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MARTINGALE DIFFERENCE HYPOTHESIS IN ASIA – PACIFIC FOREIGN EXCHANGE MARKET

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ABSTRACT

This study examines whether the Asia – Pacific Foreign Exchange Market was in a weak form of efficiency against USD, during the period from 02/01/2010 to 31/12/2019. This study employed various linear measures, to examine the martingale behaviour of Asia – Pacific Foreign Exchange Market. The analysis found that two currencies (Australian Dollar and Chinese Renminbi), out of ten currencies, rejected MDH and behaviour patterns of those two currencies were more unpredictable than other sample currencies during the study period. It was found that majority of sample currencies, including Singapore Dollar, had fallen under the weak form of efficiency.

JEL classifications: F31, G14, C12

Keywords: Exchange Rate, Martingale Difference Hypothesis, Asia – Pacific FOREX Market

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1. INTRODUCTION

Exchange rates play a vital role in a country's level of trade, which is always grave in the world today. The exchange rates are among the most monitored and directorially manipulated for economic actions. It impacts the returns of an investment portfolio and growth of explicit sector, among other determinants of the economy. The Indian rupee, which was on par with the American currency at the time of independence in 1947, got depreciated by a little more than 68 times in the past of 67 years. On 28th August 2013, the Indian Rupee had gone down to an all-time low of 68.825 against the US dollar. **Athukorala, P. (1991) and Athukorala, P., & Menon, J. (1994)** argued that in varying degrees, the exporters maintained competitiveness in world markets, by reducing their port mark-up in the face of an appreciating currency. The Efficient Market Hypothesis predicts the future prices and returns and it is expected to be zero **(Malkiel, B. G., & Fama, E. F., 1970).**

Some studies reveal that nominal exchange rates commonly pursue the random walk process and otherwise follow the martingale difference sequence. There are different models of currency movement, analyzed under the random walk hypothesis and the martingale difference hypothesis. Under both hypotheses, the exchange markets may be at weak-form efficiency so that upcoming changes in foreign exchange rates are unpredictable from previous exchange rate prices or returns **(Al-Khazali, O. M. et al, 2012)**.

The major motivation of this study was to find out whether Asia – Pacific Foreign Exchange Rates confirm the Martingale Difference Hypothesis (MDH). Majority of the studies have investigated the Efficiency Market Hypothesis, with reference to Foreign Exchange Markets, all over the world. The MDH is considered the central part of economic models where the prospects are thought to be sensible **(Dominguez, M. A., & Lobato, I. N., 2003)**. Martingale Difference Hypothesis plays a major role in economic models where the expectations are pretended to be stable. Distinctive methodology adopted varies from linear measures to non-linear measures. The prediction of the movement from the past information of asset returns is also a way to test the MDH **(Salisu, A.A., et al, 2016)**.

MDH deals with a return and not with price trends and it is a common test for assessing the efficiency of the foreign exchange market **(Morrison, W. M. 2009)**. The efficiency of Asia – Pacific Foreign Exchange Market affirmed the Martingale Difference Hypothesis, as it was clearly evidenced to estimate the methods with a number of bootstrap iterations. High power and size of data determined the linear and non-linear measures of Assets price returns respectively **(Salisu, A.A., et al, 2016)**.

Few studies have been conducted on the efficiency of the Asia – Pacific Foreign Exchange Countries **(Salisu, A.A., et al, 2016; Azad, A. S. 2009)**. These studies on African countries (**Salisu, A.A., et al, (2014, 2016). Patrick, 2016**) and European and other countries (**Liko, R., et al (2016), Yang, J et al, (2008), Lazăr, D., et al (2012) and Al-Khazali, O. M., (2006))** focused on a single or group of countries. The foreign exchange rate volatility in Asia – Pacific countries was affected by the exchange rate. Positive exchange rate, may or may not create a significant impact on the exchange rate in all Asian Countries. The aforesaid discussion indicated that the effect of exchange rate on each Asia – Pacific economy needs to

be studied. Hence this paper proposes to explore the Martingale Difference Hypothesis, in ten sample currencies of Asia – Pacific Foreign Exchange Market.

Following the Introduction in Section 1, Section 2 describes the data and summary statistics related to the study, Section 3 discusses the empirical results and Section 4 concludes the study.

