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Guglielmo Maria Caporale and Luis A. Gil-Alana

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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.

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

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, …, 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. α = β = 0 a priori); with an intercept (α unknown and β = 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 rcs0/F5.77 48[( )0ribeF5.77 4h

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 expl

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).

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.

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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)
[redacted]IEROON	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)

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

Table 3: Summary based on the asymptotic results

Mean Reversion (d < 1)	Unit Root (d = 1)		Explosive Behaviour (d > 1)
	d < 1	d > 1	

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)

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)	Reunion (1.002)	
	Guinea Bis. (0.831)	Lesotho (1.009)	
	Liberia (0.845)	Guinea (1.011)	
	SWAZILAND (0.859)	Chad (1.035)	
		Burkina Faso (1.041)	
	Sudan (0.861)	Mauritius (1.051)	
	Gambia (0.870)	Cameroon (1.053)	
	Madagascar (0.937)	Kenya (1.068)	
	Comoros (0.957)		
	Angola (0.959)		
	Togo (0.959)		
	Botswana (0.967)		
	Senegal (0.986)		
	Ivory Coast (0.996)		
	Centr. Africa (0.997)		