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Efficiency of the Foreign Exchange Markets of South Asian Countries

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C O N T E N T S

List of Tables

ABSTRACT

The purpose of this study is to test for the weak and semi-strong form efficiency of four of the seven foreign exchange markets of South Asia; namely, Pakistan, India, Sri Lanka and Bangladesh; using three bilateral foreign exchange rates. Weak-form efficiency is examined using unit root tests (Augmented Dickey Fuller and Phillips Perron), while semi-strong form efficiency is tested using co-integration and Granger causality tests. Variance Decomposition Analysis is also employed to study the trends of the exchange rates beyond the sample period. Average monthly spot exchange rates for the US dollar, the British pound and the Japanese yen for the period January 1995 to December 2010 are used. Results of indicate that all four foreign exchange markets are consistent with the weak-form of the Efficient Market Hypothesis. However, the results provide evidence against the semi-strong version of the Efficient Market hypothesis. The results of cointegration after introducing the multiplicative dummies for regime shift further confirms the markets are inefficient in semi-strong form. The results of all three tests signify that the movement of one or more exchange rates can be forecasted from the movements of the other exchange rates; implying that in this case the participants of the foreign exchange markets of all four countries can devise strategies for profitable earnings in both the short run and long run. These results have important implications for the government policy makers and participants in the foreign exchange markets of the countries included in the present study.

JEL classification: F31, G14

Keywords: Exchange Rates, Market Efficiency, Cointegration, Granger Causality, South Asian Countries

1. INTRODUCTION

The efficient market hypothesis (EMH) was proposed as an academic concept of study in the 1960s by Eugene Fama. He describes an efficient market as a market in which prices fully reflect all available information. To outperform such a market through buying and selling securities can be a game of chance but not skill. Later on Fama (1991) divided market efficiency into three categories: weak, semi-strong and strong. Initially, the term 'efficient market' was used for the stock market only, but in time it became generalised to cover other asset markets also.

When applying the hypothesis to the foreign exchange market, Fama (1984) states that if it fully reflects all available information then devices such as trading rule or statistical techniques cannot be used to predict a pattern in the foreign exchange movements.

When testing for market efficiency (or inefficiency), there are basically three indicators which are tested using different econometric procedures. The first is whether the spot exchange rate follows a random walk; the second is whether the forward exchange rate of a currency is an unbiased predictor of the future exchange rate and the last is whether there exists a co-integrating relationship among the different currencies.

Despite its popularity, and the fact that it is considered a foundation stone of modern financial theory, EMH is a controversial notion that has been oft disputed. Evidences of market inefficiency discovered by various researchers show that information alone does not cause a change in price. These evidences are referred to as anomalies.

The informational efficiency of stock prices or in the case of foreign exchange manifests in two main ways. First, the investors are concerned whether different trading strategies can produce excess returns (i.e., if they will be able to successfully "beat the market") and second, if currency prices precisely reflect all available information.

Efficient market hypothesis is a topic of intense debate among financial professionals and academics. The implications of the hypothesis are truly profound. Theoretically speaking, in case of foreign exchange markets, it is the

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profit opportunities in the form of “overvalued” and “undervalued” currencies that motivate investors to trade which moves the prices of currencies towards the present value of future cash flows. Thus, investment analysts’ search for mispriced currencies and their subsequent trading makes the market efficient and causes prices to reflect intrinsic values. Because new information is randomly unfavourable or favourable relative to expectations, changes in currency prices in an efficient market should be random, resulting in the well-known random walk. Investors, therefore, cannot earn abnormally high risk-adjusted returns in an efficient market where prices reflect the intrinsic value.

The debate about efficient markets has resulted in numerous studies that attempt to find out whether specific markets are in fact “efficient,” and if so, to what degree. Various methodologies have been adopted by the researchers to test for market efficiency. Most of the empirical studies applied the univariate and multivariate co-integration techniques or OLS estimation to test for the semi-strong form of efficiency. To test for the weak-form, various tests have been employed, including the random walk model, unit root tests (Augmented Dickey Fuller and Phillips Perron), variance ratio test and autocorrelation tests. The results of all these tests provide mixed evidence.

The main aim of this dissertation is to study two of the main forms of the EMH with respect to foreign exchange markets of four major South Asian countries; namely, Pakistan, India, Bangladesh and Sri Lanka. The weak form of efficiency is tested using two unit root tests—Augmented Dickey Fuller and Phillips Perron. The semi strong form of efficiency is tested using Johansen’s Co-integration, Granger Causality test and Variance Decomposition Analysis.

The plan of the study is as follows: Section 2 provides the brief overview of the foreign exchange market. The literature review is presented in Section 3. The methodology and data is discussed in Section 4. Section 5 presents the empirical results. The conclusion and policy implications are offered in the last section.

2. OVERVIEW OF SOUTH ASIAN FOREIGN EXCHANGE MARKETS

The past five decades have witnessed Pakistan’s foreign exchange regime moving towards an uncontrolled market-oriented direction: The Pak rupee was linked to the Pound Sterling till 1971, and later to the US Dollar due to the increasing economic influence of the United States. However, since 1982 onwards a controlled floating exchange rate regime was adopted, with the Pak rupee tied to a band of trade-weighted currencies. Then from mid 1994, the Pak rupee became convertible for current international transactions after accepting the IMF Articles of Agreement. After the nuclear explosion in 1998, trade sanctions were imposed on Pakistan. In order to reduce the pressure on official reserves and to prevent the economy from the undesirable effects of the sanctions, a multiple exchange rate system was introduced. This included an official rate (linked to the US Dollar), a Floating Interbank Rate (FIBR), and a compound rate that combined the official and FIBR rates. As the economy recovered from the economic crisis, the three exchange rates were integrated and linked to the US Dollar within a definite band width. However, effective from 2000, the State Bank is following a floating exchange rate system.

