Recursive cointegration analysis of foreign exchange market stability: An application for ASEAN countries

Article · November 2014

4 authors, including:

Mei-Se Chien
National Kaohsiung University of Applied Sciences
13 PUBLICATIONS   317 CITATIONS

SEE PROFILE

Recursive cointegration analysis of foreign exchange market stability:

An application for ASEAN countries

Mei-Se Chien[*]

Professor, Department of Finance, National Kaohsiung University of Applied Sciences,

415 Chien Kung Road, Kaohsiung, Taiwan

Tel.: 886-7-3814526 ext. 6353   Fax: 886-7-3814526

Email: cms@kuas.edu.tw

Te-Chung Hu

Department of Finance, National Kaohsiung University of Applied Sciences,

415 Chien Kung Road, Kaohsiung, Taiwan

Meng-Huei, Su

Graduate Student, Department of Finance, National Kaohsiung University of Applied Sciences

415 Chien Kung Road, Kaohsiung, Taiwan

[*] Corresponding author.

Recursive cointegration analysis of foreign exchange market stability: An application for ASEAN countries

Abstract

The aim of this paper is to study the dynamic market efficiency of foreign exchange markets in four ASEAN countries. Considering the importance of time-varying linkages in foreign exchange markets, this paper employs recursive cointegration to examine the dynamic evolution of foreign exchange market integration. The paper presents the following empirical results. First, according to the empirical results of Zivot and Andrew (1992) unit root tests, there are two main breakpoints for each country. Two financial crises, the 1997-1998 Asia financial crisis and the 2008-2009 global financial crisis, indeed caused the breakpoints of exchange rates in four ASEAN countries. Second, examining the results of recursive cointegration on the foreign exchange markets Singapore's spot and forward foreign exchange markets shows earlier cointegration, beginning around 2000, than other countries' foreign exchange markets. As to the other countries' foreign exchange markets, the beginning times for cointegration to emerge in Thailand and Philippines are around 2006, while cointegration in Indonesia does not appear until 2008. Thirdly, applying the recursive coefficients to test the forward rate unbiased hypothesis demonstrates that Singapore's foreign exchange market is efficient almost over the whole sample period, while Indonesia's foreign exchange market shows the existence of efficiency after 2004. The examining results present that the foreign exchange markets of Thailand and the Philippines are inefficient.

Keywords: Foreign exchange market efficiency, Forward unbiasedness hypothesis, Recursive cointegration, ASEAN

1. Introduction

There are many related papers in the literature that study different issues for the relationships between forward, futures, and spot prices. Whether or not foreign exchange markets are efficient is of great interest to researchers and market participants. Under the assumption of the risk neutral efficient market hypothesis, the forward rate should be an unbiased predictor of the future spot exchange rate. In other words, if exchange rate markets are efficient, then the current exchange rate fully reflects all available information of past exchange rates. In this case, investors can know the correct pricing of assets and there are no permanent opportunities for excess profit.

To confirm whether the forward rate is an unbiased predictor of the future spot rate, many studies apply cointegration analysis, but their empirical results are inconsistent. Some researchers in the literature report that the relationship between future spot returns and the forward discount rate is cointegrated, such as Crowder (1994), Rapp and Sharma (1999), Jeon and Lee (2002), Kenourgios et al. (2006), Goldman (2006), and Shmilovici et al. (2009), while others such as Chianga et al. (2010) and Kumar (2011) proclaim that it diverges from cointegration. Most of these papers unfortunately do not study any dynamic relationship by considering the time-varying aspect between spot and forward exchange rates. To capture the dynamic behaviors of exchange rates, Kutan and Zhou (2003) apply rolling cointegration tests to examine the dynamic relationship between spot and forward exchange rates, and the results confirm the existence of cointegration between the forward and spot rates for nearly all sub-sample periods. Kanas and Ioannidis (2012) employ recursive and rolling estimations to test the effects of some events, and the results show that the long-run correlation coefficients are significantly influenced by the UK's general election and by the ERM sterling crisis.

The aim of this paper is to examine the foreign exchange market efficiency for ASEAN countries, as we try to fill the gap of little relative literature on this topic for these countries. Considering the importance of time variation in foreign exchange market linkages, we employ recursive cointegration to examine the dynamic relationships between spot and forward exchange rates in ASEAN countries. A study of ASEAN financial markets is interesting for the following reasons. First, these countries have executed financial reforms to improve their economic efficiency. For example, Singapore was the first to begin liberalizing its financial systems by abolishing exchange controls in the mid-1970s (Phylaktis, 1997). Second, ASEAN countries make up the fourth largest trading region in the world (Lim, 2011). Over the past two decades, the average economic growth of ASEAN counties is approximately 5%, with a strong growing trend even through two major financial crises (Petri et al., 2012). Thirdly, ASEAN countries have recently attracted international fund managers as an opportunity for portfolio diversification.

Based on this backdrop, this study analyzes the foreign exchange markets of four major ASEAN countries - Singapore, Indonesia, Philippines, and Thailand - to discuss their exchange rate movements over the past decade. The aim is to track the dynamic relationships of time-shifting periods and display the impacts of policy changes and currency crises during those periods. The remainder of the paper is structured as follows. Section 2 is the literature review. Section 3 introduces an overview of the background of foreign exchange markets. Section 4 presents and discusses the empirical results of the recursive cointegration analysis. Section 5 concludes the paper.

2. Literature Review

The original study about the theory of market efficiency can be traced back to Fama's finding in 1970. Hereafter, there have been many various types of tests applied in the study of foreign exchange market efficiency. One of the more popular testing types of this efficiency is to discuss the relationship between spot and forward exchange rates. In an efficient foreign exchange market, the forward exchange rate should be an unbiased predictor of future spot exchange rate (Sarno, 2005), which is the so-called "unbiasedness hypothesis".

Reviewing the relative papers of foreign exchange market efficiency, there are largely inconsistent results with both rejections and confirmations of the hypothesis. The initial empirical literature, using regression analysis, shows a 'puzzle' regarding the ability of the forward rate to predict the future spot rate, including Bilson (1981), Cumby and Obstfeld (1984), Fama (1984), and Froot and Frankel (1989). Since the late 1980s, the method of cointegration has also been used to test the relationship between spot and forward exchange rates for confirming market efficiency (Baillie and Bollerslev, 1989). Many studies, such as Crowder (1994), Rapp and Sharma (1999), and Jeon and Lee (2002), apply the Johansen (1991, 1995) cointegration test, with their results supporting an existing cointegrated relationship between spot and forward exchange rates, which is evidence for the efficiency of *within-country* currency markets. Some papers also apply the cointegration method to examine across-country market efficiency in which the spot exchange rate series of several currencies are tested for cointegration (Baillie and Bollerslev, 1989; Rapp and Sharma, 1999; Jeon and Lee, 2002; Aroskar et al., 2004).

