Foreign Exchange Market Efficiency in Asia Pacific: 1997 – 2010

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Abstract

We investigate the state of foreign exchange markets efficiency in Asia Pacific under different time periods based on some of the key economic events. We employ two popular techniques to test for foreign exchange markets efficiency. First, we use the Johansen cointegration technique to test for the unbiasedness hypothesis of the forward exchange rates. Second, we run the Fama regression to determine whether the forward exchange rates are unbiased predictor of future spot exchange rates. We found that the foreign exchange markets in Asia Pacific are generally efficient *within-country* in which the spot and forward exchange rates are cointegrated. From the *across-country* perspective, the foreign exchange markets are generally efficient when tested using the bivariate cointegration method but show some evidence of inefficiency when tested using the multivariate method. However, the finding of stationary forward premium reduces the argument for markets inefficiency as the error correction term could possibly be acting as proxy for risk premium. Lastly, the Fama regression results show that the forward bias puzzle is a pervasive phenomenon which happens in all of the currency markets. From the pooled regression analysis, this phenomenon is shown to be particularly prevalent among the high income and more liberalised nations during the overall and normal periods. On the other hand, this phenomenon is present among the medium income and not-so-liberalised nations during the turbulent periods.

Keywords: *Foreign exchange markets efficiency, Forward bias puzzle, Fama regression, Johansen cointegration, Asia Pacific.*

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1. Introduction

In a period of slightly over one decade, the global financial community has witnessed two of the most devastating financial crises in modern history. Shortly after recovering from the 1997/98 Asian financial crisis (AFC), the world was struck by the unprecedented losses disclosed in the United States banking sector in 2008 and 2009. The subprime mortgage sector in the US collapsed and as a result, pulled down with it plenty of financial institutions.

We have decided to look at the Asia Pacific foreign exchange markets because they were greatly impacted during the 1997/98 AFC. The volatility of these currencies has also increased tremendously in the subprime crisis and hence heightened level of risk. The Asia Pacific currencies are generally perceived as more susceptible to crisis and speculative attacks. The main objective of this paper is to identify the markets efficiency conditions during the pre-crisis, crisis and post-crisis periods, with the focus on the AFC and the subprime crisis as the key events.

Our results show that the foreign exchange markets in Asia Pacific are generally efficient *within-country* in which the spot and forward exchange rates are cointegrated. From the *across-country* perspective, the foreign exchange markets are generally efficient when tested using the bivariate cointegration method but show some evidence of inefficiency, especially in the sub-sample periods, when tested using the multivariate method. Our analysis also shows that the AFC seems to be the more disturbing event relative to the subprime crisis in the context of foreign exchange markets efficiency in Asia Pacific. However, the finding of stationary forward premium reduces the argument for markets inefficiency as the error correction term could possibly be acting as proxy for risk premium. Lastly, the Fama regression results show that the forward bias puzzle is a pervasive phenomenon which happens in all of the currency markets at different time periods. From the pooled regression analysis, this phenomenon is shown to be particularly prevalent among the high income and more liberalised nations during the overall and normal periods but absent in the crisis periods. On the other hand, the phenomenon is mainly present among the medium income and not-so-liberalised nations during the turbulent periods.

This paper is organised as follows: Section Two reviews some of the relevant literature and followed by Section Three with the description of data and sub-sample periods classification. Section Four explains methodology while the subsequent section presents the empirical results and some discussions. Section Six concludes.

2. Literature Review

Among the earlier tests of foreign exchange markets efficiency are tests which are based on the unbiasedness hypothesis of the forward rate as predictor of future spot rate. One of the more popular approaches to test the unbiasedness hypothesis is to run a regression of changes in spot exchange rates on its corresponding forward premium as in Equation 1.

$$\Delta s_{t+m} = \alpha + \beta(f_t^m - s_t) + \mu_t \quad (1)$$

The Δ denotes first difference operator, s and f denote spot and forward exchange rates in logarithm, μ is the regression error term and the subscript t refers to time series while the superscript m denotes the maturity period of the forward contract. The null hypothesis is $\alpha = 0$ and $\beta = 1$ against the alternative of either one is not true. This regression is widely used in the study of risk-neutral efficient markets hypothesis since the 1980's up to today (e.g. Bilson, 1981; Fama, 1984; Froot & Thaler, 1990; Baillie & Bollerslev, 2000; Bansal & Dahlquist, 2000 and Frankel & Poonawala, 2010). Equation (1) is now popularly known as the Fama regression due to Fama (1984) (e.g. Clarida et al 2009; Gilmore & Hayashi, 2008) .

The null hypothesis of Fama regression is pervasively rejected in most of the studies which employed this approach. The β in Fama regression is not only significantly different from unity but found to be closer to negative unity (Sarno, 2005; Froot and Thaler, 1990). Instead of providing an unbiased prediction to the changes of future spot rate, the negative β implies that the prediction provided by the forward premium is not only biased but also wrong! This finding means that it is profitable to trade against the prediction provided by the forward premium. This phenomenon is now known as the forward bias puzzle (see Engel, 1996 and Sarno, 2005).

Bansal and Dahlquist (2000) have pooled a set of currencies and run the Fama regression to estimate the beta coefficient. They found that the forward bias puzzle is less severe (i.e. less negative or slightly positive but still significantly less than the hypothesized value of one) when the currencies are pooled than the individual currency regression. They have further divided their sample of currencies based on the country's income level and found that the forward bias puzzle is only restricted to the currencies of high income economies and only to states when the US interest rate is higher than its foreign counterparts. We have also pooled our sample of currencies a-la Bansal and Dahlquist (2000). One innovation in our study is that we grouped our sample of currencies not only based on income but also the extent of liberalisation of the foreign exchange market which is measured by the existence of non-deliverable forward (NDF) markets[1]. Currencies in our sample which are traded in the NDF markets are considered less liberalised and these currencies are not limited to low income nations but also include some of the high income economies.

Besides regression analysis, researchers have also employed cointegration techniques in the study of foreign exchange markets efficiency. Cointegration happens when the linear combination of two or more nonstationary variables is stationary (Baillie & Bollerslev, 1989).

[1] Interested readers may refer to the review articles from Ma, Ho and McCauley (2004) and Tsuyuguchi and Wooldridge (2008) on the details of NDF market in Asia Pacific.

This implies that there is at least one cointegrating vector that exists in binding up the variables. This cointegrating vector is also known as the long-run relationship and represented by an 'error correction term' (ECT) in the econometric model.

If the spot and forward exchange rates are found to be cointegrated, the forward rates are said to be unbiased predictor of future spot exchange rates. Thus this finding implies markets efficiency. Most published papers which employed this approach found that the spot and forward exchange rates are cointegrated and this finding testified to the '*within-country*' foreign exchange markets efficiency (Jeon & Seo, 2003; Kan & Andreosso-O'Callaghan, 2007). Meanwhile, if we were to take a few series of exchange rates of different currencies and run cointegration analysis, the presence of cointegrating vector implies markets inefficiency. The long-run relationship in the system of exchange rates shows the evidence of co-movement between the currencies and therefore at least one of the exchange rates is predictable using current information (Crowder, 1994).

Baillie and Bollerslev (1989) is among the pioneer studies in using the Engle-Granger two-step cointegration method in explaining the state of efficiency in a system of seven exchange rates series (i.e. British Pound (GBP), Deutsche Mark (DEM), French Franc (FFR), Italian Lira (ITL), Swiss Franc (CHF), Japanese yen (JPY) and Canadian dollar (CAD)). Their data covered the period from 1 Mar 1980 to 28 Jan 1985. They found six stochastic trends in the system which in turn implies one common cointegrating vector binding this system of exchange rates and conclude that the weak form efficient markets hypothesis (EMH) is violated. Studies which employed the Johansen (1988; 1991) multivariate cointegration tests (e.g. Crowder, 1994; Kan & Andreosso-O'Callaghan, 2007) have generally found similar results to Baillie and Bollerslev (1989). This type of EMH tests which looked at a system of exchange rates is also known as '*across-country*' efficiency tests (Kan & Andreosso-O'Callaghan, 2007).

