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Long-Run Validity of Purchasing Power Parity and Cointegration Analysis for Low Income African Countries

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Abstract

Studies on long-run purchasing power parity based on rank test for nonlinear cointegration is limited. Therefore, to formally examine if nonlinear purchasing power parity really exist in the selected low-income African countries, the current study revisits the long-run validity of purchasing power parity by using the rank tests advanced by Breitung (2011), which is not only capable in the detection of cointegration, but can further distinguish linear from nonlinear relationship if cointegration exists. In addition, this study also follows the suggestion by Liew et al. (2012) to solve the rank problem in testing the PPP hypothesis. Results from the analysis indicate that nominal exchange rates and relative prices are cointegrated in Burundi, Madagascar, Malawi and Uganda. However, further analysis only found the existence of nonlinear cointegration in Burundi.

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1. Introduction

A group of six low-income African countries (Burundi, Kenya, Rwanda, Uganda, Madagascar and Malawi) started moving forward in forming cooperation and integration region in the late-1980s and early 1990s. In December 1994, this group of African's countries jointed the Common Market for Eastern and Southern Africa (COMESA) which replaced the Preferential Trade Area that had existed since 1981. COMESA is an organization established to promote economic integration, international competitiveness and improve the standard of living of the community in the member states. As a preparatory step towards full customs union in year 2008, a free trade area between COMESA countries was established in October 2000 to reduce the tariffs step-by-step according to the country's economic status. However, progress towards closer economic integration has often been blocked by the reluctance of some states to reduce tariffs because of fears about the loss of a valuable source of government revenue. Besides, other states, particularly smaller ones with uncertainty in inflation rates and government intervention in the official foreign exchange rate market, also concerned that without tariff protection, their fledgling industries could be destroyed by competition from more established companies in larger countries.

Thus, in order to keep these economies internationally competitive, policy makers need a benchmark to judge whether the country's currency is over- or under-valued, and to monitor the movement of exchange rate in this low-income African countries. In this regard, policy makers could base their decision on purchasing power parity (PPP) hypothesis. PPP postulated that exchange rates between two currencies are determined by the relative prices of the corresponding two countries. The validity of PPP hypothesis reflects well-integrated markets and suggests the non-existence of arbitraging opportunity between domestic and foreign countries. Motivated by the above concerns, this study examines the long-run validity of purchasing power parity (PPP) hypothesis for the six low-income African countries by using the rank tests advanced by Breitung (2001).

Previously, most studies are conducted to examine the long-run validity of PPP hypothesis for both developed and developing countries, by using various well-accepted methodologies including those earlier and best-known cointegration approaches of the Engle and Granger (1987) test, Johansen (1988, 1991) multivariate cointegration test, fully modified OLS (FOLS) procedure of Phillips and Hasen (1990), as well as the Autoregressive Distributed Lag (ARDL) technique of Pesaran and Shin (1999).[1] Earlier studies conducted on African countries (Kahn and Parikh, 1998; Krichene, 1998; Odedokun, 2000; Holmes, 2000; Kargbo, 2003; Akinboade and Makina, 2006) have been based on linear unit root and cointegration tests and the findings were inconsistent depend on length of data span and econometric methods used. Recently, a number of scholars have focused their attention on investigating empirical support for long-run PPP in African countries by using black market exchange rate (Hassanain, 2005; Caporale and Cerrato, 2008; Bahmani-Oskooee and Tankui, 2008; Baharumshah *et at.*, 2011). In African countries, the volume of transactions in black or parallel market for foreign currencies is even larger than in the official market. Official exchange rates are generally controlled by the government and the black market rate tends to move freely (Baliamoune-Lutz, 2010). Nonetheless, the two rates are

[1] McNown and Wallace (1989) were among the first to apply cointegration test to examine the long-run validity of PPP hypothesis.

connected in the long-run, with the official rate adjusting toward the black market rate (Baharumshah *et al.*, 2011). But, once again, a strong consensus could not be reached even using black market rate with more advanced testing procedures of panel unit root tests and panel cointegration tests.