The origin of the foreign exchange market of India, as we know today, can be traced back to the year 1978, when the banks in India were allowed to embark on intra-day trade in foreign exchange. Until the middle of December 1973, Indian Rupee was linked to the Pound Sterling, except for the devaluations of the currency in the years 1966 and 1971. Later it was tied to the US Dollar until the year 1975. At this point India took up a managed floating exchange rate regime with the rupee coupled with a trade-weighted band of currencies (i.e. the currencies of India's major trading partners). However, in the early 1990's, under the increasing weight of trade deficit the Reserve Bank of India (RBI) was forced to take on a downward regulation of the Rupee. This regulation led to the introduction of the Liberalised Exchange Rate Management System (LERMS) in early 1992 and hence the implementation of, for the first time, a dual exchange rate regime in India. Eventually this led to the substitution of the Liberalised Exchange Rate Management System (LERMS) in 1993 by a unified exchange rate regime. The result was a market-based exchange rate system. Since then, the rate of exchange for the Indian rupee is mainly determined by the market forces of demand and supply. In recent years the principles of cautious supervision and administration of exchange rates with flexibility, without a set target, have guided the exchange rate strategy.

The Bangladesh Bank and the Ministry of Finance together govern the exchange rate policy of Bangladesh. However, certain exchange rate transactions are assigned to the authorised commercial banks. The Bangladeshi Taka (BDT) replaced the Pakistani Rupee in 1972, as the official currency of Bangladesh. From 1972 till 1979, the Taka was pegged to the British Pound Sterling and later, from 1980 to 1982, to a band of currencies of its major trading partners with the British Pound as the superseding currency. However, this changed in 1983 and till 1999 the Taka remained linked to a band of trade-weighted currencies, but this time with the US Dollar as the overruling currency. Then for the next three years, from 2000 to 2003, Bangladesh followed an adjustable pegged exchange rate regime. Starting May 2003, Bangladesh replaced the adjustable pegged exchange rate regime with a floating exchange rate system. This conversion to a floating exchange rate regime was smooth with the first year considered as a 'honeymoon' period as the exchange rate in this period remained largely steady. Subsequently it depreciated gradually till 2006. But since then, it has remained quite stable. Therefore, the floating exchange rate regime in Bangladesh is considered to be both volatile and stable.

Sri Lanka essentially followed an unhindered policy on imports in 1948 and maintained a positive foreign trade policy but the downfall in the export earnings of Sri Lanka led to the introduction of the Exchange Control Act in 1953. The purpose of this act was to place limitations on the movement of foreign currency. Then, in 1952, Sri Lanka’s exchange rate was pegged to the British Pound. Later in 1961, a meticulous exchange rate system was introduced in the wake of balance of payments problems. Permits that acted as exchange licences were granted by the regulator of international trade. In 1970, Sri Lanka adopted a dual exchange rate regime in addition to the exchange and import controls. This continued till 1977 when the exchange rate was liberalised as a result of new economic reforms, and several exchange rate controls were lifted. Since the end of the dual exchange rate system, the Sri Lankan rupee had been allowed to float freely in response to international developments and the position of the balance of payments. The resulted in the devaluation of the currency. Finally, in 2001 the Central Bank of Sri Lanka announced an independent floating exchange rate regime.

3. LITERATURE REVIEW

The efficiency of foreign exchange markets of countries across the globe have been analysed by various researchers. Some of the earliest and most important researches include that of Hakio (1981) and Fama (1984).

Hakio (1981) examined five exchange rates against US dollar for a period of five years during the mid 1970s. The result of this study implied the rejection of the EMH. Similarly, Fama (1984) examined the efficiency of nine exchange rates against the US dollar. Monthly data were subjected to OLS estimation. The findings again rejected the efficiency hypothesis.

Hideki (2006) analysed empirically the efficiency hypothesis on the renminbi rates in the Hong Kong FX market. His results showed a rejection of the hypothesis implying that the renminbi rates are not unbiased predictors of the future spot rates. Rose, *et al.* (2008) analysed the weak form efficiency of the foreign exchange market of Kenya and found it to be inefficient. They attributed their rejection of the hypothesis to significant patterns in the exchange rates, trend stationarity and autocorrelation in foreign exchange returns. Similarly, Kimani (2007) applied the unit root tests to the Kenya Shilling per US Dollar spot rate and found the proof for a unit root after differencing the data twice. He concludes that autocorrelation could be because of the presence of irrational market participants.

Some others who have rejected the efficiency hypothesis for developed economies include Domowitz and Hakio (1985) and Hodrick and Srivastava (1986). In these cases, the failure of efficiency hypothesis has been attributed to numerous factors, for instance the measurement of technical trading rules, the existence of risk premiums in forward rates, experimental irregularities in regression tests, negative correlation between the expected future spot rates and forward risk premia, and the lack of use of suitable econometric procedures.