Jeon and Seo (2003) who divided their study into sub-periods, however, found that the foreign exchange markets in Asia are generally efficient as their results show no evidence of cointegrating vector in the system of four exchange rate series (i.e. Korean won (KRW), Thai baht (THB), Indonesian rupiah (IDR) and Malaysian ringgit (MYR)). Their study shows that the foreign exchange markets efficiency in these countries was only disturbed during the 1997/98 Asian financial crisis with the emergence of cointegrating vectors in the system.

Further on cointegration, Crowder (1994) has mooted the idea that the existence of cointegrating vector in a system of exchange rates does not necessarily imply inefficiency if we can treat the error correction term (ECT) as proxy for risk premium. The ECT is by definition a stationary process. Therefore the forward premium must be stationary, or I(0), if we were to interpret the risk premium as being represented by the ECT. In a system of three exchange rates (i.e. GBP, DEM & CAD) from January 1974 to December 1991, Crowder

(1994) found two cointegrating vectors which imply one long-run relationship governing their co-movement. To test his hypothesis that the ECT is a proxy for risk premium, Crowder (1994) applied the Augmented Dickey-Fuller (ADF) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) unit root tests on the forward premium. It is found that the forward premium is nonstationary and therefore the time series properties of ECT are incompatible to be the proxy for risk premium. He concluded the market is indeed not efficient.

Nevertheless, some recent studies found different results from Crowder (1994) (e.g. Barkoulas, et al, 2003; Kan & Andreosso-O'Callaghan, 2007). Barkoulas et al (2003) have employed a panel unit root test based on Johansen likelihood ratio (JLR) which was developed by Taylor and Sarno (1998). They found that the forward premium is stationary. Similarly, Kan and Andreosso-O'Callaghan (2007) who employed Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests on the forward premium, also found that the forward premium is stationary.

We expand on the study of Kan and Andreosso-O'Callaghan (2007) which stops at 15 May 2003. Our sample includes more than seven years of additional data to 30 June 2010 and encompasses several key events such as the foreign exchange regime shift in China and Malaysia on 22 July 2005 and the subprime crisis in 2008/09. We have also drawn our study from Jeon and Seo (2003) but we have the opportunity to look at, not one, but two crises.

3. Data and Sub-sample Period

We have employed some of the most active and significant Asia Pacific currencies for this study. The prime motivation for this choice is due to the fact that this group of currencies is not as well researched as the major currencies. The currencies chosen are Australian dollar (AUD), Chinese yuan (CNY), Japanese yen (JPY), South Korean won (KRW), Indonesian rupiah (IDR), Indian rupee (INR), Malaysian ringgit (MYR), New Zealand dollar (NZD), Philippines peso (PHP), Singapore dollar (SGD), Thai baht (THB) and Taiwanese dollar (TWD). The data used are daily spot and one-month forward exchange rates. The US dollar (USD) is used as the numeraire currency. The summary statistics of the related countries are provided in Table 1.

(Table 1 about here)

This study covers the period from 1 January 1997 to 30 June 2010 for a total number of 3,521 spot and forward exchange rate observations[2]. The exchange rates data are obtained from the *Datastream*. This whole period is further broken down into six sub-sample periods according to the significant events that happened within the full period.

[2] The analysis period for CNY starts only after the shift from fixed exchange rate regime to crawling-pegged regime on 22 July 2005. Likewise, the ‘temporary’ fixed exchange rate period for MYR (i.e. from 1 September 1998 to 21 July 2005) is excluded from the analysis. The forward exchange rates data for INR and KRW start from 27 October 1997 and 11 February 2002 respectively.

The first sub-sample period is from 1 January 1997 to 30 June 1997 in order to capture the pre-Asian financial crisis (AFC) condition. The second sub-sample period is from 1 July 1997 to 31 December 1998 and termed as the AFC period. 1 January 1999 to 20 July 2005 is the third sub-sample period. This is the period where the affected countries were recovering from the severe impact of the AFC and hence called the AFC recovery period. The fourth sub-sample period is from 21 July 2005 until 31 December 2007. The beginning of this period is to coincide with the shift in the foreign exchange regime in China and Malaysia. The appreciation of Asian currencies continued from thereon for an extended period. We shall call this fourth sub-sample period the Asian currencies (AFX) appreciation period. Our next sub-sample period from 1 January 2008 to 31 December 2009 coincided with the global recession due to the subprime crisis. Finally, we call the last sub-sample, which is the first half of 2010, the subprime recovery period. The summary of our sub-sample periods is shown in Table 2.

(Table 2 about here)

4. Methodology

We have adopted two popular approaches to check the state of markets efficiency for various periods. The first approach is the Johansen (1991; 1995) cointegration technique. Before we can apply this technique, we must determine the order of integration of the spot and forward exchange rates series. We have employed the Augmented Dickey-Fuller (ADF), Phillip-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) unit root tests to determine the order of integration of the exchange rate series. The ADF and PP tests have the null hypothesis of nonstationarity while the KPSS test has a null hypothesis of stationarity. A trend and intercept are included in all the unit root tests. The lag length in the ADF test, meant to address the issue of serial correlation, is chosen based on the minimization of Akaike Information Criterion (AIC). Meanwhile the PP test is specifically devised to cater for mild serial correlation when testing for a unit root and therefore no lag is needed in this equation. The residual spectrum at frequency zero in the PP test is estimated through the Bartlett kernel approach. The critical values for the ADF and PP tests are as tabulated by MacKinnon (1996). Similar to the PP test, the residual spectrum at frequency zero in the KPSS test is estimated through the Bartlett kernel approach. The Langrange-Multiplier test statistic computed is compared against the critical values as tabulated by Kwiatkowski et al (1992).

Only nonstationary or I(1) series are tested for cointegration. The trace statistics (λ-trace) and maximum eigenvalue (λ-max) tests are used as the test statistics with critical values tabulated by Mackinnon, Haug and Michelis, 1999 (MHM). These two tests start with the first null hypothesis of no cointegrating rank (i.e. $r = 0$, in which r is the number of cointegrating rank) against the alternative of one (or at least one) (i.e. $r \geq 1$) cointegrating rank. If the first null hypothesis is rejected, we move on to test for the second hypothesis of H_0: $r = 1$ against H_1: $r \geq 2$. We repeat the same process until we fail to reject the null hypothesis and the final null indicates the number of cointegrating rank among the series. The variables are cointegrated if *r* is more than zero and less than the number of variables, k, (i.e. $0 < r < k$). If *r* is equal to the number of variables, (i.e. $r = k$), it implies the variables are independent and this is a case of trivial cointegration in which the relationship is useless. We deem trivial cointegration as equivalent to no cointegration. Lags are included to eliminate the serial correlation in the residuals. To conduct the cointegration test, we assume that there is an intercept and a trend in the cointegrating equations[3]. Similar approach has been used by Kan and Andreosso-O'Callaghan (2007), Aroskar et al (2004) and Jeon and Seo (2003).

First, we conduct a *within-country* efficiency test, in which the spot and forward exchange rates are tested for cointegration. The lag length chosen for this cointegration test is 22 given the overlapping nature of the data (Baillie & Bollerslev, 1989). The spot and forward exchange rates are cointegrated if there is one and only one cointegrating rank. If they are found to be cointegrated, we can infer that the forward rate is an unbiased predictor of future spot rate (Jeon & Seo, 2003) and this finding, in turn, supports the *within-country* markets efficiency.

Moving on to *across-country* markets efficiency tests, we have followed Kan and Andreosso-O'Callaghan (2007) to divide the tests into bivariate and multivariate forms. The lag length chosen for the *across-country* cointegration test is five[4]. If the series of exchange rates are found to be cointegrated, there is evidence to show the presence of a long-run relationship among the currencies. Any deviation of one series from the equilibrium relationship indicates that the subsequent movement of the series will return to the long-run relationship (Jeon & Seo, 2003). This implies that the subsequent changes in the exchange rates are therefore predictable. Hence this relationship clearly violates the main tenet of the efficient markets hypothesis.

