Purchasing Power Parity Hypothesis in Developing Economies: Some Empirical Evidence from Sri Lanka

Guneratne B Wickremasinghe
Department of Econometrics and Business Statistics
Monash University
Caulfield
Victoria, 3145
Email: guneratne.wickremasinghe@buseco.monash.edu.au

Abstract

Purchasing power parity (PPP) hypothesis has attracted a lot of attention from academics and policy-makers particularly, during the recent float. Most previous studies used data from the developed world. This study examines the validity of the PPP hypothesis using data during the recent float from Sri Lanka. In contrast to previous studies, we use unit root tests which take into account unknown means and trends in the real exchange rates as well as graphical techniques. Both these techniques overwhelmingly reject the empirical validity of the PPP hypothesis for Sri Lanka. The results from widely-used unit root tests, however, provide mixed evidence. We attribute these inconclusive results to the low power of the widely-used unit root tests and their inability to account for unknown trends and means in the real exchange rates.

Key Words: Real exchange rates, Sri Lanka, Purchasing power parity, ERS test, DF-GLS test, US dollar

JEL Classifications: F31, C22

Purchasing Power Parity Hypothesis: Some Empirical Evidence from Sri Lanka

1. Introduction

Purchasing power parity (PPP) is a cornerstone of many theoretical models in international finance. It asserts that the price of a particular commodity, when expressed in a common currency, should be the same in every country. The PPP is an important concept for policy makers in developing countries for at least two reasons (Holmes, 2001b). First, PPP can be used as a model to predict exchange rates and determine whether a particular currency is over or undervalued. Predicting exchange rates and determining whether a currency is over or undervalued is particularly important for less developed countries and those experiencing large differences between domestic and foreign inflation rates. Second, many theories of exchange rate determination use some notion of PPP in their construction. Therefore, the validity of PPP is important to policy makers in developing countries who make their recommendations on the basis of PPP (Liu and Burkett, 1995). Empirical evidence on PPP is abundant in relation to developed as well as developing economies (see, Moosa, 1994; Papell, 1997; Fritsche and Wallace, 1997; Kouretas, 1997; Heimonen, 1999; Gil-Alanla, 2000; Caporale et al., 2001; Esaka, 2002, for developed countries and Soofi, 1998; Choudhry, 1999; Azali et al., 2001; Nagayasu, 2002; Holmes, 2002; Achy, 2003, for developing countries). These studies use different data sets and methodologies. However, the results of empirical studies, particularly during the floating exchange rate regime, have not been consistent providing mixed evidence on the validity of PPP.

Almost all the empirical studies on PPP prior to the early part of the 1990s were conducted on the assumption of linear adjustment of real exchange rates towards

deviations from PPP. However, several recent papers (see, Dumas, 1992; Uppal, 1993; Sercu et al., 1995; Coleman, 1995) develop models of real exchange rate determination which take into account frictions existing in international trade such as transaction costs that lead to nonlinear adjustment of real exchange rates toward deviations from PPP. Subsequently, there have been several empirical studies which model the adjustment of real exchange rates toward PPP deviations as a nonlinear process using recently developed econometric techniques (see, Baum et al., 2001, Coakley and Fuertes, 2001; Enders and Dibooglu, 2001 and Chen and Wu, 2000). Most of these papers provide evidence in favour of PPP hypothesis.

To the knowledge of the author, there have been four recent studies using Sri Lankan data. These studies used data for bilateral exchange rates (Aggarwal et al., 2000; Holmes, 2001a; Holmes, 2001b) and nominal and effective exchange rates (Weliwita, 1998), and employed different econometric techniques providing mixed results. However, none of the previous studies has examined whether the PPP exists between Sri Lanka and France, Germany, the United Kingdom and India on a bilateral basis.

The objective of this paper is to extend the previous empirical literature on PPP in Sri Lanka by examining the mean-reversion of six bilateral real exchange rates. In addition to the graphical analysis used to gain a preliminary idea on the PPP, two recent unit root tests (GLS-detrended Dickey-Fuller test and ERS point optimal test (Elliot, Rothenberg and Stock, 1996)) that assume linear adjustment of real exchange rates toward PPP deviations are used in the analysis. The GLS-detrended Dickey-Fuller test has the best overall performance in terms of small sample size and power dominating the ordinary Dickey-Fuller test. The ERS point optimal test is robust to

the presence of an unknown mean or trend in a time series. For comparison, results from two widely-used unit root tests (Phillips-Perron (PP) (1988) test and Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) (1992) test) are also reported.

The paper is organized as follows. Methodology and data used are described in the second section. The penultimate section discusses the empirical results. The fourth section presents the conclusion of the paper.

