DLSU Business & Economics Review 23.2 (2014), pp. 65-79

Martingales in Floating ASEAN+3 Currencies*

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The martingale properties of the floating exchange rates of the ASEAN+3 region are analyzed in this study using contemporary (2000 to 2012) weekly data of inter-bank call rates. The main goal of the analysis is to see if informational efficiency is a feature floating (managed or independently floating) currencies in this coalition of countries still possess despite the current credit crisis and other economic shocks during the period. Employing relevant state-of-the-art econometric techniques, the study sets to empirically determine the presence of two important ingredients of informationally efficient market—the existence of the unit root component and the presence of uncorrelated increments within each exchange rate series. To address the unit root problem, a battery of tests catering to heterogeneous panel data is used while variance ratio tests robust to the occurrence of conditional volatilities are implemented.

While the stylized facts and simple correlation analysis of the currencies and their one week holding period returns give initial evidence of market efficiencies, the various analytical tests and procedures implemented in the study provide compelling evidence on the existence of martingale properties of the FX series. Both the panel unit root and variance ratio tests uphold the validity of the efficient market hypothesis (EMH) in the participating currencies. The implication of this result is that despite the occurrence of perturbations due to economic shocks (e.g. the current credit crisis) the currencies of the region, which are currently pursuing unification, are riding the crises and exhibit informational efficiency. This may be considered a testament to the success of the on-going interregional monetary coordination and other multilateral initiatives of countries within the region aimed at crisis prevention and monetary policy synchronization.

JEL Classifications: F31, F33, F36, G14, G15

Keywords: Martingales, ASEAN+3 currencies, Variance ratio, Unit roots

The foreign exchange market is the biggest financial market in the world. In any given day, about four trillion US Dollar is being traded on the currency markets worldwide, of which, close to 40% are spot transactions (Bank of International Settlements [BIS], 2010) with online retail trading a rapidly expanding portion of the market. The volume of transactions of the FX market in the US alone is more than 30 times that of the NASDAQ and NYSE combined.

Conversion of currencies supports international trade, investment, commerce, and tourism anywhere in the world. Its wide geographical dispersion, extremely high liquidity, continuous round-the-clock operation, and relatively low profit margins makes it the closest to the ideal of perfect competition, even with periodic interventions from central banks. Market participants include large commercial and investment banks, central banks, institutional investors, currency speculators, hedgers, corporations, tourists, consumers, governments, other financial institutions, and retail investors. This wide assortment of buyers and sellers determine the relative value of different currencies in a global scale.

Under the Bretton Woods system, which was adopted after the last world war, the world's currencies were pegged to the US Dollar, which itself was attached to the value of gold at USD35 per ounce. The peg was maintained until 1971, when the U.S. dollar could no longer sustain the value of the pegged rate as price of gold appreciated considerably. Since then, major governments adopted the floating system where currency values are determined by market forces, and all attempts to return to a global peg were eventually abandoned. While a floating regime is not without its flaws (prompting a number of economies to do some adjustments – "managing the float"), it has proven to be a more efficient means of determining the long-term value of a currency and creating equilibrium and stability in the international market.

The era of floating exchange rates also induced substantial volatility in values of these currencies, which in turn attracted enormous speculative interests from various sectors, employing sophisticated forecasting models to predict both the magnitudes and directions of market rates. Speculation has become so massive despite the vast literature (see Frankel & Rose, 1995 for a review) in support of the Meese-Rogoff puzzle that naïve random-walk forecasts consistently outperform out-of-sample economic models of exchange rates (Meese & Rogoff, 1983). Academics who take the opposing view to speculators, hedgers, and investors may claim that such burgeoning literature could be a validation of the Efficient Market Hypothesis (EMH) of Samuelson (1965) and Fama (1965) in foreign exchange markets.

The present paper will not attempt to add evidence to the predictability or non-predictability of exchange rates by proposing a new forecasting model, but instead examine the martingale properties of floating currencies in the ASEAN+3 region using contemporary data, in a hope of obtaining empirical support to the informational efficiency of price formation in these markets. Martingales are a more general and realistic form of random walks under the stylized facts of most financial asset prices.

METHODOLOGY

Testing for the validity of the Martingale Difference Sequence (MDS) for asset price series has been receiving considerable attention in recent literature due to its implications on the Efficiency Market Hypothesis (EMH), particularly on the predictability of returns. The most popular empirical technique used in checking the existence of an MDS in an observed realization of a time series is the so-called Variance Ratio test. This test stemmed from a simple specification of the data generating process of an MDS whose first difference or logarithmic first difference follows a white noise process (Escanciano & Lobato, 2009).

Suppose a stochastic process $\{Y_t\}$ t = 0, 1, 2, … , T satisfies the first differenced specification –

$$\Delta Y_t = Y_t - Y_{t-1} = \mu + \eta_t \qquad (1)$$

where the parameter μ is a constant representing the "drift" of the process and the random variable η_t is assumed to possess the following properties:

$$E(\eta_t) = 0 \qquad (2)$$

for all t, and

$$E(\eta_t \eta_{t-j}) = 0 \qquad (3)$$

for any positive integer j such that $t - j \geq 0$. When (2) and (3) can be empirically validated for any realization of the stochastic process $\{Y_t\}$, the process is said to follow a Random Walk (RW). In case the process is $\{\ln(Y_t)\}$, it is supposed to follow an Exponential Random Walk (ERW), when its first difference –

$$\Delta \ln(Y_t) = \ln(Y_t) - \ln(Y_{t-1}) = \mu + \eta_t \qquad (4)$$

follows (2) and (3). Additionally, if Y_t is an asset price, (1) and (4) represents, respectively, the simple algebraic return and the continuously compounded return for the asset during time t. The objective of any test of the Random Walk hypothesis (RWH) is to show that either (1) or (4) or both follow (2) and (3)—the returns have vanishing error expectations and with uncorrelated increments.

