analyses allow us to see the impact of the crisis, if any, on the real interest differentials of the countries under investigation with their major trading partners. The period that includes the crisis is important as it can provide some insights on how the crisis affected countries have been adjusting their policies and helps us to understand more about the consequences of the crisis.

5.0 EMPIRICAL EVIDENCE

The single-equation methods may not have enough variation to produce a high-powered unit root test. To overcome this problem, we adopted two types of panel based unit root tests to infer on the stationarity of the series: the LM-bar statistic proposed by Im *et al.* (2003, IPS) and panel unit root test proposed Levin *et al.* (2002, LL). The motivation of using these tests is due to the different alternative hypothesis in the tests. The alternative hypothesis in the IPS tests allows for AR(1) coefficient to differ across groups. On the other hand, the LL test assumes that each individual unit in the panel shares the same coefficient (homogenous panel test).

Having created a panel data set from the 8 East Asian economies and for the four sub-periods, we applied the two different types of the panel unit root tests to all the four panels. The results of the LL and IPS tests are summarized in Table 1. The table reveals that the null hypothesis of non-stationary is strongly rejected at the 5% (or better) significance level for the full- and 3 sub-panels by the IPS as well. The *p*-values for the LL tests are all larger than 10% thus indicating that the unit root null cannot be rejected. The LL tests are not in favor of RIP, even in the post-liberalization era (Panel C and D of Table 1). For the panel data in question, we find inconsistency among the panel results that IPS tests reject the null while the LL tests fail to reject

the null hypothesis of unit roots. The results presented so far appear to be invariant to the choice of centre country. From a statistical point of view, our results suggest the danger of relying on a single method or approach[15]. [Insert Table 1]

A pitfall in panel unit root tests is that a rejection of the joint unit root hypothesis can be driven by a few stationary series and the whole panel may erroneously be concluded as stationary (Taylor and Sarno, 1998; Breuer *et al*., 2001). These tests are uninformative about the number of series that are stationary versus the number that are nonstationary. Additionally, O'Connell (1998) has shown that these tests suffer from extreme size distortion (rejects a true null too often) when the contemporaneous error terms are correlated across groups (referred to as spatial correlation in the literature). O'Connell further demonstrates that, once this spatial correlation is controlled, the power of these tests drops significantly.

One way of resolving the weakness and the ambiguity in the earlier panel based unit root tests (IPS and LL) is to apply more powerful tests[16]. We now turn to the SURADF test advocated by Breuer *et al*. (2001, 2002) to perform well with panels of mixed order of integration. This test can also identify which of the countries in the panel is the major source of the general failure of RIP to hold. The test statistics along with the 1%, 5% and 10% critical values for each of the eight panel members are as tabulated in Tables 2 (for Asian-US pairs) and Table 3 (for Asian-Japan pairs). At the 10% significance level, the null hypotheses of nonstationarity are rejected in all but one case - China (i.e. the China-US pair). The China-Japan real interest differential series

[15] For more recent discussion on the power of these panel unit root tests, see Hlouskova and Wagner (2006).

[16] Results of power analysis by Breuer *et al.* (2001) show the power of the SURADF is substantially higher.

displays significant persistent behavior from the equilibrium during the earlier sample period (1987:M1-1997:M6).

Meanwhile, when the data is extended to include the post-crisis period, we observed that RIP holds in all the Asian (including China-US, at 10% significant level). A noteworthy aspect of our results is that we found that the capital markets in the East Asian countries, including China are integrated with the US. In other words, deregulation process that started in 1987 has been accompanied by increasing influence of the US in the region. Also, we found that RIP holds for some countries (e.g. Malaysia and China) with capital controls in 1987:M1-2005:M6 sub-period. The openness of these countries in terms of trade might have enabled investors to move funds across border and make capital control ineffective (see also Phylaktis, 1999) [Insert Tables 2].

