Navarra Center for International Development

Working Paper nº 10/2012

TESTING THE PPP HYPOTHESIS IN THE SUB-SAHARAN COUNTRIES

Guglielmo Maria Caporale
Brunel University, UK

and

Luis A. Gil-Alana
University of Navarra, Pamplona, Spain

Navarra Center for International Development WP-10/2012

Testing the PPP in the Sub-Saharan countries
Guglielmo Maria Caporale and Luis Alberiko Gil-Alana
Working Paper No. 10/2012
December 2012

ABSTRACT

This paper examines the PPP hypothesis in a number of Sub-Saharan countries by testing the order of integration in the log of their real exchange rate vis-à-vis the US dollar. I(d) techniques based on both asymptotic and finite sample results are used. The test results lead to the rejection of PPP in all cases: although orders of integration below 1 are found in fourteen countries, the unit root null cannot be rejected.

Keywords: Purchasing Power Parity (PPP), fractional integration

JEL classification: C22, F31

Corresponding author: Luis Alberiko Gil-Alana
Navarra Center for International Development
Universidad de Navarra
E-31080 Pamplona
Spain

1. Introduction

This paper examines the Purchasing Power Parity (PPP) hypothesis in a number of Sub-Saharan countries using a time series approach. Froot and Rogoff (1995) distinguish three stages in this literature on PPP. In stage one possible non-stationarities of the series of interest were not taken into account. In stage two unit root tests were carried out to establish whether or not the real exchange rate follows a random walk, the alternative being that PPP holds in the long run. However, it soon became apparent that such tests have very low power, and with relatively few observations cannot distinguish between a random walk process, and one which reverts very slowly toward PPP (see, e.g., Frankel, 1986, and Lothian and Taylor, 1997). This led to the so-called "embarrassing resiliency of the random walk model" (see Rogoff, 1996). Over longer time spans mean-reverting real exchange rate behaviour was instead found (see, e.g., Lothian and Taylor, 1996, and Cheung and Lai, 1994). In stage three cointegration tests (between the nominal exchange rate, domestic and foreign prices) were applied, but they also appeared to be affected by small sample bias.

The present study makes a twofold contribution. First, it adopts a more general framework than the standard stage-two unit root tests to investigate the presence of mean-reverting behaviour in the real exchange rate. Specifically, it uses fractional integration or I(d) techniques allowing the degree of integration d to be any real number, therefore introducing a higher degree of flexibility in the dynamic specification of the stochastic processes followed by the variables of interest. Second, it focuses on a long span of data for a large set of 44 Sub-Saharan countries whose exchange rates to our knowledge have not been previously analysed using advanced time series methods. The only previous empirical study is due to Olayungbo (2011), but it considers a smaller Subset of 16 countries over a relatively short sample period and carries out standard unit root tests whose low power has already been mentioned as well as panel unit root tests, the limitations of which have also been highlighted and extensively discussed by Caporale and Cerrato (2006). Evidence on PPP in the Sub-Saharan countries is particularly interesting in view of the current discussion on creating an African Union that would eventually have its own currency and central bank, as its feasibility would also depend on the degree of conformity to PPP.

The layout of this paper is as follows. Section 2 outlines the econometric approach. Section 3 describes the data and presents the empirical results. Section 4 offers some concluding remarks.

2. Methodology

We consider the following model

$$y_t \;=\; \alpha \;+\; \beta t \;+\; x_t\,, \qquad t \;=\; 1, 2, ..., \tag{1}$$

where y_t is the observed time series, α and β are the coefficients on the deterministic terms (an intercept and a linear trend), and x_t is assumed to be I(d) and defined as