Lo and McKinlay (1988) formulated two test statistics to undertake the Variance Ratio test for the RWH. These statistics operate well under varying assumptions on the statistical properties of η_t. The first statistic works under the strong assumption that η_t is i.i.d (identically and independently distributed) with constant variance σ^2 . The targeted null hypothesis often referred to as the homoscedastic **random walk or i.i.d. null** hypothesis. Normality may not be necessary under asymptotic condition.

In the other test statistic, Lo and McKinlay (1988) downgraded the i.i.d assumption on η_t to permit general types of time varying volatility, which are often seen in financial time series (ARCH effect). The associated null hypothesis under this assumption is the heteroscedastic random walk hypothesis or frequently called the **martingale or m.d.s. null** since η_t is technically an MDS (Escanciano & Lobato, 2009).

The Lo-McKinlay (1988) Variance Ratio test under the martingale null hypothesis will be the basic empirical procedure to be used in this study. It is anchored more specifically on property (3) – that the returns have uncorrelated increments, which means that if a series follows a martingale (heteroscedastic random walk) process, the variance of its q-differences would be q times the variance of its first differences (Liu & He, 1991). In other words, if Y_t is an exchange rate series, under MDS, the ratio of 1/q of the variance of $\Delta^q Y_t$ (or $\Delta^q \ln(Y_t)$) with the variance of ΔY_t (or $\Delta \ln(Y_t)$)would be equal to one.

The test statistic under the i.i.d. null

If $\{y_t\}$ is a realization of the process $\{Y_t\}$ with a sample size T, the variance-ratio (VR) needed to test the hypothesis that $\{Y_t\}$ is a random walk is defined by Lo and McKinlay (1988) as:

$$VR = \left\{ \frac{1}{qT} \sum_{t=q+1}^{T} (y_t + y_{t-1} + \ldots + y_{t-q} - q\hat{\mu})^2 \right\} \div \left\{ \frac{1}{T} \sum_{t=1}^{T} (y_t - \hat{\mu})^2 \right\} \qquad (5)$$

where $\hat{\mu} = \sum_{t=1}^{T} y_t / T$. VR may be seen as the ratio of 1/q times the variance of the q-period return to the variance of the 1 period return. This statistic should not differ significantly from 1 for all integer q > 1 if ΔY_t is i.i.d. but not if ΔY_t is serially correlated. Lo and McKinlay (1988) proved that if ΔY_t is i.i.d.

$$\sqrt{T}(VR - 1) \rightarrow asy \quad N\left(0, \frac{2(2q-1)(q-1)}{3q}\right) \qquad (6)$$

$$Z = (VR - 1)\sqrt{\frac{3qT}{2(2q-1)(q-1)}} \rightarrow asy \; N(0,1) \qquad (7)$$

The test statistic under the m.d.s. null

Under the heteroscedastic random walk hypothesis, Lo and McKinlay (1988) derived a robust version of (7) to account for time varying volatility and autocorrelation of the underlying series and arrived at the following test statistic –

$$Z^* = (VR - 1)\left\{\sum_{j=1}^{q-1} \left[\frac{2(q-j)}{q}\right]^2 \delta_j \right\}^{-0.5} \qquad (8)$$

where

$$\delta_j = \left\{ \sum_{t=j+1}^{T} (y_t - \hat{\mu})^2 (y_{t-j} - \hat{\mu})^2 \right\} \div \left\{ \left[\sum_{t=1}^{T} (y_t - \hat{\mu})^2 \right]^2 \right\} \qquad (9)$$

Lo and McKinlay (1988) showed that if Y_t is an MDS, then Z^* is asymptotically normally distributed with mean zero and standard deviation of 1.

The Multiple Variance Ratio Tests

Since the variance ratio restriction holds for every q difference of the underlying series, for q > 1, it is customary to evaluate the test statistics (7) and (8) at several selected values of q (in this study q is set for q = 2, 4, 8, and 16). Chow and Denning (1993) proposed a test statistic used to examine the absolute values of a set of multiple variance ratio statistics (for the different set values of q). The main purpose of this statistic is to control the size (type I error probability) of a joint variance ratio test to be implemented.