A popular method to test the semi-strong efficiency is co-integration. The existence of co-integration among different exchange rates means that it is possible to predict one exchange rate from another, a violation of the efficient market hypothesis. Baillie and Bollerslev (1989) applied the multivariate Johansen procedure to find co-integration in a sample of seven exchange rates, for the first half of 1980s using daily rates. Their study confirmed the presence of co-integration among the spot rates and rejected the efficiency hypothesis. In the case of Asian foreign exchange markets, Jeon and Seo (2003) investigated the soundness of the efficiency hypothesis by applying the co-integration tests to the daily data of the spot and forward rates of four countries—Korea, Thailand, Malaysia and Indonesia, for the period 1996-2001. Their results were consistent with the efficiency hypothesis except for the brief period immediately after the July 1997 crisis. However, a few other contributions that used co-integration could not provide a satisfactory result for foreign exchange efficiency.

A very interesting study was conducted by Oh, *et al.* (2007). They investigated the market efficiency of the *Financial Times* series of the foreign exchange rates for 17 countries, including both developed and developing nations. Their results indicate higher market efficiency for the European and North American foreign exchange markets than other foreign exchange markets under investigation. They also found that the efficiency of markets with low liquidity, such as some of the Asian markets, improved significantly after the Asian currency crisis.

Although there have been numerous studies investigating the efficiency of foreign exchange markets for countries all around the globe, there is a shortage of research on South Asian markets. With reference to India, Chakrabarti (2005) applied unit root tests—both the Augmented Dickey Fuller and Phillips Perron—to test whether the Indian rupee followed a random walk. The results showed that the rupee to dollar exchange rate, for the period 1997 to 2002, failed to reject the null hypothesis of a unit root (that is random walk) at the 5 percent confidence level, although they both reject the same at the 10 percent level. However, when an extended period from 1997 to 2004 is considered, both tests credibly reject the null hypothesis of a random walk at 1 percent levels. This result supports the weak form of efficient market hypothesis. Similarly, Nath (2006) tested the efficiency of the foreign exchange market of India using data for March 1993 to May 2004. The results of Augmented Dickey Fuller (ADF) test implied that the weak form of the market efficiency could not be rejected. The results also showed the acceptance of the mean reversion hypothesis. No evidence was found of the `day effect' although all the “days' mean” returns were significantly non-zero. Further, it was realised that the AR(2) and AR(3) models tracked the market volatility better than the other models.

Wickremasinghe (2004) investigated the weak and semi-strong form of efficiency for the foreign exchange market of Sri Lanka using six bilateral foreign exchange rates. Unit root tests were employed to test for the weak-form while semi-strong form of efficiency was tested using Johansen's co-integration, Granger causality test and variance decomposition analysis. The results of their study implied that the Sri Lankan foreign exchange market supports the weak-form. However, the results presented evidence against the semi-strong version of the EMH.

Recently, Noman and Ahmed (2008) applied various unit root tests and the variance ratio test developed by Lo and MacKinlay (1988), to test the weak-form efficiency of seven SAARC countries; namely, Pakistan, India, Bangladesh, Sri Lanka, Bhutan, Nepal and Maldives. They employed monthly data for each of these markets for the period 1985 to 2005. The results of their study supported the weak-form of market efficiency. On the other hand, Ahmed, *et al*. (2005) found that the South Asian foreign exchange markets were not efficient in weak form in their period of study. They examined the EMH for South Asian markets for the period 1999-2004. The descriptive statistics for exchange rates showed that the frequency distributions were not normal. Though the return series on exchange rates were found to be stationary but the ACFs were highly significant at various lags and Ljung-Box (Q) test rejected the joint null hypothesis of zero auto-correlations. The non-parametric Run-test also indicated rejection of the random walk model. Further, the K-S Z-test indicated that the frequency distribution of the underlying series did not fit normal distribution and the BDS-test showed evidence of non-linear relationship in the return series.

4. DATA AND METHODOLOGY

One of the objectives of the Agreement of South Asian free Trade (SAFTA) is to facilitate cross-border trade among SAARC countries.[1] Foreign exchange efficiency plays a role in establishing a framework for that purpose. The methodology adopted to test the efficiency is a variation of the model adopted by Wickremasinghe (2004). This section discusses the methodological framework and sources of data.

The data employed in this study consists of the average monthly spot exchange rates for the US dollar (USD), the British pound (BP) and the Japanese yen (JPY) against the Pak Rupee (PKR), the Indian Rupee (INR), the Sri Lankan

[1]Agreement is signed on Jan 6, 2004 among seven SAARC countries: Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Linka.

Rupee (LKR) and the Bangladeshi Taka (BDT) for the period January 1995 to December 2010.[2] All the foreign exchange series are converted into natural logarithmic transformation. The data set was obtained from the website of Pakistan's foreign exchange market (www.forex.pk).

This study applies unit root tests (Augmented Dickey-Fuller and Phillips-Perron), Johansen (1991, 1995) multivariate co-integration and Granger (1969) causality tests to examine the EMH in relation to forex markets of India, Bangladesh, Sri Lanka and Pakistan. The Variance Decomposition Analysis is used to detect causality beyond the sample period. Given below is a brief explanation of these tests.

4.1. Unit Root Tests

Unit root tests are conducted to test whether exchange rates follow a random walk, that is to say the exchange rates are weak-form efficient and also to test for the order of integration of the variables. Two tests that are carried out for this purpose are the Augmented Dickey-Fuller (1979, 1981) (ADF) test and the Phillips-Perron (1988) (PP) test. The augmented Dickey-Fuller test is carried out by estimating the following equation:

$$\Delta x_t = a_0 + b_0 x_{t-1} + \Sigma c_0 \Delta x_{t-1} + w_t \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

Where Δ is the difference operator, a_0, b_0, c_0 are coefficients to be estimated, x is a variable whose unit roots are examined and w is the error term. The null hypothesis for this is $b_0 = 0$ (i.e. the series is non-stationary) against the alternative hypothesis $b_0 < 0$ (i.e. the series is stationary).