2. Methodology and data

To investigate the empirical validity of PPP in Sri Lanka, two methodologies are used: graphical and econometric. In the first graphical method, validity of PPP is investigated by examining whether there are deviations between actual and PPP exchange rates. If PPP holds, time series plots of spot exchange rates should overlap with those for the PPP exchange rates. The PPP exchange rates are calculated using the following formula:

$$\overline{S}_t = S_0\left(\frac{P_t / P_0}{P_t^* / P_0^*}\right) \tag{1}$$

where $\overline{S}_t$ is the PPP exchange rate for period *t*, S_0 is the spot exchange rate in the base period, P_t is the domestic price level in period *t* , P_0 is the domestic price level in the base period, P_t^* is the foreign price level in period *t*, and P_0^* is the foreign price level in the base period. If PPP holds, the lines for PPP exchange rates and those for actual exchange rates should move close to each other over time.

In the second graphical method, the validity of the PPP is examined by plotting the graphs of real exchange rates for each currency. If the PPP holds real exchange rates should be stationary. This means that although there are short-run deviations of the real exchanges rates from their means, in the long-run they tend to revert to their means. Real exchange rates are calculated using the following equation:

$$r_t = s_t + p_t^* - p_t \tag{2}$$

where, r_t is the natural logarithm of the real exchange rate, p_t and p_t^* are as defined above.

Econometric analysis is undertaken using two recently developed unit root tests: Dickey-Fuller generalized least squares, (DF-GLS), and Elliott, Rothenberg and Stock (ERS) point optimal test. Two old unit root tests (Phillips-Perron (PP) and Kwiatkowski, Phillips, Schmidt, and Shin (KPSS)) that are widely used are used for comparison. Each of the unit root tests used is briefly discussed below.

Phillips-Perron (PP) test

The Phillips-Perron (PP) (1988) test suggests a non-parametric method of controlling for higher order autocorrelation in a series. This test is based on the following first order auto-regressive (AR(1)) process:

$$\Delta y_t = \alpha + \beta y_{t-1} + \varepsilon_t \tag{3}$$

where y_t is the variable of interest, Δ is the difference operator, α is the constant, β is the slope and t is a subscript for time. The non-parametric correction is made to the t-ratio of β coefficient from equation (3) to account for the autocorrelation of ε_t. This correction is based on an estimate of the spectrum of ε_t at zero frequency that is robust to heteroskedasticity and autocorrelation of unknown form. In this paper, this estimation is based on Bartlett kernel. The optimal bandwidth in the PP equation is selected using the Newey-West (1994) method. Critical values tabulated by MacKinnon (1996) are used in making inferences regarding the time series properties of the variables.

Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) Test

KPSS test is based on the residuals $(\hat{u})$ from an ordinary least squares regression of the variable of interest on the exogenous variable or variables: constant or constant and time trend. The residuals obtained are used to calculate the Lagrange Multiplier (LM) statistic (see, Kwiatkowski, Phillips, Schmidt, and Shin, 1992 for details) used in the test as follows:

$$LM = \sum_{t=1}^{T} S(t)^2 / (T^2 f_0) \tag{4}$$

where *S(t)* is $\sum_{r=1}^{t} \hat{u}_r$ and f_0 is an estimator of the residual spectrum at zero frequency and T is the number of observations. Unlike in other unit root tests, in this test it is assumed that the series is stationary under the null. The critical values tabulated by KPSS are used in making inferences regarding stationarity.

Dickey-Fuller Generalised Least Squares (DF-GLS) test

This is a more powerful test than Dickey-Fuller type tests. In the Augmented Dickey-Fuller (ADF) (1979,1981) test regression, either a constant or a constant and a linear time trend is included to take account of the deterministic components of data. Elliot, Rothenberg and Stock (ERS), however, propose a modification to ADF regression in which data are detrended before the unit root test is conducted. This de-trending is done by taking the explanatory variables out the data (see, Elliott, Rothenberg and Stock, 1996 for details). Then the following equation is estimated to test for a unit root in the variable:

$$\Delta y_t^d = \alpha y_{t-1}^d + \beta_t \Delta y_{t-1}^d + ... + \beta_p \Delta y_{t-p}^d + v_t \quad (5)$$

where Δ is the difference operator, y_t^d is the generalised least squares de-trended value of the variable, α, β_t and β_p are coefficients to be estimated and v_t is the independently and identically distributed error term. As in the case of the ADF test, test for a unit root of the variable y consists of testing whether the coefficient of the AR(1) term, in this case α , in equation (5) is zero against it is less than zero. In making inferences, critical values tabulated by Elliott, Rothenberg and stock are used.