The SURADF results of Asia-Japan rates are further demonstrated in Table 3. Panel B of Table 3 shows that RIP holds for the pre-liberalization period in all (1987: M1-2005:6), we observed the unit root null is rejected for all the Asian countries, except for China. To investigate the possibility that most of the financial and goods markets are integrated before 1997, we dropped the data from the post-crisis era. The results overwhelmingly suggest that all these countries are integrated with Japan, but again, with the sole exception of China (panel D, Table 3). Therefore, our view about the openness of China's capital market is mixed. It appears to be integrated with the US but not with Japan. [Insert Tables 3]

To sum up, the results from the two tables confirm that the ASEAN-5, Taiwan and South Korea are integrated with the major financial institutions namely, the US and Japan. Hence, these

countries are not immune to external shocks within the region as well as from outside - the US. The recent Asian financial turmoil is a point in case. It started in Thailand and spread contagiously to the other East Asian countries, except for Singapore, China and Taiwan that have less suffered from the crisis.

The unit root test itself may not be sufficient to provide an insight into the dynamic adjustments of RIP and the degree of real financial integration among these countries. In what follows, a number of researchers have estimated the half-lives to measure the persistency of deviations from RIP. The half-life is commonly used to measure the degree of mean reversion in real exchange rates to avoid the difficulties in interpreting unit root tests and some issues of interest in international economics (see Taylor and Peel, 1998; Caner and Kilian, 1999; Holmes, 2002; Murray and Papell, 2002). Meanwhile, the point estimates of the size of the half-lives alone may not provide a complete picture of the speed of convergence towards RIP[17]. To this end, we also constructed percent confidence intervals so as to offer better indications of the uncertainty around the estimates of the half-lives. The computed half-life for the East Asian countries is reported in Table 4.

Panel A of Table 4 reports the full sample period of the US and the Japan-based half-lives. The point estimates of the half-life ranged from 6.12 (Singapore) to 24.54 (South Korea) for the US-based half-lives and from 9.02 (Taiwan) to 31.30 (Malaysia) months for the Japan-based half-lives. Based on the figures in panel A of Table 3, it might be tempting to conclude that the point estimates for the US pair are somewhat lower than the estimates from the Japanese pairs. We

[17] The most commonly measure of persistence is the half-life. The half-life is defined as the number of years it takes for deviations of RIP to subside permanently below 0.5 in response to a unit shock in the level of the series.

note that Holmes (2002) provided estimates of half lives of about 2 to 2.6 months for the major European Union countries. [Insert Table 4]

It is worth noting that the half-life of RIP deviation in the post-liberalization (1987-2005) era are considerably reduced for both the US and Japanese pairs, thereby supporting our contention that capital mobility has somewhat increased in the post-liberalization period (Korea-Japan pair sole exception). The speed of convergence is faster than the pre-liberalization period but is in line with the PPP theory which suggests that the speed of reversion is between 1-2 years. In most cases, we observed that the point estimates are less than 24 months. Interestingly, the upper bound for the confidence interval is also in line with the theory with the notable exception of the China-US (45.69 months) and the Korea-Japan (46.09 months) pairs. In any case, the confidence interval lies outside Rogoff's 3-5 years range (Rogoff, 1996). During this period, we have also observed that the massive capital movements following the removal of capital controls - control on the purchasing and selling of foreign (domestic) securities - are removed. They affect both the real exchange rate and the interest rate of most of the Asian countries. All in all, we observed that the half-life is much smaller in the US pairs than the Japanese pairs, indicating that the non-Japanese Asian countries are more closely related to the US than Japan in terms of real interest linkages. We note that the exports from the Asian countries to Japan and the US are large in terms of percentage of total GDP and have increased markedly. However, some changes in the structure have occurred over the past decades. In the 1970s, Japan was the most important export market for the Asian countries. By 1994, this situation had changed, and the US is now the leading market for most of the Asian countries' exports.