Still other papers find that there is a divergence from cointegration of foreign exchange markets. For example, the results of Kenourgios et al. (2006) exhibit that the foreign exchange market is efficient in the long run, but the forward rate is a biased predictor of the future spot rate in the short run. Goldman (2006) indicates that the weak-form efficiency hypothesis for the St. Petersburg and London markets cannot be rejected. The empirical results of Chianga et al. (2010) show that some foreign exchange markets, including Japan, South Korea, and the Philippines, display weak form efficiency, whereas the foreign exchange market of Taiwan is inefficient. Kumar (2011) also offers some evidence that the market efficiency hypothesis can be rejected for India's foreign exchange market.

Most of the above papers unfortunately do not consider structural breaks of exogenous shocks or regime changes. It is important to check for structural breaks if the empirical period covers an unstable time of social and economic development (Chien, 2010). Examining the market efficiency hypothesis of the foreign exchange market under the arrival of the Euro, the empirical results of Kühl (2007), using the Johansen cointegration test and the Gregory-Hansen (1996, GH) cointegration test with a structural break, show that the foreign exchange market is broadly consistent with the market efficiency hypothesis. Considering the impacts of the Asian and global financial crises on foreign exchange market efficiency in Asia-Pacific countries, Ahmad et al. (2012) employ pre-determined breakpoints to separate the crisis period and the non-crisis period. Their results support that the foreign exchange markets are mostly efficient, and the Asian financial crisis, compared to the global financial crisis, caused more severe impacts on the foreign exchange markets in the Asia-Pacific region.

Ahmad et al. (2012) study exogenous shocks on the Asia-Pacific development of foreign exchange market efficiency, but their method of pre-determined breakpoints has been questioned by Hansen (1992) and Hansen and Johansen (1999). To improve the low power of a model with pre-determined breakpoints, Bai and Mollick (2010) use endogenous multiple structural breaks, as suggested by Zivot and Andrews (1992) and Bai and Perron (1998, 2003), to investigate the effect of the Asian crisis and the Turkish crisis on the forward discount bias in fourteen emerging countries. The results of Bai and Mollick (2010) support the finding of Ahmad et al. (2012) and show that the foreign exchange markets are mostly efficient except for the post-crisis period.

Some papers try to capture a dynamic relationship by considering the time-varying aspect between spot and forward exchange rates. Capturing the dynamic behaviors of the exchange rates by rolling 6-year sub-samples from January 1980 to June 1998, Kutan and Zhou (2003) apply rolling cointegration tests to examine the dynamic relationship between the spot and forward exchange rates of Germany, Japan, and Switzerland with respect to the US dollar. The results confirm the existence of cointegration between the forward and spot rates for nearly all sub-sample periods.

Kanas and Ioannidis (2012) employ recursive and rolling estimations to test the effects of some events, including

United Kingdom general elections, the European Exchange Rate Mechanism (ERM) sterling crisis, and the introduction of the Euro, on the relationship between spot and the forward rates. The results of the recursive estimations show that the long-run correlation coefficients are significantly influenced by the general elections and by the ERM sterling crisis. The rolling estimations of the long-run correlation coefficients are significant on April 1992 by predicting the election outcome and on September 1992. Moreover, the forward rate is an unbiased predictor under the influences of the major events.

For discussing the impact of the global financial crisis on the relationship between the future spot return and the forward discount rate, Zhao et al. (2013) also apply rolling cointegration to analyze China's foreign exchange market. The results support the existence of a cointegration between the future spot return and the forward discount rate before March 2008 and over the period from February 2009 to June 2010, but there is no cointegration from March 2008 to February 2009. However, Zhao et al. (2013) indicate that "*the cointegration relationship between the future spot return and the forward discount rate is time varying. This dynamic relationship may reflect divergence in the market expectations regarding the exchange rate of the Renminb*i."

This paper examines the foreign exchange market efficiency for ASEAN countries, as we try to fill the gap on few studies in the literature that test the forward rate unbiasedness hypothesis for these countries. Although Ahmad et al. (2012) investigate the relationships between the forward exchange rate and spot rate in emerging economies or Asia-Pacific countries, both angles employ the conventional cointegration technique, which has the problem of low power. Considering the importance of time variation in foreign exchange market linkages, recursive cointegration is applied in this paper to examine the dynamic relationships between spot and forward exchange rates in ASEAN countries. Our aim is to track the dynamic relationships of time-shifting periods and display the impacts of policy changes and currency crises.

3. Background of the foreign exchange markets

ASEAN was established on August 8, 1967 by Indonesia, Malaysia, the Philippines, Singapore, and Thailand (ASEAN-5). Five more countries joined the association by 1999: Brunei, Vietnam, Laos, Myanmar, and Cambodia. This paper examines the foreign exchange market efficiency for four ASEAN countries: Indonesia, the Philippines, Singapore, and Thailand.[1] ASEAN is the fourth largest trading region in the world (Lim, 2011), with 625.1 million people in the region, and a combined gross domestic product of US$2,298.55 billion in 2013. Comparing the members of ASEAN, each country varies substantially in population, per capita income, and economic structure. Over the past two decades, the average economic growth of ASEAN's countries was approximately 5%, showing a strong growing trend even through two major financial crises (Petri et al., 2012). The most distinguished is the extraordinary upswing of Indonesia, which is the biggest economy in ASEAN.

Figures 1(A) to 4(B) show the changes and trends in the spot and forward exchange rates of these four countries. The post-Asian financial crisis stage shaped a period of macroeconomic instability and a regime of greater volatility among the Asian currencies. Most ASEAN countries are no longer on the common path of financial development. In Thailand, there has been some progress in widening the range of financial liberalization, while more capital account restrictions are still maintained as compared to Singapore. To restore the confidence of international financial markets in the short term, Indonesia has received IMF's assistance of US$43 billion to stabilize the exchange rate through a combination of macroeconomic discipline, which results in the availability of sufficient foreign reserves and reforms towards good

---

[1] Malaysia is excluded in our investigation, because it decided to reverse its liberalization policy by imposing capital controls and pegging the exchange with the US dollar (US$1 = RM3.8) during October 1998 to July 2005, because of the breakout of the Asian financial crisis in 1997.

corporate governance and market transparency. However, the economic recovery and financial reforms in Indonesia are slower than other crisis-affected countries (Chan et al., 2005).