Elliott, Rothenberg and Stock (ERS) Point Optimal Test

The ERS point optimal test has been found to dominate other commonly used unit root tests, particularly, when a time series has an unknown mean or a linear trend. This test is based on the following quasi-differencing regression:

$$d(y_t \mid a) = d(x_t \mid a)'\delta(a) + \eta_t \quad (6)$$

where $d(y_t \mid a)$ and $d(x_t \mid a)$ are quasi-differenced data for y_t and x_t respectively and η_t is the error that is independently and identically distributed. Details on computing quasi differences are given in Elliott, Rothenberg and Stock (1996). In equation (6), y_t is the variable whose time series properties are tested, x_t may contain a constant only or both a constant and a time trend and $\delta(a)$ is the coefficient to be estimated. ERS recommend the use of $\bar{a}$ for a in equation (6) that is computed as $\bar{a} = 1 - 7/T$ and $\bar{a} = 1 - 13.5/T$ when x_t contains a constant and a constant and time trend respectively. In the ERS point optimal test, the null and alternative hypotheses tested are $\alpha = 1$ and $\alpha = \bar{a}$ respectively. The relevant test statistic (P_T) to test the above null hypothesis is:

$$P_T = (SSR(\bar{a}) - (\bar{a})SSR(1)) / f_0 \qquad (7)$$

where *SSR* is the sum of squared residuals from equation (6) and f_0 is an estimator for the residual at frequency zero. In making inferences, the test statistic calculated is compared with the simulation based critical values of ERS. In the empirical analysis, the four unit root tests are conducted with a constant and a time trend in the test equations.

Data

Data used in the study consist of the average exchange rates expressed in terms of the amount of Sri Lankan rupees per unit of German mark (DM), French franc (FF), the UK pound (GBP), Indian rupee (IR), Japanese yen (JY) and the US dollar (USD) and the consumer and wholesale price indices for Sri Lanka, Germany, France, the UK,

India, Japan and the USA on a monthly basis from January 1986 to November 2000. Monthly exchange rates were obtained from the Central Bank of Sri Lanka while data on consumer and wholesale/producer price indices with base year 1995 for each country except for producer price index for France were obtained from international financial statistics CD-ROM. The producer price index for France with base year 1995 was obtained from the DX database.

3. Empirical results

Take in Figure 1

Figure 1 depicts the graphs for the CPI-based PPP exchange rate and the actual exchange rate for each foreign currency. According to the PPP, the spot exchange rate of a particular exchange rate should be equal to the PPP exchange rate. If the line for the actual exchange rate is above/ below the line for the PPP exchange rate, the local currency is said to be under-valued and vice versa. According to the graphs, all but in one case the lines for the actual exchange rates move closely with the line for the PPP exchange rate although they do not overlap. However, in some periods they drift apart. This means that the exchange rate of the Sri Lankan rupee does not follow the PPP exchange rates. In relation to the Indian rupee, its actual exchange rate is significantly above the PPP exchange rate till 1991, but thereafter, two exchange rates move close to each other. However, they do not overlap. Out of the six exchange rates, the exchange rate for the US dollar moves very closely with the PPP exchange rate during the sample period.

Take in Figure 2

Figure 2 depicts the graphs for actual and PPP exchange rates when wholesale price index is used to proxy domestic and foreign price levels. As in the case of CPI-based PPP exchange rates, lines for actual exchange rates and those for PPP exchange rates except in the case of Indian rupee, show upward trends and move close to each other during certain periods of time. The gap between the PPP exchange rates and actual exchange rates are wider for Indian rupee. These results are consistent with the results obtained when CPI is used to proxy the price levels.

Take in Figure 3

Figure 3 exhibits the time series plots of the real exchange rates for the six currencies when CPI is used to represent the domestic and foreign price levels. Figure 1a and 1b for German mark and French franc respectively show identical behavioural patterns over time. However, the time series for the other real exchange rates behave differently over the sample period. If the PPP holds for any of the currencies, the time series plot for such a currency should be stationary. Stationarity means that although there may be fluctuations in real exchange rates around their mean in the short-run, the real exchange rates revert to their means over the long run. However, figure for each currency shows that none of them is stationary refuting the validity of PPP.

Take in Figure 4

The time series plots of WPI-based real exchange rates are shown in Figure 4. As in the case of CPI-based real exchange rates, the time series plots of German mark and French franc show similar behavioural patterns. However, the other real exchange

rates exhibit behavioural patterns different from each other during the sample period. A perusal of the figure indicates that none of the real exchange rates is stationary. Therefore, the time series behaviour of the six real exchange rates is not consistent with the PPP hypothesis.