Next, we asked how the crisis has affected these results. For this purpose, we exclude the post-crisis data (1987:M1-1997:M6). As shown in Panel C of Table 4, it did not change the picture on the RIP relationship much, although in general the reported half-lives during the pre-crisis were slightly shorter in some of the Asian countries. We found that the speed of convergence of RID deviations for the Malaysia-Japan and Taiwan-Japan is much faster than that of the respective US rates. Second, we observed that the most notable decline in half-life was that of the Korean-US (9.89 months). Thus, the answer to the question of whether the US (or Japan for that matter) is gaining economic influence in the region is clear[18]. There is no evidence to suggest a Yen bloc has been created in the region during post-liberalization era. Like Anoruo *et al*. (2002), we observed that the US has important influence in the region for the period 1987:M1-2005:M6.

6.0 Concluding Remarks

This paper has investigated the mean reverting behavior of RIP for 8 non-Japanese Asian countries over the period 1976-2005 using an array of panel unit root tests, including a recently developed integration test advocated by Breuer *et al*. (2001, 2002; SURADF). Comparing the SURADF results with those of the IPS, and LL tests reveal the weakness of the latter which are constructed on a joint test of a unit root for all members in the panel. The inference drew from the joint panel unit root tests yields conflicting results. The IPS test indicates all series the series in the panel are stationary while the LL test provides evidence not in favor of RIP for the same group of countries. Meanwhile, further evidence based on the SURADF unit root test reveals that the typically employed unit root test in panel data can lead to misleading inferences.

[18] We also computed the half-lives for the 1997:M7 to 2005: M6 period but the results are not reported here because the estimates are biased in small samples.

In this study, we have shown that the RIP holds for all of the Asian countries in the post-liberalization era, except China. The empirical results indicate that South Korea, Taiwan, Singapore, Malaysia, Thailand, Indonesia and the Philippines are closely linked with both the US and Japan, while China is linked solely to the US. Therefore, the US has strong influence on the Asian domestic interest rates, including China. China has opened its goods and service markets, albeit in a gradual fashion, long before launching financial reforms in the late 1990s. Interest rates equalization is affected by the deregulation of financial markets, and we find that the impact is regional in nature. Specifically, we find that following the liberalization of the capital markets, the half-lives of the Asian countries has significantly shortened. There is some evidence to suggest that the adjustment to deviations from RIP have been increasing during the post crisis period in most of the crisis inflicted countries.

The period also coincided with the increasing international trade and investments between these countries and the US and Japan. These findings suggest that capital mobility has been increasing in the region and matches the episode of the contagion in the Asian capital markets that started in Thailand and spread to the other Asian countries like Indonesia, South Korea, the Philippines and Malaysia. Unlike the other East Asian countries, the lack of real interest convergence towards the US and Japanese rates in China implies that it still has not lost its monetary autonomy to stabilize the domestic economy.

Finally, it is worth mentioning that there are a number of different measures of financial integration besides RIP. In this paper, the price based measure is employed to check for financial integration. For quantity based measures, we need to look at net capital flows from one country

to another. The argument here is that for financial integration, there ought to be sustained evidence of sizeable cross border transactions in financial assets (measured by the ratio of capital flows to GDP).

