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PREDICTABILITY OF EXCHANGE RATES IN SRI LANKA: A TEST OF THE EFFICIENT MARKET HYPOTHESIS

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ABSTRACT

This study examined the validity of the weak and semi-strong forms of the efficient market hypothesis (EMH) for the foreign exchange market of Sri Lanka. Monthly exchange rates for four currencies during the floating exchange rate regime were used in the empirical tests. Using a battery of tests, empirical results indicate that the current values of the four exchange rates can be predicted from their past values. Further, the tests of semi-strong form efficiency indicate that exchange rate pairs are significantly correlated at different leads and lags. These results are not consistent with the weak and semi-strong versions of the EMH. The above results have important implications for government policy makers and participants of the foreign exchange market of Sri Lanka.

Keywords: efficient market hypothesis, Sri Lanka, US dollar, cross-correlation test, foreign exchange market

INTRODUCTION

According to Fama (1970), there are three versions of the efficient market hypothesis. These three versions are known as (i) weak-form efficiency, (ii) semi-strong form efficiency and (iii) strong-from efficiency. The weak-form efficiency asserts that current foreign exchange rates reflect all available information available in past exchange rates. In other words, current foreign exchange rates instantly adjust to reflect past information contained in past exchange rates. Therefore, a speculator or an arbitrageur cannot make use of past exchange rates to predict future exchange rates. As a result a speculator or an arbitrageur cannot devise any strategy to make consistent gains from foreign exchange transactions.

On the other hand, semi-strong form of the EMH asserts that foreign exchange rates reflect not only information in past exchange rates but also the information in other exchange rates and macro-economic variables. Therefore, in addition to past exchange rates, a speculator or an arbitrageur cannot use exchange rates other than the one we are concerned with and any other variable to predict an exchange rate. As a result, a speculator or an arbitrageur cannot devise any rule or technique to beat a foreign exchange market on a consistent basis.

Strong form efficiency encompasses bother weak and semi-strong forms of the EMH. In addition, it asserts that even a central bank official or any other person, who has access to inside information of a foreign exchange market, cannot beat the foreign exchange market on a consistent basis.

The efficiency or inefficiency of a foreign exchange market has policy implications of importance (Pilbeam, 1992). When a foreign exchange market is inefficient, a model that best predicts exchange rate movements can be developed. Consequently, an inefficient foreign exchange market provides opportunities for profitable foreign exchange transactions for speculators and arbitrageurs. Further, an inefficient foreign exchange market allows government authorities to determine the best way to influence exchange rates, thus reducing exchange rate volatility and providing an opportunity to evaluate the consequences of different economic policies. On the other hand, an efficient foreign exchange market needs minimal government intervention and its participants cannot make abnormal gains from foreign exchange transactions.

Since the publication of Fama's seminal paper, foreign exchange markets, particularly in developed countries, have been extensively subjected to tests of efficiency. These studies are briefly reviewed in the next section.

To the author's knowledge, there has been only one empirical study (Wickremasinghe, 2005) on the efficiency of foreign exchange market of Sri Lanka. This study reported that the Sri Lankan foreign exchange market is efficient in the weak sense whereas it is inefficient in the semi-strong sense. The objective of the current study is to test the validity of both the weak and semi-strong versions of the EMH to the foreign exchange market during the floating exchange rate regime using a longer sample period and examine how results are sensitive to different econometric techniques. The results of such a study will be important to both participants of the foreign exchange market of Sri Lanka and economic policy makers. The paper is organized as follows: Section two discusses empirical literature, Section three provides an overview of the foreign exchange market in Sri Lanka, Section four outlines the methodology and data,

empirical results are analyzed in Section five and the last section offers conclusions and policy implications.

EMPIRICAL TESTS OF THE EFFICIENCY OF FOREIGN EXCHANGE MARKETS

The publication of Fama's seminal paper on the EMH attracted a lot of attention of academics, especially those in developed countries. Consequently, the foreign exchange markets in these countries have been extensively subjected to tests of efficiency using different econometric techniques. The main purpose of these techniques has been to determine whether (a) a spot exchange rate for a currency behaves as a random walk, (b) the forward rate for a currency is an unbiased predictor of the future spot exchange rate for that currency, and (c) there are co-integrating relationships among several currencies. The first type of tests can be classified as weak-form efficiency tests whereas the second and third type of tests can be classified as semi-strong form efficiency tests. The results of studies using these different techniques have been mixed.

The first type of tests were carried out using such techniques such as the autocorrelation test, the Ljung-Box Q-statistic, variance ratio tests, technical trading rules and runs tests. For example, Liu and He (1991) used a variance ratio test and Gupta (1981) employed an autocorrelation test, Box-Pierce statistic, runs test, filter rules and cross-correlation tests in studies on weak-form efficiency. In addition, developments in techniques for testing unit root tests provided another methodology to examine the random walk properties of financial time series (see Bleaney, 1998; Baillie & Bollerslev, 1989). The second type of tests were performed using the ordinary least squares regression method, particularly before the development of co-integration techniques (see Levich, 1978; Frankel, 1980, 1982; Edwards, 1983; Boothe & Longworth, 1986; Taylor, 1988). After the latter half of the 1980s, there was a significant change in the methodologies employed to test the efficiency of foreign exchange markets and this was due to the development of the bivariate co-integration techniques of Engle and Granger (1987) and the multivariate co-integration techniques of Johansen (1988) and Johansen and Juselius (1990). These techniques were used by researchers to examine the unbiasedness of the forward rate as a predictor of the future spot rate (see for example, Norrbin & Reffertt, 1996; Wesso, 1999; Barnhart et al., 1999). In addition, several studies employed co-integration tests to see whether there are long-run co-movements among several exchange rates. Among others, Ballie and Bollerslev (1989), Hakkio and Rush (1989), Lajaunie et al. (1996), Masih and Masih (1996), Singh (1997), Sanchez-Fung (1999) and Speight and McMillan (2001) employed this methodology in their studies on the efficiency of foreign exchange markets.