The Phillips-Perron test is based on the following equation:

$$\Delta y_t = \alpha + \beta y_{t-1} + \varepsilon_t \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

Where Δ is the difference operator, y is the variable of interest, α is a constant, β is the slope, ε is the error term and t is the transcript for time.

4.2. Co-integration and Granger Causality Tests

Co-integration and Granger causality tests are conducted to test the semi-strong form of the EMH. One condition for the co-integration tests is that the variables in the co-integrating equation must be integrated of the same order. Johansen's co-integration is based on the following vector auto regression equation:

$$y_t = A_1 y_{t-1} + \ldots + A_t y_{t-p} + B x_t + \varepsilon_t \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

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[2] These are the major trade partners in the SAARC region.

Where y_t is a k-vector of non-stationary *I(1)* variables, x_t is a vector of deterministic variables and ε_t is a vector of innovations.

The Granger causality test is useful in finding whether one time-series (x_t) can be predicted by another time-series (y_t). The test is carried out by regressing x_t on its lagged values and the lagged values of y_t. If the results indicate that x_t can be predicted by y_t, it is said that y_t Granger causes x_t. However, the Granger causality tests are used to make inferences within the sample period only.

4.3. Variance Decomposition Analysis

To detect causality beyond the sample period, the variance decomposition analysis is employed. In this analysis, the variance of the forecast error of a particular variable is divided into proportions creditable to shocks or innovations in each variable in the system as well as its own.

5. EMPIRICAL RESULTS

The results of testing the efficiency hypothesis for important South Asian currencies against three international currencies are presented in this section.

As a first step, the order of integration for each of the three exchange rates used is determined for all four currencies. This was done by using the Augmented Dickey Fuller (ADF) and Phillips Perron (PP) tests previously described. The tests are carried out at the levels and first difference of the natural log values, once by including a constant and then by including a constant and a time trend in the test equations. The level of significance for all currencies is one percent. The results of these tests are tabulated below. Tables 1 and 2 report the ADF and PP test results for the Pak Rupee (PKR), Tables 3 and 4 report the results for the Indian Rupee (INR), Tables 5 and 6 report the results for the Sri Lankan Rupee (LKR) and Tables 7 and 8 report the test results for the Bangladeshi Taka (BDT).

Table 1

Augmented Dickey Fuller for PKR

Currency	Level, Constant, No Trend	Level, Constant and Trend	1st Difference, Constant, No Trend	1st Difference, Constant and Trend
USD	–1.426 (1)	–2.107 (1)	–8.857 (0)*	–8.856 (0)*
BP	–2.534 (5)	–2.901 (5)	–8.281 (6)*	–8.258 (6)*
JPY	2.713 (5)	–1.652 (5)	–7.819 (4)*	–8.608 (4)*

Table 2

Phillips Perron for PKR

Currency	Level, Constant, No Trend	Level, Constant and Trend	1st Difference, Constant, No Trend	1st Difference, Constant and Trend
USD	–2.483 (3)	–1.163 (2)	–8.696 (3)*	–9.095 (1)*
BP	–1.919 (6)	–2.236 (3)	–10.005 (7)*	–10.148 (8)*
JPY	–1.827 (3)	–2.097 (2)	–8.322 (6)*	–8.302 (6)*

Table 3

Augmented Dickey Fuller for INR

Currency	Level, Constant, No Trend	Level, Constant and Trend	1st Difference, Constant, No Trend	1st Difference, Constant and Trend
USD	–1.366 (4)	–1.929 (5)	–8.857 (0)*	–8.856 (0)*
BP	–1.488 (8)	–2.928 (4)	–7.991 (11)*	–8.692 (13)*
JPY	2.033 (12)	–0.924 (10)	–9.533 (13)*	–10.249 (17)*

Table 4

Phillips Perron for INR

Currency	Level, Constant, No Trend	Level, Constant and Trend	1st Difference, Constant, No Trend	1st Difference, Constant and Trend
USD	–2.588 (3)	–1.586 (3)	–5.197 (2)*	–5.547 (3)*
BP	–1.789 (2)	–2.009 (2)	–9.306 (1)*	–9.384 (1)*
JPY	–0.915 (5)	–2.329 (10)	–7.539 (4)*	–7.508 (4)*

Table 5

Augmented Dickey Fuller for LKR

Currency	Level, Constant, No Trend	Level, Constant and Trend	1st Difference, Constant, No Trend	1st Difference, Constant and Trend
USD	–1.239(2)	–1.217 (2)	–10.608 (1)*	–10.659 (1)*
BP	–1.316 (1)	–1.697 (1)	–10.165 (0)*	–10.175 (0)*
JPY	–0.236 (1)	–3.154 (1)	–10.679 (0)*	–10.716 (0)*

Table 6

Phillips Perron for LKR

Currency	Level, Constant, No Trend	Level, Constant and Trend	1st Difference, Constant, No Trend	1st Difference, Constant and Trend
USD	–1.092 (2)	–0.401 (2)	–9.919 (1)*	–9.974 (1)*
BP	–0.773 (0)	–2.599 (0)	–9.773 (1)*	–9.738 (1)*
JPY	–0.711 (1)	–2.359 (1)	–8.906 (0)*	–8.871 (0)*

