Linearity and stationarity of South Asian real exchange rates

Liew, Venus Khim-Sen and Lee, Hock-Ann and Lim, Kian-Ping and Lee, Huay-Huay

February 2006

Title: Linearity and Stationarity of South Asian Real Exchange Rates

Authors: Venus Khim-Sen Liew[a], Hock-Ann Lee[a], Kian-Ping Lim[a] and Huay-Huay Lee[b]

Institutional Affiliations:

[a] *Labuan International Campus, Universiti Malaysia Sabah, P.O.Box 80594, 87015 Labuan, Malaysia.*
[b] *Faculty of Business and Law, Multimedia University, Jalan Ayer Keroh Lama, 75450, Bukit Beruang Melaka, Malaysia.*

Abstract

The linearity and stationarity of the real exchange rates of India, Nepal, Pakistan and Sri Lanka are investigated using formal linearity and the recently developed nonlinear stationary test procedures. Results obtained show that these real exchange rates are stationary albeit the presence of nonlinearity.

JEL Classification: F31, N15, C52

Key Words**:** Nonlinearity; Real exchange rates; South Asia; linearity test; nonlinear stationary test

Corresponding author:

Postal Address:
Venus Khim-Sen Liew
Labuan International Campus,
Universiti Malaysia Sabah,
P.O.Box 80594, 87015 Labuan,
Malaysia.
Tel: +6087-466716, +6016-8566436
Fax: +6087460477
Email: venusliew@yahoo, liew@mailkal.ums.edu.my

Linearity and Stationarity of South Asian Real Exchange Rates

1. Introduction

Numerous documentations on the findings of nonlinearity in the exchange rates have been recently added to the existing established exchange rate study. Micheal *et al*. (1997), Sarantis (1999), Taylor and Peel (2000), Baum *et al*. (2001) and Peel *et al*. (2001), are among some of the recent articles reporting the existence of nonlinear exchange rate behaviour in the context of developed nations. Earlier on, Peel and Speight (1996) have detected nonlinearities in the exchange rate of East European countries. In a separate endeavour, Ma and Kanas (2000) found nonlinearities from those countries under Exchange Rate Mechanism. Sarno (2000a, b), on the other hand, documented the presence of nonlinearity in the real exchange rates of Middle East and highly inflation countries. Of late, Liew *et al*. (2003, 2004) and Liew (2004) found strong evidence of nonlinear behaviour of US dollar as well as Japanese yen based real exchange rates in the Asian region. This is followed by Anuruo *et al*. (2006) complement the literature by offering empirical evidence of nonlinear real exchange rates from the African continent.

One important implication of these documentations is that linear testing frameworks may no longer be taken for granted as adequate tools in the study of exchange rate. Another equally crucial implication is that linearity property of exchange rates, which has been neglected in the past, partially due to ignorance of the plausible presence of nonlinearities and partially due to the unavailability of advance information and computer technology, must be predetermined using formal linearity test prior to the application any econometric testing and estimation procedures. Otherwise, robustness of the results and relevance of the inference made from these studies are doubtful. Conventionally, it has been a common and formal practice to subject time series including exchange rates to linear testing and estimation procedures with the unjustified assumption that the series under tested is linear in nature. Remarkably, these results are meaningful only if the null hypothesis of linearity has not been rejected by formal linearity test (Liew *et al*. 2003; Tang *et al*., forthcoming). In this respect, one easily conducted formal linearity test, which has been adopted in most of the above-mentioned studies to uncover evidence of nonlinearity in the real exchange rates is the Luukkonen-Saikkonen-Teräsvirta (LST) linearity test (Luukkonen *et al*., 1988). Remarkably, besides exchange rate study, the usefulness of LST test has been extended to the study of, among others, income convergence (Liew and Lim, 2005) and balancing item (Tang *et al*., forthcoming). Section 2 offers a brief review of this test procedure.