AN OVERVIEW OF THE FOREIGN EXCHANGE MARKET OF SRI LANKA

The foreign exchange market of Sri Lanka comprises two tiers, namely, the wholesale market (inter-bank market) and the retail market (client market). The wholesale market consists of all licensed commercial banks. The transactions in the wholesale market partly emanate from the transactions in the retail market. The main role of the wholesale market is to redistribute liquidity within the banking system. In the wholesale market, transactions take place between dealers on the spot, cash and forward basis between the Sri Lankan rupee and the US dollar. The Central Bank's role is limited to intervene in the wholesale market to maintain an orderly market as and when necessary. As at the end of September 2005, there were 22 foreign exchange dealers operating in the inter-bank market.

Sri Lanka abolished the fixed exchange rate system in favor a managed float in 1977 unifying the exchange rate at an officially depreciated rate of 46%. Thereafter, the Central Bank of Sri Lanka commenced quoting daily rates for six major currencies, the US dollar, the Deutsch Mark, French franc, Yen, UK pound and Indian Rupee, using the US dollar as the intervention currency. In 1982, the Central Bank abandoned the quotation of daily rates for currencies except for the US dollar. Consequently, the commercial banks were permitted to determine the cross-rates for other currencies based on the market conditions. An inter-bank market for forward currencies was set up in 1983. In 2005, forward volume in the inter-bank market stood at US$1,858 million. The forward transactions accounted for 23% of the total transactions in the inter-bank market for foreign exchange in both 2004 and 2005.

In 1990, the Central Bank commenced quoting daily buying and selling rates for the US dollar, abandoning quotation of daily rates for the US dollar. To facilitate the inward remittances of Sri Lankans living overseas, a Non-Resident Foreign Currency (NRFC) account scheme was introduced in 1978. In 1979, commercial banks were permitted to establish Foreign Currency Banking Units (FCBUs). These were authorized to engage in foreign currency transactions of non-residents, approved residents, and Board of Investment enterprises. In 1991, residents of Sri Lanka were also allowed to open accounts (Resident Foreign Currency Accounts) in specified foreign currencies with a minimum balance of US$500.

There has been an expansion in the activities of the foreign exchange market in the recent past. The daily average turnover in the inter-bank market (including the forward market) in 2005 was US$33 million while the minimum daily turnover was US$3 million and the maximum daily turnover was US$110 million. The average, minimum and maximum turnover figures for 2004 were

US$18 million, US$2 million and US$65 million, respectively. The inter-bank foreign exchange transaction volume including the forward market volume went up in the first nine months of 2005 partly due to Tsunami-related inward remittances and improved external trade activities. In 2005, the transaction volume in the wholesale market was US$7.939 million compared to the transaction volume in 2004 of US$4,330 million[1].

METHODOLOGY AND DATA

We use three tests to examine the weak-form of the EMH in the foreign exchange market of Sri Lanka. These include auto-correlation test, Q-statistic test and the KPSS unit root test. The above tests examine whether foreign exchange rates behave as random walks consistent with the EMH. In other words, it test whether the future value of an exchange rate can be predicted using its past values. If we can predict the future value of an exchange rate from its past values, behavior of such an exchange rate is not consistent with the weak version of the EMH. The semi-strong efficiency of the foreign exchange market of Sri Lanka is tested using the cross-correlation test. This test examines whether a pair of exchange rates are correlated at different lags and leads. Significant cross correlations at lags or leads indicate the possibility of predicting one exchange rate from the other, thus violating the EMH.

If an exchange rate follows a random walk, the first differences of that exchange rate should be stationary. The stationarity of an exchange rate can be detected by examining the autocorrelation functions of exchange rates. If the first differences of an exchange rate are stationary, they should not be autocorrelated. In other words, autocorrelation coefficients at different lags of the first differences of exchange rates should not be statistically significant. We perform the autocorrelation test on the log returns (first differences) of exchange rates which are calculated as follows:

$$R_{it} = \ln(P_{it} / P_{it-1}) \tag{1}$$

Where R_{it} is the return of currency i in month t. P_{it} is the exchange rate for currency i in month t. ln indicates natural log values.

Autocorrelation Test

This test is used to test the dependency between the price change at time t and the price change at time $t - k$ where k refers to the lag. Therefore, the change in log

[1] Central Bank of Sri Lanka (2005), *Financial Stability Review*, pp. 31–32.

values for a particular exchange rate return from the end of day *t*–1 to day *t* (defined previously as R_{it}) was used. The autocorrelation coefficient for lag *k* is given by:

$$\rho(k) = \frac{Cov(R_{it}, R_{it-k})}{Var(R_{it})} \tag{2}$$

where $\rho(k)$ is autocorrelation coefficient at lag *k*, *Cov* is covariance and *Var* is variance. According to Bartlett (l946) if a time series is purely random, the sample autocorrelation coefficients are approximately normally distributed with zero mean and variance $1/\sqrt{n}$, where n is the sample size. The hypothesis tested in this study is that the autocorrelation coefficients of successive monthly log exchange rate changes of four currencies at lag *k* (*k* = 1, …, 36) are zero. The hypothesis of zero autocorrelation is rejected at one percent and five percent levels of significance if the calculated auto-correlation coefficient exceed $\pm$ 2.58 $\times$ $1/\sqrt{n}$ and $\pm$ 1.96 $\times$ $1/\sqrt{n}$, respectively.