In the bivariate test, each nonstationary currency spot rate is tested for cointegration with another nonstationary currency spot rate. Meanwhile in the multivariate test, all the nonstationary currencies are tested for cointegration as a whole. Furthermore on the multivariate cointegration test, we have grouped the currency pairs according to their respective locality namely, Southeast Asia (i.e. IDR, MYR, PHP, SGD & THB) and Far East Asia (i.e. CNY, JPY, TWD & KRW). Since we have only two currencies from the Australasia, we are not able to conduct the multivariate cointegration test for this locality.

However, the presence of cointegrating relations among a series of exchange rates does not necessarily indicate markets inefficiency. Crowder (1994) suggests that the cointegrating vector in a system of exchange rates could be proxy for a risk premium that

[3] Our results are robust to the use of the alternative assumption of an intercept but no trend in the cointegrating equations.
[4] Generally, our results are robust to the selection of 10, 15, 20 and 25 lags in the cointegration tests.

drives their co-movement. Crowder has decomposed the forward premium into three components namely changes in spot rate, a currency risk premium and a rational expectation error which resembles a white noise as shown in Equation (2).

$$(f_t^m - s_t) = (s_{t+m} - s_t) + \delta_{t+m} + \varepsilon_{t+m} \tag{2}$$

The variables f and s follow the definitions given earlier for Equation (1) and δ denotes the risk premium while ε is the rational expectation error which follows a white noise process. The changes in spot exchange rate series, $s_{t+m} - s_t$, is widely found to be stationary. Meanwhile ε, which follows a white noise process, is also a stationary term. The stationarity of the risk premium is therefore dependent on the forward premium, $f_t^m - s_t$. The forward premium must be stationary so that it is compatible with the time series property of the error correction term (ECT) found in the cointegrated model in order for the ECT to be proxy for the risk premium.

The stationarity of the forward premium is tested with the ADF and PP unit root tests. The presence of unit roots in the forward premium would reject the suggestion that the cointegrating vector is proxy for risk premium and the market is indeed inefficient. Meanwhile if the forward premium found no evidence of unit roots, the market could possibly be efficient and the ECT as instrument for risk premium. This approach has been employed, among others, by Kan & Andreosso-O'Callaghan (2007), Aroskar et al (2004) and Barkoulas et al (2003).

The second approach to test for markets efficiency is the estimation of Fama regression described earlier. The use of overlapping data to estimate the parameters of Fama regression gives rise to the problem of serial correlation. This complication is overcome with the use of generalized method of moment (GMM) estimation technique. The standard error of estimates are heteroscedasticity and autocorrelation consistent (HAC). The null hypothesis of the regression is tested by using the Wald statistic, which has a chi-square distribution with k degrees of freedom, where k is the number of restrictions.

The Fama regression is estimated for each individual currency. Some of the estimation periods contain relatively short time series and therefore the resulting estimates of the parameters for each individual currency could be imprecise (especially the Pre-AFC and Subprime Recovery periods in which both contain 129 observations each). We address this concern by pooling the various currencies and employ a panel estimation technique. The intercept of the pooled time-series cross-section regression is allowed to vary across currencies with random effect but fixed through time[5]. The slope coefficient estimate is constant through time as well as across currencies and this figure is reported. The first pooled sample contains all the 12 Asia Pacific currencies. We exclude CNY and MYR in the second pooled sample due to the fact that both currencies adopted a fixed exchange rate regime for a substantial time period in our study.

The next four pooled samples are grouped based on two criteria. The first criterion is based on the Gross National Income (GNI) per capita as at 2009. This information is available from the World Bank database. Referring to Table 1, there are six countries which are categorised as high income nations namely Australia, Japan, South Korea, New Zealand, Singapore and Taiwan (third pooled sample). The rest of the countries are categorised as medium income nations (fourth pooled sample). Bansal and Dahlquist (2000) have conducted a panel data analysis based on the first criterion for their samples of currencies and found that the estimates of the slope coefficients for both samples are significantly different. The second criterion used is the extent of foreign exchange liberalization for the particular country and this is measured by the existence of non-deliverable forward (NDF) markets. Currencies which are traded in the NDF markets are deemed as not-so-liberalised and those that are not are categorised as liberalised. CNY, IDR, INR, KRW, MYR, PHP, THB and TWD are traded in the NDF markets (fifth pooled sample) while the rest are not (sixth pooled sample). Technically, the fourth pooled sample is a subset of the fifth pooled sample while the sixth pooled sample is a subset of the third pooled sample.

5. Empirical Results and Discussions

5.1 Approach 1: The Johansen Cointegration Test

From the Augmented Dickey-Fuller (ADF), Phillip-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) unit root tests, the results show most of the spot and forward exchange rates series contain unit roots and are identified as I(1) processes. However, there are some exceptions in which these currencies are stationary. The I(0) exchange rate series are omitted from the cointegration testing. Results of the unit roots tests are presented in Table 3.

(Table 3 about here)

First, we present the *within-country* efficiency test results. The results of the Johansen cointegration test of the spot and forward exchange rate is presented in Table 4. Most of the *within-country* foreign exchange markets are efficient as evidenced by the cointegrating relationship between spot and forward exchange rates. Even though the Philippines peso (PHP), Singapore dollar (SGD) and Taiwanese dollar (TWD) spot and forward exchange rates are trivially cointegrated for the 'Overall' period, they are cointegrated in most of the

[5] Hausman test indicates that a random-effect model is more appropriate than the fixed-effect model for the pooled time-series cross-section regression in our case.

sub-sample periods. It is interesting to note that the Indian rupee (INR) spot and forward exchange rates are cointegrated in the 'Overall' period but not cointegrated at all the other sub-sample periods. Our results generally lend support to the findings reported by Jeon and Seo (2003) and Kan and Andreosso-O'Callaghan (2007).

(Table 4 about here)

Some of the notable findings from the subsample periods are as follows:

i. In the Asian financial crisis (AFC) period, besides the INR, the Thai baht (THB) is the only currency that displays clear sign of inefficiency. The sudden floatation of the THB could have dislocated its markets efficiency in this period and the ripple effects are transmitted to the other currency markets in Asia Pacific.
ii. In the period of subprime crisis, besides the INR, the Japanese yen (JPY) is the only currency which is inefficient while the other currencies maintain their state of efficiency. The disturbance of efficiency in the JPY market could be due to the massive unwinding of the JPY-carry trade in this period.
iii. In the AFC recovery and subprime recovery periods, almost all of the currencies, except for INR in both periods and Chinese yuan (CNY) in the latter period, display cointegration between their respective spot and forward exchange rates. This indicates the *within-country* currency markets remains efficient after both the turbulent periods.

In a nutshell, these findings indicate that the state of efficiency in the Asia Pacific currency markets is resilient to crises. The forward exchange rates remain as unbiased predictor of future spot rates as evidenced by the cointegrating relations.

Next, we move on to the *across-country* efficiency test results as shown in Tables 5 and 6. We shall first discuss Table 6 which shows the results from the bivariate cointegration test. For the overall period, none of currency pairs analysed show any sign of cointegration. This finding testifies to the *across-country* efficiency in the Asia Pacific foreign exchange markets and consistent with the results from Kan and Andreosso-O'Callaghan (2007).

(Table 5 about here)

The notable findings from the subsample periods are summarised as follows:

i. In the AFC period, only THB-crosses show some sign of cointegration. We can infer that the THB is the main driver of currency co-movement in this period. This finding supports the notion of the '*tom-yum*' effect during the AFC.
ii. In the subprime crisis period, none of the currency pairs analysed showed strong sign of cointegration. It implies that the state of efficiency of the foreign exchange markets in Asia Pacific is not affected by the subprime crisis.

From the *across-country* bivariate cointegration test results, we can say that the AFC is a more disturbing period for the Asia Pacific foreign exchange markets efficiency as compared to the recent subprime crisis. Perhaps the financial institutions based in Asia Pacific are not 'fatally' hurt in the subprime crisis as compared to during the AFC, in which we witnessed plenty of casualties among the financial institutions. The central banks in Asia Pacific could also have learned the lessons from previous financial crisis and therefore better equipped to respond appropriately to the uncertain market conditions without disrupting markets efficiency.