Besides linearity, stationary is another issue in the analysis of time series. As opposed to linearity, stationary has received considerably more attention from economic researchers. In fact, stationary test is conventionally the first test prior to any other econometric testing and estimating procedures. Nonetheless, previous stationary testing procedures like the augmented Dickey-Fuller type (Dickey and Fuller, 1979) and Philips-Perrons (1988) type have implicit assumption of linear time series. Responsive to the plausible presence of nonlinearity in time series, Kapetanious *et al*. (KSS) (2003) recently developed a stationary test to test the null hypothesis of non-stationary against the alternative of nonlinear stationary. Typically, Liew *et al*. (2003, 2004, 2005) uncovered 8 (6) US dollar (Japanese yen)-based stationay real exchange out of 13 selected countries in the Asian region by this KSS test. In complementary, Anuruo *et al*. (2006) revealed that 11 out of 13 selected US dollar-based African real exchange rates are stationary by the same test. This test will be reviewed shortly in Section 3.

In reviewing the literature, it is observed that study of South Asian exchange rates in the nonlinear perspective is rare and thus more effort is needed in this context. To the best of our knowledge, Chaudhury (2004) remains the sole study in this region that incorporated nonlinear testing frameworks but the author confined their research to Bangladesh only. Earlier on, Liew *et al*. (2003, 2004) and Liew (2004) conducted a series of research on the Asia region but the Southern part of Asia is not considered in these studies. As such, it would be interesting to know what the South Asian real exchange rates have to say on this context. Motivated by the enthusiasm to put up the shutters on this literature gap, this study is therefore conducted to determine the linearity and stationary properties of South Asian real exchange rates.

The remainder of this paper is structured as follows: Sections 2 and 3 offers a brief review of the Luukkonen *et al.* (LST) (1988) linearity test and the Kapetanios *et al.* (KSS) (2003) nonlinear stationary test, which will be applied in this study. Section 3 described the data of study, whereas Section 4 presents the empirical results of the current study and offers related interpretation. The final section concludes this study.

2. Luukkonen *et al*. (LST) (1988) Linearity Test

To examine whether South Asian real exchange rates are linear or nonlinear in nature, this study adopts the following linearity test procedures suggested in the work of Luukkonen *et al.* (1988) and Teräsvirta (1994):

$$y_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i y_{t-i} + \sum_{j=1}^{p} \beta_j y_{t-j} y_{t-d} + \beta_{p+1} y_{t-d}^3 + e_t , \tag{1}$$

where y_t is the real exchange rate, p and d are the optimal autoregressive order and delay lag length respectively. As usual, e_t is the stochastic errors with zero mean and constant variance under the null hypothesis.

The test procedure as specified in Equation (1) is the augmented first order auxiliary regression in the work of Luukkonen *et al.* (1988)[1], which have been developed based on the idea of testing the null hypothesis that all β 's in the following framework are simultaneously zero, against the alternative hypothesis that at least one β is not zero.

$$y_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i y_{t-i} + G(y_{t-d}) \left[\beta_0 + \sum_{j=1}^{p} \beta_j y_{t-j} \right] + v_t , \tag{2}$$

where $G(y_{t-d})$ denotes the transition function which may be specified as exponential or logistic function (see Luukkonen *et al.*, 1988). v_t is the usual stochastic errors.

[1] See Luukkonen *et al.* (1988) for other versions of auxiliary regressions.

Equation (2) actually specifies the Smooth Transition Autoregressive (STAR) data generating process, where $G(y_{t-d})\left[\beta_0+\sum_{j=1}^{p}\beta_j y_{t-j}\right]$ is the nonlinear component. Note that if β 's =0, Equation (2) would simply reduce to the linear Autoregressive (AR) process. However, as the properties of the transition function, the coefficients of nonlinear terms (β 's) of the variable under estimation are not identified under the null hypothesis, Luukkonen *et al.* (1988) reparameterized Equation (2) into its auxiliary regression version as in Equation (1) using the basic idea of Taylor expansion approximation. Accordingly, rejection of null hypothesis of all b 's =0 in the auxiliary Equation (1) against the alternative that at least one b is non zero implies the presence of nonlinearity in favour of STAR(p) framework. Hence, the rejection of null hypothesis provides evidence against the adequacy of linear framework. As such, it is reasonable for one to doubt the reliability of econometric testing procedures constructed under the assumption of linear data generating process.