Take in Table 1

Table 1 reports the results of the four unit root tests for the CPI-based real exchange rates. Panel A of the table reports results when a constant is included in the test equation. According to the results, the real exchange rates for the UK pound are stationary under the PP and the KPSS tests. The Japanese yen real exchange rates are stationary only under the PP and the KPSS tests. The real exchange rates for the other currencies (German mark, French franc, Indian rupee and the US dollar) are non-stationary under all the unit root tests. Therefore, PPP hypothesis applies only to the Japanese yen and the UK pound. The DF-GLS and the ERS point optimal tests provide consistent results indicating that all the real exchange rates are non-stationary. These results, therefore, refute the validity of PPP hypothesis in Sri Lanka.

Panel B of Table 1 reports results when a constant and a linear trend are included in the test equations. All the four unit root tests provide consistent results indicating that the real exchange rates are non-stationary. These results are inconsistent with the PPP hypothesis.

Take in Table 2

Table 2 reports results for WPI-based real exchange rates for the six currencies. Panel A of the table reports results when a constant only is included in the test equation.

Results indicate that the UK pound real exchange rate is stationary under the PP and the KPSS unit root tests. The Japanese yen is stationary only under the PP test. These results are consistent with the PPP hypothesis. However, the other four real exchange rates are not stationary under any of the four unit root tests used. These results are inconsistent with the PPP hypothesis.

Results when a constant and a time trend are included in the test equations are shown in Panel B of Table 2. Results show that the real exchange rates for German mark, French franc and the UK pound are stationary under the PP test. Further, the real exchange rates for the Japanese yen is stationary under the KPSS test and those for the UK pound are stationary under the DF-GLS test. While the above results are consistent with the PPP hypothesis, the results among the tests are not consistent.

Overall there is some evidence in favour of PPP hypothesis in respect of the real exchange rates for the UK pound. In most of the cases, the real exchange rates for the other currencies are non-stationary. Furthermore, the results of DF-GLS and ERS point optimal tests are consistent between CPI-based and WPI-based real exchange rates except that the WPI-based UK pound real exchange rate is stationary under the DF-GLS test.

4. Conclusion

This paper examines the validity of the PPP hypothesis for Sri Lanka. Exchange rates for six foreign currencies in terms of the Sri Lankan rupee during the recent floating exchange rate regime are used in the analysis. Graphical analysis indicates that there are deviations between actual and PPP exchange rates and real exchange rates are non-

stationary. Such results provide preliminary evidence against the validity of the PPP hypothesis for Sri Lanka. Econometric analysis performed using two new unit root tests, DF-GLS test and ERS point optimal test, provide results consistent with the graphical analysis. Results of two widely-used unit root tests, PP and KPSS tests, are also reported for comparison. These unit root tests provide mixed results. These results may be due to the low power of these tests and the presence of unknown means or time trends in the real exchange rates of Sri Lanka that these tests fail to take into account.

The unit root tests used in this paper are based on the assumption of symmetric adjustment of real exchange rates to deviations from PPP. Therefore, the failure of symmetric unit root tests to provide evidence in favour of PPP may also be due to the market frictions prevailing in international trade such as transaction costs. When market frictions are present, deviations from PPP follow a nonlinear stochastic process which symmetric unit root tests fail to take into account. Nonlinear adjustment of real exchange rates to deviations from the PPP can be modelled using nonlinear econometric techniques such as exponential smooth transition autoregressive (ESTAR) and threshold autoregressive (TAR) models. These aspects are left for future research. Another avenue of future research in the area of PPP in Sri Lanka would be to use multivariate linear and nonlinear models to corroborate the results of univariate tests applied in this paper.

References

Aggarwal, R. , Montanes, A. and Ponz, M. (2000) Evidence of Long-Run Purchasing Power Parity: Analysis of Real Exchange Rates in terms of the Japanese Yen, *Japan and the World Economy*, 12, 351-361.

Achy, L. (2003) Parity Revision Persistence in Real Exchange Rates: Middle Income Country Case, *Applied Economics*, 35, 541-553.

Azali, M. et al. (2001) Does PPP Hold between Asian and Japanese Economies? Evidence Using Panel Unit Roots and Panel Cointegration, *Japan and the World Economy*, 13, 35-50.

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

Caporale, G. M., Kalyvitis, S. and Pittis, N. (2001) Testing for PPP and UIP in an FIML Framework: Some Evidence for Germany and Japan, *Journal of Policy Modelling*, 23, 637-650.

Chen, S. and Wu, J. (2000) A Re-Examination of Purchasing Power Parity in Japan and Taiwan, *Journal of Macroeconomics*, 22, 271-284.

Choudhry, T. (1999) Purchasing Power Parity in High-Inflation Eastern European Countries: Evidence from Fractional and Harris-Inder Cointegration Tests, *Journal of Macroeconomics*, 21, 293-308.

Coakley, J. and Fuertes, A. (2001) Border Costs and Real Exchange Rate Dynamics in Europe, *Journal of Policy modeling*, 23, 669-676.