LB Q-test

This test is used to test the joint hypothesis that all the autocorrelation coefficients upto lag *m* are simultaneously equal to zero. For this purpose a variant of the Box-Pierce Q-Statistic (1946) called Ljung-Box (LB) statistic (1978) which is defined as below is used.

$$LB = n(n+2)\sum_{k=1}^{m}\left(\frac{\rho_k^2}{n-k}\right) \tag{3}$$

where *n* is the number of observations, *m* is number of lags, and ρ_k is auto-correlation coefficient at lag *k*. *LB* statistic follows the Chi-Square distribution with *m* degrees of freedom. *LB* statistic has been found to be more powerful than the Box-Pierce Q-Statistic when samples are small.

Cross-correlation Test

This test examines the correlation of two series at various leads and lags. Therefore, it can be used to test whether there are any predictable relationships between two exchange rates. If there are statistically significant correlations between two series, one series can be used to predict the other series at different

leads and lags. Such an ability to predict one series from the other indicates a violation of the efficient market hypothesis in its semi-strong form.

The cross-correlations at different lags and leads[2], $r_{xy}(l)$, of two variables, *x* and *y*, can be computed using the following equation:

$$r_{xy}(l) = \frac{C_{xy}(l)}{\sqrt{C_{xx}(0)\sqrt{C_{yy}}(0)}} \tag{4}$$

where $l = 0, \pm 1, \pm 2, ...$

$$C_{xy}(l) = \begin{cases} \sum_{t=1}^{T-l} ((x_t - \bar{x})(y_{t+l} - \bar{y}))/T, \; l = 0, 1, 2, ... \\ \sum_{t=1}^{T+l} ((y_t - \bar{y})(x_{t-l} - \bar{x}))/T, \; l = 0, 1, 2, ... \end{cases}$$

The appropriate two standard error bands for cross-correlations can be computed as $\pm 2/\left(\sqrt{T}\right)$ where T is the number of observations. If a cross-correlation coefficient at a particular lag or lead is outside the two error band calculated as above, we can conclude that such cross-correlation coefficient is statistically significant. Statistically significant cross-correlation coefficients indicate that we can predict one exchange rate from the other at different leads and lags leading to the violation of the EMH in its semi-strong from.

The main source of data for this study is the official website of the Central Bank of Sri Lanka (www.cbsl.gov.lk). This website contains exchange rate data only for four foreign currencies, namely, Indian rupee, Japanese yen, UK pound, and US dollar from January 1986 to December 2004. Therefore, this study focuses only on these four exchange rates for the above period.

ANALYSIS OF EMPIRICAL RESULTS

Table 1 reports the descriptive statistics for exchange rate returns. A perusal of means for the four exchange rates indicates that the Japanese yen has the highest mean return during the sample period. This indicates that the Japanese yen has the highest amount of depreciation during the sample period. The UK pound

[2] Lags are indicated by a minus sign whereas leads are indicated by a plus sign.

indicates the second highest degree of depreciation followed by the US dollar and the Indian rupee. As far as the medians of exchange rate returns are concerned, UK pound exchange rate has the highest median followed by the Japanese yen, US dollar and Indian rupee. As far as maximum values of exchange rate returns are concerned, Japanese yen has the highest value followed by the US dollar, Indian rupee and UK pound. These results again indicate that during the period under review Japanese yen depreciated by the highest amount. However, the minimum values for the exchange rate returns indicate that the magnitude of appreciation exceeds that of depreciation with the Indian rupee appreciating approximately by 15% during the sample period.

Table 1
Descriptive Statistics for Exchange Rate Returns

Descriptive statistic	Exchange rate			
	IR	JY	UKP	USD
Mean	0.000267	0.008781	0.007217	0.005894
Median	0.002525	0.008370	0.008659	0.004076
Maximum	0.079688	0.112089	0.075186	0.082919
Minimum	–0.148271	–0.068172	–0.100389	–0.015718
Std. Dev.	0.020222	0.028371	0.025355	0.009345
Skewness	–2.852835	0.357654	–0.527156	3.563573
Kurtosis	23.79816	3.387881	4.727937	25.60615
Jarque-Bera	4399.243[a]	6.262518[a]	38.75399[a]	5314.016[a]
Probability	0.000000	0.043663	0.000000	0.000000

Note: 'a' implies statistical significance at the 1% level.

Figure 1 exhibits the time series plots of log exchange rate returns for the four currencies. A perusal of the time series plots for the UK pound exchange rate and that for the Japanese yen exchange rate indicates that the first differences of exchange returns are not stationary as predicted by the random walk hypothesis. The time series plots for the returns of Indian rupee and the US dollar show less volatility than the UK pound exchange rate and the Japanese yen exchange rate during the sample period. However, they do not show any stationary behavior during the sample period as there are spikes in a number of months during the sample period.