The decision on whether linear or nonlinear framework is appropriate may be based on F-type and the Lagrange Multiplier-type (LM) (which has asymptotical chi-squared distribution) test statistics. Note that in conducting this LST test, it has been a common practice to fix the optimal autoregressive order, p which has to be determined in advance based on partial autocorrelation function (PACF) of the series under tested; see, for instance, Taylor and Peel (2000), Liew *et al.* (2003, 2004), Liew and Lim (2005), Anuoro *et al*. (2006) and Tang *et al*. (forthcoming). As for the optimal delay parameter, d, which also needs pre-determination, this study chooses $d \in \{1,\ldots,8\}$ from the one that maximizes the LST test statistics. To avoid the use of conventional tabulated critical values, which have various assumptions including normally distributed, homoscedastic and non-serially correlated errors, this study bootstraps the relevance critical values based on 5000 replicated series using empirical probability distribution and exact sample size (124 observations). Remarkably, unlike simulation, which is based on stochastic distribution, bootstrapping has a disadvantage of case-specific (different series has different empirical probability distribution thereby different bootstrap critical values) and thus cannot be applied to all situations. Nonetheless, it is this unique feature that makes the bootstrap critical values more robust in any individual case than those simulated for general purpose.

3. Kapetanios *et al.* (KSS) (2003) Nonlinear Stationary Test

Just like a linear series, a given nonlinear series may or may not be stationary. In this perspective, the following stationary test constructed on the nonlinear framework due Kapetanios *et al.* (KSS) (2003) to may be applied:

$$\Delta z_t = \sum_{j=1}^{p} \rho_j z_{t-j} + \delta \; z_{t-1}^3 \; + \omega_t \,, \tag{3}$$

where z_t is the de-meaned and de-trended y_t series and ω_t denotes the usual stochastic errors.

The testing framework as depicted in Equation (3), which is analogue to the augmented Dickey-Fuller test, is actually a reparameterized version of the following specification:

$$\Delta z_t = \phi\, z_{t-1}[1-\exp(-\theta^2 z_{t-1}^2)] + \varepsilon_t\,, \tag{4}$$

which is constructed to detect the presence of non-stationarity against nonlinear but globally stationary STAR process, in which the direct testing of null hypothesis, $\text{H}_0: \theta^2 = 0$ against the alternative $\text{H}_1: \theta^2 > 0$ is infeasible, since ϕ is not identified under the null.

The null hypothesis, $H_0:\ \delta = 0$ may be tested against the alternative, $H_1\,\delta < 0$ in Equation (3) based on *t*-type statistic of δ, in which the asymptotical distribution is non- normal and thus decision cannot be based on the conventionally tabulated student-*t* table. The critical values obtained via stochastic simulation for a sample size of 1000 observations are available in Kapetanios *et al.* (KSS) (2003). Nonetheless, for robustness, this study bootstraps the relevance critical values based on 5000 replicated series using empirical probability distribution and exact sample size (124 observations).