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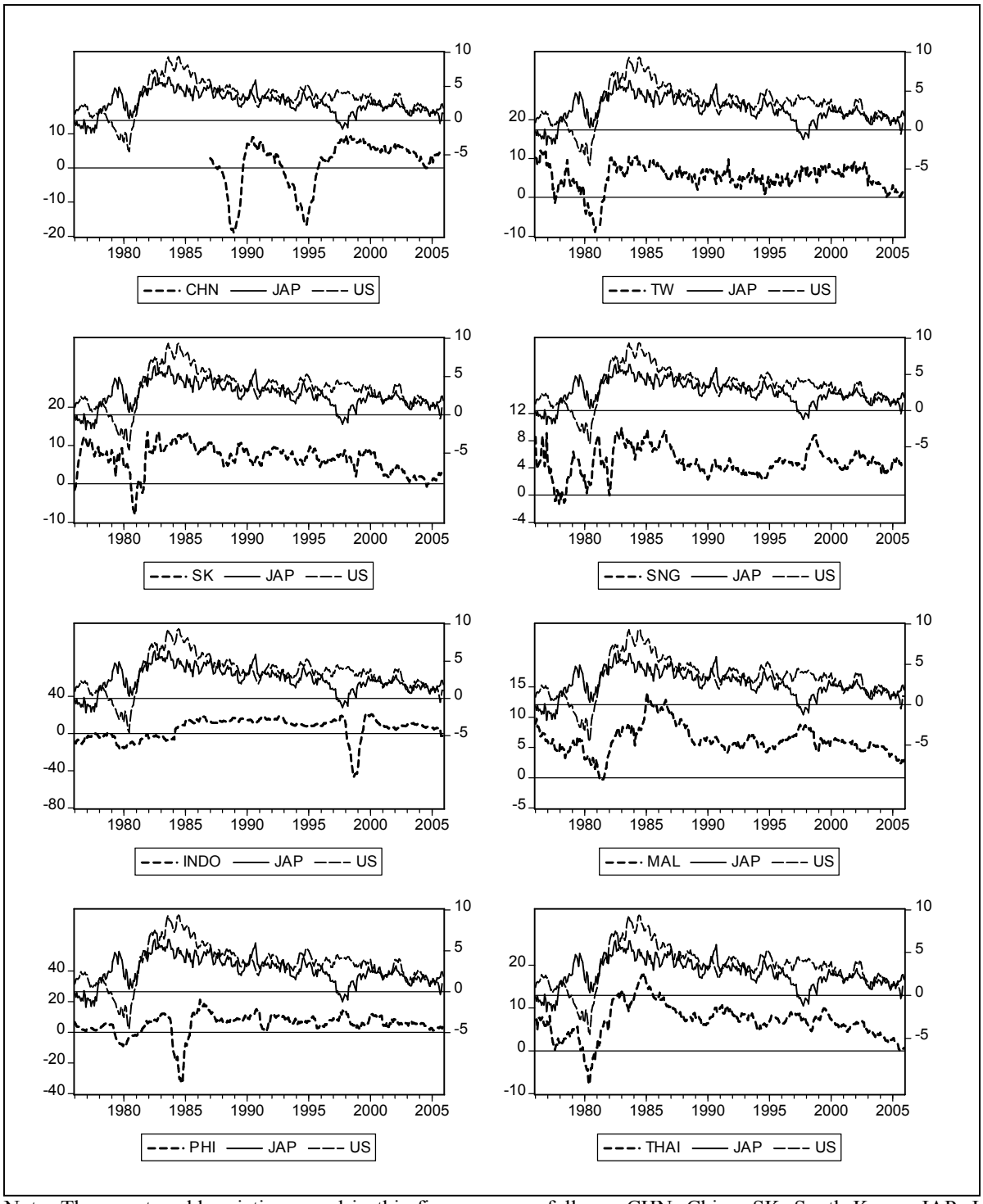
Figure 1: Real Interest Rates of East Asia, Japan and the US, 1976-2005



Note: The country abbreviations used in this figures are as follows: CHN, China; SK, South Korea, JAP, Japan; SNG, Singapore; INDO, Indonesia; MAL, Malaysia; PHI, Philippines; and THAI, Thailand: For China, the sample period begins at 1987M1 due to data unavailability. The Asian rates are referring to the left hand scales whereas the US and Japanese rates are referring to the right hand scales.

Table 1: Panel Unit Root Tests on the East Asian Real Interest Differentials

	Levin-Lin-Chu (2002)	Im-Pesaran-Shin (2003)
ASIA-US		
A: 1976M1–2005M6	-0.142 (0.556)	-6.518 [c] (0.000)
B: 1976M1–1986M12	0.032 (0.513)	-2.221 [b] (0.013)
C: 1987M1–1997M6	-0.306 (0.380)	-3.251 [c] (0.001)
D: 1987M1–2005M6	0.958 (0.831)	-3.812 [c] (0.000)
ASIA-JAPAN		
A: 1976M1–2005M6	-0.231 (0.409)	-5.811 [c] (0.000)
B: 1976M1–1986M12	-0.210 (0.417)	-1.782 [b] (0.037)
C: 1987M1–1997M6	0.499 (0.691)	-2.672 [c] (0.004)
D: 1987M1–2005M6	-0.805 (0.790)	-2.874 [c] (0.002)