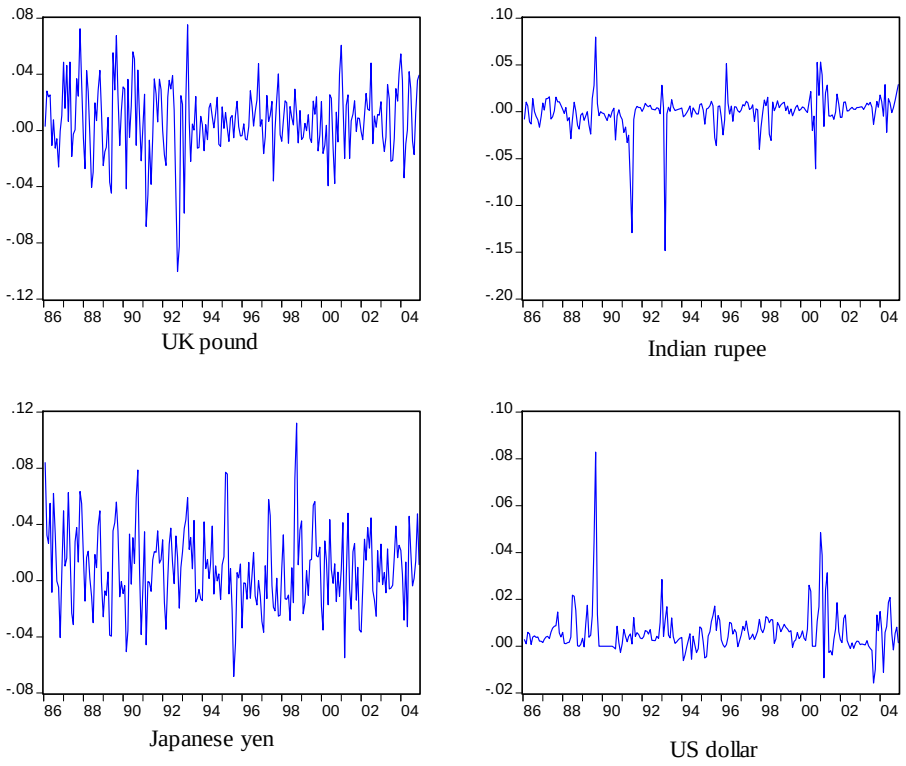

Figure 1. Time series plots of logs of exchange rate returns

Table 2 reports autocorrelation coefficients for the log returns of the four exchange rates. The results indicate that current month's exchange rate return is correlated with the previous month's exchange rate return for all four currencies. This result indicates that current month's exchange rate return is predictable from previous month's exchange rate return which is a violation of the EMH in its weak form. As far as Indian rupee return is concerned, it is predictable from the previous month's return as well as from the return 20 months ago from the current month. When the Japanese yen exchange rate is considered, its current returns are predictable from the returns in 4, 5, 6 and 11 months before the current month. The current UK pound exchange rate returns are predictable form its returns in 5, 14 and 32 months ago from the current month. The behavior of the US exchange rate returns is totally different from that of the other three exchange rates. That is, the current returns of the US dollar exchange rate are predictable only from the previous month's exchange rate returns. The above results indicate that all four exchange rates do not behave as predicted by the EMH. These results indicate that the participants of the foreign exchange market of Sri Lanka can devise

methods to predict current return movements of the four exchange rates from their past returns and earn abnormal returns on a consistent basis.

Table 2
Autocorrelation Coefficients for Exchange Rate Returns

Lag	IR	JY	UKP	USD
1	0.255[a]	0.286[a]	0.253[a]	0.437[a]
2	0.034	0.006	–0.123	0.024
3	0.023	0.021	–0.089	0.022
4	–0.007	–0.146[b]	–0.022	–0.011
5	0.074	–0.199[a]	–0.148[b]	0.023
6	0.036	–0.195[a]	–0.045	0.049
7	–0.022	–0.090	–0.085	0.020
8	–0.033	0.103	–0.021	–0.060
9	–0.012	0.107	0.029	–0.065
10	0.042	0.128	0.053	–0.002
11	0.016	0.214[a]	0.023	0.031
12	–0.004	0.049	0.101	0.038
13	–0.025	–0.008	–0.020	0.047
14	–0.029	0.036	–0.159[b]	0.032
15	–0.038	–0.039	–0.086	–0.071
16	0.021	–0.115	0.037	–0.113
17	–0.052	–0.005	0.045	–0.085
18	–0.061	0.005	0.034	–0.101
19	–0.034	0.049	0.012	–0.080
20	0.170[b]	0.063	–0.010	–0.064
21	0.027	–0.024	0.055	–0.050
22	–0.062	–0.002	0.119	–0.019
23	0.055	0.048	0.062	0.030
24	0.082	–0.027	–0.031	–0.003
25	0.083	0.018	–0.038	0.011
26	0.030	–0.010	–0.043	0.013
27	0.056	–0.049	–0.045	–0.049
28	0.034	–0.019	–0.049	–0.120
29	0.023	–0.094	0.007	–0.082
30	0.116	–0.048	–0.001	0.005
31	0.053	–0.006	0.006	–0.014
32	0.080	0.025	0.063	–0.047
33	0.083	0.065	0.143[b]	–0.008
34	0.012	0.055	0.045	–0.054
35	0.034	–0.041	0.082	–0.028
36	0.064	–0.137	–0.082	0.011

Notes: 'a' and 'b' imply statistical significance at the 1% and 5% level, respectively.