4. Data of Study

The U.S. dollar denominated real exchange rates for four selected[2] South Asian economies (India, Nepal, Pakistan and Sri Lanka) in their logarithmic form are considered in this study. These real exchange rates are derived from the relative form of purchasing power parity (PPP) hypothesis, namely $y_t = s_t + p_t^* - p_t$ where y_t and s_t are, respectively, the logarithm of real and nominal exchange rates (domestic price of US currency) at time *t*, and p_t^* and p_t are the logarithms of U.S. and domestic price levels respectively. We use the end of period nominal bilateral exchange rate data series, taken from various issues of International Financial Statistics published by IMF. The domestic price is the consumer price index (CPI) of domestic and foreign price is U.S. CPI. Our data spans from the first quarter of the year 1973 to the fourth quarter of the year 2003 (1973:1 to 2003:4). The plots of the real exchange rates series are shown in Figure 1.

[insert Figure 1 about here]

4. Empirical Results and Interpretations

As a preliminary exercise, various commonly linear stationary tests including the augmented Dickey-Fuller test (Dickey and Fuller 1979), Dickey-Fuller test with GLS detrending (Elliott *et al*., 1996), Phillips-Perron test (Phillips and Perron, 1988), Phillips-Perron test with GLS detrending of Ng and Perron (2001) and the Kwiatkowski-Phillips-Schmidt-Shin test of Kwiatkowski *et al*. (1992). The results are summarized in Table 1.

It is clear from Table 1 that all tests consistently suggest that the real exchange rate is non-stationary for India, whereas for Sri Lanka, stationary. As for the other two rates, results from the linear tests are mixed. In particular, all results except from the NP test indicate that the Nepal real exchange rate is non-stationary. On the other hand, Pakistan real exchange rate is non-stationary based on ERS, NP and KPSS tests, but stationary by the ADF and PP tests. Note that at this moment, it is rather too early to

[2] The selection is based on the availability of completed data set.

draw any conclusion from these stationarity tests, as they are only reliable under the assumption of the linear real exchange rates. In this context, Kapetanios *et al*. (2003) show via simulation that linear stationary tests have lower power if the data generating process is nonlinear in nature. Moreover, Liew *et al*. (2004) have empirical demonstrated that linear stationary tests failed to detect any stationary Asian real exchange rates, which contain nonlinearity. Hence, it is important to identify the linearity of the real exchange rate, before the selection of appropriate testing procedures, to avoid misleading statistical inference and implications. To serve this purpose, the current study adopts the formal LST linearity test of Luukkonen *et al*. (1988).

[insert Table 1 about here]

Prior the application of the LST linearity test, however, the optimum autoregressive order *p* needs to be empirical determined in advance. In this respect, the partial autocorrelation functions (PACFs) for the South Asian real exchange rates are plotted in Figure 2. It is obvious from Figure 2 that *p* equals one, in all cases, based on the PACFs criterion.

Having determined the autoregressive order, we then proceed to examine whether the South Asian real exchange rates are linear or nonlinear in nature using the Luukkonen *et al.* (1988) linearity test. This test result is summarized in Table 2. We know from Table 2 that the null of linearity has been rejected by both the *F*-type and the *LM*-type LST test statistics at standard significance levels in all cases. The rejection of the null hypothesis indicates that the nonlinear parameters are jointly significant by the *LST* test, thereby suggesting that linear framework is inadequate in characterizing the behaviour of the South Asian real exchange rates. Thus, estimating the linear stationary tests disregarding the presence of nonlinearity will yield deceptive conclusions. Particularly, the above-reported results from the linear testing procedures are neither here nor there and so should be inferred with caution.

[insert Figure 2 about here]

This finding is consistent with and complements the earlier findings of nonlinearity in the real exchange rates of industrialised nations (Baum *et al*., 2001), Asian economies (Liew *et al*., 2003) and African countries (Anuruo *et al*., 2006).

The evidence of nonlinearity in the real exchange rates of this study stipulates the application of the nonlinear stationary test. Subsequently, the KSS test is performed and the estimated results are summarized in Table 3.

