JOURNAL OF ECONOMIC DEVELOPMENT
Volume 27, Number 1, June 2002

Purchasing Power Parity and the Fractional Integration of the Real Exchange Rate: New Evidence for Less Developed Countries

Mark J. Holmes[*]

This study tests for relative purchasing power parity for a sample of thirty less developed countries. The empirical analysis is based on testing for the fractional integration of real exchange rates. Using quarterly data covering the period 1973-2001, there is evidence against purchasing power parity for the vast majority of less developed countries using ADF unit root tests. However, we find that the real exchange rates of upto eight countries are fractionally integrated thereby suggesting that mean-reversion is by no means a rare phenomenon. There is mixed evidence that purchasing power parity is restricted to high inflation less developed countries.

I. Introduction

Policy makers in less developed countries (LDCs) have a potential interest in purchasing power parity (PPP) for a number of reasons. First, PPP becomes a prediction model for exchange rates and a criterion for judging over - and undervaluation of currencies. This may be particularly relevant for small open LDCs and those experiencing large inflation differentials between domestic and foreign inflation rates. Second, many exchange rate theories employ some notion of PPP in their construction. Thus the quality of policy advice, insofar as it is based on these theories, may depend on the validity of PPP. Evidence on PPP for LDCs, however, has led to mixed conclusions regarding its validity (see, *inter alia*, McNown and Wallace (1989), Liu (1992), Bahmani-Oskooee (1993), Mahdavi and Zhou (1994), Holmes (2001)).[1] This lack of consensus is driven in part by a debate over whether PPP is stronger among the high inflation LDCs. This study tests for relative PPP in thirty LDCs using quarterly data for the period 1973Q2-01Q1. For this purpose, the test for PPP is based on whether or not LDC real exchange rates are fractionally integrated.

The recent studies of PPP in LDCs have utilised ADF tests for unit roots in real exchange rates and cointegration between various measures of domestic prices and exchange rate-adjusted foreign prices. McNown and Wallace (1989) test for unit roots in US dollar real

* Department of Economics, Loughborough University, Loughborough, Leicestershire, LE11 3TU, England. E-mail: m.j.holmes@lboro.ac.uk, Fax: 44-1509-223910. I am grateful for helpful comments received from the Editor and an anonymous referee. Any remaining errors are my own.

1. Studies on PPP for developed countries have generally provided ambiguous results without a conclusive answer. For example Balassa (1964) and Hakkio (1984) find in favor of PPP while Dornbusch (1980) and Frenkel (1981) find no evidence in favor of PPP. However, Frenkel (1978) suggests that PPP holds during periods of high inflation.

exchange rates and they employ the Engle-Granger (1987) OLS test for cointegration. Using data on consumer and wholesale prices for the 1970s and 1980s, evidence to support PPP is found in the cases of Argentina, Brazil, Chile and Israel. Bahmani-Oskooee (1993) uses quarterly data on prices and effective exchange rates for twenty five LDCs for the period 1973-88. Using the same Engle-Granger technique, evidence in favour of PPP among major trading partners is confirmed in only a minority of cases with little evidence to suggest that PPP is more likely in high inflation countries. This finding is supported by Bahmani-Oskooee (1995) who generally rejects the null of stationarity for the real effective exchange rate across a sample of twenty two LDCs. Liu (1992) tests for PPP in a sample of ten Latin American economies using quarterly data from the 1940s and 1950s to 1989. Applying the Johansen (1988) maximum likelihood technique for estimating cointegrating vectors, Liu finds general evidence in favour of PPP with respect to the US. Finally, Mahdavi and Zhou (1994) apply the Johansen technique to investigate PPP in a sample of LDCs using quarterly data for 1973Q2 onwards. They conclude that incidences of PPP are more frequently observed among high inflation countries.[2] By contrast, Holmes (2001) tests for the stationarity of LDC real exchange rates using panel data unit root tests. In this study, there is no compelling evidence in favour of PPP even if high inflationary experience is allowed for.

