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Purchasing Power Parity in African Countries: Further Evidence based on the ADL Test for Threshold Cointegration

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Abstract

In this study, we applied a newly-developed Autoregressive Distributed Lag (ADL) test for threshold cointegration, proposed by Li and Lee (2010) to test the validity of long-run purchasing power parity (PPP) for a sample of 18 African countries from January 1985 to September 2008. Empirical results indicate that PPP holds true for half of these countries studied, the long-run PPP adjustment process toward its equilibrium is asymmetric. Our results have important policy implications for these African countries under study.

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I. Introduction

Over the past several decades, empirical studies have devoted to testing the validity of long-run purchasing power parity (hereafter, PPP) hypothesis as it has important implications in the international macroeconomics.[1] While some empirical evidence of long-run PPP for both developed countries and less-developed countries seems convincing, unfortunately thus far none has been proven to be conclusive. As for methodology, recent studies of long-run PPP have mostly utilized conventional unit root tests for real exchange rates and cointegration tests for the relationship between various measures of domestic and foreign prices as well as nominal exchange rates. The conclusions drawn from these studies have primarily been based on linear tests of stationarity and/or cointegration. Since ample evidence in support of asymmetric reactions in key economic variables has been widely acknowledged in recent years, there is no reason to assume that the long-run PPP adjustment process toward equilibrium is always symmetric. Madsen and Yang (1998) and Ramsey and Rothman (1996) have shown that, for example, economic variables such as inflation rates, etc. follow an asymmetric adjustment process. Besides, Balke and Fomby (1997) pointed out that the power of linear cointegration tests is lower in an asymmetric adjustment process.

More to the point, it is very likely that the assumption of symmetric adjustments yield poor results when it comes to equilibrium relationships because conventional cointegration tests do not take asymmetric adjustments into account. Enders and Granger (1998) also show that the standard tests for unit root and cointegration all have lower power in the presence of misspecified dynamics. This is important since the linear relationship is inappropriate if prices are sticky in the downward, but not in the upward direction. Madsen and Yang (1998) have provided evidence that prices are sticky in the downward direction and that such stickiness means that real exchange rate adjustments are asymmetric.

Other reasons for the asymmetric adjustment are the presence of transactions costs that inhibit international goods arbitrage and official intervention in the foreign exchange market may be such that nominal exchange rate movements are asymmetric (see, Taylor, 2004; Juvenal and Taylor, 2008; Wu and Chen, 2001). Kilian and Taylor (2003) also suggest that nonlinearity may arise from the heterogeneity of opinion in the foreign exchange market concerning the equilibrium level of the

[1] Some references in the field are McDonald and Taylor (1992), Taylor (1995), Rogoff (1996), Taylor and Sarno (1998), Taylor and Peel (2000), Lothian and Taylor (2000, 2008), Sarno and Taylor (2002), and Taylor and Taylor (2004) who have provided in-depth information on the theoretical and empirical aspects of PPP and the real exchange rate.

nominal exchange rate: as the nominal rate takes on more extreme values, a great degree of consensus develops concerning the appropriate direction of exchange rate movements, and traders act as accordingly. All these motivate us to use the Autoregressive Distributed Lag (hereafter, ADL) test for threshold (asymmetric) cointegration in our study.

The present empirical study contributes significantly to this field of research by using the ADL test for threshold cointegraion, proposed by Li and Lee (2010), to determine whether long-run PPP existed in a sample of 18 African countries. The major advantage of this approach is that it allows us to simultaneously investigate nonlinearity and cointegration. With this, the current research hopes to fill the existing gap in the literature. To the best of our knowledge, this study is the first of its kind to utilize the ADL test for threshold cointegration to test the long-run PPP for African countries. Empirical results indicate that PPP holds true for half of these countries studied, and the long-run PPP adjustment process toward its equilibrium is asymmetric. Our results have important policy implications for these 18 African countries under study.

The plan of this paper is organized as follows. Section II presents the data used in our study. Section III briefly describes the ADL test for threshold cointegration proposed by Li and Lee (2010), and Section IV presents our empirical results. Section V concludes the paper.