[insert Table 2 about here]

It is obvious from Table 3 that the null hypothesis of non-stationary has been rejected in favour of nonlinear stationary for the real exchange rates of India, Nepal, Pakistan and Sri Lanka, implying that they are all stationary in the nonlinear sense. This neat result is in sharp contrast to the mixed results from linear tests. The contradicting results are not surprising considering the fact that linear test is not as powerful as nonlinear test in the present of nonlinearity (Kapetanious *et al*., 2003; and Liew *et al*. (2003, 2004). Moreover, the current finding provides additional empirical evidence of nonlinear stationary real exchange rates in the South Asian region to the existing literature; see among others, Baum *et al*. (2001), Liew *et al*. (2004), and Anuruo *et al*. (2006).

[insert Table 3 about here]

5. Conclusions

This study utilizes formal linearity test suggested in the work of Luukkonen *et al*. (1988) to show that South Asian real exchange rates are nonlinear in movement and so reject the appropriateness of conventional testing and estimating procedures such as stationary test, the order of integration test, the Granger causality test and the cointegration test, which are constructed based on the linear framework—in exchange rate study of this region. These linear procedures are relevance only when formal linearity test result fails to provide evidence on the existence of nonlinearity. By the same principle, exchange rate policy makers can no longer make valid decision upon disregarding the present of nonlinearity in real exchange rates in this region.

Based on the recently formulated nonlinear stationary test due to Kapetanious *et al*. (2003), it has been shown in this study that South Asian real exchange rates are not only nonlinear but also stationary. Few important implications of this finding are in line. The major one is that stationarity of real exchange rates validates the long run purchasing power parity (PPP), thereby providing fresh evidence to the old PPP literature (see Baum *et al*. 2001, for instance) from South Asia. More importantly, it signifies that the nominal exchange rates in this region are in equilibrium with their respective macroeconomic fundamental. For this, credit should be given to the leaders of these economies, which are relatively poor as compare to other Asian economies, for their successfulness in maintaining the macroeconomic equilibrium at least.

Moreover, stationary real exchange rates in the South Asia means that the corresponding nominal exchange rates exhibit long run co-movement with the corresponding CPI-based relative prices. This in turn indicates that the exchange rates forecasters (for the purpose of international trade and investment, etc) may depend on the anticipated relative price to predict the future movement of South Asia nominal exchange rates. From the other perspectives, government policy makers of the region may monitor the movement of nominal exchange rates and intervene at the right time to minimise excessive fluctuation, or to correct mis-adjustment, of nominal exchange rate when deemed necessarily judging from the relative price equilibrium. Nonetheless, attention should be given to nonlinearity when dealing with monitoring and forecasting. Last but not least, stationarity of real exchange rates implies the convergence of prices (in dollar terms) of consumer goods in South Asian countries and US, thereby indicating no arbitrage opportunity of these goods.

References

Baum, C.F., Barkoulas, J.T. and Caglayan, M. (2001). Nonlinear Adjustment to Purcahsing Power Parity in the Post-Bretton Woods Era, *Journal of International Money and Finance*, **20**, 379-399.

Chowdhury, I. (2004). Purchasing Power Parity and the Real Exchange Rate in Bangladesh: A Nonlinear Analysis, *Working Paper Series in Economics*, No. 14, University of Cologne.

Dickey, D. and Fuller, W.A. (1979). Distribution of the Estimators for Time Series Regressors with a Unit Root, *Journal of the American Statistical Association* **74**, 427 – 431.

Elliot, G. Rothenberg, T.J. and Stock, J.H. (1996). Efficient Tests for an Autoregressive Unit Root, *Econometrica*, **64**, 813-836.

Kapetanios, G., Shin, Y and Snell, A. (2003). Testing for a Unit Root in the Nonlinear STAR Framework, *Journal of Econometrics*, **112**, 359–379.

Kwiatkowski, D., Phillips, P.C.B., Schmidt, P. and Shin, Y. (1992). Testing the Null Hypothesis of Stationary against the Alternative of a Unit Root, Journal of Econometrics, **54**, 159-178.