The null hypothesis for the Chow-Denning multiple VR test is set as the joint statement:

$$VR(q_i) = 1 \text{ for i = 1, 2, …, m} \qquad (10)$$

against the alternative hypothesis

$$VR(q_i) \neq 1 \text{ for some holding period } q_i \qquad (11)$$

The Chow-Denning test statistic can be written as:

$$MV = \max\left|M(y;q_i)\right| \text{ for } 1 \leq i \leq m \qquad (12)$$

where

$$MV(y;q_i) = (VR(q_i)-1)\{\sum_{j=1}^{q-1}[\frac{2(q_i-j)}{q_i}]^2 \delta_j\}^{-0.5} \qquad (13)$$

and

$$\delta_j = \left\{\sum_{t=j+1}^{T}(y_t-\hat{\mu})^2(y_{t-j}-\hat{\mu})^2\right\} \div \left\{\left[\sum_{t=1}^{T}(y_t-\hat{\mu})^2\right]^2\right\} \qquad (14)$$

The Chow-Denning (CD) test is anchored on the idea that any decision on the null hypothesis can be based on the maximum absolute value of the individual VR statistic under the m.d.s. assumption of Lo and McKinlay (1988). Under such assumption, CD statistic follows the studentized maximum modulus (SMM) distribution with m and T degrees of freedom (Chow & Denning, 1993), whose critical values are tabulated in Stoline and Ury (1979). The p-value for the CD statistic is bounded from above by the p-value for the SMM distribution with parameters m and T, with T approaching infinity.

The Wild Bootstrap Variance Ratio Test

According to Efron (1979) who developed the concept of the bootstrap, the bootstrap is a resampling procedure that approximates the sampling distribution of a test statistic. This procedure is often resorted to in evaluating test statistics that operate under unconventional assumptions and/or under small sample conditions.

To implement the bootstrap in approximating the m.d.s. based Lo-McKinlay test statistic (8) and m.d.s based Chow-Denning test statistic (12), Kim (2006) used the wild bootstrap of Mammen (1993) to develop a procedure that can roughly estimate sampling distributions such as (8) and (12) that are robust to unknown forms of conditional and unconditional heteroscedasticity. The procedure developed by Kim (2006) has been receiving good reviews in the literature as having the most power aside from having the most superior small sample properties among competing methodologies (e.g. Charles et. al, 2011; Kim & Shamsuddin, 2008; Hoque et al, 2007).

Simply put, the Kim (2006) procedure is conducted in three stages, as applied for example, to the Chow-Denning test statistic (12):

1. Form a bootstrap sample of T observations $y^*t = \eta_t y_t$ for t = 1, 2, …, T where η_t is a random sequence having the properties: (a) $E(\eta_t) = 0$ and (b) $E(\eta^2_t) = 1$
2. Calculate $MV^* = MV(y^*_t;q_i)$ with $MV(y^*_t;q_i)$ statistic generated from the bootstrap sample obtained in stage 1.
3. Repeat 1. and 2. in sufficiently large number of replications, say m times to form a bootstrap distribution of the test

statistic (12). The bootstrap distribution is now used in approximating the sampling distribution of the CD test statistic. The p-value of the test can be obtained as the proportion of the bootstrap distribution greater than the CD test statistic value obtained from the original data.

The wild bootstrap implementation of the Lo-McKinlay test statistic (8) can be done in similar manner as a two-tailed test. To implement the wild bootstrap test, Kim (2006) suggested the use of the standard normal distribution for η_t, although simulation results are insensitive to other distributions like the two-point distribution of Mammen (1993) and the Rademacher distribution developed by Hans Rademacher (1892-1969). Results are also insensitive to various random number generators (e.g. Knuth, Mersenne, or L'Ecuyer).

Panel Unit Root Tests

Proving that the underlying asset price series follows a martingale difference sequence (MDS) is just one of the necessary requirements of an informationally efficient market. MDS, the presence of which is to be evaluated by the VR tests only signifies that any positive increments of the series are uncorrelated. The other condition is the existence of the unit root component of the series (Liu & He, 1991; Azad, 2009). If these two properties exist in a financial market, the financial series is said to follow a random walk. In this study, the presence of the unit root component will be empirically determined in the ASEAN+3 exchange rate data series using a battery of individual (Maddala & Wu, 1999; Im, Pesaran, & Shin, 2003) and joint (Levin, Lin, & Chu, 2002; Breitung, 2000; Hadri, 2000) panel unit root tests. The literature points out the superiority of panel based unit root tests (Wu & Chen, 1999; Azad, 2009) in terms of power vis-à-vis unit root tests based on individual time series (e.g. Augmented Dickey Fuller test). To conserve space, technical discussion on these tests will not be done since the study highlights on the more important MDS evaluation.

The Data Used in the Study

The ASEAN+3 region, consisting of the 10 ASEAN countries and the three East Asian economic giants—Japan, China and South Korea—is currently the most active country grouping pursuing economic integration and currency unification. Among these 13 economies, six has sufficient historical data of floating exchange rate regimes. These countries are Japan, Korea, Singapore, Indonesia, Philippines, and Thailand, whose respective currencies – Yen (JPY), Won (KRW), Singapore Dollar (SGD), Rupiah (IDR), Peso (PHP) and Bath (THB)—are under either the freely floating or managed float regimes. Please see Appendix A (Rufino & De Guia, 2011) for the IMF classified currency regimes of all of the ASEAN+3 countries. The daily inter-bank call rates of these currencies vis-à-vis the US Dollar (nominal currency value per US Dollar) for the period January 2000 to December 2012 will constitute the primary data base of the study. Data source is OANDA—the world's most trusted source of filtered currency information. The weekly data (average of bid and ask rates for Wednesdays) are used in the analysis instead of daily because of the built-in biases associated with daily series (e.g. bid and ask spread, asynchronous prices, etc. (Lo & McKinlay, 1988; Azad, 2009; Darrat & Zhong, 2000)). Eventually, a balanced panel data of 678 weekly observations for each of the six currencies was utilized in the study.