$$(1 - L)^d \; x_t \;\; = u_t\,, \qquad t \;=\; 1, 2, ... \,, \tag{2}$$

with $x_t = 0$ for $t \leq 0$, and where L is the lag operator ($Lx_t = x_{t-1}$), d can take any real value and u_t is assumed to be I(0). Thus, d may be equal to 0, a fraction between 0 and 1, 1, or even above 1. When it is not an integer, the process is said to be fractionally integrated. In this context, the parameter d plays a crucial role for the degree of persistence of the series. If d = 0 in (2), $x_t = u_t$, and the series is I(0). If d belongs to the interval (0, 0.5) the series is still covariance stationary but the autocorrelations take a longer time to disappear than in the I(0) case. If d is in the interval [0.5, 1) the series is no longer stationary; however, it is still mean-reverting in the sense that shocks affecting it disappear in the long run. Finally, if $d \geq 1$ the series is nonstationary and non-mean-reverting. Thus, by allowing d to be any real value, we introduce more flexibility in the dynamic specification of the series than in the classical I(0) and I(1) representations. These processes (with non-integer d) were first considered by

Granger (1980), Granger and Joyeux (1980) and Hosking (1981) and since then have been widely employed to describe the behaviour of many economic time series.

In the empirical analysis we test the null hypothesis:

$$H_o : \; d \; = \; d_o, \tag{3}$$

in a model given by the equations (1) and (2) where d_o in (3) can be any real value. Thus, under the null hypothesis (3) the model becomes:

$$y_t \; = \alpha \; + \; \beta t \; + \; x_t \, ; \qquad (1 - L)^{d_o} \, x_t \; = \; u_t ; \qquad t \; = \; 1, 2, ... \tag{4}$$

This is a very general specification that includes many cases of interest. Thus, for example, if we cannot reject the null with $d_o = 0$, we are in the classical trend-stationary representation with or without weak (ARMA) autocorrelation in u_t.[1] On the other hand, if we cannot reject the null with $d_o = 1$, the unit root model advocated by many authors is given support. Moreover, we can also consider cases where d_o can be a real value between 0 and 1, or even above 1. As mentioned before, the estimation of d_o is crucial to determine the degree of persistence: the higher is the degree of integration, the higher is the level of dependence across the observations, and if $d_o < 1$ the series will be mean- reverting with shocks disappearing in the long run.

To test the null hypothesis (3), we employ a parametric approach developed by Robinson (1994). This is a general testing procedure based on the Lagrange Multiplier (LM) principle that uses the Whittle function in the frequency domain. Robinson (1994) showed that, under certain very mild regularity conditions, the LM-based statistic $(\hat{r})$

$$\hat{r} \; \rightarrow_{dtb} \; N(0, 1) \qquad as \;\; T \; \rightarrow \; \infty,$$

where " $\rightarrow_{dtb}$ " stands for convergence in distribution, and this limit behaviour holds independently of the regressors used in (1) and the specific model for the I(0) disturbances

[1]Note that u_t is I(0) and therefore could incorporate stationary and invertible ARMA sequences.

u_t. The functional form of this procedure can be found in any of the numerous empirical applications based on these tests.

As in other standard large-sample testing situations, Wald and LR test statistics against fractional alternatives will have the same null and limit theory as the LM test of Robinson (1994). In fact, Lobato and Velasco (2007) essentially employed such a Wald testing procedure, and though this and other recent methods such as the one developed by Demetrescu et al (2008) have been shown to be robust with respect to even unconditional heteroscedasticity (Kew and Harris 2009), they require a consistent estimate of d, and therefore the LM test of Robinson (1994) seems computationally more attractive.

3. Data and empirical results

We use data on real exchange rates, in logged form, for forty-four Sub-Saharan countries, for the time period 1970 – 2012 (with 2005 as the base year), obtained from the Economic Research Service, US Department of Agriculture (http://www.ers.usda.gov).

We consider the model given by the equations (1) and (2), testing H_o (3) for values of d_0 from 0 to 2 with 0.001 increments, i.e., $d_o = 0, 0.001, 0.002, \ldots, 1.999$ and 2. We report in Table 1 the estimates of d based on the Whittle function in the frequency domain (Dahlhaus, 1989) along with the 95% confidence interval of non-rejection values of d using Robinson's (1994) tests, under the assumption that the error term u_t in (4) is a white noise process. Weakly (ARMA) autocorrelated errors were also considered and led to very similar results.