Table 3 reports the results of the Q-statistic test results for the returns for the four currencies. The statistical significance of the Q-statistic for any of the lags considered indicates a violation of the weak form of the EMH. The difference between the autocorrelation test and the LJung-Box Q-statistic test is

that the latter considers the significance of lags 1 to k taken together in predicting the current returns. However, the autocorrelation test considers only the significance of each lag individually in predicting the current return for a currency from its previous returns. The Q-statistic test results for the Indian rupee are reported in column two of Table 3.

Table 3
Q-Statistic Test Results for the Exchange Rate Returns

Lag	IR	JY	UKP	USD
1	15.000[a]	18.855[a]	14.711[a]	43.916[a]
2	15.273[a]	18.863[a]	18.179[a]	44.048[a]
3	15.392[a]	18.961[a]	20.010[a]	44.165[a]
4	15.405[a]	23.955[a]	20.124[a]	44.194[a]
5	16.678[a]	33.245[a]	25.260[a]	44.317[a]
6	16.974[a]	42.171[a]	25.729[a]	44.880[a]
7	17.093[b]	44.085[a]	27.435[a]	44.971[a]
8	17.353[b]	46.624[a]	27.544[a]	45.833[a]
9	17.384[b]	49.361[a]	27.738[a]	46.850[a]
10	17.808[c]	53.277[a]	28.401[a]	46.850[a]
11	17.866[c]	64.272[a]	28.527[a]	47.082[a]
12	17.870	64.862[a]	31.013[a]	47.428[a]
13	18.027	64.876[a]	31.107[a]	47.962[a]
14	18.229	65.185[a]	37.310[a]	48.206[a]
15	18.575	65.568[a]	39.131[a]	49.435[a]
16	18.681	68.805[a]	39.473[a]	52.555[a]
17	19.354	68.812[a]	39.979[a]	54.345[a]
18	20.273	68.818[a]	40.265[a]	56.886[a]
19	20.563	69.419[a]	40.300[a]	58.475[a]
20	27.785	70.413[a]	40.323[a]	59.489[a]
21	27.966	70.558[a]	41.097[a]	60.114[a]
22	28.938	70.559[a]	44.689[a]	60.202[a]
23	29.709	71.156[a]	45.657[a]	60.437[a]
24	31.424	71.349[a]	45.907[a]	60.439[a]
25	33.208	71.428[a]	46.269[a]	60.471[a]
26	33.437	71.453[a]	46.744[a]	60.515[a]
27	34.257	72.087[a]	47.280[a]	61.138[a]
28	34.556	72.177[a]	47.913[a]	64.879[a]
29	34.697	74.519[a]	47.926[b]	66.661[a]
30	38.274	75.135[a]	47.926[b]	66.668[a]
31	39.031	75.144[a]	47.937[b]	66.719[a]
32	40.751	75.314[a]	48.991[b]	67.305[a]
33	42.591	76.443[a]	54.490[a]	67.322[a]
34	42.628	77.266[a]	55.029[a]	68.099[a]
35	42.944	77.729[a]	56.848[a]	68.304[a]
36	44.062	82.857[a]	58.666[a]	68.338[a]

Notes: a, b and c imply statistical significance at the 1%, 5% and 10% level, respectively.

According to the results, Q-statistics for lags one to six are statistically significant at the 1% level and Q-statistics for lags seven to nine are statistically significant only at the 5% level. Lags 10 and 11 have Q-statistics that are significant at the 10% level. The column three of Table 3 reports Q-statistic test results for the Japanese yen. The results indicate that the Japanese yen exchange rate returns are highly predictable as all Q-statistics are statistically significant at the 1% level. The UK pound and the US dollar exchange rate returns also have statistically significant Q-statistics at all 36 lags considered. The above results confirm the results we obtain using the autocorrelation test.

Table 4 reports the results of the cross-correlation test for the lags of the pairs of exchange rates. In the cross correlation analysis, we examine whether the lags of one exchange rate is correlated with the lags of another exchange rate. In other words, the cross-correlation analysis indicates whether we can predict the value of an exchange rate at a particular lag from the value of another exchange rate at the same lag. Therefore, it constitutes a test for the semi-strong form of the efficient market hypothesis. In Table 4, we consider cross-correlation coefficients for 36 lags or 3 years. According to the results, the exchange rate returns for the UK pound and the Japanese yen, the UK pound and the Indian rupee, the UK pound and the US dollar and the Japanese and the US dollar are correlated at all 36 lags. The exchange rates for the Indian rupee and Japanese yen are correlated only up to lag 34. The exchange rates for the Indian rupee and the US dollar, however, are correlated only up to lag 27. The above results indicate that all pairs of exchange rates are correlated at most of the lags. Therefore, these results refute the validity of the EMH to the Sri Lankan foreign exchange market.

In addition to the cross-correlation coefficient for 36 lags of exchange rate returns, we also computed cross-correlation coefficients for 36 leads of the exchange rate returns. Table 5 reports the estimated cross-correlation coefficients for the pairs of exchange rates. According to the results, the cross-correlation coefficients for all 36 lags are statistically significant for the Indian rupee and the Japanese yen, Indian rupee, the UK pound and the Japanese yen, UK pound and the US dollar, and the Japanese yen and the US dollar. However, the cross-correlation coefficients for the UK pound and Indian rupee are significant only up to the 28th lead. The results indicate that the value of one currency in a particular pair of currencies can be predicted from the other currency in that pair thus refuting the validity of the semi-strong version of the EMH.