EMPIRICAL RESULTS

Stylized Facts About the ASEAN+3 Currencies During the Sample Period

Descriptive analysis of the pattern of movements of the variables under study often reveals useful insights relevant to the goal of

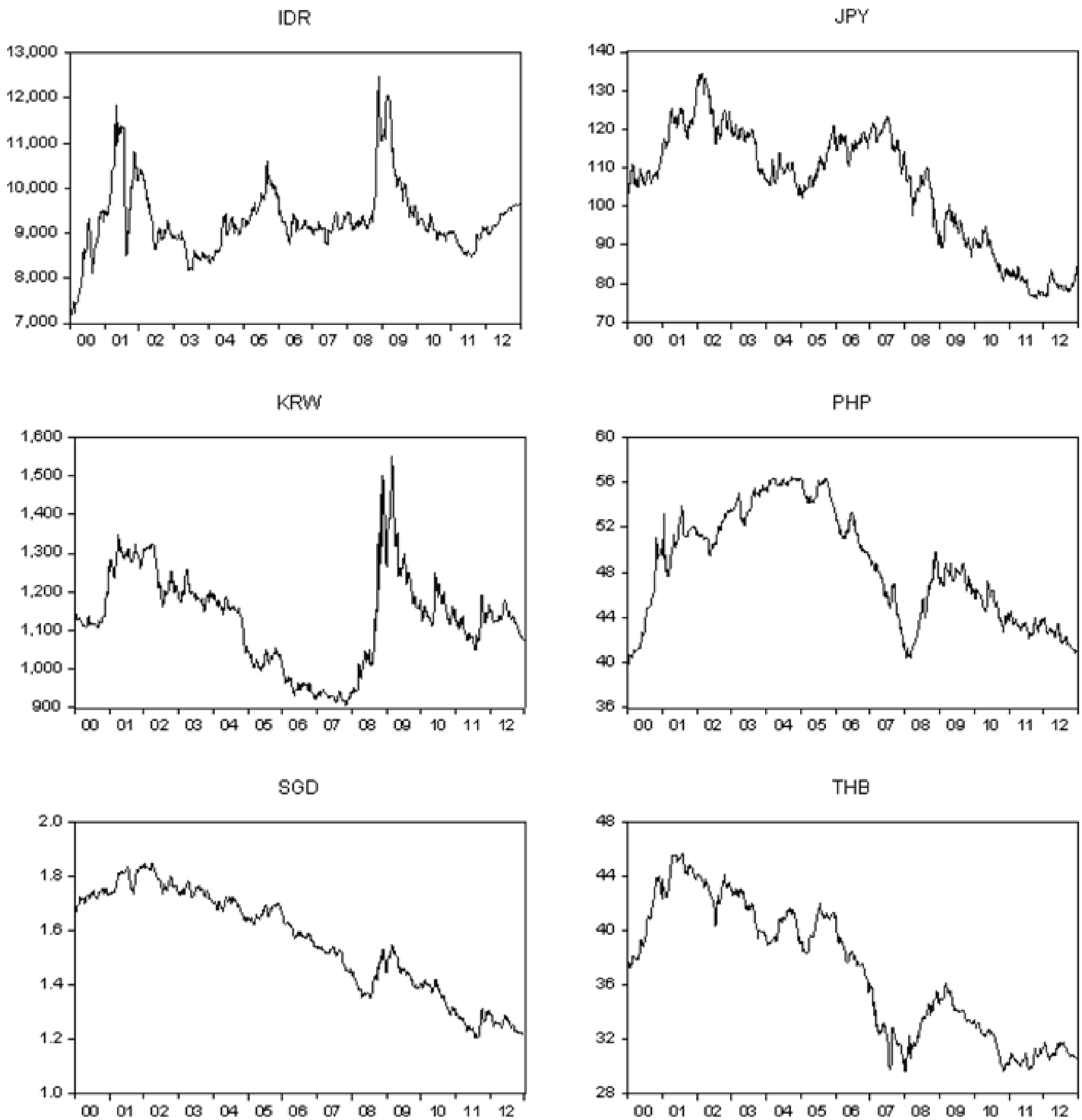

Figure 1. Line graphs of the weekly nominal exchange ates of floating ASEAN+3 currencies against the US Dollar 2000 to 2012.

the research. Figure 1 depicts the line graphs of the weekly nominal rates of the participating currencies against the US Dollar. Ocular inspection of the graphs may give a general impression that the movements of currencies are erratic. All currencies appear to be drifting in the same general direction after the height of credit crisis in 2008, that is, long term strengthening against the US Dollar, with pronounced local peaks and troughs.

