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Does the Long-Run PPP Hypothesis Hold for Africa?: Evidence from Panel Co-Integration Study

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Abstract

This paper addresses whether parallel market exchange rates in Africa behave in the long run in a manner consistent with the purchasing power parity (PPP) hypothesis. A recent econometric method, the panel co-integration test, enables us to examine the long-run PPP hypothesis by pooling the time-series data of several countries. This approach is particularly useful when analyzing African countries, which often do not have long time series. Using pooled data for 16 African countries, the study concludes that the behavior of parallel market exchange rates in Africa is consistent with the long-run PPP hypothesis.

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Summary

This paper empirically examines the validity of the long-run purchasing power parity (PPP) relationship using data for 16 African countries. Although an increased number of empirical studies are available on PPP for Africa, they have concentrated on a limited number of countries that have long data samples and have maintained "more flexible" exchange rate regimes for a long time.

A distinctive feature of this analysis is its application of the panel co-integration technique to PPP using parallel exchange rates. The approach allows us to analyze countries that do not possess long data samples and frequently change exchange rate regimes; therefore, many countries in the paper have not been extensively studied before.

Our two main findings are as follows. First, using the panel technique our data set supports the "semi-strong" PPP, which imposes symmetry restrictions, for the 16 African countries. This result contrasts with our findings from the application of the multi-co-integration test to individual countries. Second, our panel study suggests that, although some countries have adopted more flexible exchange rate regimes, there seems to be a statistically significant discrepancy between the official and parallel exchange rates in those countries.

I. INTRODUCTION

This study tests for the consistency of the long-run purchasing power parity (PPP) hypothesis with the observed behavior of parallel market exchange rates for 16 African countries, using the panel co-integration method developed by Pedroni (1995). To test for long-run PPP is important for a number of reasons: many monetary models, *à la* Dornbusch (1976), hinge on the validity of long-run PPP theory, while many other macroeconomic models often use PPP to link domestic and foreign developments. Furthermore, although the PPP hypothesis may not be regarded as an explicit exchange rate theory, it may still serve to provide fundamental determinants that can be used to calculate the long-run exchange rates and assess the appropriate level of exchange rates when a long-run relationship exists.

Because of its popularity, the PPP hypothesis has been tested extensively using data from industrial countries, but few studies have been conducted using data from developing countries, and, in particular, from Africa. The empirical studies for individual developing countries include: McNown and Wallace (1989) who use the unit root and the residual based co-integration (Engle and Granger 1987) tests to analyze data of four high-inflation countries and obtain very weak empirical support for the long-run PPP hypothesis. Somewhat stronger supportive results are reported by Liu (1992) and Krichene (1998) who analyze the long-run PPP relationship by applying the multivariate co-integration method developed by Johansen (1988).

The ability to test for the consistency of the PPP hypothesis for individual countries in Africa has been hindered by the frequent changes in these countries' exchange rate arrangements, often resulting in long periods of fixed or adjustable official exchange rates. The same specification of the PPP hypothesis is not applicable to countries which adopt different exchange rate regimes. For instance, when the country imposes tight restrictions on exchange rate transactions, the PPP with exogenous exchange rates may be a more appropriate specification, while under the freely floating exchange rate regime, the PPP normalized on nominal exchange rates will be the one to consider (Liu 1992; and Moosa 1994). Moreover, few of the time series available in Africa are sufficiently long to generate statistically reliable results.

To sidestep the problem posed by frequent changes of exchange rate arrangements, this paper focuses on parallel market rates, which by definition are more likely to move freely with market forces than the official exchange rates. In order to overcome the second problem of short time-series, this study tests the long-run PPP hypothesis by pooling time-series data, following the methodology pioneered by Hakkio (1984) and Abuaf and Jorion (1990).[2]

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[2]In the case of industrial countries, several studies have dealt with the small-sample problem by increasing the sample period. For example, Lothian and Taylor (1994) examine both the U.S. dollar and the French franc against the pound sterling over almost two centuries, and showed that the null hypothesis of the unit root test can be rejected. However, data

(continued...)

Pooling the data not only increases the statistical power to accept or reject the null hypothesis without increasing the possibility of a structural shift but also helps us draw a general conclusion that applies to a broad group of countries. Although these studies do not examine PPP in the co-integration framework, in both papers the panel data provide somewhat stronger evidence in support of the PPP hypothesis than do the individual country studies.