2. DATA AND SUMMARY STATISTICS

The empirical results, from different studies, revealed that FX market efficiency could be inconsistent over time due to changes in policies and events **(Salisu, A. A., et al. 2016)**. Hence, the main objective of this study was to re-examine the Asia – Pacific Foreign Exchange Market and to test the Martingale Difference Hypothesis. Exchange rates of selected Asia – Pacific countries were defined here as a domestic currency relative to USD. Rise in Exchange Rate would lead to deflation in the domestic currency concerning USD and vice a versa. For this study, the daily data for the exchange rates of Australian Dollar, Chinese Renminbi, Hong Kong Dollar, Indian Rupee, Indonesian Rupiah, Japanese Yen, Malaysian Ringgit, Singapore Dollar, South Korean Won, and Taiwan Dollar, for the study period from 04.01.2010 to 31.12.2019, were obtained from Pacific Exchange Rate service database. Exchange rates of Asia-Pacific countries, Descriptive statistics (FX returns of selected Asia-Pacific countries), Perron unit root, Residual statistics, Results of the Wild Bootstrap AVR, Automatic Portmanteau Test and Wright's Sign and Rank Test for MDH, were used as the tools, for the analysis.

Table -1. Currency Description

Country	Currency	Code
Australia	Australian Dollar	AUD
China	Chinese Renminbi	CNY
Hong Kong	Hong Kong Dollar	HKD
India	Indian Rupee	INR
Indonesia	Indonesian Rupiah	IDR
Japan	Japanese Yen	JPY
Malaysia	Malaysian Ringgit	MYR
Singapore	Singapore Dollar	SGD
South Korea	South Korean Won	SKW
Taiwan	Taiwanese Dollar	TWD

2.1. Testing of Martingale Difference Hypothesis

As stated earlier this study re-examines the weak-form market efficiency of the ten Asia – Pacific foreign exchange currencies against the U.S. dollar. This study employed the linear measures of the Martingale Difference Hypothesis. If a series did not depend on the past values, it is assumed that it follows the Martingale Difference Sequence. This study used the Wild Bootstrap Test and Wright's Sign and Rank Test for testing the MDH.

3. Discussion of Results

Table - 2 shows the results of descriptive statistics for sample countries (Australia, China, Hong Kong, India, Indonesia, Japan, Malaysia, Singapore, South Korea, and Taiwan), in Asia – Pacific region in respect of exchange rates, during the study period from 04.01.2010 to 31.12.2019. The results of the Table clearly indicate that out of ten sample currencies against USD, Taiwanese Dollar recorded a high mean value of 0.0019 and Singapore Dollar and South Korean Won earned the lowest value of -0.00002 as compared to all other sample

Currencies. Mean values implied that Taiwanese Dollar and Indonesia Rupiah performed well and Singapore Dollar and South Korean Won recorded the worst performance when compared to other currencies. According to the results of standard deviation, as given in the Table, Australia recorded the maximum value of Standard Deviation at **0.0075** and Hong Kong recorded the minimum value of Standard Deviation at **0.0003,** in respect of exchange rate. The values of the skewness of sample currencies should to be in between -3 to +3. It is to be noted that one currency, namely, the Chinese Renminbi, was highly skewed (0.4704) and another currency, namely, Hong Kong Dollar, was least skewed (-0.9818) than that of other samples currencies. The values of Kurtosis, for all the sample currencies, were more than three during the period of study. In other words the data series of sample currencies did follow the peak of the distribution during the study period. P-values of sample currencies were at 0.000. This indicated that the sample currencies were normally distributed during the study period. From Table – 2, the p-values of the unit root test indicated that there was stationarity of sample currencies during the study period. Indonesian Rupiah (0.000), Singapore Dollar (0.0370) and South Korean Won (0.0336) attained a value less than 5% significant level. Thus the currencies of these three (Indonesian Rupiah, Singapore Dollar and South Korean Won) currencies attained stationarity during the sample period.

Table-2 Results of Descriptive Statistics and Unit Root test

Currencies	Descriptive Statistics					Unit Root Test		
	Mean	S.D	Skewness	Kurtosis	p-value	Coefficients	T-statistic	p-value
AUD	0.00002	0.0075	0.1822	6.152	0	-0.0245	-1.2509	0.2111
CNY	0.000001	0.0016	0.4704	15.771	0	0.0301	1.5645	0.1178
HKD	0.00001	0.0003	-0.9818	31.8475	0	0.0251	1.3155	0.1885
INR	0.0001	0.0058	0.0983	5.2569	0	0.0138	0.6993	0.4844
IDR	0.0002	0.005	0.2241	9.1065	0	-0.2251	-11.8162	0.0000
JPY	0.0001	0.0062	0.0749	6.8658	0	0.0046	0.2344	0.8147
MYR	0.0001	0.0045	-0.3092	7.2569	0	0.0252	1.2904	0.1970
SGD	-0.00002	0.0036	0.0712	7.7571	0	-0.0408	-2.0873	0.0370
SKW	-0.00002	0.0063	0.2321	9.4241	0	-0.0413	-2.1327	0.0336
TWD	0.0019	0.0030	-0.3315	7.7776	0	-0.0254	-1.2991	0.1940