Plotting the logarithmic first difference of the currencies over time, which is mathematically synonymous to their continuously compounded one holding period (weekly) returns, Figure 2

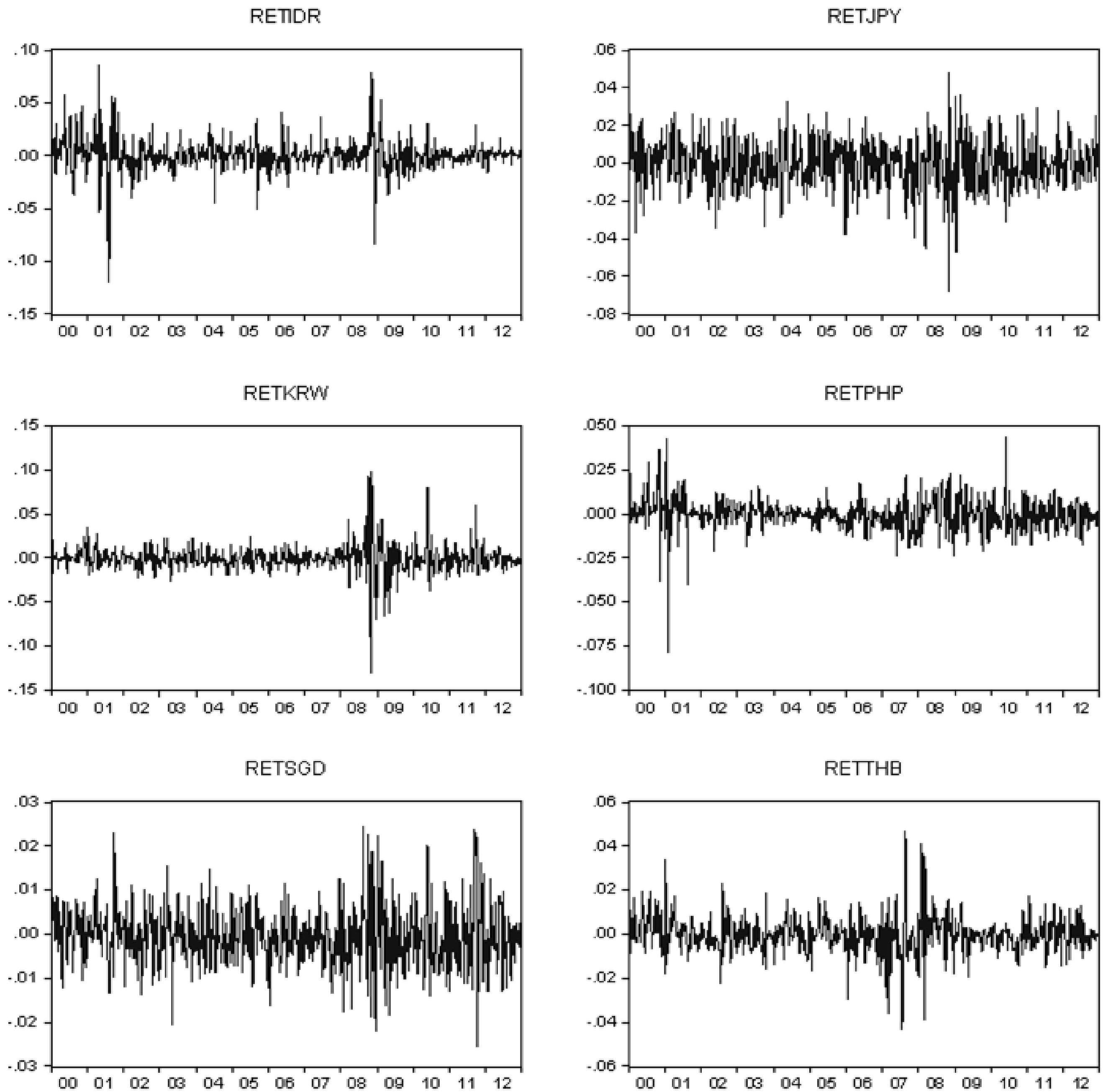

Figure 2. Line graphs of one week holding period returns.

emerged. When these return series apparently exhibit mean reversion to zero level, one may get an impression that the exchange rates have unit root component—an indication of their individual random walk movements. Additionally, as observed in most asset price series, episodic flurry of activities during certain periods are also seen in the graphs of the return series. Most of these observed volatilities occurred during the height of the crisis period in the later part of 2008. Such episodes are particularly strong for the international currencies Japanese Yen (JPY), Korean Won (KRW), and Singapore Dollar (SGD). This volatility patterns suggest the heteroscedastic nature of the return series commonly referred to as the ARCH effect, which was validated empirically

Table 1
Stylized Facts on One Week Holding Period Returns of Floating ASEAN+3 Currencies January 2000 to December 2012

Statistic	RETIDR	RETJPY	RETKRW	RETPHP	RETSGD	RETTHB
Mean	0.000443	-0.000292	-0.000066	0.000047	-0.000449	-0.000289
Median	0.000450	-0.000184	-0.001134	0.000000	-0.000703	-0.000569
Maximum	0.086858	0.047869	0.098837	0.043665	0.024469	0.047074
Std. Dev.	0.015853	0.013163	0.016279	0.009236	0.006891	0.008565
Skewness	-0.435901	-0.331503	0.124394	-0.619007	0.295915	0.410002
Kurtosis	14.53459	4.355853	17.51128	13.20450	4.138147	8.713763
ARCH (14)	142.22	51.6695	318.448	88.102	106.597	106.535
[p-value]	[0.000000]	[0.000003]	[0.000000]	[0.000000]	[0.000000]	[0.000000]
Jarque-Bera	3774.466	64.25622	5941.781	2980.621	46.42079	939.8874
[p-value]	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Table 2
Correlation Matrix of One Week Holding Period Returns of Floating ASEAN+3 Currencies January 2000 to December 2012