Liew, V.K.S. (2004). Nonlinear Adjustment of ASEAN-5 Real Exchange Rates: Symmetrical or Asymmetrical? *Economics Bulletin*, **6(8)**, 1 -8.

Liew, V.K.S., Baharumshah, A.Z. and Chong T.T.L. (2004). Are Asian Real Exchange Rates Stationary? *Economics Letters*, **83**, 313-316.

Liew, V. K. S., Chong, T. T. L. and Lim, K. P. (2003). The Inadequacy of Linear Autoregressive Model for Real Exchange Rates: Empirical Evidence from Asian Economies, *Applied Economics*, **35**, 1387–1392.

Liew, V.K.S. and Lim, K.P. (2005). Income Divergence? Evidence of Nonlinearity in the East Asian Economies, *Economics Bulletin*, **15(1)**, 1–7.

Luukkonen, R., Saikkonen, P. and Teräsvirta, T. (1988). Testing Linearity against Smooth Transition Autoregressive Models, *Biometrika*, **75**, 491-499.

Ma, Y. and Kanas, A. (2000). Testing for Non-linear Granger Causality from Fundamentals to Exchange Rates in the ERM, *Journal of International Financial Markets, Institutions and Money*, **10**, 69-82.

Micheal, P., Nobay, A. R., Peel, D. A. (1997) Transaction Costs and Nonlinear Adjustment in Real Exchange Rates: An Empirical Investigation, *Journal of Political Economy*, **105**, 862–879.

Newey, W. and West, K. (1994). Automatic Lag Selection in Covariance Matrix Estimation, *Review of Economic Studies*, **61**, 631-653.

Ng, S. and Perron, P. (2001). Lag Length Selection and the Construction of Unit Root Test with Good Size and Power, *Econometrica*, **69**, 1519 – 1554.

Peel, D.A. and Speight, A.E.H. (1996). Non-Linearities in East European Black-Market Exchange Rates, *International Journal of Finance and Economics*, **2**, 39-57.

Peel, D., Sarno, L. and Taylor, M. P. (2001). Nonlinear Mean Reversion in Real Exchange Rates: Towards a Solution to the Purchasing Power Parity Puzzles, *International Economic Review*, **42**, 1015–42.

Phillips, P.C.B. and Perron, P. (1988). Testing for a Unit Root in Time Series Regression, Biometrika, **75**, 335-346.

Sarantis, N. (1999). Modeling Nonlinearities in Real Effective Exchange Rates, *Journal of International Money and Finance*, **18**, 27-45.

Sarno, L. (2000a). Real Exchange Rate Behaviour in High Inflation Countries: Empirical Evidence from Turkey, 1980-1997, *Applied Economics Letters*, **7**, 285-291.

Sarno, L. (2000b) Real Exchange Rate Behaviour in the Middle East: A Re-Examination, *Economics Letters*, **66**, 127–136.

Tang, T.C. Lim, K.P. and Liew, V.K.S. (forthcoming) Unsustainability of Japan's Balancing Item: Evidence from Non-linear Unit Root Test, *Finance Letters*.

Taylor, M.P. and Peel, D.A. (2000) "Nonlinear adjustment, long-run equilibrium and exchange rate fundamentals", *Journal of International Money and Finance*, 19, 33-53.

Teräsvirta, T. (1994) "Specification, estimation, and evaluation of Smooth Transition Autoregressive Models", *Journal of the American Statistical Association*, 89(425), 208-218.