The above mentioned studies follow the usual understanding that any series x_t is said to be integrated of order d if it has an invertible ARMA representation after being differenced d times where $d = 0$ defines a *stationary series* and $d = 1$ defines a *non-stationary series*. However, it can be argued that conventional integration analysis fails to detect the presence of long memory in the data generation process. Defining stationarity or non-stationarity on the basis of $d = 0$ or $d = 1$ is strict because x_t will exhibit mean-reversion if $0 \le d < 1$. Moreover, any x_t may be described as being *fractionally integrated* if d is a non-integer. While $d < 1$ implies mean-reversion, $0.5 < d < 1$ implies covariance non-stationarity because the variance is not finite. However, even in this latter case, x_t will nonetheless exhibit mean-reversion. Conversely, $d = 1$ means that x_t is classified as both non-mean reverting and covariance non-stationary thus the effect of a shock is permanent rather than transitory. A limited number of studies have tested for fractional integration in the investigation of PPP in LDCs. The main contribution of this paper is to offer a more comprehensive study of fractional integration that involves a far wider sample of countries. Earlier studies have focused on single case studies. For example, Masih and Masih (1995) find evidence of *fractional cointegration* in the Taiwan/US dollar relationship and therefore support for PPP with monthly data for 1981-91. On the other hand, Alves *et al*. (2001) using annual data over the period 1855-1996 have mixed evidence of fractional cointegration in the case of Brazil.[3] These studies estimate a long-run

2. Further evidence on PPP in LDCs based on tests for unit roots and cointegration can be found in Conejo and Shields (1993) and Hoque (1995). While the latter study rejects PPP, Conejo and Shields find evidence in favor of PPP with respect to the US in the cases of Brazil and Mexico.

3. Studies of fractional integration relevant to developed countries include Cheung and Lai (1993) who employ historic data over the period 1914-89 and find evidence of PPP.

cointegrating relationship between the spot exchange rate, domestic and foreign prices and then test for the fractional integration of the residuals.

This paper is set out as follows. Section II formally describes the empirical methodology. Section III discusses the data set and results. While univariate ADF tests on real exchange rates are unable to support stationary real exchange rates in the vast majority of cases, upto a quarter of the sample are found to exhibit fractional integration of the real exchange rate and therefore mean-reversion. Section IV concludes.

II. Methodology

For a given LDC, let p_t be the natural logarithm of the domestic price index where $t = 1, 2, ..., T$ observations, let p_t^* be the natural logarithm of the base country price index and let s_t be the natural logarithm of the country i nominal spot price of foreign currency. The real exchange rate *r* for country i is computed as

$$r_t = s_t + p_t^* - p_t \,. \tag{1}$$

For a number of reasons, this study tests for *relative* rather than *absolute* PPP. Empirical studies of PPP typically employ data on price *indices* rather than price *levels*. Price indices contain base periods where the nominal exchange rate can equal the price ratio by construction. Therefore, a test for a unit root in r_t is in fact a test for a unit root in the change from base period. This is the usual test of long-run relative PPP in the literature arguing that the percentage change in the nominal spot exchange rate should equal the inflation differential between country i and the base country.[4] Second, the actual exchange rate may deviate from its parity value on account of imperfections in published prices indices (for example, in reality the price indices of different countries do not reflect the same basket of goods). Third, deviations from absolute PPP may occur on account of transport costs, tariffs and differential speeds of adjustment in the goods and foreign exchange markets. Assessing relative PPP allows for any constant of proportion based on these factors that drives a wedge between p_t and $(s_t + p_t^*)$.