Figures 1(A) and 1(B) illustrate the changes and trends in the spot and forward exchange rates of Singapore. Since 1985 the Singapore dollar has floated under the monitor of the Monetary Authority of Singapore (MAS), and it has appreciated along with rapid economic development, high productivity growth, and a high savings rate. Singapore plunged into a short recession under the Asian financial crisis, but fortunately its economy recovered and continued to grow within one year. From 1997 to 2009, its exchange rate against the US dollar varied between 1.40 and 1.90. Generally, the foreign exchange rate market of Singapore is efficienct and is less impacted by a financial crisis, because of its strong economy.

Thailand was the country that triggered the Asian financial crisis of 1997. The Thai baht, in Figures 2(A) and 2(B), dramatically depreciated due to massive speculative attacks in 1997, which caused Thailand's authority to decide to replace the fixed rate of 25 baht to the US dollar by a managed floating exchange rate regime on June 30, 1997. The Thai baht devalued quickly and reached its lowest point of 53 to the US dollar in January 1998, losing more than half of its value. By 2001, Thailand's economy had mostly recovered from the recession. From 2001 to 2010, the managed float of the Thai baht appreciated from around 46 to 29 against the US dollar. However, the Asian crisis in 1997 resulted in a managed floating exchange rate regime, and the exchange rate of the Thai baht is now   determined by market forces. The Bank of Thailand (BOT) only intervenes to avoid excessive volatilities or to attain economic policy targets. To encourage outward direct investment, BOT started relaxing regulations in its foreign exchange market since 2010.

The Philippine peso, in Figures 3(A) and 3(B), dropped from 26 pesos per US dollar to 45 pesos between 1997 to mid-1999. The Philippines experienced rare occurrences of foreign exchange intervention that only were executed to prevent large fluctuations. The independent floating exchange rate system and monetary policy continued to be adopted even pre-crisis in 1997. The Philippines saw less capital flight and suffered fewer economic damages by the shock of the Asian crisis, because of less short-term foreign currency borrowings. The peso's value declined to about 54 pesos to the US dollar, because of a scandal in the Philippine president's administration in 2001. When the economy was growing by more than 7%, the peso appreciated 23% between 2005 and 2008. The peso reached its highest level, around 41, against the US dollar in 2012, because of increasing confidence by investors and improving economic conditions.

The Indonesian rupiah, in Figures 4(A) and 4(B), depreciated significantly from 2,200 rupiah against the US dollar to 15,000 over the period of the Asian financial crisis, which was caused by the impacts from the depreciation of Southeast Asian currencies and fundamental factors, including huge private and government offshore debts and greater deteriorated risk. Regardless of a decrease in interest rates, the stimulus policy failed to support confidence in the rupiah. In 1998, Bank Indonesia changed the exchange rate system and replaced it with a free-floating exchange rate regime. To lessen exchange rate volatility, Bank Indonesia contemporaneously restricted the free movement of currency between banks and governed all transactions on forward exchange sales to non-residents. By the end of 1999, the exchange rate became relatively stable, partially from strong demand for the rupiah related to fiscal year tax payments and loan disbursements from official creditors.
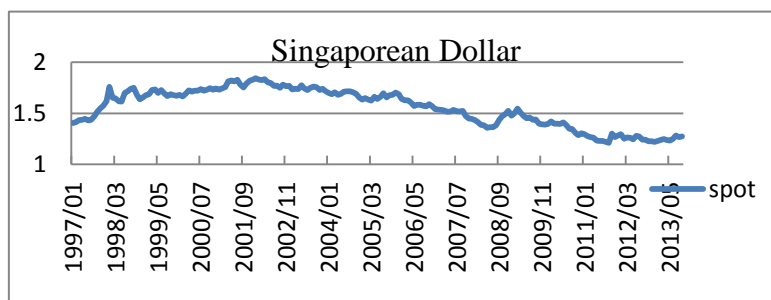
Figure 1(A). Spot rate of Singapore Dollar to US Dollar
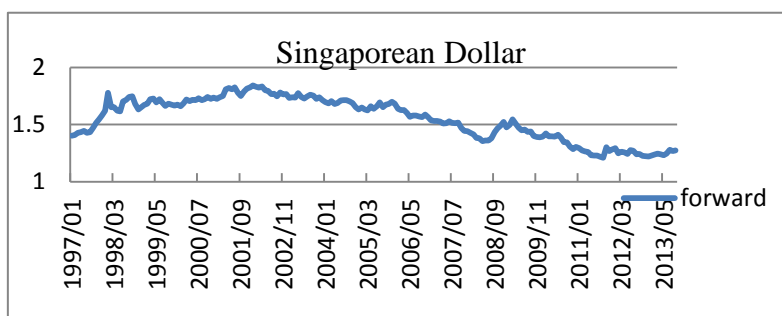

Figure 1(B). Forward rate of Singapore Dollar to US Dollar
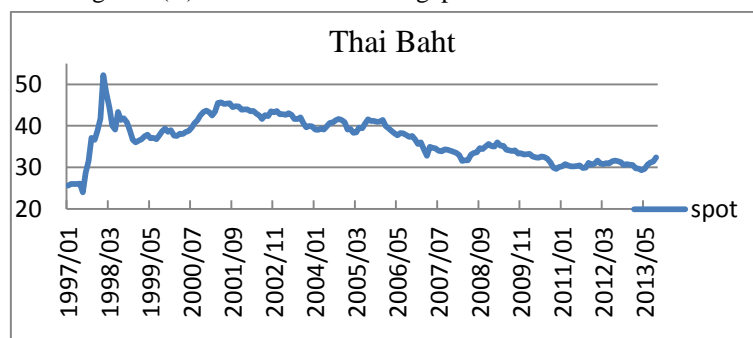

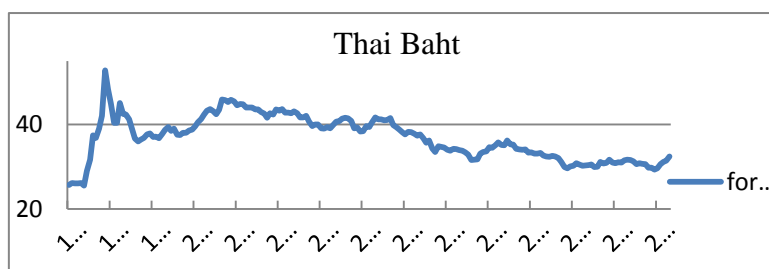
Figure 1(A). Spot rate of Thai Baht to US Dollar