[Insert Tables 1 and 2 about here]

Table 1 displays the results for the three standard cases usually analysed in the literature, i.e., with no regressors in the undifferenced regression model in (4) (i.e. $\alpha = \beta = 0$ a priori); with an intercept (α unknown and $\beta = 0$ a priori); and with an intercept and a linear time trend (α and β unknown); statistically significant deterministic terms are in bold. It appears that the time trend is only required for four series, namely those for the real exchange rates of Gambia, Guinea Bissau, Malawi and Sudan. In all the remaining cases, an intercept is sufficient to describe the deterministic part. Focusing now on the estimated orders of integration of the series (for the selected models, in Table 2), we see that for fourteen countries the value of d is strictly smaller than 1 - these are Malawi, Guinea Bissau, Liberia, Swaziland, Sudan, Gambia, Madagascar, Comoros, Angola, Togo, Botswana, Senegal, Ivory Coast and Central Africa. However, the confidence intervals for the values of d imply that the unit root null (i.e., d = 1) cannot be rejected in any single case. For the remaining countries, the estimated d is strictly above 1, and the unit root null is rejected in favour of d > 1 in the cases of Djibouti, Sierra Leone, Mauritania, Cape Verde, Eritrea, Uganda, Sao Tome, Tanzania and Ghana.

[Insert Table 3 about here]

Table 3 summarises the results in terms of the degree of persistence. The countries are divided in three groups according to the statistical significance of the estimated values of d: mean reversion (d < 1); unit roots (with d < 1 and with d > 1), and explosive behaviour (d > 1). There is no single country where mean reversion is statistically significant, implying that PPP does not hold anywhere. However, although the unit root null cannot be rejected in 35 countries, in 14 of them the estimated value of d is below 1 implying that PPP might hold in the very long run. Another group of nine countries displays explosive behaviour. Overall, the evidence does not support PPP, consistently with the findings of Olayungbo (2011), who reports that it holds only in Ghana and Uganda; in fact even for these two countries PPP is rejected according to our results, since they are found to belong to the group with the highest degree of persistence.

We also examined the finite sample behaviour of sized-corrected versions of Robinson (1994) tests by means of Monte Carlo simulations, and compared the results with those based on the asymptotic critical values. Note that in the original paper by Robinson (1994) he stressed large sample theory and suggested approximate critical values. Thus, we calculated the empirical size of the test statistic $\hat{r}$ for a sample size T = 42 as in our case, based on 10,000 replications, for the three cases of no regressors, an intercept, and an intercept with a linear time trend. In all cases, we assume u_t to be a Gaussian white noise process with zero mean and variance 1, generated by the routines GASDEV and RAN3 of Press, Flannery, Teukolsky and Vetterling (1986).

[Insert Tables 4 and 5 about here]

Table 4 displays for each country both the asymptotic and the finite sample 95% confidence intervals for the non-rejection values. We notice that in all cases the intervals are shifted to the right, implying higher degrees of integration, and therefore, even less evidence of PPP for the Sub-Saharan countries. These results are presented in Table 5. There are four countries (Mozambique, Seychelles, Burundi and Zambia) where the unit root cannot be rejected in Table 3, and is rejected in favour of d < 1 in Table 5.

4. Conclusions

This paper applies long-range dependence or fractional integration techniques to test for PPP in a set of 44 Sub-Saharan countries. The advantage of this approach is its generality and flexibility in comparison to standard time series methods restricting the degree of integration to integer values. Previous evidence (see Olayungbo, 2011) was only available for a smaller Subset of countries and a short sample period and was based on low-power unit root tests as well as panel tests whose drawbacks are also well known (see Caporale and Cerrato, 2006).

On the whole, our results suggest that PPP does not hold in this group of countries. This is in contrast to the available evidence for developed countries based on long-memory models. For instance, using a similar version of Robinson‘s (1994) tests to the one adopted here, Gil-Alana (2000) found mean reversion in the US real exchange rates vis-à-vis five major currencies with weakly autocorrelated disturbances. Similar conclusions were reached applying fractional integration and cointegration techniques by Caporale and Gil-Alana (2004) in the case of the DM/dollar and the yen/dollar real exchange rates, and by Masih and Masih (2004) for the Australian dollar real exchange rate vis-à-vis seven major OECD trading partners. Finally, Yoon (2009) applied the Exact Local Whittle estimators of Shimotsu and Phillips (2005) to estimate the long memory parameters of the real exchange rates for more than 100 years in 16 developed countries and concluded again that PPP holds in most of these countries.Overall, it appears that the degree of conformity to PPP is much less in the Sub-Saharan countries compared to the developed ones, and, as already pointed out by Olayungbo (2011), this has important implications for the proposed African Union and the creation of a common currency, namely the absence of PPP relationships between its prospective members raises some doubts about its feasibility or at least long-run sustainability.