Correlation / t-Statistic		One Week Holding Period Returns on Currencies				
	RETIDR	**RETJPY**	**RETKRW**	**RETPHP**	**RETSGD**	**RETTHB**
RETIDR	1.000000					

RETJPY	0.053628	1.000000				
	1.395299*	-----				
RETKRW	0.296507	-0.047451	1.000000			
	8.066***	-1.234203*	-----			
RETPHP	0.348087	-0.006478	0.422518	1.000000		
	9.646***	-0.168296	12.11152***	-----		
RETSGD	0.353599	0.291102	0.567902	0.427836	1.000000	
	9.821***	7.905***	17.93***	12.298***	-----	
RETTHB	0.240768	0.196417	0.317152	0.366374	0.474392	1.000000
	6.445***	5.204***	8.688***	10.23***	14.001***	-----
*p < 0.10 ***p<0.0001						

in Table 1 that depicts the stylized facts on the returns of the various currencies. Correlation matrix of the returns featured in Table 2 shows that returns are pair-wise highly correlated across currencies mostly with the same positive signs, except JPY and KRW with negative. Only the returns of the currency pairs JPY-PHP appear to be statistically unrelated.

Results on the Lagrange Multiplier (LM) ARCH (14) tests show the extremely high

Table 3
Summary of the Panel Unit Root Tests on the Floating ASEAN+3 Currencies 2000-2012

Panel Unit root tests: Summary for Level				
Method	Statistic	Prob.**	Cross-Sections	Obs
Null: Unit root (assumes common unit root process) except Hadri *				
Levin, Lin & Chu t*	0.77824	0.7818	6	4052
Breitung	-0.51647	0.3028	6	4046
Hadri	14.1947	0.0000	6	4048
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	0.05840	0.5233	6	4052
ADF – Fisher Chi-square	18.3365	0.1058	6	4052
PP – Fisher Chi-square	15.8038	0.2004	6	4062
** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution.				
All other tests assume asymptotic normality.				
Breitung and Hadri tests assume trend and intercept in auxiliary regressions, other tests assume only intercept (drift)				
*				
Panel Unit root tests: Summary for First differences				
Method	Statistic	Prob.**	Cross-Sections	Obs
Null: Unit root (assumes common unit root process) except Hadri *				
Levin, Lin & Chu t*	-59.0356	0.0000	6	4051
Breitung	-31.8023	0.0000	6	4045
Hadri	1.49116	0.0680	6	4062
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-50.3388	0.0000	6	4051
ADF – Fisher Chi-square	937.005	0.0000	6	4051
PP – Fisher Chi-square	1052.05	0.0000	6	4056
** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution.				
All other tests assume asymptotic normality.				
Breitung and Hadri tests assume trend and intercept in auxillary regressions, other tests assume only intercept (drift)				
* Hadri's Null is stationarity				

statistical significance of the ARCH effect in all currencies with p-values equivalent to zero at seven significant digits. This observed manifestation may prove to be useful in the analysis of the martingale properties (informational efficiency) of the exchange rates. Other statistics presented in Table 1 quantitatively confirm most of our cursory observations on the graphs of returns (Figure 2). Mean reversion to zero level is confirmed as both mean and median returns in all currencies are almost zero. Excessive departure from normality is observed in all return series with all Jarque-Bera statistics depicting extreme significance ($p \leq 0.000003$). These features of the return distribution are consistent with the concept of the weak form market efficiency hypothesis, popularly known as the Random Walk Hypothesis (RWH) introduced by Samuelson (1965) and Fama (1965).

Unit Root Properties of the Exchange Rate Series

Results of the application of the various panel unit root tests on the working sample are all revealed in Table 3. The top part of the table deals with the application of the tests on the level series, while the bottom portion presents the results of the different panel unit root tests on the first differenced series. Insignificant results on the level series confirm the presence of unit root component in the level or the untransformed exchange rate series, while significant results in the first differenced series validate the existence of a single unit root. Heavier consideration is often place on the results of the Levin et al. (2002) test (common unit process assumption for the cross section entities) as well as on Im et al. (2003) test (individual unit root process assumption for each cross section entity) (Wu & Chen, 1999) . The results are unmistakable—the floating ASEAN+3 currencies are non-stationary, each with a single unit root, which implies that their returns are characterized by the white noise process. Hence, the floating currencies of the expanded ASEAN region possess the necessary condition for EMH—the existence of the unit root component (Azad, 2009); thus paving the way for testing for the presence of uncorrelated increments of the exchange rate series—the sufficiency condition.

Variance Ratio Tests Results

To ascertain the presence of uncorrelated increments in each of the currencies, the variance ratio test discussed in the Methodology section is employed. In this study, the robust version of the test is used since the stylized facts on the different currencies and their returns show the presence of an unknown form of heteroscedasticity in the exchange rate series. Empirical tests on this phenomenon using the available data confirm the significance of the ARCH effects in all series; hence, the test for uncorrelated increments in the individual currencies will be assessed under the MDS null hypothesis. The procedure to test the MDS null hypothesis proposed by Lo and McKinlay (1988) is applied, the results of which are presented in Table 4 and Table 5. The first table summarizes the results of the wild bootstrap VR test on the MDS null for the log differenced currency series while the second deals with the asymptotic normal VR test of the log difference series under the same robust assumption.