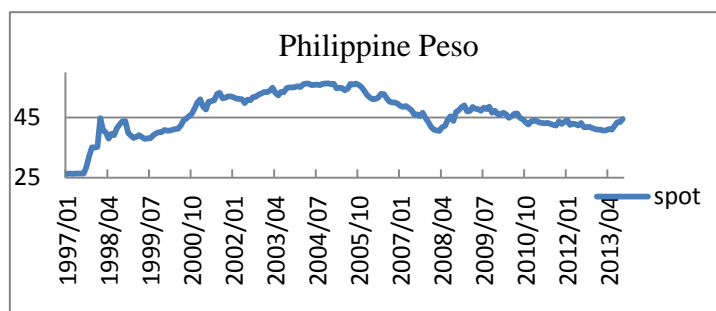Figure 3(B). Forward rate of Thai Baht to US Dollar

Figure 3(A). Spot rate of Philippine Peso to US Dollar
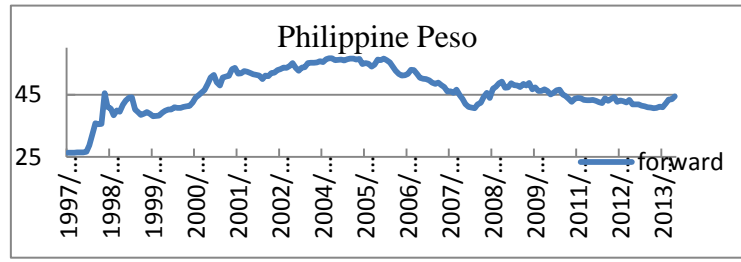
6

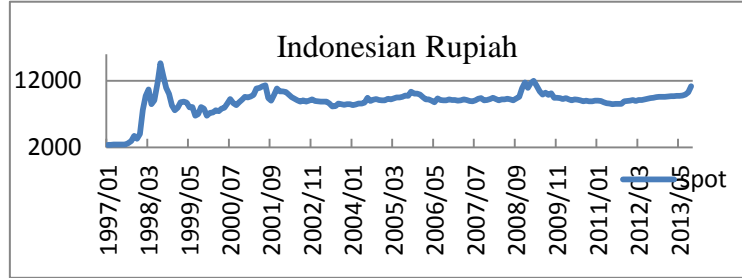Figure 3(B). Forward rate of Philippine Peso to US Dollar

Figure 4(A). Spot rate of Indonesian Rupiah to US Dollar

Figure 4(B). Forward rate of Indonesian Rupiah to US Dollar

4. Empirical Results

4.1 Data and results of the unit-root tests

This empirical analysis covers ASEAN-4 countries: Singapore, Thailand, Philippine, and Indonesia. The monthly spot exchange rates and one-month forward rates of these four countries, including the Indonesian rupiah (IDR), the Philippine peso (PHP), the Singaporean dollar (SGD), and the Thai baht (THB) against the US dollar, are obtained from Datastream. The sample period is from December 1996 to September 2013 for all currency pairs. All the exchange rates are in logarithms, and the US dollar is regarded as the numéraire currency.

To examine the stationarity of all variables, we apply three different unit root tests without a structural break: the augmented Dickey and Fuller (1979; ADF) test, as shown in Table 1, at the 5% significant level, whereby the integration orders of all variables are I(1) processes. Additionally, to take into account the possible shift in regime in the unit root tests, we apply the Zivot and Andrews (1992, hereafter ZA) test to allow an endogenous structural break. Table 2 presents the results of these univariate unit root tests of ZA, which also show that all variables follow I(1) processes at the 5% significance level. There are two main breakpoints of ZA's tests for most of the countries. In Figure 2, the first breakpoint is around 1997-1998, caused by the 1997-1998 Asia financial crisis, and the impact of the 2008-2009 global financial crisis brought about the other breakpoint.

7

Table 1. Results of ADF unit root test

Spot rate		Forward rate	
Without trend	With trend	Without trend	With trend
-0.53	-2.99[10]	-0.45[7]	-2.04[7]
-2.51	-2.94[10]	-2.48[0]	-2.35[0]
-2.28	-3.12[0]	-1.54[9]	-1.91[9]
-2.27	-2.451]	-2.66[4]	-2.90[4]
-6.39[4] **	-5.84[5] **	-4.63[7]**	-4.86[7] **
-4.76[5] **	-6.32[10] **	-4.69[4] **	-4.83[4] **
-5.28[4] **	-5.71 [4] **	-3.70[9] **	-4.03[9] **
-4.52[1] **	-4.54[1] **	-5.08[4] **	-4.82[4] **
-5.06[1] **	-5.13[1] **	-4.52[2] **	-4.57[2] **

Notes: ** shows rejection of the null hypothesis at the 5% level. The numbers in parentheses are the lag order,
being selected on the basis of Akaike's Information Criterion (AIC).

Table 2. Results of Zivot-Andrews unit root test

	Spot rate		Forward rate	
	ZA statistic	Month of break	ZA statistic	Month of break
SGD	-4.02(C)	2000M2	-4.25(C)	2001M4]
THB	-4.81(C)	1997M7	-4.56(C)	2000M7
PHP	-3.76(C)	2000M6	-3.78(C)	2000M6
IDR	-4.35(C)	1997M12	-4.35(C)	2009M4
dSGD	-8.229**(C)	2008M6	-5.632**(C)	2008M8
dTHB	-7.968**(C)	1998M2	-5.709**(C)	2008M4
dPHP	-5.454**(C)	2008M4	-5.130**(C)	2008M4
dIDR	-7.465**(C)	1998M8	-6.441**(C)	1999M12

Notes: 1. ** shows rejection of the null hypothesis at the 5% level.

2. The characters in the parentheses indicate the appropriate model according to the results from the ADF test; model B
is a model with a change in slope, and model C is a model with changes of both intercept and slope.