References

Caporale, G.M. and M. Cerrato (2006), “Panel data tests of PPP: a critical overview”, Applied Financial Economics, 16, 1-2, 73-91.

Caporale, G.M. and L.A. Gil-Alana (2004), “Fractional cointegration and real exchange rates”, Review of Financial Economics, 13, 4, 327-340.

Cheung, Y.-W.and K.S. Lai (1994), “Mean reversion in real exchange rates”, Economics Letters, 46, 3, 251-256.

Dahlhaus, R. (1989), “Efficient Parameter Estimation for Self-similar Process”, *Annals of Statistics*, 17, 1749-1766.

Demetrescu, M., V. Kuzin and U. Hassler. 2008. Long memory testing in the time domain, Econometric Theory 24: 176-215.

Frankel, J. (1986), “International capital mobility and crowding out in the U.S. economy: imperfect integration of financial markets or goods markets?” in R. Hafer (ed.), How Open is the U.S. Economy?, Lexington Books, Lexington.

Froot, K.A. and K. Rogoff (1995), “Perspectives on PPP and long-run real exchange rates”, in G. Grossman and K. Rogoff (eds.), The Handbook of International Economics, vol. 3, Elsevier Press, Amsterdam.

Gil-Alana, L.A. (2000), Mean reversion in the real exchange rates, Economics Letters 69, 285-288.

Granger, C.W. 1980.Long memory relationships and the aggregation of dynamic models. Journal of Econometrics 14: 227-38.

Granger, C.W. and R. Joyeux. 1980. An introduction to long memory time series and fractionally differencing. Journal of Time Series Analysis 1: 15-29.

Hosking, J.R. 1981.Fractional differencing.Biometrika 68: 168-76.

Kew, H. and D. Harris. 2009. Heteroskedasticity robust testing for a fractional unit root. Econometric Theory 25: 1734-53.

Lothian, J.R. and M. P. Taylor (1996), “Real exchange rate behavior: the recent float from the perspective of the past two centuries”, Journal of Political Economy, 104, 3, 488-509.

Lobato, I. and C. Velasco. 2007. Efficient Wald tests for fractional unit roots. Econometrica 75: 575-89.

Lothian, J.R. and M. P. Taylor (1997), “Real exchange rate behavior”, Journal of International Money and Finance, 16, 6, 945-954.

Masih, R. and M.R.R. Masih, 2004, Fractional cointegration, low frequency dynamics and long run purchasing power parity. An analysis of the Australian dollar over its recent float, Applied Economics 36, 6, 593-605.

Olayungbo, D.O. (2011), "Purchasing power parity in selected Sub-Saharan countries: evidence from panel unit-root tests", Journal of Emerging Trends in Economic and Management Sciences, 2, 4, 270-274.

Press, W.H., B.P. Flannery, S.A. Teukolsky and W.T. Wetterling, 1986, Numerical Recipes.The Art of Scientific Computing, Cambridge University Press, Cambridge.

Robinson, P.M., 1994, Efficient tests of nonstationary hypotheses, Journal of the American Statistical Association 89, 1420-1437.

Rogoff, K. (1996), "The purchasing power parity puzzle", Journal of Economic Literature, 34, 647-668.

Shimotsu, K. and P.C.B. Phillips, 2005, Exact local Whittle estimation of fractional integration, Annals of Statistics 33, 4, 1890-1953.

Yoon, G., 2009, Purchasing power parity and long memory, Applied Economics Letters 16, 1, 55–61.