However, the above findings against PPP have been based on linear econometric frameworks. The mixed findings on long-run PPP validity must be interpreted with caution and they imply two possibilities. First, exchange rate and relative price are not interrelated at all. Second, exchange rate and relative price exhibit nonlinear relationship, which can only be uncovered by nonlinear testing frameworks (Taylor, 2004, 2006; Reitz and Taylor, 2008). In this respect, markets frictions (Baum *et al*., 2001; Sarno *et al*., 2004; Taylor and Taylor, 2004), costs of arbitrage in international goods and government intervention (Juvenal and Taylor, 2008), among others have been identified in the literature as plausible sources of nonlinear dynamic in PPP relationship. The literature has also used an array of nonlinear techniques in an attempt to validate PPP hypothesis. Recent contributions have considered nonlinear stationary methods (Bahmani-Oskooee *et al.*, 2008) and nonlinear cointegration tests (Liew *et al*, 2009; 2010; 2012) to model the behavior of exchange rate and relative price. Bahmani-Oskooee *et al.* (2008) applied nonlinear augmented Dickey-Fuller unit root test to eighty-eight less developed countries, but PPP hypothesis is only validated in forty-one countries. On the other hand, Liew *et al*, (2009; 2010; 2012) uncovered evidences of nonlinear PPP for central Asian countries and Papua New Guinea by employing the rank tests due to Breitung (2001).

In this regard, to formally examine the existence of nonlinear PPP in the six selected low-income African countries, this current study revisits the long-run validity of PPP hypothesis for these countries by using the rank tests. The Breitung (2001) rank tests are not only capable in the detection of conintegration, but can further distinguish linear from nonlinear relationship if cointegration exists. Moreover, the rank tests are based on the rank transformation of the data series and do not require any functional forms to be specified in advance. Importantly, the rank tests are known to be robust to outliers. However, Liew *et al*. (2012) also warned against a blind application of the rank tests to economic data series that show certain behaviours which cause the tests to seriously lack power. This phenomenon is known as rank problem and this study also address this issue in later part.

The remainder of this paper is organized as follows. Section 2 describes the data and methodology and Section 3 presents the main findings. Finally, Section 4 presents the conclusions reached by this study.

2. Data and Methodology

A sample of six low income African countries is considered in this study, where four of them are from the East African (Burundi, Kenya, Rwanda and Uganda) and the remaining two are from the Southern African (Madagascar and Malawi). The annual data sets of prices and official exchange rates for all stated countries are taken from International Financial Statistics, International Monetary Fund (IFS, IMF) over the period from year 1981 to 2012.

In this case, the consumer price index (CPI) is chosen as price level. The nominal exchange rates (E) is calculated as home country's price level (P) per foreign price level (P^*), which is

$E = P/P*$. As driven by data availability in the IFS database, United States economy variables are considered as a proxy for the world economy.

Unit Root Test

The properties of the individual series are established before conducting the cointegration test. The Kwiatkowshi-Phillips-Schmidt-Shin (KPSS) unit root test and Breitung nonparametric unit root test are utilized to determine the stationarity of the series.

(a) KPSS Unit Root Test

The KPSS test assumes the series y_t to be (trend-) stationary under the null. The KPSS statistic is based on the residuals from the ordinary least square regression of y_t on the exogenous variables x_t:

$$y_t = x_t^{'}\delta + \varepsilon_t \qquad [1]$$

The LM statistic is defined as:

$$LM = \sum_t S(t)^2 /(T^2 f_0) \qquad [2]$$

where f_0 is an estimator of the residual spectrum at frequency zero and $S(t)$ is a cumulative residual function calculated as $S(t) = \sum_{r=1}^{t} \hat{\varepsilon}_t$ based on the residuals $\hat{\varepsilon}_t = Y_t - x_t^{'}\hat{\delta}(0)$. The critical values for the LM test statistic are provided in Kwiatkowski et al. (1992, Table 1).