4.2 Results of the recursive cointegration

To display the dynamics of foreign exchange market efficiency in these four countries, we employ the recursive cointegration tests of Johansen (1988, 1991) to analyze the degree of convergence and test the recursive cointegration coefficients of the forward rate and future spot rate in the following. The Johansen tests apply the following vector autoregressive (VAR) system:

$$\Delta Y_t = \sum_{i=1}^{k-1} \Gamma_i \, \Delta Y_{t-i} + \Pi Y_{t-1} + \varepsilon_t \quad , t = 1, \dots, T \quad , \quad i = 1, \dots, k-1 \quad ,$$

$$\Gamma_i = -I + \Pi_1 + \cdots + \Pi_i \quad , \qquad \Pi = -(I - \Pi_1 - \Pi_2 - \cdots - \Pi_k), \qquad (1)$$

where Yt is a vector covering the forward and spot foreign exchange rates. The impact matrix Π could be decomposed as $\alpha\beta'$, and α is the matrix of the short-run adjustment coefficients to the cointegrating vectors (β matrix). If the rank of Π is r, where r ≤ n-1, then r is called the cointegration rank.

There are two test statistics for the rank of ∏ as follows:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{g} \ln(1-\hat{\lambda}_i) \qquad\qquad (2)$$

$$\lambda_{\max}(r,r+1) = -T\ln(1-\hat{\lambda}_{r+1}), \qquad\qquad (3)$$

where $\hat{\lambda}_i$ are the eigenvalues of the estimated Π matrix and T is the number of observations. The statistic of equation (2) is called the trace statistic, and the statistic of equation (3) is called the maximum eigenvalue statistic.

Using the recursive cointegration rank tests of Johansen (1988, 1991), we can subsequently examine the dynamic degree of convergence in these foreign exchange markets during different sub-sample periods. The continuous graph of trace test statistics for a recursive, fixed-length window shows essential information about the dynamics of the number of cointegrating vectors. Here, we adopt a three-calendar year of initial recursive cointegration estimation and add one observation to the end as time increases. For displaying the dynamic estimating results of the standardized trace statistics for the number of common trends in the VAR over time, Figures 5 to 8 plot the scaled trace test statistics for the null hypotheses $r \le i, i = 0,1$. If the upper line in Figures 5 to 8 showing the path of tests for $\mathcal{H}(r \le 0|r = 1)$ is over the 5% critical value, then it implies that the spot and forward exchange rates are linked together by one cointegration vector.

According to the results of Figures 5-8, the largest eigenvalue of the recursive trace statistics shows an increasing trend, indicating an increasing linkage of spot and forward foreign exchange markets in these four ASEAN countries. All of these countries present similar cointegrated patterns and support the cointegration relationship between the two variables after 2008. After the Asian financial crisis of 1997-1998, several regional initiatives, including the Chiang Mai Initiative and the Asian Bond Markets Initiative, strengthened financial cooperation and integration in the region. Except for the regional initiatives, globalization has also created a deeper integration of foreign exchange markets in these Asian countries. However, there are some different cointegrated patterns between these four markets before 2008. In light of Singapore (as Figure 5), the existence of cointegration began around 2000, which is earlier than other countries. Singapore has recorded impressive growth in the financial services industry over the past two decades. Being a financial center in Asia, excluding Japan, Singapore has the largest bond market, foreign exchange market, and derivatives market in this region (Sagaram & Wickramanayake, 2012). Actually, Singapore is one of the top seven active foreign exchange markets[2] in the world. Because of liberalized and impressive growing financial markets, Singapore's spot and forward foreign exchange markets show earlier cointegration, beginning around 2000, than other countries' foreign exchange markets.

As to the other countries' foreign exchange markets, the beginning times of cointegration's presence in Thailand and Philippines, as in Figures 6 and 7, are around 2006, while cointegration in Indonesia, in Figures 8, appears 2008.

In light of the foreign exchange market in Indonesia, cointegration did not show up until 2008, and the main reason was the lower degree of openness and financial liberalization. The figure of Indonesia's net exports to average GDP growth is merely 7.7% from 2005 to 2008, which is far lower than 27.3% for Singapore and 10.4% for Thailand. Indonesia's financial sector faced a variety of problems in the past, such as a long period of financial repression, low transparency, and low asset quality. As to the development of the foreign exchange market, the Indonesian rupiah showed remarkable stability until the Asian crisis. The rupiah floating against a basket of major world currencies happened as early as 1978, but in 1997 (during the Asian crisis), there was huge fluctuation in the rupiah. The rupiah regime bounced back post October 1999. In 2001, Bank Indonesia executed policies to reduce the impact of speculative rupiah trading by offshore players, while maintaining its commitment to a free foreign exchange regime. The aim of this regulation is to stabilize the

---

[2] King & Rime (2010) indicate the "seven countries with the most active FX markets are (in decreasing order): the United Kingdom, the United States, Japan, Singapore, Switzerland, Hong Kong SAR, and Australia."

rupiah without sacrificing real economic transactions and foreign investment (Park & Shin, 2011). Afterwards, although there have been frequent currency market interventions by Bank Indonesia to smooth the rupiah-dollar rate (Patnaik et al., 2011), the country has maintained an exchange rate regime close to a free floating regime, which indeed has increased the linkage of spot and forward foreign exchange markets after 2008.

All of these countries present a cointegration relationship between spot and forward exchange rates after 2008. Although ASEAN-4 did confront the hardest impact from the 2008 global recession, they all withstood this financial turbulence well, because they were better prepared for this shock due to the experience of the 1997-98 Asian financial crisis (World bank, 2009).
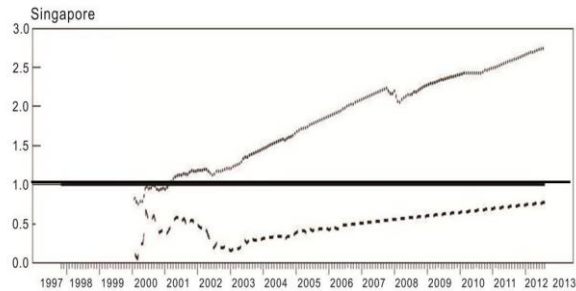

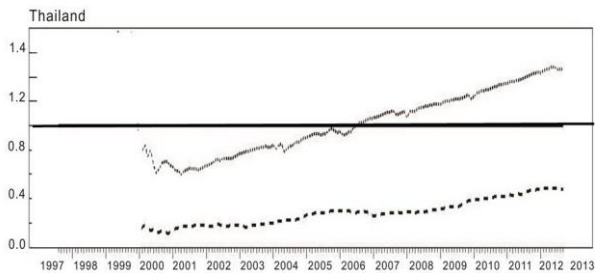Figure 5. Recursive standardized trace statistic of Sinapore