Masih and Masih (1995) and Alves *et al*. (2001) look for PPP by estimating $s_t = \alpha_0 + \alpha_1 p_t + \alpha_2 p_t^* + u_t$ and $p_t^* = \beta_0 + \beta_1 (p_t / s_t) + v_t$ respectively and then testing for fractional integration of the residuals u_t and v_t. This study differs in the sense that Equation (1) has imposed the restrictions $\alpha_0 = 0,\ \alpha_1 = 1,\ \alpha_2 = -1$ or $\beta_0 = 0,\ \beta_1 = 1$ and looked at the fractional integration of r_t. Moreover, rather than estimating α or β, there is a more direct examination of the real exchange rate. Allowing for the possibility that at least some of the restrictions on α or β do not hold means that u_t and v_t do not constitute a measure of the real exchange rate. This study is therefore able to assess a stronger notion of relative PPP than is investigated in Masih and Masih (1995) and Alves *et al*. (2001).

4. See Crownover, Pippenger and Steigerwald (1996) for an elaboration on this point.

For the purposes of testing for the fractional integration of r_t, the estimation of d first involves the use of a semi-nonparametric procedure due to Geweke and Porter-Hudak (1983).[5] This is necessary because standard unit root tests exhibit low power against fractional alternatives. For each series, values for d can be obtained through the OLS estimation of

$$\ln\left[I(\omega_j)\right] = c - d\ln\left[4\sin^2\left(\omega_j/2\right)\right] + \eta_j\ , \tag{2}$$

where $\omega_j = 2\pi j/T \quad (\forall\ j = 1,.....T-1)$, the number of observations, that is the number of frequencies used in the estimation of the regression is $n = g(T) < T$ and where $I(\omega_j)$ is the periodogram of r_t at frequency ω_j defined as

$$I(\omega_j) = \frac{1}{2\pi T}\left|\sum_{t=1}^{T} e^{jt\omega}\left(r_t - \bar{r}_t\right)\right|^2 . \tag{3}$$

Since the periodogram is used as an estimator of the spectral density, d may be approximated by regression. However, a choice of truncation parameter needs to be made for the number of low Fourier frequencies, n, in the spectral regression. Although GPH recommend using T^{λ} where T is the number of observations and $\lambda = 0.5$, Cheung and Lai (1993) suggest choosing a range for λ from 0.5 to 0.6. We follow this procedure on the grounds that it avoids making a subjective choice for λ that is too high or too low. It can be shown that the estimator of d is consistent and hypothesis tests can be performed on the parameter using the asymptotic distribution derived by GPH.

$$\hat{d} \rightarrow N\left(d, \frac{\pi^2}{6\sum_{t=1}^{T}\left(x_t - \bar{x}\right)^2}\right), \tag{4}$$

where x_t is now defined as the regressor $\ln\left(4\sin^2(\omega_t/2)\right)$.

Sowell (1992a) and Smith, Sowell and Zin (1997) argue that a maximum likelihood method for the estimation of d is more efficient than the semi-nonparametric procedure of Geweke and Porter-Hudak (1983). Furthermore, there is a tendency for the GPH method to produce lower estimates of d than the maximum likelihood method.[6] This could mean that GPH estimation is more likely to indicate fractional integration of the real exchange rate and therefore evidence in favour of PPP whereas higher estimates of d obtained through maximum likelihood estimation are in fact much less supportive of fractional integration. In

5. Hereafter denoted as 'GPH'.

6. For example, see Crato and Rothman (1994).

order to allow for this possibility, the cases where the GPH method supports fractional integration are also analysed using the maximum likelihood estimation of d.