(b) Breitung Nonparametric Unit Root Test

The Breitung nonparametric unit root test assumes the series y_t to be nonstationary under the null hypothesis. The Breitung nonparametric unit root test is expressed by the following variance ratio statistic equation:

$$T^{-1}\hat{\rho}_T = T^{-4}\sum_{t=1}^{T}\hat{U}_t^2 / T^{-2}\sum_{t=1}^{T}\hat{u}_t^2 \qquad [3]$$

where $\hat{U}_t = \hat{u}_1 + \ldots + \hat{u}_t$ and $\hat{u}_t = y_t - \hat{\delta}^{'} z_t$ are the ordinary least square residuals from the regression of the series y_t on (i) $z_t = 0$, so $\hat{u}_t = y_t$, with no deterministic term; (ii) $z_t = 1$ with an intercept; or (iii) $z_t = (1,t)'$, with an intercept and linear trend, respectively. The critical values for the test statistic are provided in Breitung (2002, Table 5).

Rank Test for Nonlinear Cointegration

The Breitung nonlinear cointegration test involves two steps, namely the rank test for cointegration and the score test for neglected nonlinearity. The rank test is first used to test the cointegration with the null hypothesis of no cointegration against the alternative of cointegration of either linear or nonlinear form. The rank test is based on the measurement of the distance between the ranked series and two distance measures as proposed by Breitung (2001):

$$\kappa_T^* = T^{-1} \max_t | d_t | / \hat{\sigma}_{\Delta d} \text{ and} \qquad [4]$$

$$\xi_T^* = T^{-3}\sum_{t=1}^{T} d_t^2 / \hat{\sigma}_{\Delta d}^2 \qquad [5]$$

where $d_t = R_T(y_t) - R_T(x_t)$, for $R_T(y_t) =$ Rank [of y_t among $y_1, \ldots, y_t$] and $R_T(x_t) =$ Rank [of x_t among $x_1, \ldots, x_t$], $\max_t |d_t|$ is the maximum value of $|d_t|$ over $t = 1, 2, \ldots, T$ and $\sigma^2_{\Delta d} = T^{-2}\sum_{t=2}^{T}(d_t - d_{t-1})^2$ serves to adjust for possible correlation between the two series of interest. The rank test can be employed for two or more than two variables with the following multivariate statistic:

$$\Xi^*_T[k] = T^{-3}\sum_{t=1}^{T}(\tilde{u}_t^R)^2 / \hat{\sigma}^2_{\Delta\hat{u}} \qquad [6]$$

where k is the number of dependent variables involved in the model. $\tilde{u}_t^R = R_T(y_t) - \sum_{j=1}^{k}\tilde{b}_j R_T(x_{jt})$ are the estimated residuals of the multiple regression of $R_T(y_t)$ on $R_T(x_{jt})$ while $\hat{\sigma}^2_{\Delta\tilde{u}} = T^{-2}\sum_{t=2}^{T}(\tilde{u}_t^R - \tilde{u}_{t-1}^R)^2$ serves to eliminate the possible correlation among the variables.

The basic idea of the rank test is the sequences of the ranked series tend to diverge when there is no cointegration relationship between variables. Else, the sequences of the ranks evolve similarly when there is cointegration relationship between variables, due to the variables move closely together over time and do not drift too far apart. Therefore, Breitung rank test checks whether the ranked series move together over time towards a long-run cointegrating equilibrium which may be linear or nonlinear. The critical values for the rank test are provided in Breitung (2001, Table 1). The null hypothesis of no cointegration between y_t and x_t is rejected if these tests statistics are below their respective critical values.

The score test is then used to test the nonlinearity of the cointegration with the null hypothesis of linear cointegration against the alternative hypothesis of nonlinear cointegration. To determine the nonlinearity of a cointegrating relation, the following two regressions are run consecutively:

$$y_t = \alpha_0 + \sum_{i=1}^{p}\alpha_{1j}y_{t-i} + \sum_{j=1}^{k}\alpha_{2j}x_{jt} + \sum_{j=1}^{k}\sum_{i=-p}^{p}\alpha_{3ij}\Delta x_{jt-i} + \tilde{u}_t \qquad [7]$$

$$\tilde{u}_t = \beta_0 + \sum_{i=1}^{p}\beta_{1j}y_{t-i} + \sum_{j=1}^{k}\beta_{2j}x_{jt} + \sum_{i=1}^{k}\sum_{i=-p}^{p}\beta_{3ij}\Delta x_{jt-i} + \sum_{j=1}^{k}\theta_j R_T(x_{jt}) + \tilde{v}_t \qquad [8]$$