Under the null hypothesis that each currency follow a Martingale Difference Sequence (MDS)—a version of the Random Walk Hypothesis (RWH) that is immune to the inferential ill effects of the Auto Regressive Conditional Heteroscedasticity (ARCH) whose presence is earlier established analytically on the continuously compounded returns, Chow-Denning joint VR tests support the RWH for all currencies. Few individual VR test for some holding periods however posted significant results (for IDR, SGD and THB) in both the wild bootstrap and asymptotic normal p-values. Overall, however, on the basis of the more powerful Chow-Denning test, MDS is affirmed in all currencies.

With the established presence of the unit root component and the martingale properties in each of the floating currencies in the ASEAN+3 region, it is now safe to conclude that the foreign exchange markets in the region are informationally efficient. This means that all exchange rates fully and instantaneously reflect all available and relevant information, such that adjustments are immediate and accurate in a manner that returns can not be reliably predicted (Samuelson, 1965; Fama, 1965).

CONCLUDING REMARKS

The martingale properties of the floating exchange rates of the ASEAN+3 region are analyzed in this study using contemporary (2000 to 2012) weekly data of interbank call rates. The main goal of the analysis is to see if informational efficiency is a feature floating (managed or independently floating) currencies in this coalition

Table 4

Variance Ratio Test for Exponential Random Walk of East Asian Currencies Using Wild Bootstrap

Ho: log(SGD) is a Martingale		**Individual Variance Ratio Tests**				
Chow-Denning Joint Variance Ratio Test		Holding Period (q)				
		Period	2	4	8	16
		Var. Ratio	1.1128	1.2110	1.1553	1.1711
Max |z|	2.18646	Std. Error	0.0520	0.0965	0.1497	0.2167
Degrees of Freedom	677	z-Statistic	2.1698	2.1865	1.0371	0.7896
p-value	0.0790	p-value	0.0280	0.0290	0.3010	0.4200

Ho: log(JPY) is a Martingale		**Individual Variance Ratio Tests**				
Chow-Denning Joint Variance Ratio Test		Holding Period (q)				
		Period	2	4	8	16
		Var. Ratio	0.9838	1.0178	0.9455	0.9892
Max |z|	0.42566	Std. Error	0.0465	0.0837	0.128	0.1876
Degrees of Freedom	677	z-Statistic	-0.3495	0.213	-0.4257	-0.0578
p-value	0.9610	p-value	0.7560	0.8520	0.6930	0.9540

Ho: log(PHP) is a Martingale		**Individual Variance Ratio Tests**				
Chow-Denning Joint Variance Ratio Test		Holding Period (q)				
		Period	2	4	8	16
		Var. Ratio	0.9756	1.0672	1.1282	1.3084
Max |z|	1.2379	Std. Error	0.0756	0.1298	0.1858	0.2491
Df	677	z-Statistic	-0.3228	0.5173	0.6902	1.2379
p-value	0.4370	p-value	0.8200	0.6450	0.5210	0.2170

Ho: log(IDR) is a Martingale		**Individual Variance Ratio Tests**				
Chow-Denning Joint Variance Ratio Test		Holding Period (q)				
		Period	2	4	8	16
		Var. Ratio	1.1154	1.3149	1.4335	1.3348
Max |z|	2.44291	Std. Error	0.0661	0.1289	0.2064	0.2872
Degrees of Freedom	677	z-Statistic	1.7458	2.4429	2.0996	1.1658
p-value	0.048	p-value	0.0810	0.0190	0.0380	0.2500

Ho: log(KRW) is a Martingale		**Individual Variance Ratio Tests**				
Chow-Denning Joint Variance Ratio Test		Holding Period (q)				
		Period	2	4	8	16
		Var. Ratio	0.9697	0.9445	0.9234	0.9713
Max |z|	0.24283	Std. Error	0.1246	0.2312	0.3480	0.4641
Degrees of Freedom	677	z-Statistic	-0.2428	-0.2400	-0.2201	-0.0619
p-value	0.9920	p-value	0.8120	0.8150	0.8480	0.9610

Ho: log(THB) is a Martingale		**Individual Variance Ratio Tests**				
Chow-Denning Joint Variance Ratio Test		Holding Period (q)				
		Period	2	4	8	16
		Var. Ratio	1.0915	1.2423	1.2663	1.3768
Max |z|	2.04569	Std. Error	0.0676	0.1184	0.1817	0.2496
Degrees of Freedom	677	z-Statistic	1.3528	2.0457	1.4658	1.5095
p-value	0.1534	p-value	0.1761	0.0408	0.1427	0.1312

Table 5

Variance Ratio Test for Exponential Random Walk of Floating ASEAN+3 Currencies Using Asymptotic Normal Approximation

Ho: log(SGD) is a Martingale		**Individual Variance Ratio Tests**				
Chow-Denning Joint Variance Ratio Test		Holding Period (q)				
		Period	2	4	8	16
		Var. Ratio	1.1128	1.2110	1.1553	1.1711
Max |z|	2.18646	Std. Error	0.0520	0.0965	0.1497	0.2167
Degrees of Freedom	677	z-Statistic	2.1698	2.1865	1.0371	0.7896
p-value	0.1103	p-value	0.0300	0.0288	0.2997	0.4298