Notes:
A - Full Sample
B - Pre-liberalization
C - Post-liberalization without Crisis
D - Post-liberalization with Crisis
China is only included in the Panel C and D due to data unavailability. Alphabet a, b and c denote the significant statistics at 10%, 5% and 1% respectively. P-values are presented in the parentheses. Levin-Lin-Chu (2002) test is designed for homogenous panels which share a common unit root process whereas Im-Pesaran-Shin (2003) advocate unit root test corrected for heterogeneous panels. Both tests employ the null hypothesis of a unit root in the series. The choices of lag length are based on the Modified Schwarz Information Criteria.

Table 2: SURADF Estimation and the Critical Values (ASIA-US)

RID-US	lag	SURADF Statistics	Critical Values		
			99% [c]	95% [b]	90% [a]
		A: 1976:M1 – 2005:M6			
Taiwan	10	-4.482 [c]	-3.658	-3.047	-2.744
South Korea	9	-4.599 [c]	-3.718	-3.139	-2.831
Singapore	8	-4.827 [c]	-3.709	-3.092	-2.797
Indonesia	13	-5.593 [c]	-3.634	-3.026	-2.697
Malaysia	6	-6.472 [c]	-3.815	-3.296	-2.966
Philippines	16	-3.588 [c]	-3.572	-2.986	-2.664
Thailand	8	-4.814 [c]	-3.585	-3.022	-2.716
		B: 1976:M1 – 1986:M12			
Taiwan	2	-4.360 [c]	-4.131	-3.476	-3.137
South Korea	3	-4.802 [c]	-4.112	-3.516	-3.181
Singapore	4	-3743 [b]	-4.181	-3.417	-3.093
Indonesia	4	-4.940 [c]	-4.270	-3.589	-3.245
Malaysia	4	-3.857 [b]	-4.231	-3.574	-3.253
Philippines	4	-4.641 [c]	-3.772	-3.151	-2.829
Thailand	5	-3.480 [b]	-4.111	-3.450	-3.118
		C: 1987:M1 – 1997:M6			
China	1	-1.702	-3.872	-3.217	-2.874
Taiwan	5	-4.606 [c]	-3.777	-3.196	-2.854
South Korea	3	-5.381 [c]	-3.805	-3.126	-2.778
Singapore	4	-6.154 [c]	-3.895	-3.221	-2.890
Indonesia	2	-5.148 [c]	-3.764	-3.136	-2.807
Malaysia	6	-3.343 [b]	-3.871	-3.157	-2.817
Philippines	4	-4.945 [c]	-3.943	-3.230	-2.888
Thailand	4	-5.423 [c]	-3.808	-3.153	-2.814
		D: 1987:M1 – 2005:M6			
China	4	-2.889 [a]	-3.748	-3.142	-2.814
Taiwan	2	-3.131 [b]	-3.718	-3.111	-2.797
South Korea	5	-5.887 [c]	-3.653	-3.075	-2.735
Singapore	8	-4.184 [c]	-3.696	-3.035	-2.732
Indonesia	6	-4.937 [c]	-3.677	-3.094	-2.763
Malaysia	4	-6.791 [c]	-3.674	-3.078	-2.767
Philippines	7	-3.765 [c]	-3.681	-3.108	-2.811
Thailand	8	-3.777 [c]	-3.666	-3.033	-2.732