Table 7

Augmented Dickey Fuller for BDT

Currency	Level, Constant, No Trend	Level, Constant and Trend	1st Difference, Constant, No Trend	1st Difference, Constant and Trend
USD	–1.168 (3)	–0.787 (2)	–9.244672 (6)*	–9.297064 (7)*
BP	–0.762 (9)	–2.618 (2)	–11.31256(10)*	–11.31696(10)*
JPY	–0.526 (0)	–2.066 (1)	–8.905220 (3)*	–8.870256 (3)*

Table 8

Phillips Perron for BDT

Currency	Level, Constant, No Trend	Level, Constant and Trend	1st Difference, Constant, No Trend	1st Difference, Constant and Trend
USD	–1.487 (9)	–1.364 (7)	–10.720 (12)*	–10.711 (13)*
BP	–1.199 (5)	–1.681 (5)	–10.129 (3)*	–10.135 (3)*
JPY	–0.041 (4)	–2.969 (3)	–10.461 (6)*	–10.457 (7)*

Notes: [1]BP, JPY and USD denote the nominal exchange rates for British Pound, Japanese yen and the US dollar respectively.

[2]The null and the alternative hypotheses for both the tests respectively are H0: series is non-stationary and H1: series is stationary.

[3]* Implies significance at 1 percent and 5 percent levels.

[4]Figures in brackets indicate the number of lags of the dependent variable used to obtain white noise residuals.

[5]For the ADF test the lags of the dependent variable are determined using Akaike Information Criterion (AIC) and for the PP test the lags were determined by Newey-West using Bartlett Kernel.

Table 9

Johansen Co-integration Test Results for PKR

Null Hypothesis	Trace Statistics	5% Critical Value	1% Critical Value	Maximal Eigen Value Statistics	5% Critical Value	1% Critical Value
0=r	82.2.45*	47.85	51.07	54.461*	27.58	29.81
1≤r	27.743	19.96	24.60	20.178	21.13	23.20
2≤r	7.565	15.49	16.97	5.727	14.26	15.97

Table 10

Johansen Co-integration Test Results for INR

Null Hypothesis	Trace Statistics	5% Critical Value	1% Critical Value	Maximal Eigen Value Statistics	5% Critical Value	1% Critical Value
0=r	28.2122*	42.44	48.45	14.773*	25.54	30.34
1≤r	13.4390	25.32	30.45	9.533	18.96	23.65
2≤r	3.9056	12.25	16.26	3.906	12.52	16.26

Table 11

Johansen Co-integration Test Results for LKR

Null Hypothesis	Trace Statistics	Prob	1% Critical Value	Maximal Eigen Value Statistics	5% Critical Value	1% Critical Value
0=r	27.85*	0.30	48.45	18.3225*	25.54	30.34
1≤r	9.5328	0.91	30.45	6.8474	18.96	23.65
2≤r	2.6853	0.87	16.26	2.6853	12.52	16.26

Table 12

Johansen Co-integration Test Results for BDT

Null Hypothesis	Trace Statistics	5% Critical Value	Prob	Maximal Eigen Value Statistics	5% Critical Value	Prob
0=r*	74.02*	54.08	0.17	45.01*	28.58	0.19
1≤r	28.91	35.19	0.23	18.56	22.30	0.36
2≤r	10.36	20.26	0.27	7.27	15.99	0.27

Notes for the above tables:

[1]BP, JPY and USD denote the nominal exchange rates for British Pound, Japanese yen and the US dollar respectively.

[2]* Indicates the number of co- integrating equations corresponding to that row of the table.

[3]Two lags included in the vector auto regressions are determined using the Likelihood Ratio (LR) test.

From the results of both the Augmented Dickey Fuller and the Phillips Perron tests for the four currencies, it can be seen that all three exchange rates are not stationary in their levels but become stationary when they are first differenced. These results are in line with the weak-form of market efficiency. Hence, it can be concluded that the foreign exchange markets of Pakistan, India, Sri Lanka and Bangladesh are efficient in terms of the weak form of EMH. That is to say that past exchange rates cannot be used to predict future exchange rates and hence no trading rule can be devised to gain consistently by trading in the foreign exchange market.

Once it has been established that all variables are integrated of the same order, we move on to the next step, that is, to find a co-integrating relationship between the variables. The next four Tables 9, 10, 11 and 12 report the Johansen co-integration test results carried out to test for long-run co-movement among the three exchange rates, for all four currencies. The co-integrating properties are examined using two test statistics, trace and maximum Eigen value. The values of trace statistics are given in column two, with five and one percent critical values in columns three and four, respectively. Similarly the values of maximum Eigen value are shown in column five, with five and one percent critical values in columns six and seven, respectively.

The results of both the trace statistics and the maximum Eigen value statistics show no evidence of a co-integrating relationship among the three exchange rates for all four currencies. That is to say, the value of one currency cannot be used to predict the value of another, indicating that the foreign exchange markets of Pakistan, India, Sri Lanka and Bangladesh are not efficient in terms of the semi-strong form. Nevertheless, the results of co-integration test are not conclusive.

The effect of regime shift in the foreign exchange policy on the long run relationship between the three international currencies is examined on the South Asian countries. For Pakistan, the three exchange rates were integrated and linked to the US Dollar within a definite band width effective from 2000, therefore, the dummy is constructed which takes value 1 for the period 2000 onwards and zero otherwise. Bangladesh has followed an adjustable pegged exchange rate regime from May 2003 and the dummy takes value one for the period 2003 onwards and zero otherwise. In case of Sri Linka a dummy is introduced which takes value 1 for the period 2001 and onwards and zero otherwise as in 2001 the Central bank of Sri Lanka announced an independent floating exchange rate regime. All these dummies are incorporated in the VAR model by multiplying with the exchange rates of the respective country and co-integration is tested by Johansen co-integration method. The results reported in Tables 13, 14, 15 indicate co-integration exists for all the three countries based on trace statistics and maximum Eigon values.