III. The Data and Results

The thirty LDCs included in the sample are Argentina, Barbados, Brazil, Chile, Columbia, Costa Rica, Ecuador, El Salvador, Egypt, Ghana, Guatemala, Honduras, India, Indonesia, Israel, Jamaica, Kenya, Mauritius, Mexico, Morocco, Netherlands Antilles, Nigeria, Pakistan, Philippines, Singapore, South Africa, Suriname, Thailand, Uruguay and Venezuela. The justification for choosing this range of thirty countries is based on the need for a comprehensive study of PPP in LDCs. Also, this particular sample is consistent with most of the above-mentioned studies of PPP insofar as it nests the vast majority of countries that have been analysed elsewhere. All price and exchange rate data are taken from the *International Financial Statistics* database. Real exchange rates are based on the consumer price index (line 64) and exchange rates, which are end of period spot rates with respect to the US dollar. All real exchange rate data are expressed in natural logarithm form. Quarterly data for the period 1973Q2-2001Q1 provide a sample of size of upto 112 observations on each series for each country where the use of quarterly data is dictated by data availability across this large sample.[7] The start of 1973 is consistent with Bahmani-Oskooee (1993), Mahdavi and Zhou (1994) and Holmes (2001) in their investigations of PPP in LDCs and can be regarded as the start of modern "floating rate" period with respect to the US dollar.

Table 1 ADF Unit Root Tests on Real Exchange Rates

	s		p		r	
	ADF (no trend)	ADF (trend)	ADF (no trend)	ADF (trend)	ADF (no trend)	ADF (trend)
Argentina	-1.988	-0.623	-1.055	-1.338	-4.918***	-4.244***
Barbados	-3.254**	-4.520***	-2.518	-1.332	-3.288**	-2.727
Brazil	-0.709	-2.176	-0.721	-2.044	-1.574	-1.768
Chile	-2.285	-3.942**	-2.166	-6.421***	-1.025	-1.760
Columbia	-0.176	-1.748	-1.758	-0.202	-1.348	-1.792
Costa Rica	-0.559	-2.559	-0.276	-2.742	-1.956	-1.863
Ecuador	0.794	-2.444	1.672	-1.902	-1.091	-2.291
El Salvador	-0.612	-1.892	-1.112	-0.696	-1.416	-3.239*
Egypt	-0.821	-2.423	-1.620	0.461	-2.323	-2.568
Ghana	-0.174	-2.318	-2.877*	-1.175	-1.022	-2.452
Guatemala	-0.191	-2.025	-0.510	-1.524	-1.294	-2.078
Honduras	0.417	-1.633	1.208	-1.432	-1.328	-1.941
India	0.883	-2.085	1.031	-4.124***	-1.167	-2.137

7. Current data limitations mean that the real exchange rate series for Suriname and South Africa end in 1999Q4 and 2000Q3 respectively. Also, the series for Barbados, Ghana, Guatemala, India, Indonesia, Morocco, Netherlands Antilles and Nigeria each end in 2000Q4.

Table 1 (Continued)

	s		*p*		*r*	
	ADF (no trend)	ADF (trend)	ADF (no trend)	ADF (trend)	ADF (no trend)	ADF (trend)
Indonesia	0.394	-2.326	-0.147	-1.926	-0.541	-3.356*
Israel	-2.192	-1.107	-1.869	-1.528	-2.830*	-2.650
Jamaica	-0.521	-2.532	-0.472	-2.131	-1.693	-1.759
Kenya	0.163	-2.333	-0.872	-1.915	-1.213	-2.087
Mexico	-1.179	-1.493	-1.328	-1.047	-2.678*	-2.590
Mauritius	-0.679	-2.030	-2.185	-1.736	-1.208	-1.942
Morocco	-1.121	-2.162	-3.109**	-0.653	-1.586	-2.268
N’ Antilles	-0.843	-2.105	-2.331	-1.490	-1.403	-2.658
Nigeria	0.689	-2.124	-0.082	-1.895	-1.917	-2.053
Pakistan	2.668	-2.311	-0.492	-2.227	0.721	-2.597
Philippines	-0.256	-2.048	-1.463	-0.791	-1.553	-1.877
Singapore	-0.768	-2.333	-2.331	-2.320	-0.585	-2.475
S Africa	0.223	-2.702	-1.273	-0.653	-1.480	-2.548
Suriname	0.147	-1.324	0.578	-1.489	-2.300	-2.221
Thailand	0.364	-1.427	-1.758	-1.488	-0.177	-1.693
Uruguay	-1.573	-0.642	-2.222	-0.496	-2.169	-2.355
Venezuela	1.252	-2.241	0.232	-2.157	-1.208	-0.669
US	N/A	N/A	-1.812	-1.395	N/A	N/A