Coleman, A. M. (1995) Arbitrage, Storage and the "Law of One Price": New Theory for the Time Series Analysis of an Old Problem, Unpublished Working Paper, Princeton University, NJ.

Dickey, D.A., and Fuller, W.A. (1979) Distribution for the Estimates for Auto Regressive Time Series with a Unit Root, *Journal of the American Statistical Association,* 74, 427-31.

Dickey, D.A., and Fuller, W.A. (1981) Likelihood Ratio Statistics for Autoregressive Time series with a Unit Root, *Econometrica*, 49, 1057-72.

Dumas, B., (1992) Dynamic Equilibrium and the Real Exchange Rate in a Spatially Separated World, *Review of Financial Studies*, 5, 153-180.

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

Enders, W. and Dibooglu, S. (2001) Long-Run Purchasing Power Parity with Asymmetric Adjustment, *Southern Economic Journal*," 68, 433-445.

Esaka, T. (2002) Panel Unit Root Tests of Purchasing Power Parity between Japanese Cities, 1960-1998: Disaggregated Price Data, *Japan and the World Economy*, 15, 233-244.

Fritsche, C. P. and Wallace, M. (1997) Forecasting the Exchange Rate PPP Versus a Random Walk, *Economics Letters*, 54, 69-74.

Gil-Alana, L. A. (2000) Mean Reversion in the Real Exchange Rates, *Economics Letters*, 69, 285-288.

Heimonen, K. (1999) Stationarity of the European Real Exchange Rates – Evidence from Panel Data, *Applied Economics*, 31, 673-677.

Holmes, M. J. (2001a) Principal Components, Stationarity, and New Evidence of Purchasing Power Parity in Developing Countries, *Developing Economies* 39: 189-98.

Holmes, M. J. (2001b) New Evidence on Real Exchange Rate Stationarity and Purchasing Power Parity in less developed countries, *Journal of Macroeconomics* 23: 601-614.

Holmes, M. J. (2002) Purchasing Power Parity and the Fractional Integration of Real Exchange Rate: New Evidence for Less Developed Countries, *Journal of Economic Development*, 27, 125-135.

Kouretas, G. P. (1997) The Canadian Dollar and Purchasing Power Parity during the Recent Float, *Review of International Economics*, 5, 467-477.

Kwiatkowski, D., Phillips, P. C. B., Schmidt, P. and Shin, Y. (1992) Testing the Null Hypothesis of Stationarity against the Alternative of a Unit Root: How Sure are We that the Economic Time Series Have a Unit Root?, *Journal of Econometrics*, 54, 159-178.

Liu, P. and Burkett, P. (1995) Instability in Short-Run Adjustment to Purchasing Power Parity: Results for Selected Latin American Countries, *Applied Economics*, 27, 973-83.

MacKinnon, J. G. (1996) Numerical Distribution Functions for Unit Root and Cointegration Tests, *Journal of Applied Econometrics*, 11, 601-618.

Moosa, I. A. (1994) Testing Proportionality, Symmetry and Exclusiveness in Long-Run PPP, *Journal of Economic Studies*, 21, 3-21.

Nagayasu, J. (2002) Does the Long-Run PPP Hypothesis Hold for Africa? Evidence from a Panel Cointegration Study, *Bulletin of Economic Research*, 54, 181-187.

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

Papell, D. (1997) Searching for Stationarity: Purchasing Power Parity under the Current Float, *Journal of International Economics*, 43, 313-332.

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

Sercu, P., Uppal, R. and Van Hull, C. (1995) The Exchange Rate in the Presence of Transaction Costs: Implications for Tests of Purchasing Power Parity, *Journal of Finance*, 50, 1309-1319.

Soofi, A. S. (1998) A Fractional Cointegration Test of Purchasing Power Parity: The Case of Selected Members of OPEC, *Applied Financial Economics*, 8, 559-566.

Uppal, R. (1993) A General Equilibrium Model of International Portfolio Choice, *Journal of Finance*, 48, 529-553.

Weliwita, A. (1998) Cointegration Tests and the Long-Run Purchasing Power Parity: Examination of Six Currencies in Asia, *Journal of Economic Development*, 23, 103-115.