Table 13

Johansen Co-integration Test Results for PKR with Regime Shift

Null Hypothesis	Trace Statistics	5% Critical Value	Prob	Maximal Eigen Value Statistics	5% Critical Value	1% Critical Value
0=r*	204.89*	117.71	0.00	79.82*	44.49	0.00
1≤r*	125.07*	88.80	0.00	62.72*	38.33	0.00
2≤r	62.36	63.87	0.03	24.91	32.12	0.29
3≤r	37.43	42.92	0.16	18.43	25.82	0.35
4≤r	19.01	25.87	0.28	12.18	19.39	0.40
5≤r	6.83	12.52	0.36	6.83	12.52	0.36

Table 14

Johansen Co-integration Test Results for LKR with Regime Shift

Null Hypothesis	Trace Statistics	5% Critical Value	Prob	Maximal Eigen Value Statistics	5% Critical Value	1% Critical Value
0=r*	117.71*	88.60	0.00	44.50*	30.81	0.00
1≤r	57.80	88.80	0.71	20.84	38.33	0.31
2≤r	36.95	63.88	0.73	17.14	32.11	0.55
3≤r	19.81	42.91	0.96	9.78	25.82	0.97
4≤r	10.03	25.87	0.92	7.31	19.38	0.88
5≤r	2.72	12.51	0.91	2.72	12.51	0.91

Table 15

Johansen Co-integration Test Results for BDT with Regime Shift

Null Hypothesis	Trace Statistics	5% Critical Value	Prob	Maximal Eigen Value Statistics	5% Critical Value	Prob
0=r*	103.85*	97.50	0.00	40.96*	30.05	0.00
1≤r	67.45	76.97	0.21	28.27	34.81	0.24
2≤r	39.45	54.07	0.51	20.74	28.58	0.37
3≤r	18.44	35.19	0.81	9.21	22.29	0.89
4≤r	9.23	20.26	0.71	6.37	15.89	0.74
5≤r	2.82	9.16	0.60	2.85	9.16	0.61

Notes for the above tables:

[1]BP, JPY and USD denote the nominal exchange rates for British Pound, Japanese yen and the US dollar respectively. Multiplicative Dummy variables are used as for regime shift in exchange rate for each country.

[2]* Indicates the number of co- integrating equations corresponding to that row of the table.

[3]Two lags included in the vector auto regressions are determined using the Likelihood Ratio (LR) test.

The regime changes have not affected the results indicating that the foreign exchange markets of Pakistan, India, Sri Lanka and Bangladesh are all not efficient in terms of the semi-strong form.[3]

Nevertheless, the results of co-integration test are not conclusive. To further check for the presence of any relationship between the variables, we proceed to carry out the Granger Causality test. The results of which are tabulated below.

F-Statistics and probability values show the presence of various causal relationships in Tables 16, 17, 18 and 19. In the case of Pakistan, there exists

[3]Separate co-integration analysis for the different exchange rate regime based on sub-samples will give similar results.

only one causal relationship from the US Dollar to the Japanese Yen. For India, again there is evidence of only one causal relationship from the Japanese Yen to the US Dollar. However, for Sri Lanka two causal relationships are found; one from the US Dollar to the Japanese Yen and one from the British Pound to the Japanese Yen. Lastly, for Bangladesh, there is evidence of the existence of only one causal relationship, that is, from the British Pound to the Japanese Yen. The existence of causal relationships indicates that one exchange rate can be predicted by one or more of the other exchange rates. These results provide evidence against semi-strong form of the EMH.

Table 16

Granger Causality Results for PKR

Null Hypothesis	F-Statistic	Probability
BP does not Granger Cause USD	0.91476	0.40254
USD does not Granger Cause BP	0.42059	0.65733
JPY does not Granger Cause USD	0.72831	0.48418
USD does not Granger Cause JPY	3.25131	0.04110*
JPY does not Granger Cause BP	1.16745	0.31360
BP does not Granger Cause JPY	1.07460	0.34370

Table 17

Granger Causality Results for INR

Null Hypothesis	F-Statistic	Probability
BP does not Granger Cause USD	0.76697	0.46659
USD does not Granger Cause BP	0.48955	0.61407
JPY does not Granger Cause USD	3.65273	0.02873*
USD does not Granger Cause JPY	2.00412	0.13909
JPY does not Granger Cause BP	0.62356	0.53769
BP does not Granger Cause JPY	1.11999	0.32953

Table 18

Granger Causality Results for LKR

Null Hypothesis	F-Statistic	Probability
BP does not Granger Cause USD	0.86576	0.46092
USD does not Granger Cause BP	1.34492	0.26302
JPY does not Granger Cause USD	0.49176	0.68865
USD does not Granger Cause JPY	2.98794	0.03379*
JPY does not Granger Cause BP	0.91112	0.43782
BP does not Granger Cause JPY	2.19088	0.09256*

Table 19

Granger Causality Results for BDT

Null Hypothesis	F-Statistic	Probability
USD does not Granger Cause BP	0.96650	0.38246
BP does not Granger Cause USD	1.10624	0.33313
JPY does not Granger Cause BP	0.21426	0.80735
BP does not Granger Cause JPY	4.53996	0.01198*
JPY does not Granger Cause USD	0.01764	0.98252
USD does not Granger Cause JPY	2.30015	0.10330

Notes for the above tables:

[1]BP, JPY and USD denote the nominal exchange rates for British Pound, Japanese yen and the US dollar respectively.