Table 1: Estimates of d and 95% confidence intervals

Country	No regressors	An intercept	A linear time trend
ANGOLA	0.936 (0.742, 1.234)	**0.959 (0.689, 1.367)**	0.957 (0.646, 1.365)
BURKINA FASO	0.867 (0.640, 1.175)	**1.041 (0.837, 1.358)**	1.041 (0.814, 1.358)
BENIN	0.896 (0.691, 1.186)	**1.138 (0.926, 1.458)**	1.134 (0.927, 1.453)
BOTSWANA	0.741 (0.401, 1.109)	**0.967 (0.735, 1.347)**	0.964 (0.639, 1.345)
BURUNDI	0.882 (0.666, 1.187)	**1.233 (0.989, 1.637)**	1.233 (0.986, 1.634)
CAPE VERDE	0.889 (0.677, 1.193)	**1.308(1.082, 1.663)**	1.304(1.078, 1.671)
CAMEROON	0.876 (0.665, 1.178)	**1.053 (0.775, 1.432)**	1.054 (0.793, 1.420)
CENTRAL AF.	0.852 (0.630, 1.158)	**0.997 (0.802, 1.299)**	0.996 (0.779, 1.297)
CHAD	0.861 (0.642, 1.163)	**1.035 (0.824, 1.355)**	1.033 (0.802, 1.355)
COMOROS	0.864(0.643, 1.165)	**0.957 (0.764, 1.251)**	0.954 (0.748, 1.250)
CONGO REP.	0.878 (0.676, 1.179)	**1.106 (0.629, 1.515)**	1.105 (0.787, 1.496)
DJIBOUTI	0.904 (0.707, 1.194)	**1.228 (1.033, 1.562)**	1.229 (1.033, 1.564)
EQ. GUINEA	0.856 (0.632, 1.177)	**1.085 (0.929, 1.314)**	1.083 (0.926, 1.312)
ERITREA	0.868 (0.636, 1.212)	**1.314 (1.102, 1.642)**	1.307 (1.099, 1.654)
ETHIOPIA	0.728 (0.495, 1.075)	**1.102 (0.906, 1.428)**	1.100 (0.890, 1.428)
GABON	0.866 (0.641, 1.179)	**1.115 (0.909, 1.416)**	1.112 (0.919, 1.398)
GAMBIA	0.841 (0.592, 1.159)	0.895 (0.729, 1.175)	**0.870 (0.602, 1.179)**
GHANA	1.385 (1.119, 1.873)	**1.459 (1.152, 2.003)**	1.457 (1.153, 2.004)
GUINEA B.	0.863 (0.637, 1.167)	0.840 (0.712, 1.079)	**0.831 (0.684, 1.072)**
GUINEA	0.748 (0.410, 1.123)	**1.011 (0.837, 1.292)**	1.006 (0.804, 1.293)
IVORY COAST	0.884 (0.672, 1.185)	**0.996 (0.708, 1.375)**	0.998 (0.729, 1.370)
KENYA	0.899 (0.685, 1.204)	**1.068 (0.907, 1.305)**	1.070 (0.908, 1.310)
LESOTHO	0.733 (0.176, 1.134)	**1.009 (0.717, 1.465)**	1.009 (0.681, 1.464)
LIBERIA	0.808 (0.648, 1.081)	**0.845 (0.695, 1.102)**	0.825 (0.633, 1.105)
MADAGASCAR	0.902 (0.702, 1.193)	**0.937 (0.775, 1.196)**	0.936 (0.768, 1.199)
MALAWI	0.856 (0.629, 1.166)	0.828 (0.683, 1.174)	**0.744 (0.375, 1.177)**
MAURITANIA	0.846 (0.609, 1.164)	**1.293 (1.109, 1.565)**	1.291 (1.109, 1.543)
MAURITIUS	0.879 (0.655, 1.195)	**1.051 (0.810, 1.427)**	1.050 (0.786, 1.427)
MOZAMBIQUE	0.916 (0.699, 1.271)	**1.189 (0.972, 1.561)**	1.191 (0.961, 1.557)
NAMIBIA	0.789 (0.466, 1.153)	**1.131 (0.841, 1.580)**	1.132 (0.842, 1.583)
NIGER	0.866 (0.633, 1.184)	**1.078 (0.903, 1.345)**	1.078 (0.895, 1.343)
NIGERIA	0.848 (0.580, 1.192)	**1.122 (0.822, 1.543)**	1.122 (0.816, 1.540)
REUNION	0.857 (0.633, 1.165)	**1.002 (0.823, 1.270)**	1.001 (0.817, 1.265)
SIERRA LEONE	0.841 (0.606, 1.159)	**1.265 (1.042, 1.635)**	1.261 (1.042, 1.607)
SOUTH AFRICA	0.144 (0.087, 0.686)	**1.239 (0.527, 2.217)**	1.227 (0.306, 2.194)
SAO TOME	0.856 (0.629, 1.171)	**1.371 (1.149, 1.758)**	1.366 (1.149, 1.747)
SENEGAL	0.867 (0.646, 1.174)	**0.986 (0.782, 1.285)**	0.985 (0.763, 1.282)
SEYCHELLES	0.843 (0.645, 1.144)	**1.223 (0.952, 1.623)**	1.205 (0.963, 1.544)
SUDAN	0.917 (0.741, 1.193)	0.875 (0.719, 1.139)	**0.861 (0.678, 1.144)**
SWAZILAND	0.853 (0.576, 1.222)	**0.859 (0.580, 1.327)**	0.856 (0.541, 1.327)
TANZANIA	0.893 (0.679, 1.194)	**1.428 (1.191, 1.797)**	1.428 (1.190, 1.798)
TOGO	0.883 (0.664, 1.194)	**0.959 (0.749, 1.276)**	0.958 (0.730, 1.274)
UGANDA	0.781 (0.472, 1.140)	**1.358 (1.117, 1.707)**	1.349 (1.167, 1.683)
ZAMBIA	0.880 (0.669, 1.178)	**1.304 (0.995, 1.811)**	1.306 (0.998, 1.810)