Note: These are Augmented Dickey Fuller (ADF) unit root tests conducted on the spot exchange rate with respect to the US dollar (*s*), the domestic price level (*p*) and the real exchange rate with respect to the US dollar (*r*) as defined in Equation (1). The full sample period is 1973Q2-2001Q1. For each test, the lag length was chosen using Said and Dickey’s (1984) $T^{1/3}$ rule where T is the number of observations in each time series. ***, ** and * indicate rejection of the null of non-stationarity at the 1, 5 and 10% levels of significance respectively in the ADF tests. Relevant ADF critical values taken from Fuller (1976) are -3.51, -2.89 and -2.58, while for regressions including a trend, these are -4.04, -3.45 and -3.15 respectively.

Table 1, reports univariate ADF unit root tests on the spot exchange rate with respect to the US dollar (*s*), the domestic price level (*p*), the US price level and the real exchange rate with respect to the US (*r*) for the full sample of thirty countries. In terms of lag length selection, it is well known that information criteria based on the Schwarz model has a tendency to advocate relatively few lags with the strong possibility that the null of a unit root is over-rejected. Alternatively, the Akaike information criteria (AIC) tends to advocate a longer lag length which can have negative implications for the power of the test. As a compromise, this study utilises Said and Dickey’s (1984) $T^{1/3}$ rule in determining the lag length of each ADF regression. Essentially, the lag length is set large enough to allow a good approximation for any autoregressive moving-average processes that might be present in the data thereby ensuring that the residuals are approximately white noise.[8] Given the length of

8. Other methods include the Phillips-Perron unit root test that is based on a non-parametric correction. Monte Carlo

each time series, each lag length is therefore set at 5 quarters. The results indicate that the null of non-stationarity is accepted at the 5% significance level throughout except for s in the cases of Barbados and Chile, p in the cases of Chile, India and Morocco and r in the cases of Argentina and Barbados. Given the non-stationarity of the Argentinean real exchange rate, this result implies cointegration among s, p and p^*.

Table 2 GPH Tests for Fractional Integration

l / d	0.5	0.55	0.575	0.6
Brazil	1.180	1.223	1.225	1.138
Chile	0.998	0.770	0.750	0.711
Columbia	1.211	1.165	1.241	1.211
Costa Rica	1.038	0.914	1.033	1.004
Ecuador	1.015	1.210	1.182	1.207
El Salvador	0.924	0.890	0.941	0.975
Egypt	0.880	1.218	1.209	1.219
Ghana	1.016	0.794	0.750	0.693
Guatemala	0.934	0.692	0.549^{**}	0.507^{**}
Honduras	0.863	0.835	0.740	0.714
India	0.877	0.728	0.662	0.623^{*}
Indonesia	0.722	0.554	0.455^{**}	0.424^{**}
Israel	0.881	1.233	1.272	1.274
Jamaica	0.818	0.814	0.715	0.707
Kenya	0.766	0.704	0.715	0.691
Mexico	0.791	0.865	0.793	0.853
Mauritius	0.996	1.092	1.052	1.059
Morocco	0.925	0.667	0.580^{*}	0.559^{**}
N' Antilles	0.392^{**}	0.231^{***}	0.161^{***}	0.154^{***}
Nigeria	0.780	0.694	0.758	0.878
Pakistan	1.267	1.160	1.145	1.149
Philippines	0.773	0.804	1.068	1.144
Singapore	0.996	0.939	0.914	0.902
South Africa	0.567	0.564^{*}	0.490^{**}	0.457^{**}
Suriname	0.073^{***}	0.110^{***}	0.268^{***}	0.305^{***}
Thailand	0.832	0.778	1.118	1.087
Uruguay	1.058	1.140	1.044	1.114
Venezuela	0.699	0.578^{*}	0.478^{**}	0.444^{**}