Table 4
Cross-Correlation Coefficient for Lags

Lag	UKP and IR	UKP and JY	UKP and USD	IR and JY	IR and USD	JY and USD
0	–0.2053*	0.9508*	0.9798*	–0.3868*	–0.2647*	0.9682*
1	–0.2288*	0.9181*	0.9494*	–0.3900*	–0.2676*	0.9431*
2	–0.2466*	0.8877*	0.9200*	–0.3915*	–0.2697*	0.9197*
3	–0.2630*	0.8589*	0.8917*	–0.3915*	–0.2698*	0.8966*
4	–0.2780*	0.8323*	0.8652*	–0.3899*	–0.2681*	0.8748*
5	–0.2928*	0.8061*	0.8394*	–0.3891*	–0.2663*	0.8529*
6	–0.3055*	0.7792*	0.8129*	–0.3894*	–0.2654*	0.8304*
7	–0.3151*	0.7542*	0.7877*	–0.3872*	–0.2632*	0.8091*
8	–0.3236*	0.7308*	0.7631*	–0.3831*	–0.2603*	0.7892*
9	–0.3335*	0.7083*	0.7374*	–0.3788*	–0.2591*	0.7703*
10	–0.3413*	0.6846*	0.7108*	–0.3730*	–0.2569*	0.7510*
11	–0.3475*	0.6605*	0.6834*	–0.3682*	–0.2559*	0.7316*
12	–0.3529*	0.6364*	0.6564*	–0.3633*	–0.2548*	0.7122*
13	–0.3574*	0.6147*	0.6311*	–0.3571*	–0.2525*	0.6936*
14	–0.3611*	0.5943*	0.6064*	–0.3507*	–0.2500*	0.6752*
15	–0.3647*	0.5745*	0.5826*	–0.3430*	–0.2465*	0.6562*
16	–0.3682*	0.5561*	0.5592*	–0.3343*	–0.2424*	0.6383*
17	–0.3727*	0.5402*	0.5367*	–0.3248*	–0.2380*	0.6215*
18	–0.3768*	0.5247*	0.5139*	–0.3155*	–0.2333*	0.6053*
19	–0.3813*	0.5071*	0.4908*	–0.3070*	–0.2282*	0.5875*
20	–0.3840*	0.4889*	0.4689*	–0.2982*	–0.2222*	0.5692*
21	–0.3881*	0.4724*	0.4484*	–0.2880*	–0.2148*	0.5517*
22	–0.3921*	0.4558*	0.4280*	–0.2770*	–0.2062*	0.5339*
23	–0.3939*	0.4416*	0.4099*	–0.2644*	–0.1956*	0.517*
24	–0.3956*	0.4271*	0.3927*	–0.2510*	–0.1839*	0.4997*
25	–0.3909*	0.4132*	0.3778*	–0.2378*	–0.1711*	0.4825*
26	–0.3833*	0.3985*	0.3629*	–0.2249*	–0.1579*	0.4651*
27	–0.3802*	0.3850*	0.3486*	–0.2120*	–0.1443*	0.4476*
28	–0.3765*	0.3725*	0.3356*	–0.2003*	–0.1306	0.4307*
29	–0.3728*	0.3602*	0.3232*	–0.1899*	–0.1170	0.4135*
30	–0.3685*	0.3472*	0.3100*	–0.1808*	–0.1045	0.3966*
31	–0.3632*	0.3331*	0.2968*	–0.1717*	–0.0924	0.3794*
32	–0.3575*	0.3199*	0.2842*	–0.1614*	–0.0797	0.3633*
33	–0.3527*	0.3084*	0.2718*	–0.1495*	–0.0670	0.3499*
34	–0.3495*	0.2984*	0.2600*	–0.1371*	–0.0547	0.3378*
35	–0.3467*	0.2893*	0.2493*	–0.1250	–0.0429	0.3258*
36	–0.3431*	0.2798*	0.2389*	–0.1138	–0.0309	0.3132*

Notes: '*' implies that the cross-correlation coefficients are outside the two standard error bands calculated as $\pm 2 / \sqrt{T}$.