Table 2: Estimates of the coefficients of the selected models

Country	d (95% conf. intv.)	Intercept (t-value)	Time trend (t-value)
ANGOLA	0.959 (0.689, 1.367)	6.20967 (12.707)	xxx
BURKINA FASO	1.041 (0.837, 1.358)	5.66871 (43.262)	xxx
BENIN	1.138 (0.926, 1.458)	5.39981 (42.137)	xxx
BOTSWANA	0.967 (0.735, 1.347)	1.35546 (14.791)	xxx
BURUNDI	1.233 (0.989, 1.637)	6.46216 (75.155)	xxx
CAPE VERDE	1.308 (1.082, 1.663)	3.81408 (42.779)	xxx
CAMEROON	1.053 (0.775, 1.432)	6.40020 (50.700)	xxx
CENTRAL AF.	0.997 (0.802, 1.299)	5.81394 (41.872)	xxx
CHAD	1.035 (0.824, 1.355)	5.70189 (48.731)	xxx
COMOROS	0.957(0.764, 1.251)	5.47811 (34.271)	xxx
CONGO REP.	1.106 (0.629, 1.515)	6.91253 (55.646)	xxx
DJIBOUTI	1.228 (1.033, 1.562)	5.08840 (128.831)	xxx
EQ. GUINEA	1.085 (0.929, 1.314)	5.57779 (45.230)	xxx
ERITREA	1.314 (1.102, 1.642)	3.59273 (34.883)	xxx
ETHIOPIA	1.102 (0.906, 1.428)	1.04824 (8.315)	xxx
GABON	1.115 (0.909, 1.416)	6.65016 (48.584)	xxx
GAMBIA	0.870 (0.602, 1.179	2.53210 (24.089)	0.01906 (1.783)
GHANA	1.459 (1.152, 2.003)	-0.63878 (-2.670)	xxx
GUINEA B.	0.831 (0.684, 1.072)	5.09053 (35.901)	0.02781 (2.168)
GUINEA	1.011 (0.837, 1.292)	4.85004 (12.119)	xxx
IVORY COAST	0.996 (0.708, 1.375)	6.39430 (46.111)	xxx
KENYA	1.068 (0.907, 1.305)	4.48362 (49.601)	xxx
LESOTHO	1.009 (0.717, 1.465)	1.70969 (12.518)	xxx
LIBERIA	0.845 (0.695, 1.102)	1.14239 (2.047)	xxx
MADAGASCAR	0.937 (0.775, 1.196)	8.54757 (31.018)	xxx
MALAWI	0.744 (0.375, 1.177)	3.77871 (35.692)	0.02360 (3.137)
MAURITANIA	1.293 (1.109, 1.565)	5.05752 (65.745)	xxx
MAURITIUS	1.051 (0.810, 1.427)	3.08119 (43.292)	xxx
MOZAMBIQUE	1.189 (0.972, 1.561)	1.26190 (5.498)	xxx
NAMIBIA	1.131 (0.841, 1.580)	1.93323 (16.374)	xxx
NIGER	1.078 (0.903, 1.345)	5.79951 (48.370)	xxx
NIGERIA	1.122 (0.822, 1.543)	4.49616 (14.982)	xxx
REUNION	1.002 (0.823, 1.270)	5.95668 (47.192)	xxx
SIERRA LEONE	1.265(1.042, 1.635)	7.64194 (41.282)	xxx
SOUTH AFRICA	1.239 (0.527, 2.217)	1.49571 (7.966)	xxx
SAO TOME	1.371 (1.149, 1.758)	8.59936 (64.862)	xxx
SENEGAL	0.986 (0.782, 1.285)	6.00882 (45.434)	xxx
SEYCHELLES	1.223 (0.952, 1.623)	2.31383 (33.982)	xxx
SUDAN	0.861 (0.678, 1.144)	5.62238 (7.303)	-0.12472 (-1.637)
SWAZILAND	0.859 (0.580, 1.327)	1.71516 (14.499)	xxx
TANZANIA	1.428 (1.191, 1.797)	6.35066 (57.359)	xxx
TOGO	0.959 (0.749, 1.276)	6.10023 (50.497)	xxx
UGANDA	1.358 (1.117, 1.707)	7.12414 (27.905)	xxx
ZAMBIA	1.304 (0.995, 1.811)	8.46670 (56.915)	xxx