Note: These are GPH tests for fractional integration where d refers to the number of times that a given series must be differenced to achieve stationarity, l refers to the power associated with the Fourier transformation. ***, ** and * denote rejection of the null $d = 1$ at the 1, 5 and 10% significant levels respectively. Each test is based on the asymptotic standard error where critical values were simulated using 50000 replications (see Cheung and Lai (1993)).

studies, most notably by Schwert (1989), suggest that the Phillips-Perron test has a tendency to reject the null of non-stationarity when it is true if the data generating process has moving average components. Indeed, Banerjee *et al.* (1993) favour the Said and Dickey procedure over Phillips-Perron approach.

It is possible that acceptance of the null of non-stationary real exchange rates for the vast majority of the sample is due to the strict $d = 0$ interpretation of a stationary series. Table 2 reports the tests for fractional integration that are based on the GPH methodology.[9] At the 10% significance level, there is evidence of fractional integration in the cases of Guatemala, India, Indonesia, Morocco, Netherlands Antilles, South Africa, Suriname and Venezuela. For each of these countries the ADF test in Table 1 accepted the null of a non-stationarity real exchange rate ($d = 1$) against the stationary alternative ($d = 0$). However, Table 2 suggests that null $d = 1$ can be rejected in favour of the alternative $d < 1$ and so there is evidence of fractional integration where the real exchange rates are mean-reverting. In two cases - Guatemala and India - it is possible that $0.5 < d < 1$ so these real exchange rates are mean-reverting but covariance non-stationary. Overall, these results indicate that over a quarter of the sample are characterised by PPP.[10]

A key prediction of the sticky price model of real exchange rate fluctuations is that fluctuations in the real exchange rate should be less persistent in countries with high inflation relative to those with low inflation. In high inflationary environments, prices adjust more frequently. Since firms experience a more rapid change in their relative price, the nominal inertia due to sticky prices should be less important.[11] There is some evidence that the LDCs exhibiting stationarity and fractional integration are those characterised with high inflation. Using *International Financial Statistics* data, it can be shown that the average annual inflation rate for these eight countries plus Argentina and Barbados who were stationary according to the ADF tests, was 62.8% across the study period. This compares with an average of 53.4% for the full sample of thirty LDCs. However, the set of countries characterised by fractional integration has a vast range of inflationary experiences from Suriname (46.1%) and Venezuela (28.2%) to Indonesia (9.01%) and Netherlands Antilles (5.49%). Similarly, the two countries that rejected non-stationarity in the ADF tests are characterised by different experiences: Argentina (486%) and Barbados (7.57%). These results corroborate the recent findings of Khan (2001) who employs cross-country regression analysis and finds fragile support for an inverse relationship between persistence and inflation.

Table 3 Maximum Likelihood Tests for Fractional Integration

	d	$H_0 : d = 1$	Q(8)
Guatemala	0.743 (0.247)	-1.040	0.961
India	0.993 (0.107)	-0.065	0.990

9. The table excludes Argentina and Barbados who are identified as stationary according to the ADF tests.
10. Given that Table 1 suggests that both s and p are both non-stationary in the cases of Guatemala, Indonesia, Netherlands Antilles, South Africa, Suriname and Venezuela, this implies fractional cointegration among s, p and p^* for these countries.
11. Examples of the sticky price approach include Betts and Devereux (1996) and Bergin and Feenstra (1999).