Table 5
Cross-Correlation Coefficient for Leads

Lag	UKP and IR	UKP and JY	UKP and USD	IR and JY	IR and USD	JY and USD
0	–0.2053*	0.9508*	0.9798*	–0.3868*	–0.2647*	0.9682*
1	–0.2154*	0.9143*	0.9485*	–0.4060*	–0.2877*	0.9384*
2	–0.2245*	0.8808*	0.9191*	–0.4216*	–0.3069*	0.9101*
3	–0.2324*	0.8481*	0.8894*	–0.4356*	–0.3252*	0.8830*
4	–0.2380*	0.8177*	0.8617*	–0.4480*	–0.3418*	0.8572*
5	–0.2450*	0.7891*	0.8347*	–0.4604*	–0.3582*	0.8328*
6	–0.2545*	0.7599*	0.8068*	–0.4709*	–0.3731*	0.8078*
7	–0.2609*	0.7355*	0.7825*	–0.4795*	–0.3856*	0.7847*
8	–0.2647*	0.7141*	0.7604*	–0.4873*	–0.3967*	0.7630*
9	–0.2683*	0.6920*	0.7383*	–0.4968*	–0.4085*	0.7401*
10	–0.2707*	0.6690*	0.7155*	–0.5049*	–0.4189*	0.7171*
11	–0.2735*	0.6453*	0.6935*	–0.5114*	–0.4281*	0.6930*
12	–0.2758*	0.6204*	0.6708*	–0.5165*	–0.4366*	0.668*
13	–0.2756*	0.5969*	0.6490*	–0.5212*	–0.4442*	0.6456*
14	–0.2746*	0.5743*	0.6278*	–0.5256*	–0.4513*	0.6224*
15	–0.2714*	0.5523*	0.6070*	–0.5297*	–0.4577*	0.5994*
16	–0.2657*	0.5333*	0.5876*	–0.5333*	–0.4636*	0.5777*
17	–0.2591*	0.5161*	0.5689*	–0.5363*	–0.4691*	0.5565*
18	–0.2521*	0.4990*	0.5505*	–0.5386*	–0.4735*	0.5353*
19	–0.2445*	0.4811*	0.5321*	–0.5408*	–0.4782*	0.5136*
20	–0.2353*	0.4638*	0.5141*	–0.5412*	–0.4810*	0.4928*
21	–0.2247*	0.4481*	0.4969*	–0.5417*	–0.4846*	0.4729*
22	–0.2136*	0.4322*	0.4799*	–0.5421*	–0.4890*	0.4529*
23	–0.2012*	0.4178*	0.4635*	–0.5402*	–0.4903*	0.4347*
24	–0.1888*	0.4037*	0.4470*	–0.5373*	–0.4906*	0.4176*
25	–0.1759*	0.3924*	0.4334*	–0.5280*	–0.4843*	0.4028*
26	–0.1629*	0.3814*	0.4203*	–0.5154*	–0.4754*	0.3880*
27	–0.1502*	0.3697*	0.4059*	–0.5062*	–0.4703*	0.3733*
28	–0.1381*	0.3591*	0.3923*	–0.4960*	–0.4639*	0.3595*
29	–0.1272	0.3482*	0.3776*	–0.4855*	–0.4570*	0.3460*
30	–0.1178	0.3367*	0.3620*	–0.4753*	–0.4494*	0.3324*
31	–0.1088	0.3251*	0.3470*	–0.4655*	–0.4413*	0.3189*
32	–0.0991	0.3136*	0.3319*	–0.4547*	–0.4325*	0.3061*
33	–0.0886	0.3027*	0.3180*	–0.4442*	–0.4240*	0.2936*
34	–0.0783	0.2920*	0.3040*	–0.4345*	–0.4155*	0.2820*
35	–0.0683	0.2817*	0.2904*	–0.4252*	–0.4064*	0.2713*
36	–0.0583	0.2708*	0.2768*	–0.4144*	–0.3960*	0.2609*

Notes: '*' implies that the cross-correlation coefficients are outside the two standard error bands calculated as $\pm 2 / \sqrt{T}$.

CONCLUSIONS AND POLICY IMPLICATIONS

In this paper, we investigated the validity of the weak and semi-strong versions of the efficient market hypothesis to the foreign exchange market of Sri Lanka. Four

exchange rates during the floating exchange rate regime, the Indian rupee, the Japanese yen, the UK pound and the US dollar, were used in the empirical analysis. The results of the weak and semi-strong form efficiency tests indicate that the efficient market hypothesis does not apply to the foreign exchange market of Sri Lanka. These results have important implications for the participants of the foreign exchange market and government policy makers of Sri Lanka.

Implications for the government authorities are that they can intervene in the foreign exchange market in order to bring about stability in exchange rates. Such intervention will assist government to affect imports to and exports from Sri Lanka in an optimal way to alleviate trade imbalances. However, it should be noted that ability to influence imports and exports by intervening in the foreign exchange market depends mainly on the elasticity of demand for and supply of Sri Lankan imports and exports, respectively on the world market. Government can also influence domestic interest rates and price levels by influencing exchange rates[3].

As far as the banks and other participants in the foreign exchange market are concerned, they can engage in speculative activities by buying and selling foreign currencies. For example, if a speculator predicts that the US dollar will appreciate in future, he can enter into a forward contract to buy US dollars on a future date at a fixed rate. The speculator can make a profit by selling US dollars at the spot rate prevailing at the time of settling the forward contract.

The main reason for the inefficiency of the foreign exchange market of Sri Lanka is that it is not well-developed. As a result, information on exchange rates is disseminated only to commercial banks by the Central Bank of Sri Lanka only at the beginning of each business day. However, in developed markets, information on exchange rates is available to participants, for example, on an hourly basis. Participants in the retail market (client market) in Sri Lanka can obtain information on exchange rates only after it is released to the commercial banks. Therefore, there is a need to bring about regulatory changes to provide information to all participants simultaneously via electronic media.