The remainder of the paper is organized as follows: Section II discusses briefly the exchange rate regimes that African countries adopted over the period 1981-94, and Section III summarizes the PPP hypothesis. Section IV describes the econometric techniques that are used–in particular the unit root test developed by Im, Pesaran and Shin (1997) and the panel co-integration test developed by Pedroni (1995)–to test the time-series properties of the data and to examine the consistency of parallel market exchange rate trends with the long-run PPP hypothesis, respectively. Section V presents the empirical results, and Section VI summarizes our conclusions.

II. Exchange Rate Regimes for African Countries

Table 1 summarizes the exchange rate regimes over the period 1981-94 of the 16 African countries that will be examined in our study of PPP. It is clear that in Africa there are a wide variety of exchange rate arrangements. Furthermore, many countries have changed exchange rate regimes over time. However, one recent trend that can be observed in this table is the increase in the number of countries that have adopted a so-called more flexible exchange rate regime.

Broadly, the exchange rate regimes in Africa can be categorized into three groups. The first group comprises the countries that have adopted relatively flexible exchange rates; Nigeria and South Africa are examples, although Nigeria pegged its exchange rates against the U.S. dollar in 1994. These countries can be viewed as exceptional cases during our sample period as most countries did not allow such flexibility in their exchange rates for such a long time. However, the number of countries in this group has significantly increased since the end of the 1980s; in 1994, 10 countries out of the 16 listed in our table had relatively flexible exchange rate arrangements.

At the other extreme are the countries that have fixed their exchange rates against a single currency or a composite currency, such as the SDR, throughout our sample period. In Africa, the Communauté Financière Africaine (CFA) and Common Monetary Area (CMA) typify this exchange rate arrangement. The CFA consists of 13 countries that, with the exception of some realignments, have pegged their currencies to the French franc. The CFA can be divided into two currency groups: the Central African Currency Union and the West

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[2](...continued)
availability precludes such a route when analyzing African countries.

African Currency Union.[3] In neither group, are there exchange rate controls for transactions with France. The CMA was established in 1986 and now consists of four countries: Lesotho, Namibia, South Africa, and Swaziland, with the South African rand as the center of the system. In our study, Cameroon and South Africa are used as representatives of the CFA and CMA, respectively. In addition to these countries, some other African countries maintained fixed exchange rate arrangements during our sample period. For instance, Botswana and Zimbabwe pegged their currencies against the composite of weighted currencies of major trading partners.

Most countries in Table 1 fall into the third group: countries that have changed their exchange rate arrangements over the period under study. Notably, Sierra Leone and Zambia have shifted their exchange rate regimes more than five times in 14 years. We do not go into detailed explanations for such frequent changes in exchange rate regimes, but these changes may well make it difficult to conduct research using a standard time-series method.

III. PURCHASING POWER PARITY MODEL

The PPP hypothesis has been widely discussed and analyzed since it was first put forward by Cassel, and criticism of its validity has been intense on both theoretical and empirical grounds.[4] Yet its intuitive appeal and simplicity make the PPP hypothesis one of the most popular economic theories of all time. A strict interpretation of this concept is that, in the long run, exchange rate trends are determined predominantly by relative price developments at home and abroad. Using logarithmic form, a testable specification of the long-run PPP hypothesis can be expressed in a panel data context as

$$s_{it}=\alpha_i+\beta_i\, p_{it}+\beta^*_i\, p^*_{it}+\epsilon_{it}\,, \qquad (1)$$

where i represents the set of countries $1...N$, t represents the time period $1...T$, ϵ_{it} is the residual term, s_{it} is a vector of parallel market exchange rates, and domestic and foreign prices are denoted by p_{it} and p^*_{it}, respectively. The strict interpretation of long-run PPP requires the joint parameter restrictions: $\alpha_i = 0$, and homogeneity restriction, $\beta_i = 1$ and

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[3] The Central African Currency Union is made up of Cameroon, the Central African Republic, Chad, the People's Republic of Congo, Equatorial Guinea, and Gabon, and the West African Currency Union comprises Benin, Burkina Faso, Côte d'Ivoire, Mali, Niger, Senegal, and Togo

[4] Officer (1976) has reviewed the theoretical debate on the PPP hypothesis. Breuer (1994), MacDonald (1995), and Froot and Rogoff (1995) have surveyed the empirical evidence as to whether exchange rate behavior complies with the long-run PPP hypothesis.