From Equation [8], $\beta_0 + \sum_{i=1}^{p}\beta_{1i}y_{t-i} + \sum_{j=1}^{k}\beta_{2j}x_{jt} + \sum_{i=1}^{k}\sum_{i=-p}^{p}\beta_{3ij}\Delta x_{jt-i}$ is the linear part of the relationship and it involves again the ranked series $R_T(x_{jt})$. Under the null hypothesis, it is assumed that the coefficients for the ranked series are equal to zero, $\theta_j = 0$, as a evidence that the cointegration is in linear form. The Akaike Information Criterion (AIC) is used to select the appropriate value of p. The score statistic, $T \cdot R^2$, is distributed asymptotically as a χ^2 distribution, where T is the number of observations and R^2 is the coefficient of determination of Equation [8]. A significant $T \cdot R^2$ indicates that θ_j are nonzero, which can be taken as evidence of nonlinearity in cointegration. The null hypothesis may be rejected in favor of the alternative hypothesis of nonlinear relationship if the test statistic value exceeds the χ^2 critical values with k degree of freedom.

3. Empirical Result

Table 1 summarizes the results of KPSS unit root test. For Kenya, Rwanda and Uganda, the test statistics indicated that exchange rate is stationary at level while relative price is stationary at first difference. For the other three countries, namely Burundi, Madagascar and Malawi, both the exchange rate and relative price are integrated of order one, I(1) process.

Table 1: KPSS Unit Root Test (Trend and intercept)

	Exchange Rate		Relative Price	
	Level	First Difference	Level	First Difference
Burundi	0.154 (13.3)**	0.071 (3.24)	1.030 (64.9)*	0.077 (1.02)
Kenya	0.117 (6.04)		0.711 (44.5)*	0.097 (1.78)
Madagascar	0.136 (5.15)***	0.041 (0.169)	0.228 (20)*	0.040 (1.07)
Malawi	0.154 (12.2)**	0.098 (1.45)	0.510 (31.6)*	0.062 (1.62)
Rwanda	0.107 (9.52)		0.167 (9.79)**	0.064 (1.16)
Uganda	0.118 (7.85)		0.404 (20.9)*	0.113 (3.9)

Notes: ***, **, * denote statistical significance at the 10%, 5%, 1% level, respectively. Terms in the parenthesis show the bandwidth chosen with the help of an automatic model selection criterion (Andrews Bartlett Kernel.).

Since KPSS unit root test results indicated that exchange rate and relative price are integrated to different order for a few countries, the stationary process is further affirmed with Breitung nonparametric unit root test. According to Breitung's (2002) Monte Carlo simulations, this nonparametric test has favorable small sample properties and it is suitable for a small sample study. Table 2 shows the results of Breitung's (2002) nonparametric unit root test. The test statistics indicated that both the exchange rate and relative price are stationary at first difference for all the six countries.

Table 2: Breitung Nonparametric Unit Root Test

	Exchange Rate		Relative Price	
	Level	First Difference	Level	First Difference
Burundi	0.0166	0.0031**	0.0204	0.0026**
Kenya	0.0128	0.0013*	0.0171	0.0038***
Madagascar	0.0093	0.0013*	0.0211	0.0014*
Malawi	0.0137	0.0031**	0.0238	0.0022**
Rwanda	0.0119	0.0042***	0.0107	0.0043***
Uganda	0.0057	0.0028**	0.0108	0.0107**

Notes: ***, **, * denote statistical significance at the 10%, 5%, 1% level, respectively. The null hypothesis of a unit root process is rejected if the test statistic falls below the respective critical values of 0.0021 (1%), 0.0034 (5%) and 0.0044 (10%).

Table 3 presents the results of the Breitung rank cointegration test. The bivariate test (ξ_T^*) and multivariate test ($\Xi_T^*[1]$) revealed that exchange rate and relative price are cointegrated in Burundi, Madagascar, Malawi and Uganda. The results of nonlinearity test are also shown in Table 3. Notice that the score test for nonlinearity is meaningful only in the cases where cointegration is detected. Therefore, the nonlinearity test is only applicable to the cases of

Burundi, Madagascar, Malawi and Uganda. The computed score statistics $T \cdot R^2$ showed that only Burundi exchange rate and relative price are cointegrated in nonlinear form at 5% significance level. Meanwhile, exchange rate and relative price for Madagascar, Malawi and Uganda are linearly cointegrated.