Table 3: Summary based on the asymptotic results

Mean Reversion (d < 1)	Unit Root (d = 1)		Explosive Behaviour (d > 1)
	d < 1	d > 1	
xxx	Malawi (0.744)	Reunion (1.002)	Djibouti (1.228)
	Guinea Bis. (0.831)	Lesotho (1.009)	Sierra Leone (1.265)
	Liberia (0.845)	Guinea (1.011)	Mauritania (1.293)
	Swaziland (0.859)	Chad (1.035)	Cape Verde (1.308)
	Sudan (0.861)	Burkina Faso (1.041)	Eritrea (1.314)
	Gambia (0.870)	Mauritius (1.051)	Uganda (1.358)
	Madagascar (0.937)	Cameroon (1.053)	Sao Tome (1.371)
	Comoros (0.957)	Kenya (1.068)	Tanzania (1.428)
	Angola (0.959)	Niger (1.078)	Ghana (1.459)
	Togo (0.959)	Eq. Guinea (1.085)	
	Botswana (0.967)	Ethiopia (1.102)	
	Senegal (0.986)	Congo Rep. (1.106)	
	Ivory Coast (0.996)	Gabon (1.115)	
	Centr. Africa (0.997)	Nigeria (1.122)	
		Namibia (1.131)	
		Benin (1.138)	
		Mozambique (1.189)	
		Seychelles (1.223)	
		Burundi (1.233)	
		South Africa (1.239)	
		Zambia (1.304)	