Figure 1. Actual and CPI-based PPP exchange rates

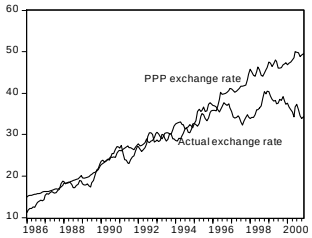

Figure 1a. German mark

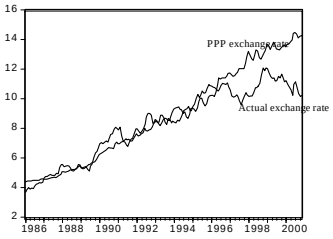

Figure 1b. French franc

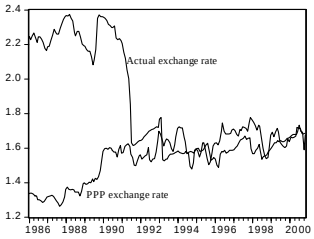

Figure 1c. Indian rupee

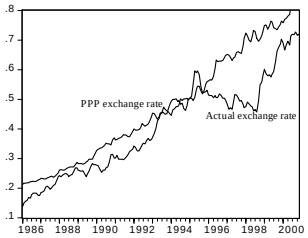

Figure 1d. Japanese yen

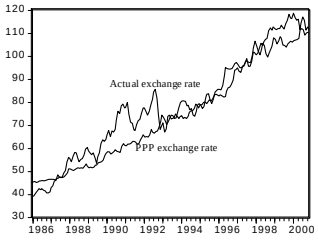

Figure 1e. UK pound

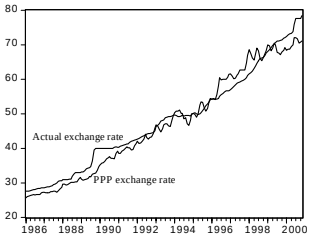

Figure 1f. US dollar

Figure 2. Actual and WPI-based PPP exchange rates

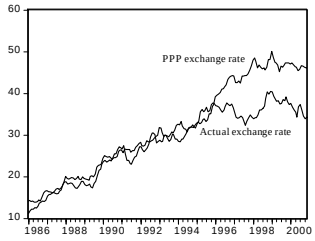

Figure 2a. German mark

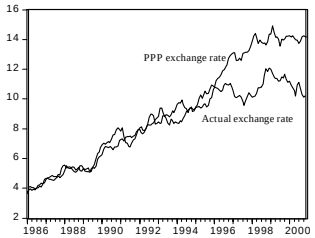

Figure 2b. French franc

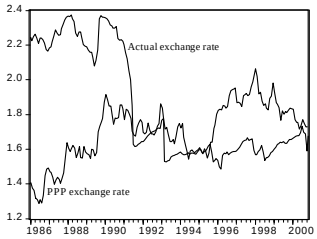

Figure 2c. Indian rupee

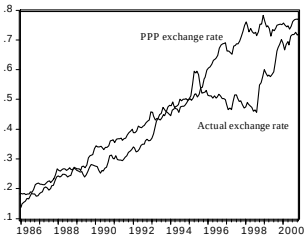

Figure 2d. Japanese yen

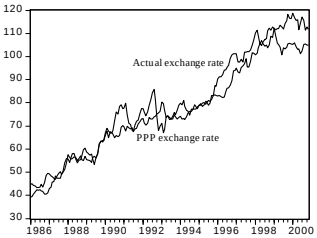

Figure 2e. UK pound

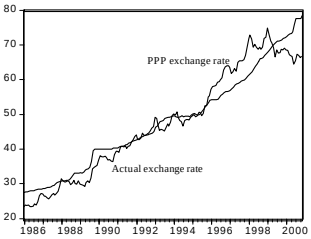

Figure 2f. US dollar

Figure 3. CPI-based real exchange rates

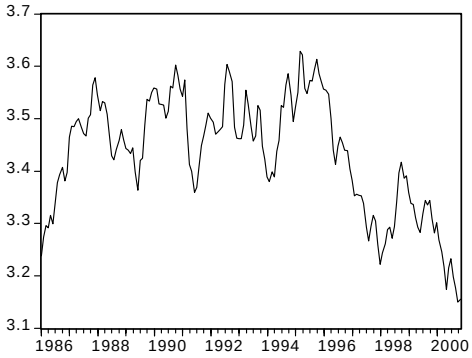

Figure 1a. German mark

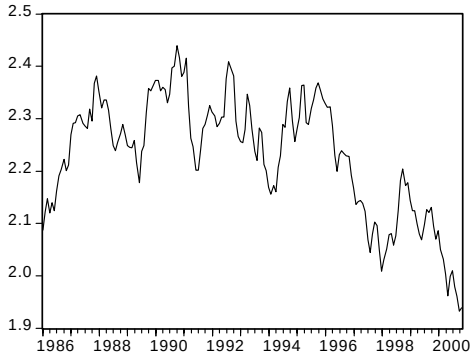

Figure 1b. French franc

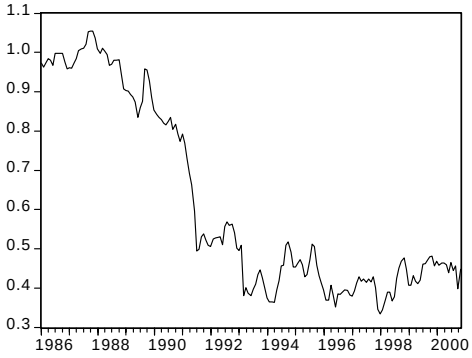

Figure 1c. Indian rupee

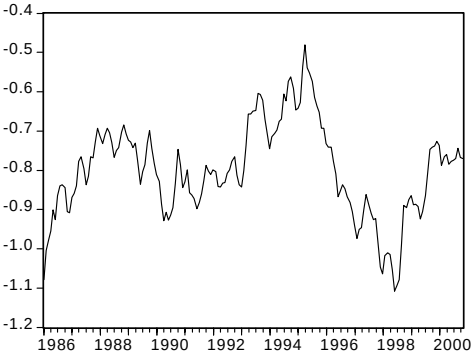

Figure 1d. Japanese yen

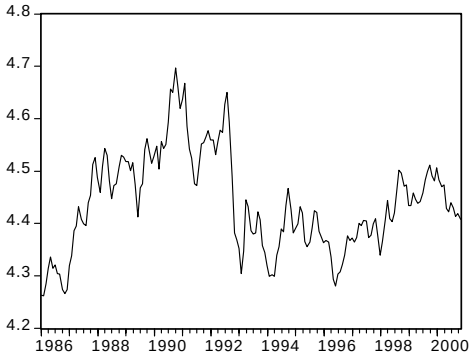

Figure 1e. UK pound

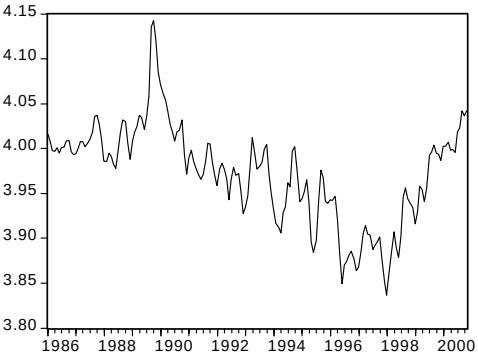

Figure 1f. US dollar

Figure 4. WPI-based real exchange rates