Table 3: Breitung Cointegration Test

	Rank Test for Cointegration			Score Test for Nonlinearity
	Bivariate		Multivariate	
	κ_T^*	ξ_T^*	$\Xi_T^*[1]$	
Burundi	0.3041*	0.0150**	0.0150**	5.1807** (2)
Kenya	0.4880	0.0292	0.0290	
Madagascar	0.4454	0.0238	0.0238***	1.5716 (1)
Malawi	0.4472	0.0125*	0.0125*	0.7224 (2)
Rwanda	0.8218	0.0271	0.0290	
Uganda	0.4619	0.0222***	0.0221***	1.3559 (2)
Critical Values				
10%	0.3941	0.0232	0.0248	2.71
5%	0.3635	0.0188	0.0197	3.84
1%	0.3165	0.0130	0.0136	6.63

Notes: ***, **, * denote statistical significance at the 10%, 5%, 1% level, respectively. The null hypothesis of no cointegration is rejected when the test statistic is less than the critical values given in Table 1 of Breitung (2001). Terms in the parenthesis show the number of lags (p).

According to Liew *et al*. (2012), the application of the rank cointegration may causes bias if the economic variables evidence certain behavior. Breitung cointegration test only allows positive cointegrating coefficient and thus it is assumed that the series move together. This can be checked through the cointegrating regression of $y_t = \alpha + \beta x_t + \varepsilon_t$. If β as a cointegrating coefficient has a negative value, then the application of the rank tests could generate unreliable results. Thereby, to avoid the rank problem, the cointegrating coefficient of the regression is checked for each country and the results are shown in Table 4. Positive values are obtained for all cases, indicating the appropriateness of applying the rank cointegration in the data series.

Table 4: Cointegrating Coefficient of the Regression

	Burundi	Kenya	Madagascar	Malawi	Rwanda	Uganda
β	992.76*	44.21*	1586.42*	135.91*	484.45*	1679.47*

Note: * denotes statistical significance at 1% level.

4. Conclusions

Using the yearly data for the period of 1981 to 2012, this study empirically tested whether PPP holds among the six low-income African countries (Burundi, Kenya, Rwanda, Uganda, Madagascar and Malawi). Overall, this finding implies that PPP can be used to determine the equilibrium exchange rate for these four countries (Burundi, Madagascar, Malawi and Uganda). However, based on the advantage of Breitung (2001) rank tests, this study found that the nominal exchange rates and relative prices are nonlinear cointegrated in Burundi. This finding provided evidence that PPP may follow a nonlinear stochastic process due to frictions such as transportations costs prevailing in international trade. Besides, Breitung (2001) rank tests also found exchange rate and relative price for Madagascar, Malawi and Uganda are linearly cointegrated. Nevertheless, reaping unbounded gains from arbitrage in traded goods and services are not possible in these four countries.

5. References

Akinboade, O.A. and Makina, D. (2006) Purchasing power parity and real rand-dollar exchange rate. *Journal for Studies in Economics and Econometrics*, 30(3): 43-51.

Baharumshah, A.Z., Hamizah, S.M. and Soon, S.V. (2011) Purchasing Power Parity and Efficiency of Black Market Exchange Rate in African Countries. *Emerging Markets Finance and Trade*, 47(5): 52-70.

Bahmani-Oskooee, M. and Tankui, A. (2008) The Black Market Exchange Rate vs. the Official Rate in Testing PPP: Which Rate Fosters the Adjustment Process? *Economics Letters*, 99(1): 40-43.

Bahmani-Oskooee, M., Kutan, A.M. and Zhou, S. (2008) Do real exchange rates follow a non-linear mean-reverting process in developing countries? *Southern Economic Journal,* 74(4): 1049–1062.

Baliamoune-Lutz, M. (2010) Black and Official Exchange Rates in Morocco: An Analysis of their Long-Run Behaviour and Short-Run Dynamics (1974-1992). *Applied Economics*, 42(27): 3481-3490.