Now we discuss the multivariate cointegration test results as presented in Table 6. For the overall period, the Asia Pacific foreign exchange markets are generally efficient with no cointegration among the various series of spot exchange rates. However, after breaking the overall sample into the pre-specified sub-sample periods, there are evidences of cointegrating relations among the exchange rate series and this finding violates the efficient markets hypothesis (EMH).

(Table 6 about here)

Analysis of the subsample periods provides us some worthy insights as follows:

i. In the Pre-AFC and AFC periods, the Asia Pacific and the Southeast Asia's currencies show stronger sign of cointegration. Nevertheless, the Far East Asia's currencies display no sign of cointegration. This finding means that the foreign exchange markets efficiency is intact within the Far East Asia locality.
ii. The inefficiency became less severe in the AFC recovery period as indicated by the smaller number of cointegrating rank.
iii. In the subprime recovery period, the currencies of Asia Pacific are showing strong signs of cointegration. This finding indicates that the inefficiency became more severe and the global recovery from the subprime crisis in the first half of 2010 fails to restore efficiency in the Asia Pacific foreign exchange markets.

To probe whether the cointegrating relations could possibly be acting as proxy for the risk premium, we have tested the stationarity behaviour of the forward premium. The results from the Augmented Dickey-Fuller (ADF) and Phillip-Perron (PP) unit root tests on the forward premium, presented in Table 7, show that most of them are stationary or I(0) processes. This finding supports the results reported by Jeon and Seo (2003) and Kan and Andreosso-O'Callaghan (2007) but contradicts with Crowder (1994).

(Table 7 about here)

The finding implies that the error correction term (ECT) could possibly be acting as proxy for risk premium and therefore it reduces the argument that the foreign exchange markets are inefficient. Even with the presence of cointegration, the market could still be efficient but contains risk premium which is represented by the ECT.

5.2 Approach 2: The Fama Regression Test

The results of the Fama regression are presented in Table 8. Panel A reports the Wald F-test statistic for the null hypothesis of $(\alpha,\beta) = (0,1)$ against the alternative of at least one is not true. The results show that there is a widespread rejection of the unbiasedness hypothesis of the forward rate for almost all of the periods for all currencies. The failure of the unbiasedness hypothesis implies a breakdown in the markets efficiency. In general, this finding is consistent with the vast majority of the literature (e.g. Kan & Andreosso-O'Callaghan, 2007 and Frankel & Poonawala, 2010). Next, we analyse the estimation of the beta coefficients from the individual currency Fama regression as presented in Panel B. The beta coefficient of Fama regression may provide useful information regarding the subsequent changes of the spot exchange rate.

(Table 8 about here)

For the overall period, five of the 12 currencies show negative beta (i.e. Australian dollar (AUD), Indian rupee (INR), Japanese yen (JPY), New Zealand dollar (NZD) and Singapore dollar (SGD)). It is interesting to note that the countries with negative beta are relatively richer and more liberalized in terms of foreign exchange regulations (except for INR) than those countries with positive beta. As explained in the literature review, a negative beta indicates that the forward bias puzzle is severe. This result is consistent to the findings by Frankel and Poonawala (2010) and Bansal and Dahlquist (2000) which pointed out that the forward bias puzzle is less pronounced in developing countries.

Looking at the subsample periods, two notable findings merit some highlights:

i. In the Pre-AFC, AFC and subprime crisis periods, most of the currencies from the more developed countries show positive beta while those from the developing countries show negative beta coefficient. This finding shows that the forward bias puzzle is generally more prominent in the developing countries and absent from the wealthier ones during time of crisis.

ii. In time of tranquillity, which is represented by the AFC recovery, AFX appreciation and subprime recovery periods, majority of the currencies (especially those from developed countries) report negative beta coefficient. This finding is consistent with the result from the study by Clarida et al (2009) which pointed out that negative beta coefficient happens mostly in time of low volatility.

Finally, we analyse the results of the beta coefficient estimates from the pooled time-series cross-section regression as shown in Panel C. The estimates of the beta coefficients become more concentrated (or precise) for all of the pooled samples as well as across all sub-sample periods except for the subprime recovery period. The notable findings from the pooled time-series cross-section regression are given as follows:

i. The exclusion of Chinese yuan (CNY) and Malaysian ringgit (MYR) from the pooled sample generally increased the precision of the estimates of the beta coefficients although the sign of the estimate remains unchanged.

ii. For the overall period, high income countries report negative beta coefficient, while the low income countries positive beta coefficient. The sign of the beta estimates for these two pooled samples are different for three of the six sub-sample periods.

iii. For the overall period, the currencies without NDF markets report negative beta coefficient, while those with NDF positive beta coefficient. The sign of the beta estimates for these two pooled samples are different for all the sub-sample periods except for the subprime recovery period.

From the results, we can draw an inference that the forward bias puzzle is a pervasive phenomenon; it happens in crisis as well as non-crisis periods albeit for different set of currencies. For the more developed countries without NDF markets (e.g. Australia, New Zealand and Japan), the phenomenon is prevalent during the non-crisis periods while it reverses in the crisis period. Meanwhile, for the developing countries with relatively restricted currency markets (e.g. Indonesia, Malaysia, Thailand and Philippines), the forward bias puzzle is less prominent during non-crisis periods and only amplified in the crisis periods. Notwithstanding the sign of the beta coefficient, the foreign exchange markets in the Asia Pacific are inefficient as shown by the widespread failure of the unbiasedness hypothesis tested through the Fama regression.

6. Conclusion

Our key findings can be summarised into five main points. First, the *within-country* efficiency test shows that the Asia Pacific foreign exchange markets are generally efficient and resilient to crises with only a handful of currency markets which show sign of inefficiency in the sup-sample periods. Second, in the bivariate cointegration test, the *tom-yum* effect is prominently disturbing the Asia Pacific foreign exchange markets during the Asian financial crisis period. However, in the subprime crisis period, the reportedly massive unwinding of Japanese yen (JPY) carry trade is not affecting any of the Asia Pacific foreign exchange markets efficiency. Third, the finding of stationary forward premium reduces the argument for markets inefficiency.

Fourth, the forward bias puzzle is a pervasive phenomenon that happens in all of the currency markets as evidenced by the rejection of the Wald test for the Fama regression. Finally, from the pooled regression, the forward bias puzzle is prevalent among the high income and more liberalised nations during the overall and normal periods. On the other hand, this phenomenon is present among the medium income and not-so-liberalised nations during the turbulent periods. This finding sheds more light into the results reported in Bansal and Dahlquist (2000) and Frankel and Poonawala (2010), in which they pointed out that the emerging markets currencies are less biased as compared to more developed countries' currencies.

As final remarks, we would like to highlight two of the possible improvements for our current study. First, our sub-sample periods are arbitrarily chosen based on the key economic events. We could alternatively create these sub-sample periods based on the long-run trend of some of the macroeconomic indicators such as the Industrial Production Index. Secondly, our markets efficiency tests are focused on the use of time-series econometric techniques. We could alternatively employ an event-study analysis to test the responses of the exchange rates to the surprises of 'news' in order to gauge the state of markets efficiency. For our future research, we will employ an event-study approach to test for efficiency in the foreign exchange markets. We will also undertake a research to explore the possible factors that could explain the currency carry trade returns following the findings of negative beta coefficients of the Fama regressions among the Asia Pacific currencies.

References

Aroskar, R., Sarkar, S. K., & Swanson, P. E. (2004). European foreign exchange market efficiency: Evidence based on crisis and noncrisis periods. *International Review of Financial Analysis, 13*(3), 333-347.

Baillie, R. T., & Bollerslev, T. (1989). Common Stochastic Trends in a System of Exchange Rates. *The Journal of Finance, 44*(1), 167-181.

Baillie, R. T., & Bollerslev, T. (2000). The forward premium anomaly is not as bad as you think. *Journal of International Money and Finance, 19*(4), 471-488.