[2]*Implies the rejection of the null hypothesis.

[3]Two lags included in the vector auto regressions are determined using the Likelihood Ratio (LR) test.

However, since Granger causality test can only be used to test causality within the sample period, therefore, to draw conclusions about causality beyond the period of study, the variance decomposition analysis is applied. Results of the analysis are tabulated below. Columns three through five explain how much of an exchange rate's own shock is described by the movements in its own variance over the forecast horizon (i.e., 60 months).

According to the results reported in Table 20, USD explains up to 89 percent of its variance and JPY explains up to 10 percent of the remaining 11 percent, even after the 60 months following the once only shock. For BP, it explains up to 81 percent of its own variance and the major proportion of the remaining 19 percent is explained by USD. On the other hand, JPY explains almost 59 percent of its own variance. However, in the case of JPY, even after the 60 month's period, almost 40 percent of its variance is explained by USD.

Table 20

Results of Variance Decomposition for PKR

	Relative Variance	Percentage of Forecast Variance Explained by Innovations in		
Months	in	ΔUSD	ΔBP	ΔJPY
12	ΔUSD	99.06019	0.819439	0.120367
24		97.76779	1.028143	1.204069
36		95.50652	1.148021	3.345464
48		92.60493	1.234707	6.160363
60		89.39449	1.301063	9.304446
12	ΔBP	3.501577	95.36322	1.135203
24		5.735830	91.84725	2.416917
36		7.708470	88.46301	3.828515
48		5.519468	85.14846	5.332072
60		11.22712	81.87451	6.898371
12	ΔJPY	26.36398	1.370513	85.15049
24		31.20779	1.501492	67.29072
36		34.67093	1.558542	63.77052
48		37.31497	1.592506	61.09252
60		39.37096	1.615214	59.01383

As results presented in Table 21 illustrate, USD explains up to 96 percent of its variance even after the 60 months following the once only shock. For BP, it explains up to 58 percent of its own variance and out of the remaining 42 percent, 25 percent is explained by USD and the rest 17 percent by JPY. However, when JPY is considered, almost 55 percent of its variance is accounted for by its own variance and 41 percent of it by USD.

Table 21

Results of Variance Decomposition for INR

Months	Relative Variance in	Percentage of Forecast Variance Explained by Innovations in		
		ΔUSD	ΔBP	ΔJPY
12	ΔUSD	97.30068	1.555201	1.144123
24		97.41755	1.629060	0.953386
36		97.16355	1.532738	1.303715
48		96.95681	1.450308	1.592886
60		96.85075	1.410564	1.738689
12	ΔBP	14.52139	74.97713	10.50148
24		18.05578	66.19021	15.75401
36		21.35376	61.22681	17.41942
48		23.55848	58.87527	17.56625
60		24.81028	57.80173	17.38799
12	ΔJPY	32.08884	1.126395	66.78477
24		36.38854	2.478862	61.13260
36		38.85135	3.464217	57.68444
48		40.24932	3.882079	55.86860
60		41.02467	4.005670	54.96966

As the results given in Table 22 show, USD explains up to 89 percent of its variance and BP explains up to 10 percent of the remaining 11 percent, even after the 60 months following the once only shock. When BP is considered, it explains up to only 30 percent of its own variance and more than 50 percent of its variance is accounted for by USD, even after 36 months, 48 months and 60 months following the once only shock. On the other hand, JPY explains only 43 percent of its own variance. And again most of its variance (almost 50 percent) is explained by USD after the 60 months.

Table 22

Results of Variance Decomposition for LKR

Months	Relative Variance in	Percentage of Forecast Variance Explained by Innovations in ΔUSD	ΔBP	ΔJPY
12	ΔUSD	95.30986	4.678611	0.011531
24		93.13836	6.760766	0.100876
36		91.60953	8.112748	0.277727
48		90.52380	9.004327	0.471869
60		89.75218	9.603439	0.644378
12	ΔBP	25.67404	68.42386	5.902100
24		42.44230	48.19097	9.366733
36		52.77402	38.04256	9.183420
48		58.70448	33.14505	8.150470
60		62.17193	30.53926	7.288807
12	ΔJPY	10.15087	1.284301	88.56483
24		24.92765	2.407549	72.66480
36		37.11204	3.678987	59.20897
48		45.28501	4.806763	49.90822
60		50.62845	5.713575	43.65798

The results presented in Table 23 indicate that USD explains more than 90 percent of its variance even after the 60 months following the once only shock. However, BP explains less than 50 percent (almost 45 percent) of its own variance and the major proportion of the remaining 55 percent is explained by USD. On the other hand, JPY explains almost 50 percent of its own variance even after the 60 months. Nonetheless, 42 percent of its remaining 50 percent is accounted for by USD.