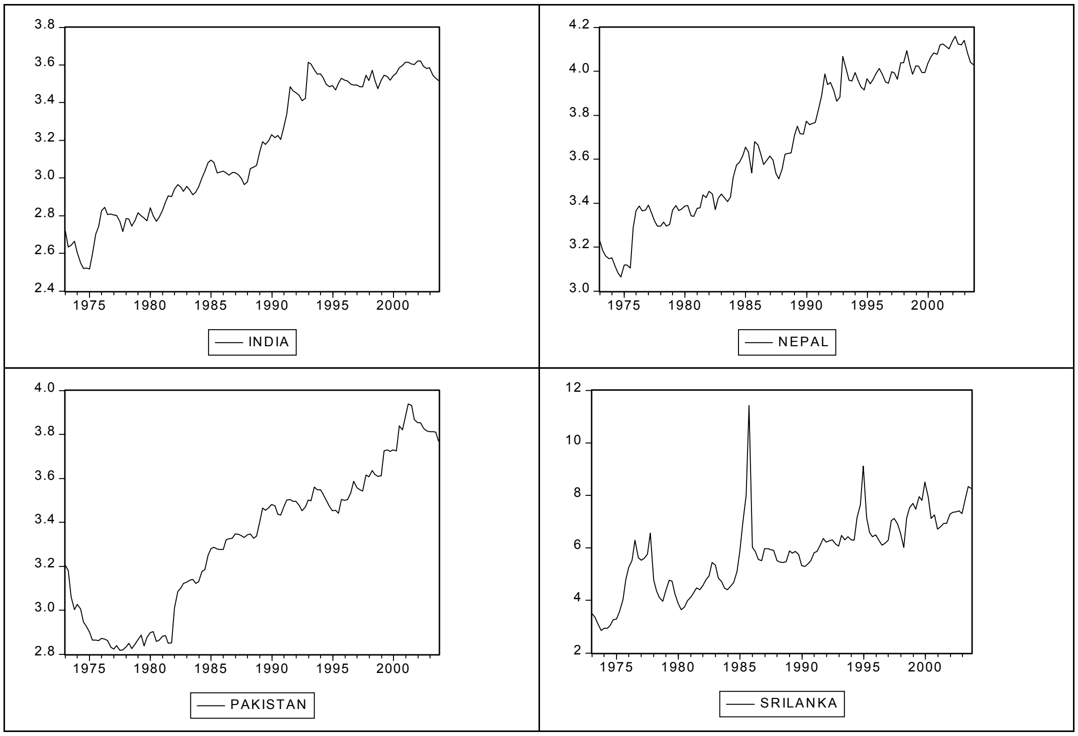

Figure 1: Plots of real exchange rates by country

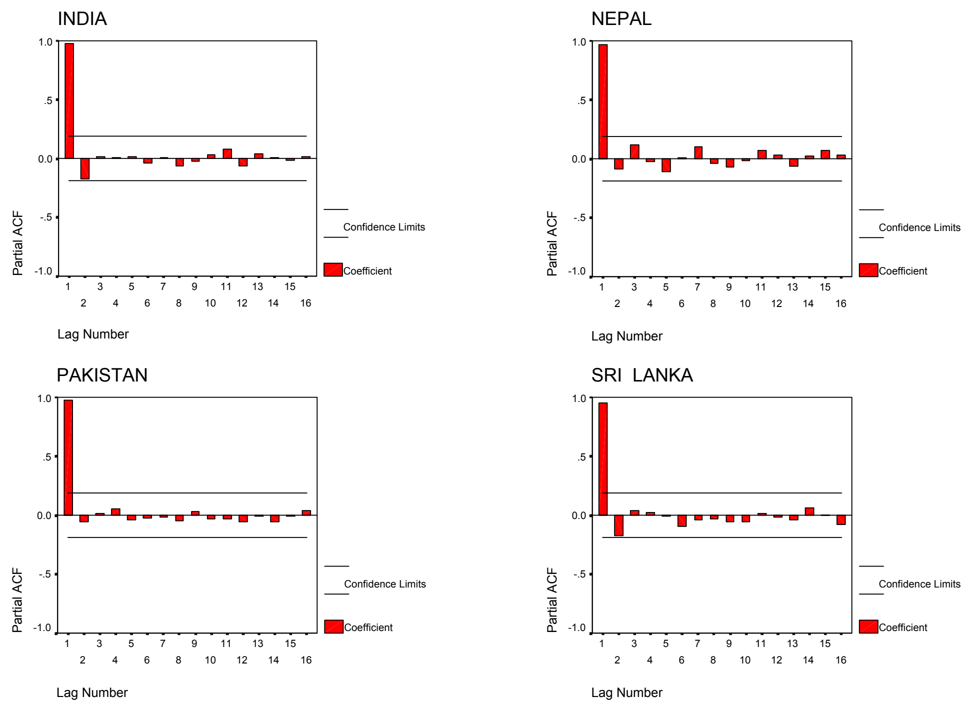

Figure 2: The PACFs of real exchange rates by country

Table 1. Result of Linear Stationary Tests.

	Test Statistic (optimal lag)				
Country	ADF	ERS	PP	NP	KPSS
India	-2.1056 (0)	-1.9432 (0)	-2.4904 (3)	-1.8760 (0)	0.1293 (8)^{X}
Nepal	-2.0078 (0)	-2.4688 (7)	-3.4031 (6)	-2.7805 (0)^{X}	0.1320 (8)^{X}
Pakistan	-4.2090 (0)^{I}	-1.1649 (0)	-4.1448 (5)^{I}	-1.0481 (0)	0.1002 (8)
Sri Lanka	-4.8839 (0)^{I}	-4.8667 (0)^{I}	-4.8948 (5)^{I}	-4.0907 (0)^{I}	0.0369 (6)
Critical Values					
1%	-4.03	-3.55	-4.03	-3.42	0.216
5%	-3.45	-3.00	-3.45	-2.91	0.146
10%	-3.15	-2.72	-3.15	-2.62	0.119

Note: ADF, ERS, PP, NP and KPSS are, in that order, the augmented Dickey-Fuller test (Dickey and Fuller 1979), Dickey-Fuller test with GLS detrending (Elliott *et al*., 1996), Phillips and Perron (1988), PP test with GLS detrending of Ng and Perron (2001) test Kwiatkowski-Phillips-Schmidt-Shin test of Kwiatkowski *et al*. (1992). The null (alternative) hypothesis of the KPSS test is stationary (non-stationary), whereas the reverse is true for all other tests. Superscripts