Bansal, R., & Dahlquist, M. (2000). The forward premium puzzle: different tales from developed and emerging economies. *Journal of International Economics, 51*(1), 115-144.

Barkoulas, J., Baum, C. F., & Chakraborty, A. (2003). Forward premiums and market efficiency: Panel unit-root evidence from the term structure of forward premiums. *Journal of Macroeconomics, 25*(1), 109-122.

Bilson, J. F. O. (1981). The "Speculative Efficiency" Hypothesis. *The Journal of Business, 54*(3), 435-451.

Clarida, R., Davis, J., & Pedersen, N. (2009). Currency carry trade regimes: Beyond the Fama regression. *Journal of International Money and Finance, 28*(8), 1375-1389.

Crowder, W. J. (1994). Foreign Exchange Market Efficiency and Common Stochastic Trends. *Journal of International Money and Finance, 13*(5), 551-564.

Engel, C. (1996). The forward discount anomaly and the risk premium: A survey of recent evidence. *Journal of Empirical Finance, 3*(2), 123-192.

Fama, E. F. (1984). Forward and Spot Exchange Rates. *Journal of Monetary Economics, 14*(3), 319-338.

Frankel, J., & Poonawala, J. (2010). The forward market in emerging currencies: Less biased than in major currencies. *Journal of International Money and Finance, 29*(3), 585-598.

Froot, K. A., & Thaler, R. H. (1990). Anomalies: Foreign Exchange. *The Journal of Economic Perspectives, 4*(3), 179-192.

Gilmore, S., & Hayashi, F. (2008). Emerging Market Currency Excess Returns. *NBER WP 14528*.

Jeon, B. N., & Seo, B. (2003). The impact of the Asian financial crisis on foreign exchange market efficiency: The case of East Asian countries. *Pacific-Basin Finance Journal, 11*(4), 509-525.

Johansen, S. (1995). Identifying restrictions of linear equations with applications to simultaneous equations and cointegration. *Journal of Econometrics, 69*(1), 111-132.

Johansen, S. r. (1991). Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models. *Econometrica, 59*(6), 1551-1580.

Kan, D., & Andreosso-O'Callaghan, B. (2007). Examination of the efficient market hypothesis--the case of post-crisis Asia Pacific countries. *Journal of Asian Economics, 18*(2), 294-313.

Kwiatkowski, D., Phillips, P. C. B., Schmidt, P., & Shin, Y. C. (1992). Testing the Null Hypothesis of Stationarity against the Alternative of a Unit-root - How Sure Are We that Economic Time-series have a Unit-root. *Journal of Econometrics, 54*(1-3), 159-178.

Ma, G., Ho, C., & McCauley, R. N. (2004). The markets for non-deliverable forwards in Asian currencies. *BIS Quarterly Review, June 2004*.
Mackinnon, J. G. (1996). Numerical distribution functions for unit root and cointegration tests. *Journal of Applied Econometrics, 11*(6), 601-618.
Mackinnon, J. G., Haug, A. A., & Michelis, L. (1999). Numerical distribution functions of likelihood ratio tests for cointegration. *Journal of Applied Econometrics, 14*(5), 563-577.
Sarno, L. (2005). Viewpoint: Towards a solution to the puzzles in exchange rate economics: where do we stand? *Canadian Journal of Economics-Revue Canadienne D Economique, 38*(3), 673-708.
Tsuyuguchi, Y., & Wooldridge, P. D. (2008). The evolution of trading activity in Asian foreign exchange markets. *Emerging Markets Review, 9*(4), 231-246.

<u>Tables:</u>

Table 1: Summary Statistics of the Exchange Rates Series

	Mean Spot Rate	Spot Range		Mean Forward Rate	1-month Mean Spot Changes (%)	1-month Spot Changes Range (%)		Income Category	Existence of NDF
		Highest	Lowest			Highest	Lowest		
Australia	1.4422	2.0866	1.0216	1.4445	-0.0552	32.73	-11.80	H	N
China	8.0994	8.7129	6.7817	7.6948	-0.1541	0.86	-5.13	M	Y
India	44.16	51.97	35.69	44.92	0.8487	92.79	-47.36	M	Y
Indonesia	8450	15500	2361	8490	0.1635	8.99	-7.22	M	Y
Japan	112.84	147.27	86.36	112.51	-0.1616	10.22	-16.86	H	N
South Korea	1130	1960	844	1101	0.2245	61.89	-20.05	H	Y
Malaysia	3.6084	4.6852	2.4715	3.6673	0.1697	24.56	-25.58	M	Y
New Zealand	1.6940	2.5481	1.2237	1.6979	0.0101	22.98	-16.15	H	N
Philippines	46.30	56.46	26.28	46.52	0.3547	25.96	-13.37	M	Y
Singapore	1.6177	1.8540	1.3480	1.6162	-0.0031	9.33	-9.44	H	N
Thailand	37.73	56.00	22.70	38.03	0.1468	29.21	-26.07	M	Y
Taiwan	32.52	35.22	27.31	32.51	0.1004	10.13	-6.15	H	Y

The exchange rates are quoted in terms of the Asia Pacific currency per unit of US dollar. In the Income Category column, 'H' means high and 'M' means medium. This classification is obtained from the World Bank as at 2009. In the Existence of NDF column, 'Y' means yes and 'N' means no. This is a proxy for the measure of the extent of liberalisation of the particular country's foreign exchange system; 'Y' indicates less-liberalised and 'N' indicates liberalised.

Table 2: Sub-sample Periods

Sample Periods	Date
Overall	1 Jan 1997 - 30 Jun 2010
Pre-AFC	1 Jan 1997 - 30 Jun 1997
AFC	1 Jun 1997 - 31 Dec 1998
AFC Recovery	1 Jan 1999 - 20 Jul 2005
AFX Appreciation	21 Jul 2005 - 31 Dec 2007
Subprime Crisis	1 Jan 2008 - 31 Dec 2009
Subprime Recovery	1 Jan 2010 - 30 Jun 2010

Table 3: Unit Roots Tests Results on Spot and Forward Exchange Rates

Panel A: Spot Exchange Rates

ADF	Spot											
	AUD	CNY	IDR	INR	JPY	KRW	MYR	NZD	PHP	SGD	THB	TWD
Overall	-2.49	-	**-3.75***	-2.29	-2.53	-3.02	**-4.13***	-2.38	-2.73	-3.02	**-3.70***	-2.98
Pre-AFC	-1.44	-	-1.88	**-4.11***	-1.59	-1.26	-4.68*	-2.90	**-3.86***	-1.53	-2.63	-2.90
AFC	-2.10	-	-1.22	-1.17	-0.93	-2.02	-1.94	-1.84	-1.77	-2.04	-3.29	-0.98
AFC Recovery	-1.37	-	-2.45	-0.72	-1.91	-1.48	-	-1.75	-1.42	-2.27	-1.98	-1.11
AFX Appreciation	-2.79	-1.14	-1.58	-1.79	-2.23	-1.78	-2.71	-1.87	-1.44	-3.39	-3.05	-2.96
Subprime Crisis	-0.82	**-3.81***	-1.67	-0.93	-2.56	-1.22	-1.06	-0.81	-1.03	-1.27	-1.55	-1.28
Subprime Recovery	-1.94	-1.68	-2.32	-1.77	-2.15	-2.03	-2.03	-2.46	-1.95	-2.44	-1.52	-1.30