II. Data

Our empirical analysis covers a sample of 18 African countries: Burkina Faso, Burundi, Congo, Cote d'Ivoire, Egypt, Ethiopia, Gabon, Ghana, Kenya, Madagascar, Mauritius, Morocco, Niger, Nigeria, Sierra Leone, South African, Tanzania, and Zambia. Monthly data are employed in this study, and the time span is from January 1985 to September 2008 period. All consumer price indices, CPI (based on 2005 = 100) and nominal exchange rates relative to the USA dollar data are taken from the International Monetary Fund¡s International Financial Statistics CD-ROM. Each of the consumer price index and nominal exchange rate series was transformed into natural logarithms before the econometric analysis.

III. Li and Lee¡s (2010) ADL Test for Threshold Cointegration

In this study, we employ the ADL test for threshold cointegration technique advanced by Li and Lee (2010) to test for long-run PPP with asymmetric adjustments for a sample of 18 African countries. The major advantage of this approach is that it allows us to simultaneously investigate nonlinearity and cointegration. Following Li and Lee (2010), we also relax the assumption of a pre-specified cointegrating vector and consider estimating the cointegrating vector. Therefore, the threshold ADL model is appropriate and threshold cointegration tests are suggested. First the estimated cointegrating vector is given by the following regression:

$$e_t = \alpha_0 + \alpha_1 P_t^* + \alpha_2 P_t + u_t \qquad [1]$$

where e_t is the logarithm of the foreign exchange rate in the domestic currency; P_t^* and P_t represent the logarithm of foreign and domestic price levels, respectively, $\alpha_0, \alpha_1, \alpha_2$ are parameters estimated, and u_t is the stochastic disturbance term. Two indicators, *Indicator A* with $I_t^a = I(u_{t-1} < u_{t-1}^*(\tau))$ and *Indicator B* with $I_t^b = I(\Delta u_{t-1} < \Delta u_{t-1}^*(\tau))$, are considered. Specifically, the threshold ADL regression model of PPP is described as follows

$$\begin{aligned}\Delta e_t = \beta_0 + \beta_1 e_{t-1} I_t + \beta_2 e_{t-1}(1 - I_t) + \beta_3 P_{t-1} I_t + \beta_4 P_{t-1}(1 - I_t) + \\ \beta_5 P_{t-1}^* I_t + \beta_6 P_{t-1}^*(1 - I_t) + \beta_7 \Delta P_t + \beta_8 \Delta P_t^* + \beta_9 \Delta e_{t-1} + \beta_{10} \Delta P_{t-1} + \beta_{11} \Delta P_{t-1}^* + \varepsilon_t\end{aligned} \qquad [2]$$

where I_t can be replaced with I_t^b if *Indicator B* is adopted. Most important, the adjustment speeds toward the long-run equilibrium, as measured by β_i (*i* = 1, 2, 3, 4, 5, 6) are allowed to vary in the threshold model. Thus, the conventional ADL model is a special case of the threshold ADL model when $\beta_1 = \beta_2$, $\beta_3 = \beta_4$, and $\beta_5 = \beta_6$. Here, only one lag of Δe_t, ΔP_t and ΔP_t^* is included in the regression following the the parsimony principle. The lag-selection is guided by the partial autocorrelation function (PACF) of Δe_t. Li and Lee (2010) proposed two tests for threshold cointegration. The first - the BO type test, is due to Boswijk (1994), who suggests testing the coefficients of e_{t-1}, P_{t-1}, and P_{t-1}^* in the testing regression. In contrast, the second-the BDM type test of Banerjee et al. (1998) suggesting adding lead of both P_{t-1} and P_{t-1}^* to the regression so that the asymptotic results are valid in the absence of strict exogeneity. The threshold BO and BDM tests are based on testing the following two null hypotheses, respectively:

$$H_0 : \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = 0 \qquad \text{BO test}$$

$$H_0 : \beta_1 = \beta_2 = 0 \qquad \text{BDM test,}$$

Based on their Monte Carlo experiment, Li and Lee (2010) indicate that the BO test performs better than any of other tests in terms of size and power. Given this, we recommend using the BO threshold cointegration test for our empirical research. As there is generally no prescribed rule as to whether to use the *Indicator A* or *Indicator*

B in our model, the recommendation is to select the adjustment mechanism using a model selection criterion such as the Akaike Information criteria (AIC) or Schwartz criteria (SC).