I, V and X denote statistically significant at 1, 5 and 10% level respectively. The optimal lags in ADF, ERS and NP tests are selected based on modified AIC, whereas the Newey-West bandwith (Newey and West, 1994) selection method is employed in PP and KPSS tests.

Table 2. Linearity Test Results

Country	*p*	*d*	*LST test statistic*	Bootstrap *critical* values		
				10%	5%	1%
			F-type			
India	1	1	6.8181^{X}	6.130	7.706	10.923
Nepal	1	4	4.412^{X}	4.274	5.576	8.642
Pakistan	1	8	5.701^{V}	4.138	5.431	8.382
Sri Lanka	1	1	50.017^{I}	6.047	7.657	11.453
			LM-type			
India	1	1	7.431^{X}	6.720	8.591	12.611
Nepal	1	4	4.706^{X}	4.596	6.078	9.731
Pakistan	1	8	6.617^{X}	4.798	7.096	9.369
Sri Lanka	1	1	90.204^{I}	6.623	8.531	13.301

Note: Superscripts I, V and X denote statistically significant at 1, 5 and 10% level respectively.

Table 3. Nonlinear Test Results

Country	p^a	*KSS statistic*	Bootstrap *KSS critical* values		
			10%	5%	1%
India	1	-2.578^{V}	-1.711	-1.952	-2.875
Nepal	1	-3.461^{I}	-1.665	-1.996	-2.756
Pakistan	1	-5.131^{I}	-1.663	-2.041	-2.787
Sri Lanka	2	-9.961^{I}	-1.599	-1.886	-2.746

Note: Superscripts V and X denote statistically significant at 5 and 10% level respectively.