PP	Spot											
	AUD	CNY	IDR	INR	JPY	KRW	MYR	NZD	PHP	SGD	THB	TWD
Overall	-2.59	-	-3.32**	-2.18	-2.58	-2.90	**-3.54***	-2.37	-2.54	-2.96	**-3.41***	-3.01
Pre-AFC	-1.91	-	-1.94	**-4.06***	-1.64	-1.23	**-4.16***	-2.92	**-4.46***	-1.35	-3.14	-2.80
AFC	-2.07	-	-0.84	-1.46	-0.83	-1.41	-1.98	-1.90	-2.02	-2.10	-3.30	-0.95
AFC Recovery	-1.32	-	-2.26	-0.70	-1.92	-1.34	-	-1.66	-1.29	-2.44	-1.87	-1.03
AFX Appreciation	-2.83	-1.05	-1.82	-1.77	-2.29	-1.91	-2.37	-1.89	-1.60	-2.68	-4.09*	-2.55
Subprime Crisis	-0.90	**-3.81***	-0.92	-0.92	-2.37	-1.20	-1.12	-0.79	-1.10	-1.24	-1.66	-1.32
Subprime Recovery	-2.09	-0.19	-2.45	-1.73	-2.19	-2.12	-2.02	-2.54	-1.81	-2.46	-1.63	-1.59

KPSS	Spot											
	AUD	CNY	IDR	INR	JPY	KRW	MYR	NZD	PHP	SGD	THB	TWD
Overall	0.92*	-	**0.53**	**0.99**	0.46*	0.44*	0.77*	**0.82**	1.54*	1.51*	1.03*	0.71*
Pre-AFC	0.22*	-	0.15*	**0.07**	0.28*	0.28*	0.22*	**0.11**	0.11	0.33*	0.25*	0.24*
AFC	0.27*	-	0.48*	0.26*	0.41*	0.44*	0.45*	0.35*	0.40*	0.31*	0.42*	0.47*
AFC Recovery	0.12**	-	0.57*	1.23*	0.80*	0.86*	-	1.15*	1.00*	1.08*	1.03*	0.84*
AFX Appreciation	0.53*	0.55*	0.48*	0.64*	0.26*	0.44*	0.19*	0.54*	0.28*	0.14**	0.24*	0.13**
Subprime Crisis	0.60*	0.58*	0.53*	0.67*	0.13**	0.63*	0.60*	0.66*	0.65*	0.52*	0.72*	0.43*
Subprime Recovery	0.20*	**0.11**	0.16*	0.23*	0.18*	0.24	0.18*	**0.09**	0.22*	**0.11**	0.24*	0.22*

Panel B: 1-month Forward Exchange Rates

ADF	1-m Forward, *f*											
	AUD	CNY	IDR	INR	JPY	KRW	MYR	NZD	PHP	SGD	THB	TWD
Overall	-2.51	-	**-3.82****	-2.29	-2.46	-1.46	**-3.68***	-2.36	-2.75	-3.00	**-3.88***	**-3.45***
Pre-AFC	-1.55	-	-2.14	-	-2.30	-	-4.89*	-3.48*	-3.09	-1.54	**-4.61***	-2.91
AFC	-1.98	-	-0.66	-2.03	-0.89	-	-2.40	-1.94	-2.00	-1.95	-2.16	-0.94
AFC Recovery	-1.36	-	-2.11	-0.86	-1.93	-1.93	**-4.15***	-1.76	-1.41	-2.36	-2.00	-1.13
AFX Appreciation	-3.03	0.65	-1.79	-1.90	-2.28	-1.51	-2.54	-2.04	-1.40	**-3.45***	-3.07	-2.52
Subprime Crisis	-0.76	**-4.18***	-1.63	-1.00	-2.57	-1.18	-1.04	-0.86	-0.78	-1.23	-1.08	-1.29
Subprime Recovery	-1.76	-2.55	-2.19	-1.78	-2.05	-1.90	-2.11	-2.39	-1.71	-2.42	-1.72	-1.44

PP	1-m Forward, *f*											
	AUD	CNY	IDR	INR	JPY	KRW	MYR	NZD	PHP	SGD	THB	TWD
Overall	-2.56	-	**-3.35****	-2.18	-2.62	-1.58	**-3.40****	-2.38	-2.56	-2.98	**-3.56***	-3.00
Pre-AFC	-1.70	-	-2.14	-	-1.60	-	**-4.28***	-2.95	**-4.72***	-1.33	-4.76*	-2.80
AFC	-2.09	-	-0.91	-1.99	-0.81	-	-2.54	-1.85	-1.95	-2.20	-2.78	-0.92
AFC Recovery	-1.32	-	-2.18	-0.67	-1.91	-2.11	**-4.20***	-1.66	-1.28	-2.44	-1.87	-1.07
AFX Appreciation	-2.89	-0.58	-1.79	-1.68	-2.36	-1.88	-2.39	-1.94	-1.34	-2.65	**-3.46***	-2.55
Subprime Crisis	-0.88	**-3.91***	-0.90	-0.88	-2.39	-1.20	-1.11	-0.83	-0.92	-1.25	-1.08	-1.32
Subprime Recovery	-2.01	-1.76	-2.38	-1.75	-2.05	-2.09	-2.05	-2.49	-1.73	-2.48	-1.73	-1.78

KPSS	1-m Forward, *f*											
	AUD	CNY	IDR	INR	JPY	KRW	MYR	NZD	PHP	SGD	THB	TWD
Overall	0.93*	-	0.51*	0.99*	0.46*	1.12*	0.44*	0.82*	1.53*	1.50*	1.01*	0.70*
Pre-AFC	0.22*	-	0.13**	-	0.28*	-	0.24*	**0.08**	0.23*	0.33*	0.15*	0.24*
AFC	0.27*	-	0.48*	**0.24**	0.41*	-	0.22*	0.35*	0.40*	0.32*	0.42*	0.47*
AFC Recovery	1.17*	-	0.59*	1.23*	0.80*	0.45*	0.54*	1.15*	0.99*	1.08*	1.03*	0.85*
AFX Appreciation	0.53*	0.69*	0.49*	0.65*	0.25*	0.44*	0.18*	0.54*	0.27*	0.14**	0.24*	0.14**
Subprime Crisis	0.60*	0.41*	0.54*	**0.67**	0.13**	0.63*	**0.60**	0.66*	0.66*	0.52*	0.61*	0.44*
Subprime Recovery	0.19*	**0.07**	0.16*	0.23*	0.18*	0.24*	0.18*	**0.09**	0.23*	0.12**	0.23*	0.20*

ADF – Augmented Dickey-Fuller, PP – Phillip-Perron, KPSS – Kwiatkowski-Phillips-Schmidt-Shin

*Significant at the 0.05 level (ADF & PP Critical values are computed by MacKinnon (1996))

** Significant at the 0.10 level (KPSS Critical values are computed by Kwiatkowski et al (1992)

Value in bold indicates stationary series and the series with at least two tests indicating stationarity are omitted from the cointegration tests.

'-' indicates that the series are either under the fixed exchange rate regime or the data is unavailable.

Table 4: *Within-country* Efficiency Test Results

	Overall		Pre-AFC		AFC		AFC Recovery		AFX Appreciation		Subprime Crisis		Subprime Recovery	
	λ-trace	λ-max	λ-trace	λ-max	λ-trace	λ-max	λ-trace	λ-max	λ-trace	λ-max	λ-trace	λ-max	λ-trace	λ-max
AUD	1	1	1	1	1	1	1	1	1	1	1	1	1	1
CNY	NA	NA	NA	NA	NA	NA	NA	NA	1	1	NA	NA	0	0
IDR	NA	NA	1	1	1	1	1	1	1	1	1	1	1	1
INR	1	1	NA	NA	0	0	0	0	0	0	0	0	0	0
JPY	1	1	1	1	1	1	1	1	1	1	2	2	1	1
KRW	1	1	NA	NA	NA	NA	1	1	1	1	1	1	1	1
MYR	NA	NA	NA	NA	1	1	NA	NA	1	1	1	1	1	1
NZD	1	1	2	2	1	1	1	1	1	1	1	1	1	1
PHP	2	2	NA	NA	1	1	1	1	2	2	1	1	1	1
SGD	2	2	1	1	1	1	1	1	1	1	1	1	1	1
THB	NA	NA	NA	NA	2	2	1	1	1	1	1	1	1	1
TWD	2	2	2	2	1	1	1	1	1	1	1	1	1	1