Table 3 (Continued)

	d	$H_0 : d = 1$	Q(8)
Indonesia	0.792 (0.241)	-0.863	0.140
Morocco	0.978 (0.096)	-0.229	0.220
N' Antilles	0.116 (0.270)	-3.274***	0.160
S. Africa	0.148 (0.467)	-1.824**	0.067
Suriname	-0.229 (0.238)	5.163***	0.999
Venezuela	1.198 (0.564)	0.351	0.907

Note: The estimates of d reported above are derived from the estimation of an Autoregressive, Fractionally Integrated, Moving Average (ARFIMA) model using maximum likelihood estimation. In each case, the results are based on the estimation of a chosen $(1, d, 1)$ model. Figures in parentheses refer to the standard error associated with each d. $H_0 : d = 1$ is a one-tailed Wald test of the null hypothesis $d = 1$ that is asymptotically normally distributed (see Sowell (1992b) where *** and ** denote rejection of the null at the 1 and 5% levels respectively. Q(8) is the p-value of the Ljung-Box Q-Statistic for the residuals of the ARFIMA model.

For the eight cases where $d < 1$ using GPH estimation, Table 3 reports the findings from Autoregressive, Fractionally Integrated, Moving Average (ARFIMA) maximum likelihood estimation. As expected, this maximum likelihood method yields estimates of d that are generally higher than under GPH estimation. The Wald test for $d = 1$ (distributed as asymptotically normal on the null) is rejected at the 5% significance level in only three cases - Netherlands Antilles, South Africa and Suriname. In each of these cases, there is evidence that $d < 0.5$ which suggests both mean-reversion and covariance stationarity of the real exchange rate. However, these results nonetheless demonstrate that fractional integration of the real exchange rate is confined to a smaller minority of LDCs than initially suggested through GPH estimation.

IV. Summary and Conclusion

This study has tested for relative purchasing power parity among a sample of thirty less developed countries using a test for the fractional integration of the real exchange rate. This technique has advantages over conventional unit root tests that restrict the order of integration to be zero or one. A given real exchange rate is fractionally integrated and mean-reverting if the order of integration is between zero and one. Using quarterly data for 1973-2001, the conventional ADF null of non-stationarity is accepted for twenty eight countries. However, further investigation reveals that eight of these real exchange rates are fractionally integrated if testing is conducted using the Geweke and Porter-Hudak method.

On the other hand, only three of these real exchange rates (Netherlands Antilles, South Africa and Suriname) are confirmed as fractionally integrated using maximum likelihood estimation. While the analysis confirms that the majority of less developed countries are not characterised by purchasing power parity, there could be a significant minority of countries that have mean-reverting real exchange rates if we allow for fractionally integrated processes. This study finds weak support for the view that inflation and persistence are inversely related. While the range of countries that feature mean-reversion have a higher average inflation, the individual inflationary experiences of these countries is diverse.

References

Alves, D.C.O., R.C. Cati, and V.L. Fava (2001), "Purchasing Power Parity in Brazil: A Test for Fractional Integration," *Applied Economics*, 33, 1175-85.

Bahmani-Oskooee, M. (1993), "Purchasing Power Parity Based on Effective Exchange Rate and Cointegration: 25 LDCs Experience with its Absolute Formulation," *World Development*, 21, 1023-31.

_____ (1995), "Real and Nominal Effective Exchange Rates for 22 LDCs," *Applied Economics*, 27, 591-604.

Balassa, B. (1964), "The Purchasing Power Doctrine: A Reappraisal," *Journal of Political Economy*, 72, 584-96.

Banerjee, A., J. Dolado, J. Galbraith, and D. Hendry (1993), *Cointegration, Error Correction, and the Econometric Analysis of Non-stationary Data*, Oxford: Oxford University Press.

Bergin, P., and R.C. Feenstra (1999), "Pricing-to-market, Staggered Contracts, and Real Exchange Rate Persistence," NBER Working Paper No. 7026.

Betts, C., and M. Devereux (1996), "The Exchange Rate in a Model of Pricing-to-Market," *European Economic Review*, 40, 1007-21.

Cheung, Y.W., and K.S. Lai (1993), "A Fractional Cointegration Analysis of Purchasing Power Parity," *Journal of Business & Economics Statistics*, 11, 1, 103-11.