IV. Empirical Results

As we mentioned earlier that there is generally no prescribed rule as to whether to use the *Indicator A* or *Indicator B* in our model, the recommendation is to select the adjustment mechanism using a model selection criterion such as the Akaike Information criteria (AIC) or Schwartz criteria (SC). Here, we use the AIC in our study. When we use the AIC model selection criterion, the ADL model with the *Indicator A* is favored in 11 cases and *Indicator B* is favored in 7 cases. This means that for Burkina Faso, Congo, Cote d'Ivoire, Ethiopia, Gabon, Ghana, Madagascar, Morocco, Niger, Nigeria, and Sierra Leone, we use ADL model with *Indicator A function,* and for Burundi, Egypt, Kenya, Mauritius, South African, Tanzania, and Zambia, we use ADL model with *Indicator B function.* Table 1 and 2 report the results from our ADL test for threshold cointegration using the *Indicator A* and *Indicator B functions,* respectively. Based on the results from Tables 1 and 2, we find that the null hypothesis is rejected in favor of the alternative hypothesis for nine countries (i.e., Burkina Faso, Congo, Cote d'Ivoire, Gabon, Ghana, Mauritius, Niger, Tanzania, and Zambia). Apparently, the ADL test for threshold cointegration employed in our study provided some evidence favoring the long-run validity of PPP for half of these 18 African countries under study, and the long-run PPP adjustment process toward its equilibrium is asymmetric, as indicated by the significant coefficients of β_i (i = 1, 2, 3, 4, 5, 6) for each country (see Tables 1 and 2). Trade barriers, transaction costs, as well as the interventions in the exchange market, could be behind this nonlinear (and/or asymmetric) behavior. Our results have important policy implications for these African countries under study.

The major policy implication that emerges from this study is that that PPP can be used to determine the equilibrium exchange rate for half of the 18 African countries (i.e., Burkina Faso, Congo, Cote d'Ivoire, Gabon, Ghana, Mauritius, Niger, Tanzania, and Zambia). The governments of these nine African countries can use PPP to predict exchange rate that determine whether a currency is over or undervalued and experiencing difference between domestic and foreign inflation rates. Nevertheless, reaping unbounded gains from arbitrage in traded goods is not possible in these nine countries.

V. Conclusions

In this study, we applied the ADL test for threshold cointegration to test the validity of long-run PPP for a sample of 18 African countries from January 1985 to September 2008. The empirical results indicate that PPP holds true for half of the 18 African countries under study, and the adjustment process toward its long-run equilibrium is asymmetric. Our results have important policy implications for these 18 African countries under study. As concerns major policy, our study implies that PPP can be used to determine the equilibrium exchange rate for half of these African countries under study.

References

Balke, N.S. and T. B. Fomby, T.B. (1997) Threshold cointergration, *International Economic Review*, 38, 627-645

Banerjee, A., Dolado, J.H. and Mestre, R. (1998) Error-correction mechanism tests for cointegration in a single-equation framework, J*ournal of Time Series Analysis*, 19(3), 267-83.

Boswijk, P. (1994) Testing for an unstable root in conditional and structural error correction models, *Journal of Econometrics,* 63, 37-60.

Enders, W. and Granger, C.W. F. (1998) Unit-root tests and asymmetric adjustment with an example using the term structure of interest rates, *Journal of Business Economics & Statistics*, 16, 304-311.

Juvenal, L. and Taylor, M.P. (2008) Threshold adjustment of deviations from the law of one price, *Studies in Nonlinear Dynamics and Econometrics,* 12(3), 1-44.