Selected number of cointegrating vector at the critical value of 0.05 level (Mackinnon, Haug and Michelis, 1999).
The existence of one cointegrating vector implies markets efficiency while 0 and 2 imply inefficiency.
Not applicable (NA) is either due to the stationarity of the spot or forward exchange rate or both or data availability issue.
λ-trace= trace statistics test; λ-max= maximum eigenvalue test statistic

Table 5: *Across-country* Efficiency (Bivariate) Test Results

	Overall		Pre-AFC		AFC		AFC Recovery		AFX Appreciation		Subprime Crisis		Subprime Recovery	
	λ-trace	λ-max	λ-trace	λ-max	λ-trace	λ-max	λ-trace	λ-max	λ-trace	λ-max	λ-trace	λ-max	λ-trace	λ-max
AUD-CNY	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AUD-IDR	NA	NA	0	0	0	0	0	0	0	1	0	0	0	0
AUD-INR	0	0	NA	NA	0	0	1	1	0	0	0	0	0	0
AUD-JPY	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AUD-KRW	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AUD-MYR	NA	NA	NA	NA	0	0	NA	NA	0	0	0	0	0	0
AUD-NZD	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AUD-PHP	0	0	NA	NA	0	0	0	0	0	0	0	0	0	0
AUD-SGD	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AUD-THB	NA	NA	0	0	1	1	1	1	0	0	0	0	0	0
AUD-TWD	0	0	0	0	0	0	1	0	0	0	0	0	0	0
CNY-IDR	NA	NA	NA	NA	NA	NA	NA	NA	0	1	NA	NA	0	0
CNY-INR	NA	NA	NA	NA	NA	NA	NA	NA	0	0	NA	NA	0	0
CNY-JPY	NA	NA	NA	NA	NA	NA	NA	NA	0	0	NA	NA	0	0
CNY-KRW	NA	NA	NA	NA	NA	NA	NA	NA	0	0	NA	NA	0	0
CNY-MYR	NA	NA	NA	NA	NA	NA	NA	NA	0	0	NA	NA	0	0
CNY-NZD	NA	NA	NA	NA	NA	NA	NA	NA	0	0	NA	NA	0	0
CNY-PHP	NA	NA	NA	NA	NA	NA	NA	NA	0	0	NA	NA	0	0
CNY-SGD	NA	NA	NA	NA	NA	NA	NA	NA	0	0	NA	NA	0	0
CNY-THB	NA	NA	NA	NA	NA	NA	NA	NA	0	0	NA	NA	0	0
CNY-TWD	NA	NA	NA	NA	NA	NA	NA	NA	0	0	NA	NA	0	0
IDR-INR	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0	0
IDR-JPY	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0
IDR-KRW	NA	NA	0	0	0	0	0	0	0	0	0	1	0	0
IDR-MYR	NA	NA	NA	NA	0	0	NA	NA	0	0	0	0	0	0
IDR-NZD	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0
IDR-PHP	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0	0
IDR-SGD	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0
IDR-THB	NA	NA	0	0	1	1	0	0	0	0	0	0	0	0
IDR-TWD	NA	NA	0	0	0	0	0	1	0	0	0	0	0	0
INR-JPY	0	0	NA	NA	0	0	0	0	0	0	0	0	0	0
INR-KRW	0	0	NA	NA	0	0	0	0	0	0	0	0	0	0
INR-MYR	0	0	NA	NA	0	0	NA	NA	0	0	0	0	0	0
INR-NZD	0	0	NA	NA	0	1	1	1	0	0	0	0	0	0
INR-PHP	0	0	NA	NA	0	1	0	0	0	0	0	0	0	0
INR-SGD	0	0	NA	NA	0	0	1	1	0	0	0	0	0	0
INR-THB	NA	NA	NA	NA	1	1	0	0	0	0	0	0	0	0
INR-TWD	0	0	NA	NA	0	0	0	0	0	0	0	0	0	0
JPY-KRW	0	0	0	0	0	0	0	0	0	0	0	0	0	0
JPY-MYR	NA	NA	NA	NA	0	0	NA	NA	0	0	0	0	0	0
JPY-NZD	0	0	0	0	0	1	0	0	0	0	0	0	0	0
JPY-PHP	0	0	NA	NA	0	0	0	0	0	0	0	0	0	0
JPY-SGD	0	0	0	0	0	0	0	0	0	0	0	0	0	0
JPY-THB	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0
JPY-TWD	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KRW-MYR	NA	NA	NA	NA	0	0	NA	NA	0	0	0	0	0	0
KRW-NZD	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KRW-PHP	0	0	NA	NA	0	0	0	0	0	0	0	0	0	0
KRW-SGD	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KRW-THB	NA	NA	0	0	1	1	0	0	0	0	0	0	0	0
KRW-TWD	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MYR-NZD	NA	NA	NA	NA	0	0	NA	NA	0	0	0	0	0	0
MYR-PHP	NA	NA	NA	NA	0	0	NA	NA	0	0	0	0	0	0
MYR-SGD	NA	NA	NA	NA	0	0	NA	NA	0	0	0	0	0	0
MYR-THB	NA	NA	NA	NA	0	0	NA	NA	0	0	0	0	0	0
MYR-TWD	NA	NA	NA	NA	0	0	NA	NA	0	0	0	0	0	0
NZD-PHP	0	0	NA	NA	0	0	0	0	0	0	0	0	0	0
NZD-SGD	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NZD-THB	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0
NZD-TWD	0	0	0	0	0	0	2	2	0	0	0	0	0	0
PHP-SGD	2	2	NA	NA	0	0	0	0	0	0	0	0	0	0
PHP-THB	NA	NA	NA	NA	2	2	0	0	0	0	0	0	0	0
PHP-TWD	0	0	NA	NA	0	0	0	0	0	0	0	0	1	1
SGD-THB	NA	NA	0	0	1	1	0	0	0	0	0	0	0	0
SGD-TWD	0	0	0	0	0	0	1	1	0	0	0	0	0	0
THB-TWD	NA	NA	0	0	1	1	2	0	0	0	0	0	0	0

Selected number of cointegrating vector at the critical value of 0.05 level (Mackinnon, Haug and Michelis, 1999)
Zero cointegrating vector implies markets efficiency while1 implies inefficiency and 2 is inconclusive.
Not applicable (NA) is either due to the stationarity of the spot exchange rate series or data availability issue.
λ-trace= trace statistics test; λ-max= maximum eigenvalue test statistic

Table 6: *Across-country* Efficiency (Multivariate) Test Results

	Asia Pacific		Southeast Asia		Far East Asia	
	λ-trace	λ-max	λ-trace	λ-max	λ-trace	λ-max
Overall (ex- CNY,IDR,MYR & THB)	0	0	-	-	0	0
Pre-AFC (ex- CNY,INR,MYR & PHP)	3	2	0	0	0	1
AFC (ex-CNY)	2	2	1	1	0	0
AFC Recovery (ex- CNY & MYR)	1	1	0	0	0	0
AFX Appreciation	1	1	0	0	0	0
Subprime Crisis (ex-CNY)	2	1	0	0	0	0
Subprime Recovery	9	6	0	0	0	0

Selected number of cointegrating vector at the critical value of 0.05 level (Mackinnon, Haug and Michelis, 1999)
Asia Pacific consists of all the 12 currencies in our sample. Southeast Asia comprises five (5) currencies (i.e. IDR, MYR, PHP, SGD & THB) while Far East Asia is made up of three (4) currencies (i.e. CNY, JPY, KRW & TWD). Australasia is not included in the multivariate test because it only consists of two (2) currencies in our sample. Stationary series are excluded from the tests.
Zero cointegrating vector implies markets efficiency and non-zero otherwise.
λ-trace= trace statistics test; λ-max= maximum eigenvalue test statistic