Table 4: Asymptotic and finite sample confidence intervals for the values of d

	Asymptotic	Finite samples
ANGOLA	(0.689, 1.367)	(0.756, 1.501)
BURKINA FASO	(0.837, 1.358)	(0.889, 1.473)
BENIN	(0.926, 1.458)	(0.982, 1.576)
BOTSWANA	(0.735, 1.347)	(0.793, 1.485)
BURUNDI	(0.989, 1.637)	(1.051, 1.796)
CAPE VERDE	(1.082, 1.663)	(1.140, 1.797)
CAMEROON	(0.775, 1.432)	(0.853, 1.568)
CENTRAL AF.	(0.802, 1.299)	(0.852, 1.408)
CHAD	(0.824, 1.3 55)	(0.878, 1.468)
COMOROS	(0.764, 1.251)	(0.813, 1.354)
CONGO REP.	(0.629, 1.515)	(0.837, 1.644)
DJIBOUTI	(1.033, 1.562)	(1.083, 1.703)
EQ. GUINEA	(0.929, 1.314)	(0.969, 1.397)
ERITREA	(1.102, 1.642)	(1.158, 1.781)
ETHIOPIA	(0.906, 1.428)	(0.956, 1.564)
GABON	(0.909, 1.416)	(0.966, 1.528)
GAMBIA	(0.602, 1.179)	(0.682, 1.279)
GHANA	(1.152, 2.003)	(1.222, 2.226)
GUINEA B.	(0.684, 1.072)	(0.743, 1.181)
GUINEA	(0.837, 1.292)	(0.878, 1.394)
IVORY COAST	(0.708, 1.375)	(0.791, 1.507)
KENYA	(0.907, 1.305)	(0.949, 1.388)
LESOTHO	(0.717, 1.465)	(0.789, 1.636)
LIBERIA	(0.695, 1.102)	(0.737, 1.203)
MADAGASCAR	(0.775, 1.196)	(0.813, 1.294)
MALAWI	(0.375, 1.177)	(0.484, 1.337)
MAURITANIA	(1.109, 1.565)	(1.154, 1.662)
MAURITIUS	(0.810, 1.427)	(0.869, 1.563)
MOZAMBIQUE	(0.972, 1.561)	(1.026, 1.707
NAMIBIA	(0.841, 1.580)	(0.924, 1.755)
NIGER	(0.903, 1.345)	(0.943, 1.442)
NIGERIA	(0.822, 1.543)	(0.902, 1.684)
REUNION	(0.823, 1.270)	(0.872, 1.366)
SIERRA LEONE	(1.042, 1.635)	(1.094, 1.773)
SOUTH AFRICA	(0.527, 2.217)	(0.636, 2.447)
SAO TOME	(1.149, 1.758)	(1.206, 1.915)
SENEGAL	(0.782, 1.285)	(0.835, 1.389)
SEYCHELLES	(0.952, 1.623)	(1.026, 1.757)
SUDAN	(0.678, 1.144)	(0.759, 1.243)
SWAZILAND	(0.580, 1.327)	(0.655, 1.511)
TANZANIA	(1.191, 1. 797)	(1.253, 1.935)
TOGO	(0.749, 1.276)	(0.807, 1.392)
UGANDA	(1.117, 1.707)	(1.180, 1.825)
ZAMBIA	(0.995, 1.811)	(1.073, 1.998)

Table 5: Summary based on the finite sample results

Mean Reversion (d < 1)	Unitroot (d = 1)		Explosivebehavior (d > 1)
	d < 1	d > 1	
xxx	Malawi (0.744) Guinea Bis. (0.831) Liberia (0.845) SWAZILAND (0.859) Sudan (0.861) Gambia (0.870) Madagascar (0.937) Comoros (0.957) Angola (0.959) Togo (0.959) Botswana (0.967) Senegal (0.986) Ivory Coast (0.996) Centr. Africa (0.997)	Reunion (1.002) Lesotho (1.009) Guinea (1.011) Chad (1.035) Burkina Faso (1.041) Mauritius (1.051) Cameroon (1.053) Kenya (1.068) Niger (1.078) Eq. Guinea (1.085) Ethiopia (1.102) Congo Rep. (1.106) Gabon (1.115) Nigeria (1.122) Namibia (1.131) Benin (1.138) South Africa (1.239)	Mozambique (1.189) Seychelles (1.223) Djibouti (1.228) Burundi (1.233) Sierra Leone (1.265) Mauritania (1.293) Zambia (1.304) Cape Verde (1.308) Eritrea (1.314) Uganda (1.358) Sao Tome (1.371) Tanzania (1.428) Ghana (1.459)