Apart from the above reasons, the methodologies employed in this paper assume that the adjustment processes of exchange rates are symmetric and the relationship between exchange rates is nonlinear. However, a number of recent studies have pointed out that important economic and financial variables follow

[3] International Fisher effect shows the relationship between percentage change in the spot exchange rate over time and the differential between comparable interest rates in comparable national markets (Eiteman et al., 2007, p. 112).

asymmetric adjustment processes. These studies have modeled the asymmetry in univariate series as well as in the relationships. To cite a few, Nefti (1984) investigated the issue of asymmetric adjustment of unemployment rates and their implications for business cycles. Granger and Lee (1989) examined asymmetric adjustment in the context of sales, production and inventory management in the US. On the other hand, in a recent paper, Enders and Dibooglu (2001) investigated the asymmetric purchasing power parity condition in several countries. The finding in this paper that the Sri Lankan foreign exchange market is inefficient may be due to the fact that the exchange rates in Sri Lanka follow asymmetric adjustment paths and the relationship between exchange rates are asymmetric. In addition, this paper focuses only on four currencies traded on the foreign exchange market of Sri Lanka. Due to the above limitations, caution must be exercised in using the results of this study.

REFERENCES

Baillie, R. T., & Bollerslev, T. (1989). Common stochastic trends in a system of exchange rates. *Journal of Finance, XLIV,* 167–181.

Barnhart, S. W., McNown, R., & Wallace, M. S. (1999). Non-informative tests of the unbiased forward exchange rate. *Journal of Financial and Quantitative Analysis, 34,* 265–291.

Bleaney, M. (1998). Market efficiency and apparent unit roots: An application to exchange rates. *Economic Record, 74,* 139–144.

Boothe, P., & Longworth, D. (1986). Foreign exchange market efficiency tests: Implications of recent empirical findings. *Journal of International Money and Finance, 5,* 135–150.

Eiteman, D. K., Stonehill, A. I., & Moffett, M. H. (2007). *Multinational Business Finance*. Boston: Pearson Addison Wesley.

Enders, W., & Dibooglu, S. (2001). Long run purchasing power parity with asymmetric adjustment. *Southern Economic Journal, 68,* 433–445.

Engle, R. F., & Granger, C. W. J. (1987). Cointegration and error correction representation, estimation and testing. *Econometrica, 55,* 251–276.

Fama, E. F. (1970). Efficient capital markets: A review of theory and empirical work. *Journal of Finance,* May, 383–417.

Frankel, J. A. (1980). Tests of rational expectations in the forward exchange market. *Southern Economic Journal, 46,* 1083–1101.

_____. (1982). In search of the exchange risk premium: A six country test assuming mean variance optimization. *Journal of International Money and Finance, 1,* 255–274.

Edwards, S. (1983). Floating exchange rates, expectations and new information. *Journal of Monetary Economics, 11,* 321–336.

Granger, C. W. J., & Lee, T. H. (1989). Investigation of production, sales and inventory relationships using multicointegration and nonsymmetric error-correction models. *Journal of Applied Econometrics, 4,* S145–S159.

Gupta, S. (1991). A note on the efficiency of black markets in foreign currencies. *Journal of Finance, 36,* 705–710.

Hakkio, C. S., & Rush, M. (1989). Market efficiency and cointegration: An application to the sterling and deutsche mark exchange rates. *Journal of International Money and Finance, 8,* 75–88.

Johansen, S. (1988). Statistical analysis of co-integration vectors. *Journal of Economic Dynamics and Control, 12,* 231–254.

Johansen, S., & Juselius, K. (1990). Maximum likelihood estimation and inference on co-integration with applications to the demand for money. *Oxford Bulletin of Economics and Statistics, 52,* 169–210.

Lajaunie, J. P., McManis, B. L., & Naka, A. (1996). Further evidence on foreign exchange market efficiency: An application of co-integration tests. *Financial Review, 31,* 553–564.

Levich, R. M. (1978). Tests of forecast models of market efficiency in international money market. In J. A. Frankel & H. G. Johnson (Eds.). *The Economics of Exchange Rates.* Reading, Mass: Addison-Wesley.

Liu, C. Y., & He, J. (1991). A variance-ratio test of random walks in foreign exchange rates. *Journal of Finance, 46,* 773–785.

Ljung, G. M., & Box, G. P. E. (1978). On a measure of lack of fit in time series models. *Biometrica, 66,* 66–72.

Masih, A. M. M., & Masih, R. (1996). Common stochastic trends, multivariate market efficiency and the temporal causal dynamics in a system of daily spot exchange rates. *Applied Financial Economics, 6,* 495–504.

Nefti, S. N. (1984). Are economic time series asymmetric over the business cycle? *Journal of Political Economy, 92,* 307–328.

Norrbin, S., & Reffertt, K. (1996). Exogeneity and forward rate unbiasedness. *Journal of International Money and Finance, 15,* 267–274.

Pilbeam, K. (1992). *International Finance*. London: Macmillan.

Sanchez–Fung, J. R. (1999). Efficiency of the black-market foreign exchange rates and PPP: The case of the Dominican Republic. *Applied Economics Letters, 6,* 173–176.

Singh, T. C. (1997). Efficiency of Australian foreign exchange market – Empirical evidence from co-integration tests. *Indian Economic Journal, 44,* 155–69.

Speight, A., & McMillan, D. G. (2001). Co-integration and predictability in pre-reform East European black-market exchange rates. *Applied Economics Letters, 8,* 775–759.

Taylor, M. P. (1988). A dynamic model of forward foreign exchange risk with estimates for three major exchange rates. *The Manchester School, 56,* 55–68.

Wesso, G. R. (1999). The forward rate as an optimal predictor of the future spot rate in south africa: An econometric analysis. *Occasional Paper No. 13,* South African Reserve Bank.

Wickremasinghe, G. B. (2005). Efficiency of foreign exchange markets: A developing country perspective. *Asian Academy of Management Journal, 10,* 1–17.