Baum, C.F., Barkoulas, J.T. and Caglayan, M. (2001) Non-linear adjustment to purchasing power parity in the post-Bretton Woods era. *Journal of International Money and Finance*, 20: 379-399.

Breitung, J. (2001) Rank tests for nonlinear cointegration. *Journal of Business and Economic Statistics*, 19: 331-340.

Breitung, J. (2002). Nonparametric tests for unit roots and cointegration. *Journal of Econometrics*, 108(2): 343 – 363.

Caporale, G.M. and Cerrato, M. (2008) Black Merket and Official Exchange Rates: Long-Run Equilibrium and Short-Run Dynamics. *Review of International Economics*, 16(3): 401-412.

Engle, R.F. and Granger, C.W.J. (1987) Co-integration and error-correction: representation, estimation and testing. *Econometrica,* 55: 1251–1276.

Hassanain, K. (2005) The Real Exchange Rate and the Black Market Exchange Rate in Developing Countries. *Empirical Economics*, 30(2): 483-492.

Holmes, M.J. (2000) Does purchasing power parity hold in African less developed countries? Evidence from a panel data unit root test. *Journal of African Economies*, 9(1): 63–78.

Johansen, S. (1988) Statistical analysis on cointegration vectors. *Journal of Economic Dynamics and Control*, 12: 231-254.

Johansen, S. (1991) Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models. *Econometrica*, 59: 1551-1581.

Juvenal, L. and Taylor, M.P. (2008) Threshold adjustment of deviations from the law of one price. *Studies in Nonlinear Dynamics and Econometrics*, 12, Article Number 8.

Kahn, B. and Parikh, A. (1998) Does purchasing power parity survive political shocks in South Africa? *Weltwirtschaftliches Archiv/Review of World Economics*, 134(1): 99-116.

Kargbo, J.M. (2003) Cointegration tests of purchasing power parity in Africa. *World Development,* 31(10): 1673–1685.

Krichene, N. (1998) Purchasing power parities in five east African countries: Burundi, Kenya, Rwanda, Tanzania and Uganda. IMF Working Paper No. WP/98/148, African Department, International Monetary Fund, Washington, DC, October.

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. *Journal of Econometrics,* 54: 159–178.

Liew, V.K.S., Lee, H.A. and Lim, K.P. (2009) Purchasing power parity in Asian economies: further evidence from rank tests for cointegration. *Applied Economics*, 16: 51-54.

Liew, V.K.S., Chia, R.C.J. and Ling, T.H. (2010) Long-run validity of purchasing power parity and rank tests for cointegration for Central Asian countries. *Applied Economics Letters*, 17: 1073-1077.

Liew, V.K.S., Ling, T.H., Chia, R.C.J. and Yoon, G. (2012) On the application of the rank tests for nonlinear cointegration to PPP: The case of Papua New Guinea. *Economic Modelling*, 29: 326-332.

McNown, R. and Wallace, M.S. (1989) National price levels, purchasing power parity, and cointegration: a test of four high inflation economies. *Journal of International Money and Finance*, 8(4): 533-545.

Odedokun, M.O. (2000) Fulfilment of purchasing power parity conditions in Africa: The differential role of CFA and non-CFA membership. *Journal of African Economies*, 9(2): 213-234.

Pesaran, H.M. and Shin, Y. (1999) An autoregressive distributed lad modeling approach to cointegration analysis. In: S. Storm, ed., *The Econometrics and Economic Theory in the 20th Century*. Cambridge: Cambridge University Press.

Phillips, P.C.B. and Hansen, B.E. (1990) Statistical inference in instrumental variable regression with *I*(1) processes. *Review of Economics Studies*, 57: 99-125.

Reitz, S. and Taylor, M.P. (2008) The coordination channel of foreign exchange intervention: A nonlinear microstructural analysis. *European Economic Review*, 52: 55-76.

Sarno, L., Chowdhury, I. and Taylor, M.P. (2004) Non-linear dynamics in deviations from the law of one price: a broad-based empirical study. *Journal of International Money and Finance*, 23: 1-25.

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

Taylor, M.P. (2006) Real exchange rates and purchasing power parity: mean reversion in economic thought. *Applied Financial Economics*, 16: 1-17.

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