Kilian, L. and Taylor, M.P. (2003) Why is it so difficult to beat the random walk forecast of exchange rates? *Journal of International Economics*, 60(1), 85-107.

Li, J. and Lee, J. (2010) ADL test for threshold cointegration, *Journal of Time Series Analysis*, 31, 241-254.

Lothian, J.R. and Taylor, M.P. (2000) Purchasing power parity over two centuries: strengthening the case for real exchange rate stability reply to Cuddington and Liang, *Journal of International Money and Finance*, 19(5), 759-764.

Lothian, J.R. and Taylor, M.P. (2008) Real exchange rates over the past two centuries: how important is the Harrod-Balassa-Samuelson effect? *Economic Journal,* 118(532), 1742-1763.

MacDonald, R. and Taylor, M.P. (1992) Exchange rate economics: A survey, *Staff Papers- International Monetary Fund*, 39(1), 1-57.

Madsen, J. and Yang, B. (1998) Asymmetric price adjustment in a menu cost model, *Journal of Economics*, 68, 295-309

Ramsey, J.B. and Rothman, P. (1996) Time irreversibility and business cycle asymmetry, *Journal of Money Credit and Banking,* 28, 1-21.

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

Sarno, L. and Taylor, M.P. (2002) Purchasing power parity and the real exchange rate, *IMF Staff Papers*, 49, 65-105.

Taylor, A.M. and Taylor, M.P. (2004) The purchasing power parity debate, *Journal of Economic Perspectives,* 18(4), 135-158.

Taylor, M.P. (1995) The economics of exchange-rates, *Journal of Economic Literature,* 33(1), 13-47.

Taylor, M.P. (2004) Is official exchange rate intervention effective? *Economica*, 71(281), 1-11

Taylor, M. P and D. A. Peel (2000) Nonlinear Adjustment, Long-Run Equilibrium and Exchange Rate Fundamentals, *Journal of International Money and Finance,* 19, 1, 33-53.

Taylor, M.P. and Sarno, L. (1998) The Behavior of real exchange rates during the post-Bretton Woods period, *Journal of International Economics*, 46(2), 281-312.

Wu, J. and Chen, S. (2001) Nominal exchange rate prediction: Evidence from a nonlinear approach, *Journal of International Money and Finance,* 20, 521-532.