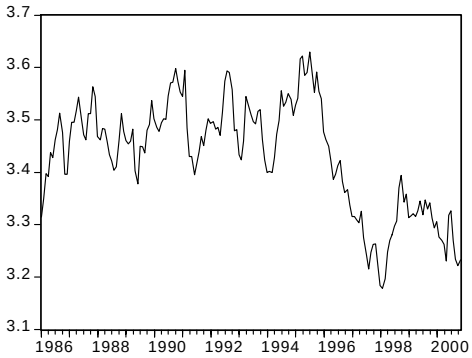

Figure 2a. German mark

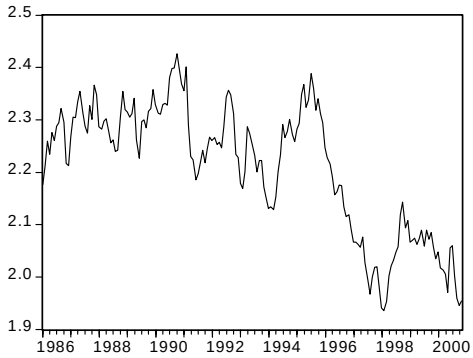

Figure 2b. French franc

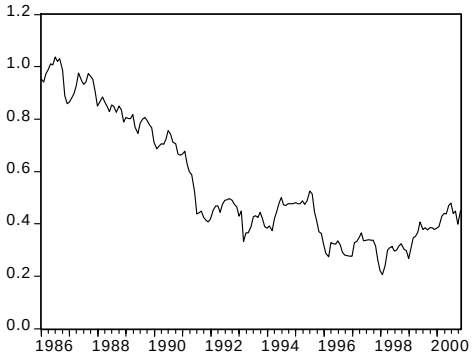

Figure 2c. Indian rupee

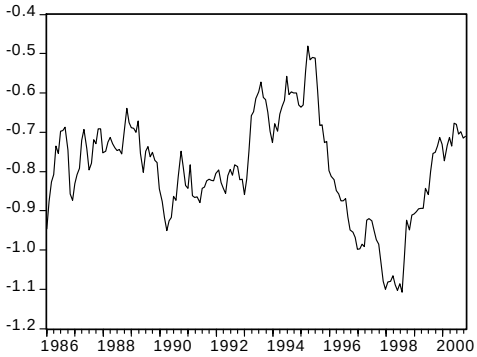

Figure 2d. Japanese yen

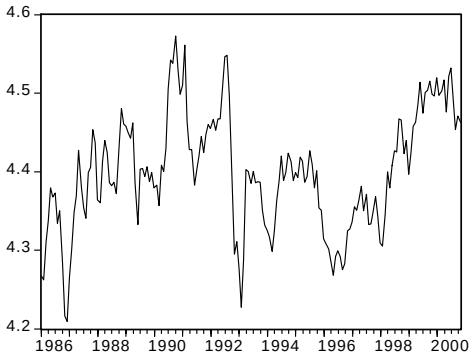

Figure 2e. UK pound

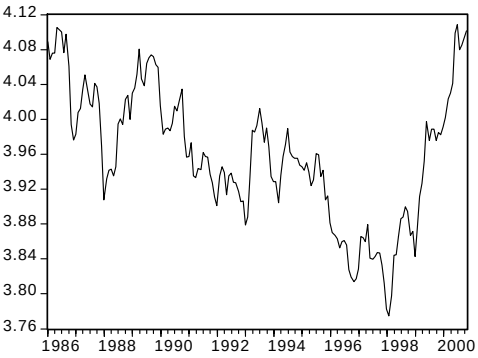

Figure 2f. US dollar

Table 1

Unit root tests of CPI-based real exchange rates

Exchange rate	PP	DF-GLS	KPSS	ERS
Panel A: Constant				
GM	1.744 (8)	-0.936 (4)	0.643 (10)[b]	6.230 (1)
FF	-1.289 (9)	-1.086 (5)	0.874 (10)[a]	5.279 (1)
IR	-1.324 (2)	-0.021 (1)	1.450 (10)[a]	52.648 (1)
JY	-2.920 (4)[b]	-1.002 (11)	0.163 (10)	9.907 (1)
GBP	-2.751 (6)[b]	-1.288 (2)	0.246 (10)	5.580 (1)
USD	-2.059 (25)	-1.041 (11)	0.802 (10)[a]	6.158 (3)
Panel B: Constant and linear trend				
GM	-2.665 (10)	-0.878 (4)	0.292 (10)[a]	17.438 (1)
FF	-2.676 (11)	-1.162 (5)	0.292 (10)[a]	16.442 (1)
IR	-1.192 (2)	-1.465 (1)	0.347 (10)[a]	16.536 (1)
JY	-2.954 (5)	-1.767 (11)	0.149 (10)[b]	14.100 (1)
GBP	-2.837 (6)	-1.823 (2)	0.188 (10)[b]	10.159 (1)
USD	-1.889 (23)	-1.433 (13)	0.178 (10)[b]	14.724 (3)

Notes:

1. a and b imply significance at the 1% and 5% level, respectively.
2. GM, FF, IR, JY, GBP and USD denote respectively the real exchange rates for German mark, French franc, Indian rupee, Japanese yen, the UK pound and the US dollar.