Note: The column of SURADF refers to the estimated Augmented Dickey-Fuller statistics obtained through the SUR estimation of the RID-US ADF regression and optimal lags are reported. The three right-hand-side columns reported the estimated critical values tailored by the simulation experiments based on 354 (1976:M1 – 2005:M6), 132 (1976:M1 – 1986:M12), 126 (1987:M1 – 1997:M6) and 222 (1987:M1 – 2005:M6) observations respectively for each series and 10000 replications, following the work by Breuer *et al.* (2002). The error series were generated in such a manner to be normally distributed with the variance-covariance matrix given from the SUR estimation of the RID-US panel structures. Each of the simulated RID series was then generated from the error series using the SUR estimated coefficients on the lagged differences. For China, the data is available since 1987: M1. Alphabets a, b and c denote the significant statistics at 10%, 5% and 1% respectively. All the estimations and the calculation of the SURADF estimation were carried out in RATS 5.02 using the algorithm kindly provided by Myles Wallace.

Table 3: SURADF Estimation and the Critical Values (ASIA-JAP)

RID-JAPAN	lag	SURADF Statistics	Critical Values		
			99% [c]	95% [b]	90% [a]
		A: 1976:M1 – 2005:M6			
Taiwan	10	-4.102 [c]	-3.516	-2.985	-2.684
South Korea	15	-4.038 [c]	-3.619	-2.995	-2.685
Singapore	6	-7.990 [c]	-3.684	-3.040	2.730
Indonesia	6	-5.781 [c]	-3.573	-2.976	-2.686
Malaysia	14	-3.755 [c]	-3.637	-3.075	-2.762
Philippines	8	-4.771 [c]	-3.513	-2.960	-2.677
Thailand	10	-4.395 [c]	-3.570	-3.013	-2.715
		B: 1976:M1 – 1986:M12			
Taiwan	3	-4.679 [c]	-4.079	-3.478	-3.154
South Korea	9	-2.560	-4.157	-3.548	-3.194
Singapore	6	-5.314 [c]	-3.806	-3.149	-2.814
Indonesia	4	-3.432 [b]	-4.065	-3.414	-3.094
Malaysia	4	-4.444 [c]	-4.268	-3.608	-3.256
Philippines	8	-2.401	-4.228	-3.584	-3.250
Thailand	5	-4.123 [c]	-4.072	-3.429	-3.099
		C: 1987:M1 – 1997:M6			
China	1	-1.535	-3.872	-3.251	-2.914
Taiwan	5	-4.834 [c]	-3.780	-3.116	-2.778
South Korea	4	-3.813 [c]	-3.759	-3.159	-2.809
Singapore	4	-3.030 [a]	-3.921	-3.238	-2.890
Indonesia	4	-5.094 [c]	-3.786	-3.345	-2.832
Malaysia	4	-3.985 [b]	-4.034	-3.346	-3.017
Philippines	4	-5.825 [c]	-3.851	-3.204	-2.898
Thailand	4	-5.310 [c]	-3.785	-3.142	-2.797
		D: 1987:M1 – 2005:M6			
China	1	-1.922	-3.666	-3.045	-2.719
Taiwan	10	-3.028 [a]	-3.623	-3.037	-2.741
South Korea	5	-5.264 [c]	-3.692	-3.109	-2.793
Singapore	5	-5.345 [c]	-3.618	-3.075	-2.737
Indonesia	6	-4.961 [c]	-3.7457	-3.173	-2.836
Malaysia	7	-4.242 [c]	-3.651	-3.052	-2.743
Philippines	10	-5.357 [c]	-3.691	-3.076	-2.783
Thailand	10	-3.576 [b]	-3.688	-3.076	-2.752

Note: The column of SURADF refers to the estimated Augmented Dickey-Fuller statistics obtained through the SUR estimation of the RID-JAP ADF regression and optimal lags are reported. The three right-hand-side columns reported the estimated critical values tailored by the simulation experiments based on 354 (1976:M1 – 2005:M6), 132 (1976:M1 – 1986:M12), 126 (1987:M1 – 1997:M6) and 222 (1987:M1 – 2005:M6) respectively for each series and 10000 replications, following the work by Breuer *et al.* (2002). The error series were generated in such a manner to be normally distributed with the variance-covariance matrix given from the SUR estimation of the RID-JAP panel structures. Each of the simulated RID series was then generated from the error series using the SUR estimated coefficients on the lagged differences. Alphabets a, b and c denote the significant statistics at 10%, 5% and 1% respectively. All the estimations and the calculation of the SURADF estimation were carried out in RATS 5.02 using the algorithm kindly provided by Myles Wallace.