Table 1. Conditional threshold ADL model of PPP with Indicator A

	β_0	β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9	β_{10}	β_{11}
Burkina Faso	0.158	-0.058	-0.305	0.106	-0.064	-0.793	1.194	0.008	-0.447	-0.073	-0.447	0.013
	(1.861)	(-2.532)	(-5.891)	(1.894)	(-1.339)	(-5.854)	(10.561)	(0.058)	(-0.477)	(-1.362)	(-3.186)	(0.014)
	$E_t^*(\tau)=0.114$, $\tau=0.77$, $BO\ stat: 168.61$***, $AIC=-211.371$											
Congo	-0.160	-0.054	-0.026	-0.150	0.252	0.013	0.058	0.244	0.098	-0.025	0.676	-0.461
	(-0.725)	(-1.256)	(-0.969)	(-2.440)	(3.323)	(0.273)	(0.893)	(2.138)	(0.088)	(-0.444)	(5.963)	(-0.410)
	$E_t^*(\tau)=-0.095$, $\tau=0.302$, $BO\ stat: 27.442$**, $AIC=-120.286$											
Cote d'Ivoire	0.072	-0.016	-0.180	0.022	-0.016	0.035	0.204	1.472	-0.624	-0.051	-0.113	-0.156
	(0.263)	(-0.486)	(-5.226)	(0.268)	(-0.158)	(0.454)	(1.739)	(5.115)	(-0.564)	(-0.860)	(-0.402)	(-0.140)
	$E_t^*(\tau)=0.090$, $\tau=0.754$, $BO\ stat: 34.88$***, $AIC=-126.478$											
Ethiopia	0.080	-0.127	0.004	0.232	-0.211	0.012	-0.031	0.022	0.245	-0.002	-0.057	0.273
	(0.318)	(-3.585)	(0.197)	(3.765)	(-2.380)	(0.339)	(-0.390)	(0.148)	(0.198)	(-0.035)	(-0.386)	(0.215)
	$E_t^*(\tau)=-0.276$, $\tau=0.151$, $BO\ stat: 21.068$, $AIC=-63.321$											
Gabon	0.103	-0.013	-0.330	-0.018	0.011	-0.047	0.495	0.343	0.190	-0.029	0.021	-0.272
	(1.537)	(-0.559)	(-4.400)	(-0.387)	(0.434)	(-0.315)	(6.345)	(2.283)	(0.181)	(-0.451)	(0.142)	(-0.255)
	$E_t^*(\tau)=0.131$, $\tau=0.782$, $BO\ stat: 86.017$***, $AIC=-149.088$											
Ghana	-0.806	-0.589	0.000	0.696	-0.671	-0.025	0.203	0.311	0.765	0.015	-0.328	-0.106
	(-1.448)	(-4.898)	(-0.008)	(4.588)	(-2.997)	(-0.819)	(1.446)	(1.189)	(0.580)	(0.263)	(-1.258)	(-0.080)
	$E_t^*(\tau)=-0.203$, $\tau=0.151$, $BO\ stat: 35.66$***, $AIC=-24.816$											
Mauritius	-0.554	0.000	-0.016	-0.125	0.248	-0.081	0.213	-0.074	0.112	0.026	-0.242	-0.908
	(-1.573)	(0.002)	(-0.566)	(-1.551)	(1.841)	(-1.105)	(1.568)	(-0.387)	(0.190)	(0.422)	(-1.301)	(-1.525)
	$E_t^*(\tau)=-0.087$, $\tau=0.158$, $BO\ stat: 20.480$, $AIC=-484.876$											
Morocco	0.027	0.014	-0.008	-0.067	0.055	0.048	-0.051	0.080	-0.498	0.118	-0.227	0.542
	(0.449)	(0.442)	(-0.405)	(-1.318)	(1.080)	(1.160)	(-1.066)	(0.469)	(-0.963)	(1.992)	(-1.358)	(1.028)
	$E_t^*(\tau)=-0.064$, $\tau=0.249$, $BO\ stat: 15.523$, $AIC=-553.124$											
Niger	0.115	-0.046	-0.293	0.016	0.019	-0.270	0.661	0.341	-0.276	-0.086	-0.257	-0.226
	(1.661)	(-1.805)	(-5.284)	(0.470)	(0.785)	(-3.081)	(9.807)	(2.397)	(-0.273)	(-1.424)	(-1.937)	(-0.222)
	$E_t^*(\tau)=0.088$, $\tau=0.684$, $BO\ stat: 116.1$***, $AIC=-169.886$											
Nigeria	-0.562	-0.221	-0.025	0.224	0.079	-0.008	0.153	0.314	1.700	0.039	-0.327	-1.395
	(-0.616)	(-2.793)	(-1.194)	(2.928)	(0.359)	(-0.315)	(0.673)	(1.049)	(0.681)	(0.657)	(-1.094)	(-0.556)
	$E_t^*(\tau)=-0.541$, $\tau=0.151$, $BO\ stat: 17.601$, $AIC=-338.741$											
Sierra Leone	0.236	-0.089	-0.102	0.099	0.000	0.083	0.034	0.232	2.831	0.221	-0.107	-3.060
	(0.542)	(-1.380)	(-2.852)	(1.381)	(0.001)	(2.371)	(0.326)	(2.247)	(1.368)	(4.286)	(-1.050)	(-1.460)
	$E_t^*(\tau)=-0.128$, $\tau=0.200$, $BO\ stat: 18.04$, $AIC=234.43$											

Note: 1. The critical values for BO statistic are tabulated at Li and Lee's (2010) Table 1 of their paper. The critical values of BO test for 10%, 5%, and 1% are 22.11, 24.67, and 30.09, respectively.
2. *** and ** indicates significance at the 1% and 5% levels, respectively.
3. The number in parenthesis indicates the robust t-statistic.