Ho: log(JPY) is a Martingale		**Individual Variance Ratio Tests**				
Chow-Denning Joint Variance Ratio Test		Holding Period (q)				
		Period	2	4	8	16
		Var. Ratio	0.9838	1.0178	0.9455	0.9892
Max |z|	0.42566	Std. Error	0.0465	0.0837	0.128	0.1876
Degrees of Freedom	677	z-Statistic	-0.3495	0.2130	-0.4257	-0.0578
p-value	0.9882	Probability	0.7267	0.8314	0.6704	0.9539

Ho: log(PHP) is a Martingale		**Individual Variance Ratio Tests**				
Chow-Denning Joint Variance Ratio Test		Holding Period (q)				
		Period	2	4	8	16
		Var. Ratio	0.9756	1.0672	1.1282	1.3084
Max |z|	1.2379	Std. Error	0.0756	0.1298	0.1858	0.2491
Degrees of Freedom	677	z-Statistic	-0.3228	0.5173	0.6902	1.2379
Probability	0.6217	Probability	0.7468	0.6049	0.4901	0.2157

Ho: log(IDR) is a Martingale		**Individual Variance Ratio Tests**				
Chow-Denning Joint Variance Ratio Test		Holding Period (q)				
		Period	2	4	8	16
		Var. Ratio	1.1154	1.3149	1.4335	1.3348
Max |z|	2.44291	Std. Error	0.0661	0.1289	0.2064	0.2872
Degrees of Freedom	677	z-Statistic	1.7458	2.4429	2.0996	1.1658
Probability	0.0570	Probability	0.0808	0.0146	0.0358	0.2437

Ho: log(KRW) is a Martingale		**Individual Variance Ratio Tests**				
Chow-Denning Joint Variance Ratio Test		Holding Period (q)				
		Period	2	4	8	16
		Var. Ratio	0.9697	0.9445	0.9234	0.9713
Max |z|	0.24283	Std. Error	0.1246	0.2312	0.3480	0.4641
Degrees of Freedom	677	z-Statistic	-0.2428	-0.2400	-0.2201	-0.0619
Probability	0.9986	Probability	0.8081	0.8103	0.8258	0.9507

Ho: log(THB) is a Martingale		**Individual Variance Ratio Tests**				
Chow-Denning Joint Variance Ratio Test		Holding Period (q)				
		Period	2	4	8	16
		Var. Ratio	1.0915	1.2423	1.2663	1.3768
Max |z|	2.04569	Std. Error	0.0676	0.1184	0.1817	0.2496
Degrees of Freedom	677	z-Statistic	1.3528	2.0457	1.4658	1.5095
Probability	0.1534	Probability	0.1761	0.0408	0.1427	0.1312

of East Asian countries still possess despite the current credit crisis and other economic shocks during the period. Employing relevant state-of-the-art time series econometric techniques, the study sets to empirically determine the presence of two important ingredients of informationally efficient market—the existence of the unit root component and the presence of uncorrelated increments within each exchange rate series. To address the unit root problem, a battery of tests catering to heterogeneous panel data is used while variance ratio tests robust to the occurrence of conditional volatilities are implemented.

While the stylized facts and simple correlation analysis of the currencies and their one week holding period returns give initial evidence of market efficiencies, the different analytical tests and procedures provide compelling evidence on the existence of martingale properties of the FX series. Both the panel unit root tests and the variance ratios uphold the validity of the efficient market hypothesis (EMH) in the participating currencies. The implication of this result is that despite the occurrence of perturbations in the economies due to shocks (e.g. the current credit crisis) the currencies of the region, which are set to be unified, are riding the crises and exhibit informational efficiency. This may be considered a testament to the success of the on-going interregional monetary coordination and other multilateral initiatives aimed at crisis prevention and monetary policy synchronization.

NOTE

* Presented at the 38th Annual Conference of the Federation of ASEAN Economic Associations (FAEA), Nov. 28 -29, 2013 in Singapore.

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APPENDIX A

ASEAN+3 Countries, Local Currency and Exchange Rate Regime

Country	Local Currency		Exchange Rate Regime
Brunei	BND	Brunei Dollar	Currency Board Arrangement
Cambodia	KHR	Cambodian Riel	Managed Float
China	CNY	Chinese Yuan Renminbi	Fixed Peg Arrangement (against a single currency)
Indonesia	IDR	Indonesian Rupiah	Managed Float
Japan	JPY	Japanese Yen	Independently Floating
Laos	LAK	Laos Kip	Managed Float
Malaysia	MYR	Malaysian Ringgit	Fixed Peg Arrangement (against a single currency)
Myanmar	MMK	Myanmar Kyat	Managed Float
Philippines	PHP	Philippine Peso	Independently Floating
Singapore	SGD	Singapore Dollar	Managed Float
South Korea	KRW	South Korean Won	Independently Floating
Thailand	THB	Thai Baht	Managed Float
Vietnam	VND	Vietnamese Dong	Fixed Peg Arrangement

Source: International Monetary Fund – Classification of Exchange Rate Arrangements