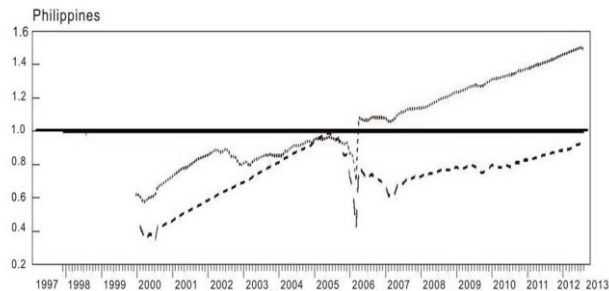Figure 6. Recursive standardized trace statistic of Thailand

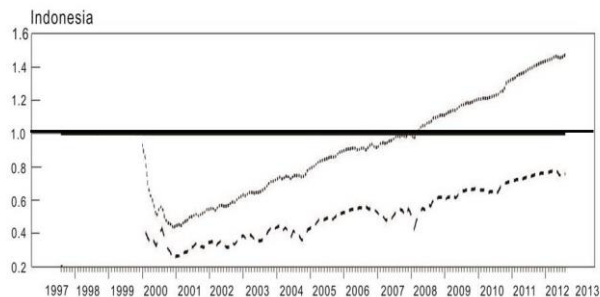Figure 7. Recursive standardized trace statistic of Philippines

Figure 8. Recursive standardized trace statistic of Indonesia

4.3 Tests for the forward rate unbiased hypothesis

Ahmad et al. (2012) indicate that the "Foreign exchange market is efficient within-country if the forward exchange rates served as unbiased predictor of future spot exchange rates. If the forward rate fails as unbiased predictor, a profit opportunity is available and hence excess returns are possible". Hence, to confirm whether the forward rate unbiased hypothesis (FRUH) is true or not (Fama, 1998) in these four?????? countries, we test the recursive cointegration coefficients of the forward rate and future spot rate. Pilbeam and Olmo (2011) suggest a modified form of regression to test FRUH allowing for the presence of a risk premium. The modified equation of Pilbeam and Olmo (2011) is as follows:

$$\left[\left(\frac{S_{t+1}}{F_t}\right) - 1\right] = \alpha + \rho\frac{1}{F_t} + \varepsilon_{t+1} \qquad (1)$$

FRUH means that the market is efficient if the coefficient estimates are insignificantly different from zero ($\alpha = \rho = 0$) under equation (1), where ρ is on behalf of a proxy for the risk premium. However, when the coefficients diverge far from the value of zero, the unbiased hypothesis is not true in that country even if cointegration is clearly present.

Figures 9 to 12 present the dynamic examining results of the recursive coefficients, ρ and α, for the foreign exchange markets in these four ASEAN countries, where FT and DSTFT represent ρ and α, respectively. The examining result of Singapore, as in Figure 9, shows that both coefficients, ρ and α, are insignificantly from zero over the whole sample period except around 2000, which implies that FRUH is true and the foreign exchange market is efficient in Singapore. Indonesia's foreign exchange market (as in Figure 12) also shows that both coefficients, ρ and α, are insignificantly from zero over most of the time after 2004. As with the above discussions, although frequent currency market interventions by Bank Indonesia have reduced the impact of speculative rupiah trading, the country has maintained an exchange rate regime close to a free floating regime after 2001, which made the foreign exchange market be efficient over most of the time after 2004, and this efficiency is only broken at the end of 2008, because this country faced the risk of sudden shortages of US dollars soon after the Lehman Brothers shock bankruptcy in the fall of 2008.
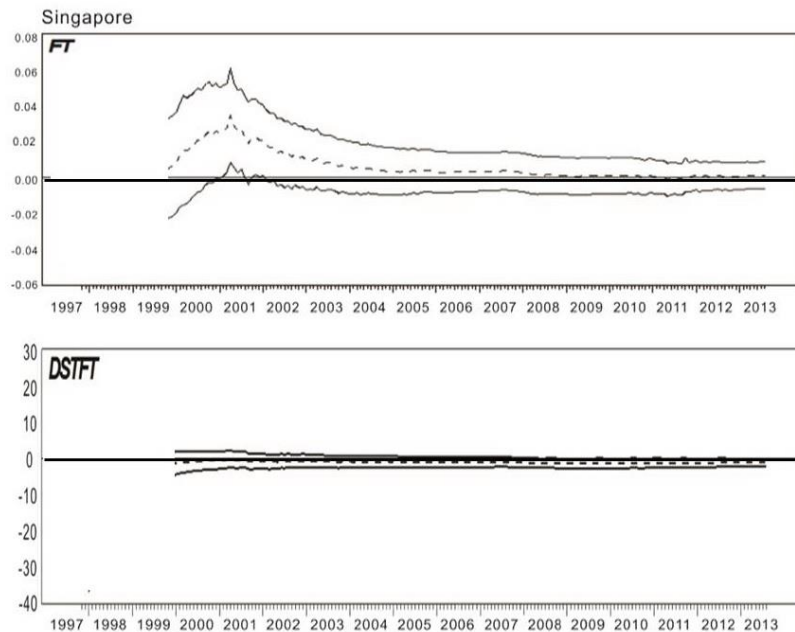