Source: Pacific Exchange Rate service database and computed by using E-views

The results of the autocorrelation of residuals, and squared residuals for all the exchange rates of Australia, China, Hong Kong, India, Indonesia, Japan, Malaysia, Singapore, South Korea, and Taiwan, during the study period from 04.01.2010 to 31.12.2019, at lag 5 and lag 10, are given in **Table - 3**. The residuals of autocorrelation at lag 5 show that the Chinese Renminbi, Hong Kong Dollar, Indian Rupee, Indonesian Rupiah, and Taiwan Dollar accepted the presence of conditional heteroscedasticity. At lag 10 of Autocorrelation, the residual revealed that the Japanese Yen was the only currency, which reported absence of conditional heteroscedasticity. In the squared, the residual of sample currencies showed the existence of conditional heteroscedasticity. From the overall analysis, the residual test revealed that the Chinese Renminbi, Hong Kong Dollar, Indian Rupee, Indonesian Rupiah, and Taiwan Dollar confirmed the presence of conditional hetroscedascity during the study period.

Table-3 Results of Residual Diagnostics

Currencies	Q-Statistic(5)	Q-Statistic(10)	Q^2-Statistic(5)	Q^2-Statistic(10)
AUD	4.163	15.690*	147.20***	340.20***
CNY	17.066***	27.340***	154.60***	192.13***
HKD	33.676***	49.538***	136.14***	275.78***
INR	36.087***	39.015***	807.47***	1073.5***
IDR	138.81***	139.93***	64.805***	74.280***
JPY	5.196	12.313	60.332***	106.32***
MYR	8.772	17.647*	339.59***	644.64***
SGD	6.306	24.073***	230.17***	325.51***
SKW	6.640	25.525***	363.33***	646.28***
TWD	9.092*	19.644**	102.08***	157.11***

Source: Pacific Exchange Rate service database and computed by using E-views

Note: *, ** and *** implies a rejection of null hypothesis at 10%, 5% and 1% significant levels respectively.

Table -4 presents the results of the Wild Bootstrap AVR and Automatic Portmanteau tests. It is to be noted that the p-values, above 0.10 indicated the acceptance of the null hypothesis and rejection of the Martingale Difference Hypothesis. From actual p-values of AVR test, Hong Kong Dollar represented highly weak form of efficiency, with the p values of 0.047 and 0.071, obtained for 300 and 500 bootstrap iterations respectively while South Korean Won appeared the least weak form of efficiency, with values of 0.015 and 0.047, obtained after the 300 and 500 bootstraps iterations respectively. In the Automatic Portmanteau Test, the p-values of Indonesian Rupiah were of 0.9396 and 0.9839, obtained from 300 and 500 bootstrap iterations respectively, which showed high weak form of efficiency. Chinese Renminbi and Indian Rupee recorded low weak form of efficiency, with 300 and 500 bootstrap iterations, with p-values of 0.000 and 0.000 respectively, during the study period.

From p-values of AVR test and Automatic Portmanteau Test displayed in **Table - 4**, it is clear that the AP test produced significant values, for all the sample currencies, compared to the AVR test. The currencies of China, South Korea, and India's FX market accepted the Martingale Difference Hypothesis, which indicated that the advisability of changes in the FX market influenced to alter over the period with varies in events and policies.

Table-4 Results of Wild bootstrap AVR and Automatic Portmanteau Test for MDH

Currencies	AVR test (p-value)		Automatic Portmanteau Test (p-value)	
	300	500	300	500
AUD	0.021**	0.051*	0.0712*	0.0043***
CNY	0.039**	0.061*	0.0000***	0.0000***
HKD	0.047**	0.071*	0.3358	0.7946

INR	0.045**	0.071*	0.0000***	0.0000***
IDR	0.022**	0.056*	0.9396	0.9839
JPY	0.028**	0.054*	0.2804	0.4108
MYR	0.046**	0.070*	0.1012	0.0763*
SGD	0.045**	0.071*	0.4720	0.1333
SKW	0.015**	0.047**	0.0178**	0.0172**
TWD	0.032**	0.060*	0.0634*	0.0277**
Source: Pacific Exchange Rate service database and computed by using E-views Note: *, ** and *** implies a rejection of null hypothesis at 10%, 5% and 1% significant levels respectively				