Table 7: Forward Premium Stationarity Test Results

ADF	1-month Forward Premium											
	AUD	CNY	IDR	INR	JPY	KRW	MYR	NZD	PHP	SGD	THB	TWD
Overall	-5.32*	-	-5.99*	-4.64*	-3.67*	-4.14*	-3.28**	-5.24*	-5.91*	-4.58*	-3.79*	-6.14*
Pre-AFC	-7.46*	-	-6.05*	-	-9.82*	NA	-4.03*	-9.27*	**-2.55**	-3.31**	-4.69*	-12.40*
AFC	-10.25*	-	-6.87*	-3.25**	-17.77*	NA	**1.55**	-10.14*	-6.51*	**-2.35**	-4.63*	**-2.42**
AFC Recovery	-4.81*	-	-4.46*	-4.08*	-3.42*	-5.03*	NA	-5.52*	-4.31*	**-2.69**	-6.89*	-4.59*
AFX Appreciation	-25.47*	-3.79*	-4.85*	**-2.07**	-4.61*	-3.63*	-4.98*	-26.71*	-6.15*	-10.85*	**-2.92**	-4.12*
Subprime Crisis	-8.50*	**-1.58**	**-1.50**	-3.77*	-10.05*	**-2.91**	-3.52*	-8.77*	-4.69*	**-3.08**	-7.59*	-3.78*
Subprime Recovery	-4.30*	**-2.23**	-10.79*	-9.51*	-12.36*	-7.01*	-9.70*	-3.79*	-10.25*	-6.87*	-10.59*	-9.36*

PP	1-month Forward Premium											
	AUD	CNY	IDR	INR	JPY	KRW	MYR	NZD	PHP	SGD	THB	TWD
Overall	-71.02*	-	-6.91*	-37.36*	-76.37*	-46.13*	-3.41**	-70.26*	-39.11*	-60.67*	-7.48*	-39.61*
Pre-AFC	-11.83*	-	-6.02*	-	-12.86*	NA	-8.03*	-11.63*	-4.74*	-9.43*	-3.43**	-12.40*
AFC	-19.94*	-	-15.12*	-7.92*	-17.77*	NA	**-1.50**	-20.51*	-9.99*	-11.98*	-12.43*	-12.76*
AFC Recovery	-42.01*	-	-3.13**	-21.67*	-45.38*	-25.55*	NA	-43.52*	-18.80*	-49.26*	-26.09*	-22.51*
AFX Appreciation	-25.26*	-3.94*	-21.21*	-11.60*	-26.50*	-20.66*	-11.69*	-26.75*	-22.80*	-24.30*	-4.99*	-15.63*
Subprime Crisis	-28.14*	**-2.48**	-5.64*	-16.25*	-25.28*	-19.82*	-9.07*	-26.58*	-17.43*	-21.02*	-5.37*	-11.18*
Subprime Recovery	-15.17*	**-2.50**	-11.00*	-9.49*	-12.54*	-8.83*	-9.70*	-13.48*	-10.22*	-15.47*	-10.57*	-9.37*

ADF – Augmented Dickey-Fuller; PP – Phillip-Perron,
*Significant at the 0.05 level(ADF & PP Critical values are computed by MacKinnon (1996))
** Significant at the 0.10 level
Value in bold indicates nonstationary series and the cointegrating relations are unlikely to be proxy for risk premium.

Table 8: Fama Regression Results

Panel A: Wald F-Statistics	AUD	CNY	IDR	INR	JPY	KRW	MYR	NZD	PHP	SGD	THB	TWD
Overall	14.54*	-	14.19*	8.69*	6.20*	1.41	1.53	13.18*	0.32	3.78*	9.72*	2.19
Pre-AFC	1.04	-	0.29	-	0.00	-	0.82	0.19	103.33*	7.13*	18.59*	7.85*
AFC	4.64*	-	2.75**	8.32*	1.31	-	6.42[n]	2.18	0.36	2.70**	1.31	1.50
AFC Recovery	13.47*	-	3.20*	16.53*	5.53*	7.22*	-	18.00*	3.85*	12.15*	8.76*	0.15
AFX Appreciation	4.78*	1.05	0.53	17.39*	2.91**	0.42	4.41*	3.06*	20.20*	1.55	26.55*	2.08
Subprime Crisis	2.52**	-	0.29	0.07	0.33	0.16	0.94	0.96	0.21	1.27	14.57*	0.14
Subprime Recovery	0.11	3.17*	1.45	0.57	3.07*	0.07	2.43**	0.50	0.79	4.14*	4.79*	1.29
Panel B: Individual Currency Beta Estimates												
Beta	AUD	CNY	IDR	INR	JPY	KRW	MYR	NZD	PHP	SGD	THB	TWD
Overall	-0.17	0.58	0.19	-0.74	-0.21	0.01	1.01	-0.13	0.84	-0.45	0.29	0.58
s.e.	0.22	0.18	0.15	0.76	0.72	0.91	0.40	0.47	0.67	0.77	0.16	0.26
Pre-AFC	1.11	-	-1.00	-	0.51	-	1.22	0.65	0.15	-4.53	-0.56	0.58
s.e.	0.71	-	3.09	-	13.35	-	0.35	1.78	0.28	3.36	0.96	4.28
AFC	0.86	-	-2.96	-2.14	-0.19	-	-0.85[n]	0.67	0.47	-1.42	2.00	-1.19
s.e.	0.39	-	2.05	1.25	4.64	-	0.66	0.73	1.9	1.11	0.98	2.16
AFC Recovery	-0.73	-	0.26	0.47	-0.55	0.24	-	-0.81	-1.44	-1.29	-1.12	0.89
s.e.	0.59	-	0.3	1.49	1.11	1.6	-	0.59	1.03	0.92	0.63	0.41
AFX Appreciation	-0.31	0.62	2.2	-2.20	-0.26	0.44	1.18	0.38	0.51	-0.35	0.19	0.16
s.e.	0.55	0.31	1.24	0.76	4.07	1.78	2.41	1.91	1.27	3.18	0.26	4.13
Subprime Crisis	0.29	-	-1.39	-0.05	0.71	1.36	-1.69	0.42	0.30	-0.07	0.16	1.11
s.e.	0.81	-	8.37	3.25	0.54	1.61	1.96	1.18	2.41	0.91	0.16	1.24
Subprime Recovery	-0.35	-0.13	-0.21	-0.09	0.26	-0.51	0.95	-0.13	0.55	-0.64	-0.51	-0.96
s.e.	3.39	2.37	17.81	8.53	0.33	4.44	1.65	1.69	3.86	0.59	1.64	3.47

Panel C: Pooled Beta Estimates

Beta	Pooled	Pooled Ex-MYR&CNY	Pooled High Income	Pooled Medium Income	Pooled Non-NDF	Pooled NDF
Overall	0.0541	0.2114	-0.0517	0.2233	-0.1096	0.2250
s.e.	0.0109	0.0375	0.0818	0.0389	0.0897	0.0386
Pre-AFC	-0.1180	-0.1456	1.2206	-0.5649	1.2370	-0.5696
s.e.	0.3955	0.4012	0.5751	0.4519	0.5758	0.4434
AFC	-0.1506	-0.3939	-0.0795	-0.7000	0.0707	-0.6016
s.e.	0.0426	0.2719	0.2478	0.3251	0.2764	0.3103
AFC Recovery	0.0554	0.2370	-0.4399	0.2536	-0.7307	0.2560
s.e.	0.0102	0.0388	0.0936	0.0396	0.1111	0.0393
AFX Appreciation	0.1575	0.1492	-0.0588	0.1738	-0.0624	0.1742
s.e.	0.0241	0.0263	0.1521	0.0254	0.1833	0.0230
Subprime Crisis	0.2188	0.2086	0.5362	0.1361	0.4378	0.1683
s.e.	0.0524	0.0586	0.1610	0.0496	0.2210	0.0511
Subprime Recovery	-0.0865	-0.1055	0.2787	0.1912	0.2012	-0.1746
s.e.	0.2942	0.2950	0.3168	0.3395	0.4340	0.2842

n - estimation period is from 1Jul1997 - 31Aug1998

Panel A: Wald Test of Fama regression $\Delta s_{t+m} = \alpha+\beta(f_t^m - s_t)$ for H_0: $(\alpha, \beta) = (0, 1)$ and H_1: at least one is not true

*Rejection of H_0 at the 0.05 level **Rejection of H_0 at the 0.10 level Rejection indicates that the market is not efficient.