Table 2. Conditional threshold ADL model of PPP with Indicator B

	β_0	β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9	β_{10}	β_{11}
Burundi	-0.098	-0.071	-0.064	0.088	0.038	0.043	0.069	0.034	1.138	-0.300	-0.037	1.225
	(-0.410)	(-1.890)	(-2.373)	(2.209)	(0.538)	(1.418)	(0.987)	(0.376)	(0.936)	(-4.856)	(-0.370)	(0.994)
$E_t^*(\tau) =$ -0.019, $\tau = 0.309$, $BO\ stat:$ 19.956, $AIC =$ -69.653												
Egypt	0.136	-0.005	-0.088	0.018	-0.046	0.132	-0.129	0.182	-0.366	0.043	0.200	-0.614
	(0.559)	(-0.331)	(-3.355)	(0.571)	(-0.585)	(2.834)	(-1.601)	(1.018)	(-0.317)	(0.649)	(0.949)	(-0.527)
$E_t^*(\tau) =$ 0.007, $\tau = 0.849$, $BO\ stat:$ 16.076, $AIC =$ -96.708												
Kenya	-0.119	-0.050	-0.008	-0.004	0.074	-0.004	0.036	0.160	0.888	0.335	0.108	-0.286
	(-0.429)	(-1.937)	(-0.536)	(-0.130)	(0.979)	(-0.164)	(0.480)	(1.227)	(1.118)	(4.957)	(0.733)	(-0.350)
$E_t^*(\tau) =$ -0.033, $\tau = 0.151$, $BO\ stat:$ 11.912, $AIC =$ -316.313												
Madagascar	-0.049	-0.016	-0.195	0.005	0.030	0.130	0.188	0.235	1.256	0.031	-0.230	-0.590
	(-0.122)	(-0.684)	(-3.514)	(0.162)	(0.284)	(2.514)	(1.614)	(1.318)	(0.975)	(0.410)	(-1.271)	(-0.449)
$E_t^*(\tau) =$ 0.035, $\tau = 0.849$, $BO\ stat:$ 23.765**, $AIC =$ -29.264												
South Africa	-0.498	-0.064	-0.006	-0.006	0.138	-0.069	0.183	-0.878	-0.818	-0.084	-1.001	0.131
	(-1.615)	(-1.901)	(-0.369)	(-0.120)	(1.303)	(-1.785)	(1.789)	(-1.646)	(-0.801)	(-1.009)	(-1.963)	(0.127)
$E_t^*(\tau) =$ -0.036, $\tau = 0.161$, $BO\ stat:$ 18.043, $AIC =$ -190.223												
Tanzania	0.073	0.007	-0.110	-0.010	-0.013	0.071	0.078	-0.180	0.528	0.167	0.012	-2.193
	(0.413)	(0.826)	(-6.030)	(-0.864)	(-0.290)	(3.754)	(1.637)	(-2.946)	(0.631)	(2.569)	(0.188)	(-2.585)
$E_t^*(\tau) =$ 0.03, $\tau = 0.839$, $BO\ stat:$ 70.27***, $AIC =$ -275.66												
Zambia	4.344	-0.159	-0.179	0.182	-0.852	0.216	-0.846	0.891	-0.102	-0.203	-0.582	-2.537
	(3.717)	(-3.506)	(-3.986)	(3.595)	(-3.452)	(4.395)	(-3.366)	(3.622)	(-0.031)	(-3.061)	(-2.179)	(-0.737)
$E_t^*(\tau) =$ 0.006, $\tau = 0.547$, $BO\ stat:$ 29.28***, $AIC =$ -484.605												

Note: 1. The critical values for BO statistic are tabulated at Li and Lee's (2010) Table 1 of their paper. The critical values of BO test for 10%, 5%, and 1% are 20.90, 23.43, and 28.66, respectively.

2. ***, **, and * indicates significance at the 1% and 5% levels, respectively.

3. The number in parenthesis indicates the robust t-statistic.