3. The numbers within brackets followed by DF-GLS and ERS statistics represents the lag length of the dependent variable used to obtain white noise residuals.
4. The lag lengths for DF-GLS equation were selected using Akaike Information Criterion (AIC).
5. The numbers within brackets followed by PP and KPSS statistics represent the bandwidth selected based on Newey-West method using Bartlett Kernel.
6. The numbers within brackets shown after the ERS statistic indicate the spectral OLS AR based on SIC.

Table 2

Unit root tests of WPI-based real exchange rates

Exchange rate	PP	DF-GLS	KPSS	ERS
Panel A: Constant				
GM	-1.916 (5)	-1.481 (2)	0.822 (10)[a]	5.826 (0)
FF	-1.239 (4)	-1.272 (2)	1.196 (10)[a]	5.908 (0)
IR	-1.691 (3)	-0.182 (1)	1.471 (10)[a]	71.704 (0)
JY	-2.393 (4)	-1.551 (1)	0.219 (10)	5.462 (1)
GBP	-3.331 (0)[a]	-1.622 (2)	0.191 (10)	5.827 (0)
USD	-1.774 (0)	-1.143 (4)	0.684 (10)[b]	7.971 (1)
Panel B: Constant and linear trend				
GM	-3.176 (5)[c]	-1.611 (2)	0.268 (10)[a]	18.398 (0)
FF	-3.278 (2)[c]	-2.065 (1)	0.210 (10)[b]	15.646 (0)
IR	-1.274 (3)	-1.495 (1)	0.333 (10)[a]	21.581 (0)
JY	-2.517 (4)	-1.984 (1)	0.108 (10)	12.230 (1)
GBP	-3.335 (0)[c]	-3.194 (1)[b]	0.165 (10)[b]	7.105 (0)
USD	-1.358 (2)	-1.604 (1)	0.173 (10)[b]	13.324 (1)

Notes:

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

2. See notes for Table 1 for the definitions of variables in column 1.