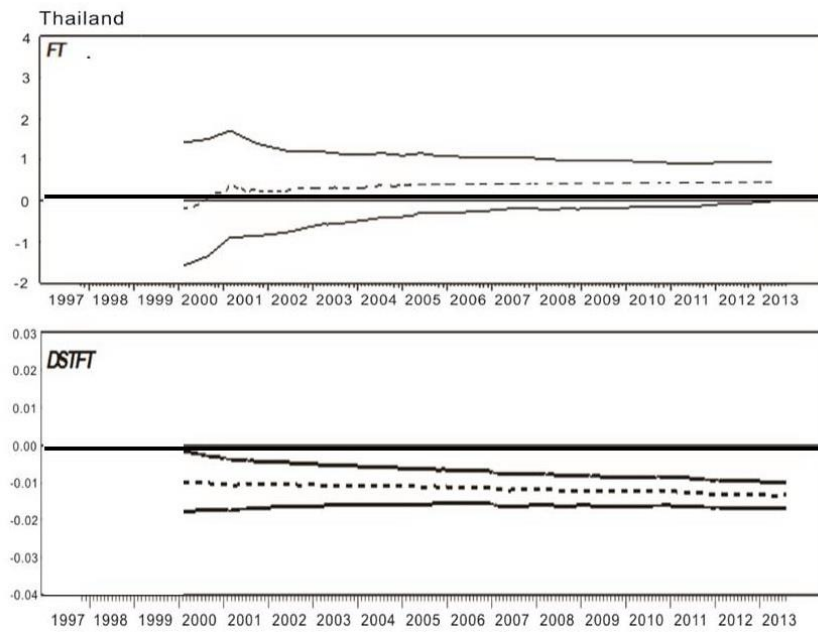Figure 9. Singapore's coefficient tests

11

Figure 10. Thailand's coefficient tests

The results of the other two countries do not support the forward rate unbiased hypothesis. In the upper parts of Figures 10 and 11, for the Thai baht and Philippine peso, the coefficients ρ of a risk premium are insignificantly different from zero over the whole period, implying that these two foreign exchange markets do not contain a constant risk premium. Conversely, for the lower parts of Figures 10 and 11, the coefficients α are significantly different from zero over the whole period. Hence, these results do not support FRUH, and the foreign exchange markets are inefficient in Thailand and the Philippines.
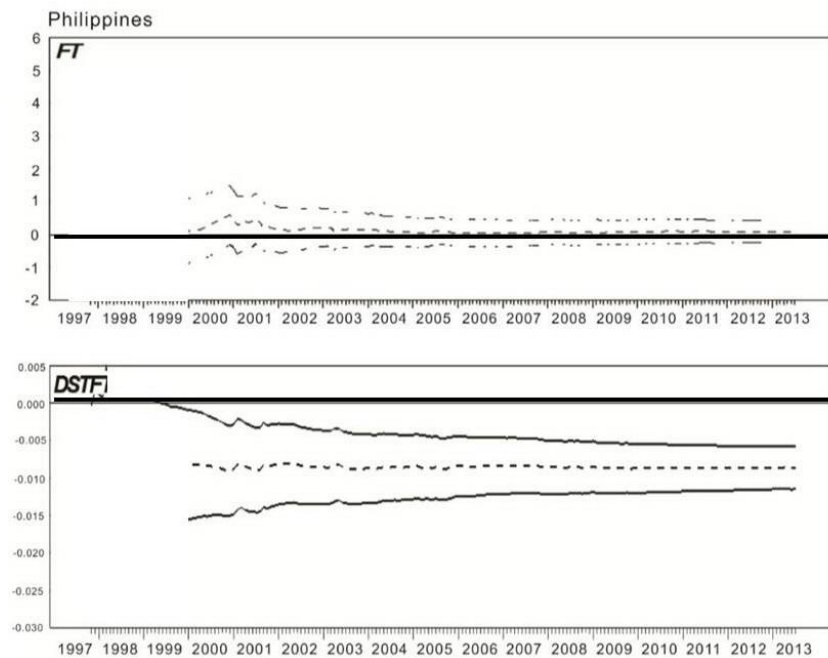

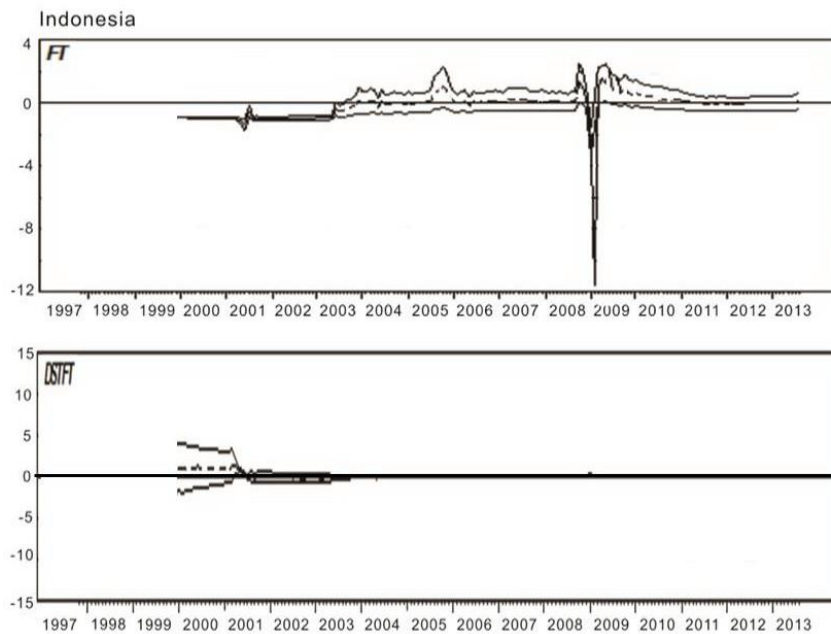Figure 11. Philippines' coefficient tests

Figure 12. Indonesia's coefficient tests

5. Conclusion

The aim of this paper is to study the dynamic market efficiency of foreign exchange markets in four ASEAN countries from December 1996 to September 2013. For discussing the implications of time-varying behaviour in these four foreign exchange markets, this paper employs recursive cointegration to examine the dynamic relationship between the spot rate and forward rate in the foreign exchange market. We now show the following empirical results.

First, according to the empirical results of ZA unit root tests with an endogenous structural break, we do find two main breakpoints of ZA's tests for most of the [** can't really say "most of", when there are only 4. Seems odd.**] countries. Two financial crises, the 1997-1998 Asia financial crisis and the 2008-2009 global financial crisis, indeed caused the breakpoints of exchange rates in the four ASEAN countries.

Second, we use the recursive cointegration technique to trace the pictures of the possible dynamic long-run relationships between the spot and forward rates for each country respectively. All four ASEAN countries present similar cointegrated patterns and support the cointegration relationship between the two variables after 2008. However, there are some different cointegrated patterns between these four markets before 2008. Because of liberalized and impressively growing financial markets, Singapore's spot and forward foreign exchange markets show earlier cointegration, beginning around 2000, than other countries' foreign exchange markets. As to the other countries' foreign exchange markets, the beginning times of cointegration for Thailand and Philippines are around 2006, while cointegration in Indonesia appeared in 2008.

Third, applying the recursive coefficients to test the forward rate unbiased hypothesis, the examining results show that Singapore's foreign exchange market is efficient over the whole sample period except around 2000, and Indonesia's foreign exchange market also shows the presence of efficiency over most of the time after 2004. As to Thailand and the Philippines, the examining results present that their foreign exchange markets are inefficient.

Reference

1. Ahmad, R., Rhee, S. G., & Wong, Y. M. (2012). Foreign exchange market efficiency under recent crises: Asia-Pacific focus. *Journal of International Money and Finance*, 31(6), 1574-1592.

2. 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.

3. Baillie, R. T., & Bollerslev, T. (1989). Common stochastic trends in a system of exchange rates. *The Journal of Finance*, 44(1), 167-181.