The results of the Wright Sign and Rank Variance Ratio test, with reference to Martingale Difference Hypothesis, are given in **Table - 5**. In the sign test, Australian Dollar, Hong Kong Dollar, Indonesian Rupiah attained significant values at 1%, 5% & 10% for both 300 and 500 iterations. But in the case of the Chinese Renminbi, Japanese Yen and Malaysian Ringgit, the null hypothesis, based on 300 bootstrap iterations, was rejected. Out of ten sample currencies, South Korean Won was the only sample currency, which did not attain significant levels, at the 1%, 5% and 10%, for the 500 bootstrap iterations in the Rank Test. Besides, in the case of the entire sample currencies, except South Korean Won, the martingale difference hypothesis was rejected. From the overall analysis of Wright's Sign and Rank Test, the Martingale Difference Hypothesis was rejected for the Hong Kong Dollar and Indonesian Rupiah, out of all currencies, considered for this study.

Table – 5 Results of Wright Sign and Rank Variance Ratio test for MDH

Currencies	Sign test (p-value)		Rank test (p-value)	
	300	500	300	500
AUD	0.037**	0.100*	0.010***	0.012**
CNY	0.072*	0.218	0.004***	0.009***
HKD	0.007***	0.007***	0.007***	0.006***
INR	0.160	0.460	0.007***	0.006***
IDR	0.011**	0.020**	0.005***	0.008***
JPY	0.003***	0.147	0.006***	0.010***
MYR	0.045**	0.150	0.004***	0.007***
SGD	0.138	0.301	0.005***	0.006***
SKW	0.161	0.430	0.005***	0.520
TWD	0.170	0.406	0.010***	0.008***
Source: Pacific Exchange Rate service database and computed by using E-views Note: *, ** and *** implies a rejection of null hypothesis at 10%, 5% and 1% significant levels respectively.				

Table – 6 shows the compiled form of the results of **Table -4** and **Table -5**. It clearly shows the presence of MDH in selected Asia – Pacific currencies for the study period. It is understood that in the case of Australian Dollar, Martingale Difference Hypothesis was rejected, in both tests and it attained as the best performance currency. This was followed by Chinese Renminbi, which also rejected the MDH. Singapore Dollar was the only currency

which rejected the MDH in AVR test and Rank test and thus attained the Worst Performance. From the overall results, Australia and China were found to be the best country for both investment and international trade. In future, investors are advised to be cautious about trading with Singapore.

Table – 6 Presence of Martingale Difference Hypothesis in selected Asia – Pacific currencies

Currencies	Wild Bootstrap Test				Wright's Rank & Sign test			
	AVR		AP		Sign		Rank	
	300	500	300	500	300	500	300	500
AUD	+	+	+	+	+	+	+	+
CNY	+	+	+	+	+	-	+	+
HKD	+	+	-	-	+	+	+	+
INR	+	+	+	+	-	-	+	+
IDR	+	+	-	-	+	+	+	+
JPY	+	+	-	-	+	-	+	+
MYR	+	+	-	+	+	-	+	+
SGD	+	+	-	-	-	-	+	+
SKW	+	+	+	+	-	-	+	-
TWD	+	+	+	+	-	-	+	+

Source: Compiled from Table 4 and Table 5
Note: + denotes the rejection of MDH, - indicates the acceptance of MDH

4. CONCLUSION

This study examined the Martingale Difference Hypothesis, for ten selected Asia-Pacific foreign exchange currencies. Asia – Pacific FOREX market has been one of the fastest-growing FX markets in the world. It engages the return sequence of the related foreign exchange rate and therefore, the statistical properties of the series were examined. This study employed recent techniques in variance-ratio and ranks and sign tests, both of which involved the wild bootstrapping procedure. According to the Wild Bootstrap Test, the forex markets of Hong Kong, Indonesia, Japan, and Singapore did not come under the weak form of efficiency for the full sample period. The results of this study suggested that (i) Singapore Dollar, which was the most of the currency that did not behaved in a random walk manner and rejected the martingale difference hypothesis, ii) the Australian dollar and the Chinese Renminbi were not found to be a weak form of efficiency in Asia – pacific Foreign Exchange Market (Not Rejection of MDH) and (iii) the other sample currencies, under this study, reported little distinct development towards weak-form efficiency. The findings of this study revealed that the investors in Australia and China may not receive abnormal profits from the speculating behaviour and arbitrating activities. The results of this study indicated that the Singapore Dollar attained weak form of efficiency, compared with other sample currencies. In future, Singapore has to create policy towards relaxation through intervention of foreign exchange market and need to support and enlarge roles of foreign banks. Economies of any country

need to develop necessary competence to accept the fluctuations of exchange rates **(Azad, A. S., 2009)**.

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