Conejo, C., and M.P. Shields (1993), "Relative PPP and the Long-Run Terms of Trade for 5 Latin-American Countries: A Cointegration Approach," *Applied Economics*, 25, 1511-5.

Crato, N., and P. Rothman (1994), "Fractional Integration Analysis of Long-run Behaviour for US Macroeconomic Time Series," *Economics Letters*, 287-91.

Crownover, C., J. Pippenger, and D. Steigerwald (1996), "Testing for Absolute Purchasing Power Parity," *Journal of International Money and Finance*, 15, 783-96.

Dornbusch, R. (1980), "Exchange Rate Economics: Where Do We Stand?", *Brookings Papers on Economic Activity*, 1, 143-85.

Engle, R.F., and C.W.J. Granger (1987), "Cointegration and Error Correction: Representation, Estimation and Testing," *Econometrica*, 55, 255-76.

Frenkel, J.A. (1978), "Purchasing Power Parity: Doctrinal Perspective and Evidence from the 1920s," *Journal of International Economics*, 8, 169-91.

_____ (1981), "The Collapse of Purchasing Power Parities During the 1970s," *European Economic Review*, 16, 145-65.

Fuller, W.A. (1976), *Introduction to Time-Series Analysis*, New York: John Wiley & Sons.

Geweke, J., and S. Porter-Hudak (1983), "The Estimation and Application of Long Memory Time Series Models," *Journal of Time Series Analysis*, 4, 4, 221-38.

Hakkio, C.S. (1984), "A Re-examination of Purchasing Power Parity: A Multi-Country and Multi-Period Study," *Journal of International Economics*, 17, 265-77.

Holmes, M.J. (2001), "New Evidence on Real Exchange Rate Stationarity and Purchasing Power Parity in Less Developed Countries," *Journal of Macroeconomics*, 23, 4, 601-14.

Hoque, A. (1995), "A Test of the Purchasing Power Parity Hypothesis," *Applied Economics*, 27, 311-5.

Khan, H. (2001), "Price Stickiness, Inflation, and Persistence in Real Exchange Rate Fluctuations: Cross-Country Results," *Economics Letters*, 71, 247-53.

Johansen, S. (1988), "Statistical Analysis of Cointegrating Vectors," *Journal of Economic Dynamics and Control*, 12, 231-54.

Liu, P. (1992), "Purchasing Power Parity in Latin America: A Cointegration Analysis," *Weltwirtschaftliches Archiv*, 128, 662-80.

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

McNown, R., and M. Wallace (1989), "National Price Levels, Purchasing Power Parity, and Cointegration: A Test of Four High Inflation Economies," *Journal of International Money and Finance*, 8, 533-45.

Mahdavi, S., and S. Zhou (1994), "Purchasing Power Parity in High Inflation Countries: Further Evidence," *Journal of Macroeconomics*, 16, 403-22.

Masih, R., and A.M.M. Masih (1995), "A Fractional Cointegration Approach to Empirical Tests of PPP: New Evidence and Methodological Implications from an Application to the Taiwan/US Dollar Relationship," *Weltwirtschaftliches Archiv*, 131, 4, 673-94.

Said, S.E., and D.A. Dickey (1984), "Testing for Unit Roots in Autoregressive Moving Average Models of Unknown Order," *Biometrica*, 71, 599-608.

Schwert, G.W. (1989), "Tests for Unit Roots: A Monte Carlo Investigation," *Journal of Business and Economic Statistics*, 7, 147-59.

Smith, A., F. Sowell, and S. Zin (1993), "Fractional Integration with Drift Estimation in Small Samples," *Empirical Economics*, 22, 103-16.

Sowell, F. (1992a), "Maximum Likelihood Estimation of Stationary Univariate Fractionally Integrated Time Series Models," *Journal of Econometrics*, 53, 165-88.

_____ (1992b), "Modeling Long-run Behaviour with the Fractional ARMA Model," *Journal of Monetary Economics*, 29, 277-302.