4. Bai, J., & Perron, P. (1998). Estimating and Testing Linear Models with Multiple Structural Changes. *Econometrica*, 66(1), 47-78.

5. Bai, J., & Perron, P. (2003). Critical values for multiple structural change tests. *Econometrics Journal*, 6(1), 72-78.

6. Bai, S., & Mollick, A. V. (2010). Currency crisis and the forward discount bias: Evidence from emerging economies under breaks. *Journal of International Financial Markets, Institutions & Money*, 20, 556-574.

7. Bilson, J. F. O. (1981). The speculative efficiency hypothesis. *Journal of Business*, 54, 435-451.

8. Chan, T. H., Baharumshah, A. Z., & Lau, E. (2005). Real financial integration among the East Asian economies: A SURADF panel approach.

9. Chianga, S. M., Leeb, Y. H., Su, H. M., & Tzou, Y. P. (2010). Efficiency tests of foreign exchange markets for four Asian countries. *Research in International Business and Finance*, 24, 284-294.

10. Chien, M. S. (2010). Structural breaks and the convergence of regional house prices. *Journal of Real Estate Finance and Economics*, 40:1, 77-88.

11. Crowder, W. J. (1994). Foreign exchange market efficiency and common stochastic trends. *Journal of International Money and Finance*, 13(5), 551-564.

12. Cumby, R. E., & Obstfeld, M. (1984). International interest rate and price level linkages under flexible exchange rates: a review of recent evidence. In: Bilson, J. F. O., Marston, R. C. (eds.) *Exchange Rate Theory and Practice*, University of Chicago Press, Chicago.

13. Dicky, D. A., & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association*, 74, 427-431.

14. Fama, E. F. (1984). Forward and spot exchange rates. *Journal of Monetary Economics*, 14(3), 319-338.

15. Fama, E. F. (1998). Market efficiency, long-term returns, and behavioral finance. *Journal of Financial Economics*, 49(3), 283-306.

16. Froot, K. A., & Frankel, J. A. (1989). Forward discount bias: Is it an exchange risk premium? *The Quarterly Journal of Economics*, 139-161.

17. Goldman, E. (2006), Testing efficiency of the ruble-sterling foreign-exchange Mark and the Japanese Yen. *An International Journal*, 6(2), 163-182.

18. Gregory, A. W., & Hansen, B. E. (1996). Residual-based tests for cointegration in models with regime shifts. *Journal of Econometrics*, 70, 99-126.

19. Hansen, B. E. (1992). Testing for parameter parameter instability in linear models. *Journal of Policy Modeling*, 14, 517-533.

20. Hansen, H., & Johansen, S. (1999). Some tests for parameter constancy in cointegrated VAR-models. *Econometrics Journal*, 2, 306-333.

21. Jeon, B. N., & Lee, E. (2002). Foreign exchange market efficiency, cointegration, and policy coordination. *Applied Economics Letters*, 9(1), 61-68.

22. Johansen, S. (1988). Statistical Analysis of Cointegration Vectors. *Journal of Economic Dynamics and Control*, 12, 231-254.

23. Johansen, S. (1991). Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive

Models. *Econometrica*, 59, 1551-1580.

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

25. Kanas, A., & Ioannidis, C. (2012). Revisiting the forward—spot relation: an application of the nonparametric long-run correlation coefficient. *Journal Economy Finance*, 36, 148-161.

26. Kenourgios, D., Samitas, A., & Christodoulou, A. (2006). Long run and short run test for market efficiency: Evidence for the British Pound, the German Mark and the Japanese Yen. *Operational Research*, 6(2), 163-182.

27. King, M. R., & Rime, D. (2010). The $4 trillion question: what explains FX growth since the 2007 survey? *BIS Quarterly Review*, 4, 27-42.

28. Kühl, M. (2007). Cointegration in the foreign exchange market and market efficiency since the introduction of the Euro: Evidence based on bivariate cointegration analyses. *Governance and Economic Development Research Discussion Papers*, 68.

29. Kumar, A. S. (2011). Testing for Weak Form of Market Efficiency in Indian Foreign Exchange Market. *The IUP Journal of Monetary Economics*, IX(3), 7-19.

30. Kutan, A. M., & Zhou, S. (2003). Has the link between the spot and forward exchange rates broken down evidence from rolling cointegration tests. *Open Economies Review*, 14, 369-379.

31. Lim, L. K. (2011). Common currency in East Asia: An analysis of currency convergence. *International Journal of Business Studies*, 19(1), 53-67.

32. Park, Y. C., & Shin, K. (2011). Internationalisation of currency in East Asia: implications for regional monetary and financial cooperation. *BIS Papers*, 180.

33. Patnaik, I., Shah, A., Sethy, A., & Balasubramaniam, V. (2011). The exchange rate regime in Asia: From crisis to crisis. *International Review of Economics & Finance*, 20(1), 32-43.

34. Petri, P. A., Plummer, M. G., & Zhai, F. (2012). ASEAN economic community: A general equilibrium analysis. *Asian Economic Journal*, 26(2), 93-118.

35. Phylaktis, K. (1997). Capital market integration in the Pacific-Basin region: An analysis of real interest rate linkages. *Pacific-Basin Finance Journal*, 5, 195-213.

36. Pilbeam, K., & Olmo, J. (2011). The forward discount puzzle and market efficiency. *Annual Finance*, 7, 119-135.

37. Rapp, T. A., & Sharma, S. C. (1999). Exchange rate market efficiency: across and within countries. *Journal of Economics and Business*, *51*(5), 423-439.

38. 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'économie*, *38*(3), 673-708.

39. Sagaram, J. P. A., & Wickramanayake, J. (2012). Financial centers in the Asia-pacific region: an empirical study on Australia, Hong Kong, Japan and Singapore. *PSL Quarterly Review*, 58(232).

40. Shmilovici, A., Kahiri, Y., Ben-Gal, I., & Hauser, S. (2009). Measuring the efficiency of the intraday Forex market with a universal data compression algorithm. *Computational Economics*, 33, 131-154.

41. World Bank, (2009). Battling the forces of global recession, *East Asia and Pacific Update.*

42. Zhao, Y., Haan, J. D., Scholtens, B., & Yang, H. (2013). The relationship between the Renminbi future spot return and the forward discount rate. *Journal of International Money and Finance*, 32, 156-168.

43. Zivot, E., & Andrews, K. (1992). Further evidence on the Great Crash, the oil price shock, and the unit root hypothesis. *Journal of Business and Economic Statistics*, 10 (10), 251-70.