Table 4: Half-Lives and Confidence Intervals

RID Series	ASIA-US			ASIA-JAP		
	B	Half-life	CI at 95%	β	Half-life	CI at 95%
			A: 1976M1–2005M6			
Taiwan	-0.0684	9.79	[0, 25.62]	-0.0740	9.02	[2.65, 15.39]
South Korea	-0.0278	24.54	[0, 119.65]	-0.0490	14.50	[1.82, 27.19]
Singapore	-0.1070	6.12	[0, 12.63]	-0.0388	17.52	[0.49, 34.55]
Indonesia	-0.0443	15.29	[0,52.28]	-0.0513	13.16	[0, 29.67]
Malaysia	-0.0606	11.09	[0, 39.57]	-0.0219	31.30	[6.22, 56.37]
Philippines	-0.0428	15.84	[0, 73.65]	-0.0377	18.73	[0, 51.21]
Thailand	-0.0392	17.32	[0, 65.98]	-0.0393	17.30	[0, 36.17]
			B: 1976M1–1986M12			
Taiwan	-0.0663	10.11	[2.07, 18.15]	-0.0453	14.97	[0.01, 29.92]
South Korea	-0.0218	32.21	[0, 86.92]	-	-	-
Singapore	-0.0434	16.31	[3.18, 29.45]	-0.0438	16.15	[0, 39.13]
Indonesia	-0.0366	19.27	[0, 46.47]	-0.0436	16.23	[0, 37.00]
Malaysia	-0.0163	42.88	[0, 132.26]	-0.0208	33.63	[0, 90.21]
Philippines	-0.0436	16.23	[0, 35.24]	-	-	-
Thailand	-0.0253	27.71	[0, 74.52]	-0.0302	23.32	[0, 57.23]
			C: 1987M1–1997M6			
China	-	-	-	-	-	-
Taiwan	-0.0776	8.59	[0, 30.66]	-0.1226	5.30	[0, 13.69]
South Korea	-0.0840	8.60	[1.18, 16.02]	-0.0726	9.89	[1.24, 18.53]
Singapore	-0.1429	5.19	[2.09, 8.29]	-0.0447	15.84	[0, 31.84]
Indonesia	-0.1250	5.89	[0.68, 11.09]	-0.0999	7.28	[0.64, 13.92]
Malaysia	-0.0550	12.94	[0, 27.24]	-0.0602	11.85	[0, 26.60]
Philippines	-0.1114	6.57	[2.48, 10.65]	-0.0526	13.53	[0, 28.60]
Thailand	-0.1602	4.66	[1.49, 7.84]	-0.1297	5.68	[0.59, 10.78]
			D: 1987M1–2005M6			
China	-0.0263	26.04	[6.38, 45.69]	-	-	-
Taiwan	-0.0774	8.60	[3.20, 14.01]	-0.0602	11.17	[3.49, 18.84]
South Korea	-0.0600	11.20	[4.14, 18.27]	-0.0274	24.92	[3.75, 46.09]
Singapore	-0.1080	6.06	[2.95, 9.17]	-0.0904	7.31	[3.90, 10.73]
Indonesia	-0.1042	6.30	[2.90, 9.69]	-0.0939	7.03	[3.16, 10.90]
Malaysia	-0.0909	7.28	[3.14, 11.41]	-0.0822	8.08	[2.83, 13.33]
Philippines	-0.1161	5.61	[4.36, 6.87]	-0.1155	5.65	[2.46, 8.84]
Thailand	-0.1196	5.44	[4.49, 6.39]	-0.0935	7.06	[3.29, 10.83]

Note: Estimation of half-life and 95% confident intervals only applicable for RID series that were found stationary under the SURADF test statistic (at least 10% significant).