Table 23

Results of Variance Decomposition for BDT

Months	Relative Variance in	Percentage of Forecast Variance Explained by Innovations in		
		ΔUSD	ΔBP	ΔJPY
12	ΔUSD	99.62545	0.336770	0.037779
24		97.76048	1.732498	0.507021
36		95.11218	3.445246	1.442579
48		92.73170	4.750977	2.517324
60		90.86291	5.635985	3.501101
12	ΔBP	25.27310	69.64774	5.079161
24		30.57907	58.68376	10.73717
36		34.24349	51.85625	13.90046
48		36.97771	47.68812	15.33417
60		39.07156	45.03280	15.89564
12	ΔJPY	13.89017	0.959370	85.15049
24		23.76907	2.954718	73.27621
36		32.53735	5.070315	62.39234
48		38.75547	6.469819	54.77471
60		42.92073	7.259851	49.81942

Notes for the above Tables 17, 18, 19 and 20:

1. BP, JPY and USD denote the nominal exchange rates for British Pound, Japanese yen and the US dollar respectively.
2. Figures in column 1 refer to months after a once-only shock. Cholesky ordering for the variance decomposition was log(USD), log(BP) and log(JPY).
3. Variance decompositions for the months 12, 24, 36, 48 and 60 have only been reported. All figures in columns three through five have been rounded to two decimal places.

The results of the Variance Decomposition analysis for all four South Asian currencies indicate that the forecast variance of one exchange rate is explained by others showing the causal relationships between currencies. The presence of such causal relationships can be used to forecast the future value of a particular currency from the previous values of one or more of the other currencies. These results do not support the semi-strong form of the EMH to the countries under consideration; namely, Pakistan, India, Sri Lanka and Bangladesh.

6. CONCLUSIONS

This study examines the weak form and the semi-strong form of the efficient market hypothesis for the foreign exchange markets of Pakistan, India, Sri Lanka and Bangladesh. The data used consists of the log of average monthly spot exchange rates for these four currencies against the US Dollar, the British Pound and the Japanese Yen for the period January 1995 to December 2010. To tests the weak form of EMH, the unit root tests (the Augmented Dickey Fuller and Phillips Perron) are used. However, to test the semi-strong form of the hypothesis, the Johansen's multivariate co-integration test, the Granger causality test and variance decomposition analysis are used.

Results of both the ADF and PP show that the currencies of all four countries follow random walks. These results provide evidence in favour of the EMH in its weak-form. The implications of these results are that the participants of the foreign exchange markets of Pakistan, India, Sri Lanka and Bangladesh cannot formulate a trading rule or technique that can be used to forecast the future movements of an exchange rate from its previous values. On the other hand, the Johansen co-integration test, the Granger causality test and variance decomposition analysis give evidence against the semi-strong form of the hypothesis. The results of co-integration after introducing the multiplicative dummies for regime shift further confirm the markets are inefficient in semi-strong form. The results of all three tests signify that the movement of one or more exchange rates can be forecast from the movements of the other exchange rates; implying that in this case the participants of the foreign exchange markets of all four countries can devise strategies for profitable earnings in both the short and the long run.

The results of the present research have important implications for government policy-making institutions as well as for the participants of the foreign exchange markets. The government can make well-versed decisions on exchange rates. They can take action to minimise exchange rate instability and appraise the effects of different economic policies on the behaviour of exchange rates. The participants of the foreign exchange market can benefit by devising trading rules or strategies to make profits from transactions in the foreign exchange market.

Appendix Table 1

Summary Statistics of Monthly BP, PJPY and PUSD

		Pakistan	
	PAKBP	PJPY	PUSD
Mean	0.019	2.161	0.019
t(u=0)	3.330	53.359	51.261
Prob	0.001	0.000	0.000
Std. Dev.	0.076	0.543	0.005
Skewness	12.403	0.277	1.189
Kurtosis	160.732	2.539	3.751
Q(6)	781.05	753.63	819.02
Prob	0.000	0.000	0.000
Q(12)	1164.3	1167.9	1268.0
Prob	0000	0000	0000
Jarque-Bera	191211.3	3.903	46.651
Probability	0.000	0.142	0.000
		India	
	IndBP	IJPY	IUSD
Mean	0.014	2.657	0.024
t(u=0)	84.274	96.424	105.224
Prob	0.000	0.000	0.000
Std. Dev.	0.002	0.369	0.003
Skewness	1.050	0.166	1.174
Kurtosis	3.276	2.834	3.529
Q(6)	881.06	674.72	829.56
Prob	0.000	0.000	0.000
Q(12)	1484.3	950.86	1265.1
Prob	0000	0000	000
Jarque-Bera	33.685	1.037	43.468
Probability	0.000	0.595	0.000
		Bangladesh	
	BBP	BJPY	BUSD
Mean	0.011	2.109	0.018
t(u=0)	57.842	65.047	75.766
Prob	0.000	0.000	0.000
Std. Dev.	0.369	0.002	0.003
Skewness	0.073	0.154	0.466
Kurtosis	1.859	2.103	1.961
Q(6)	970.25	824.80	943.56
Prob	0.000	0.000	0.000
Q(12)	1735.5	1358.8	1644.8
Prob	0000	0000	0000
Jarque-Bera	9.908	6.737	14.611
Probability	0.007	0.034	0.000
		Sri-Lanka	
	SBP	SJPY	SUSD
Mean	0.008	1.401	0.012
t(u=0)	41.525	46.016	48.873
Prob	0.000	0.000	0.000
Std. Dev.	0.002	0.408	0.003
Skewness	0.548	0.479	0.732
Kurtosis	2.090	1.888	2.041
Q(6)	958.96	905.48	946.46
Prob	0.000	0.000	0.000
Q(12)	1705.5	1565.4	1673.9
Prob	0000	0000	0000
Jarque-Bera	15.24293	16.14352	22.98753
Probability	0.000490	0.000312	0.000010

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