$\beta^*_i = -1$. Clearly, specification (1) may not be directly relevant in Africa when the official exchange rates are used.[5] Some other conditions required for (1) to hold are discussed by Officer (1976), including the existence of nontrade barriers and nontransportation costs.[6]

The second method is to use the panel co-integration technique which does not require a priori parameter restrictions. This test may be more appropriate since the strict interpretation is not often supported by data from industrialized countries (MacDonald, 1995). Several arguments have been used to justify the failure to find support for the homogeneity restriction. Taylor (1988), for instance, argues that measurement errors and/or transportation costs cause a deviation from homogeneity. More recently, Bryan and Cecchetti (1993) have suggested that in the United States the price index may be biased upward because the weights are invariant over time while the true relative weights change; this causes the CPI-based inflation measure to be overstated by about 0.6 percent. Finally, the introduction of new goods into the price basket may also cause deviations from homogeneity, as these goods are not fully taken into account in the construction of the price index.

As a result, MacDonald and Marsh (1994) advocate a weak version of PPP that imposes no parameter restrictions (i.e., $\beta_{it} \neq 1$ and $\beta^*_{it} \neq -1$) in equation (1), and a semi-strong version that requires only a symmetry restriction on prices (i.e., $\beta_{it} = -\beta^*_{it}$). Although it may be plausible to analyze the weak form of PPP, the subsequent sections of our study focus on the semi-strong form, following the method developed by Pedroni (1995). The following specification will be examined:

$$s_{it} = \alpha_i + \gamma_i (p_{it} - p^*_{it}) + \epsilon_{it} , \qquad (2)$$

where all notations remain the same as before except γ, the parameter on prices.

IV. Econometric Methods

A. The Panel Unit Root Test

In addition to the standard Augmented Dickey-Fuller (ADF) test for time series for specific countries, the panel unit root tests developed by Im, Pesaran, and Shin (1997) will be employed to examine the order of integration of the time-series. The latter test was developed because the application of the ordinary least squares (OLS) to panel data results in consistent

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[5] Although it is not reported here, we have also used the specification consistent with Liu (1992) in our panel study (i.e., $p_{it} = \iota_{it} + \kappa_i (s_{it} + p^*_{it}) + u_{it}$, where ι_{it} and κ_{it} represent the constant and a parameter, respectively); our final conclusion remains valid regardless of whether the exchange rates or prices are endogenous variables.

[6] There is, however, no dearth of explanation for the real exchange rate (ϵ_{it}) to follow the unit root process. See for example Roll (1979) and Rogoff (1992).

and asymptotically normal, but biased estimates (Quah, 1994). The Im-Pesaran-Shin test is more flexible than its two predecessor panel tests for unit roots (Quah, 1994; and Levin and Lin, 1993). The Levin-Lin test is often regarded as a more general form than that of Quah (1994) since their test explicitly addresses the issue of heterogeneity across individuals, allowing a different order of serial correlation across individuals and different individual effects. However, the Levin-Lin test has some problems in controlling the cross-sectional dependence of the data. O'Connell (1998) has shown that the size and power property of the Levin-Lin test will be affected by correlation between variables. For instance, when exchange rates are denominated by the same currency, it is likely that there is high correlation among these rates. In this case, ignorance of this correlation leads to over-rejection of the null hypothesis of the unit root test. Therefore, the Im-Pesaran-Shin test, which also allows heterogeneity in the dynamic panels, is used here.

Im, Pesaran and Shin (1997) propose the use of two statistics, *LR-bar* and *t-bar* (or t_b), to test the null hypothesis of the unit root test. Their tests are based on the average of statistics obtained from individual tests. The *LR-bar* test can be obtained by using log-likelihood ratio statistics, while t_b is based on individual ADF statistics. Only t_b is used in this study since Monte Carlo experiments (Im, Pesaran and Shin, 1997) show that, in the absence of autocorrelation, this statistic performs slightly better than the *LR-bar* with finite samples, in particular, when N increases. The statistic, t_b, can be calculated as follows:

$$t_b = \frac{\sqrt{N}(t_{NT} - Et_T)}{\sqrt{Var(t_T)}}$$

where t_{NT} is the cross-sectional average of the t_{iT} statistics (i.e., $t_{NT}=1/N\sum_{i=1}^{N} t_{iT}$), which are the t-statistics used to evaluate the null hypothesis of the unit root in the standard individual ADF. The terms, Et_T and $VAR(t_T)$, are the finite common mean and variance of t_{iT} respectively under the null, and for $N \to \infty$, this test statistic (t_b) is distributed as standard normal under the null hypothesis. A slight modification of this statistic allows for autocorrelation in individual equations and shall be employed in our analysis (Im, Pesaran and Shin, 1997). The exact critical values for the finite sample are also presented in their paper based on their Monte Carlo simulation, and similarly the common mean and variance are obtained from 50,000 replications and are tabulated in Im, Pesaran and Shin (1997) according to the size of T and N. Therefore, this test also allows for heterogeneity across individuals. Their Monte Carlo simulation results show that t_b has considerably greater power than the Levin-Lin or individual unit root tests. The size property of this test is very accurate even for $N=5$ in the absence of autocorrelation; furthermore, they demonstrate that the Levin-Lin test tends to over-reject the null hypothesis as N increases.

B. The Panel Co-integration Test

The panel co-integration test used in this paper was developed by Pedroni (1995). In a bivariate context, Pedroni (1995) develops asymptotic and finite-sample properties of test

statistics to test the null hypothesis of non-co-integration in the panel. As in the Im-Pesaran-Shin test, he considers several types of specifications, including the homogeneous and heterogeneous models. The latter allow for different individual effects by introducing parameters that may vary across individuals. The nonstationary relationship in the panel introduces several difficulties, as one needs to take into account the off-diagonal terms in the long-run covariance of the residuals, as well as the issue of "spurious regression". Pedroni argues that spurious regression affects the asymptotic distributions in the panel, and that these effects are likely to be more severe in the heterogeneous model. For the homogeneous model, consistent long-run estimates can be obtained when N is large, even under the null hypothesis of non-co-integration; however, the same results cannot be obtained under the heterogeneous model. Convergent panel statistics can be transformed into nonconvergent ones owing to spurious effects in the heterogeneous model.

In order to cope with these problems, Pedroni proposes several tests, including the residual-based rho (ρ), parametric, and nonparametric stationarity tests. The second test resembles the standard, single-equation ADF test, and the third test is similar to those in Phillips and Perron (1988). Pedroni (1995), furthermore, considers the finite-sample properties of these tests using Monte Carlo experiments. While either homogeneous or heterogeneous panel models are possible, the heterogeneous model–such as equation (2), which would be consistent with this class of models if the parameters α and β were allowed to vary across countries–is employed in our analysis because there is no reason to believe that all parameters are the same across countries, as is assumed in the homogeneous model. For the heterogeneous model, Pedroni's test statistics are calculated as

$$\rho \text{ statistic } Z_{\rho}=\left(\sum_{i=1}^{N}\sum_{t=1}^{T} L_{11i}^{-2}\epsilon_{it-1}^{2}\right)^{-1}\sum_{i=1}^{N}\sum_{t=1}^{T} L_{11i}^{-2}(\epsilon_{it-1}\Delta\epsilon_{it}-\eta_{i})$$

$$\text{Parametric t statistic } Z_{t}=\left(\sigma^{*2}\sum_{i=1}^{N}\sum_{t=1}^{T} L_{11i}^{-2}\epsilon^{*2}_{it-1}\right)^{-1/2}\sum_{i=1}^{N}\sum_{t=1}^{T} L_{11i}^{-2}\epsilon^{*}_{it-1}\Delta\epsilon^{*}_{it}$$

$$\text{Nonparametric t statistic } Z_{pp}=\left(\sigma^{2}\sum_{i=1}^{N}\sum_{t=1}^{T} L_{11i}^{-2}\epsilon_{it-1}^{2}\right)^{-1/2}\sum_{i=1}^{N}\sum_{t=1}^{T} L_{11i}^{-2}(\epsilon_{it-1}\Delta\epsilon_{it}-\eta_{i})$$

where L_i is the ith component of the lower-triangular Cholesky decomposition of the long-run asymptotic covariance matrix, Ω_i, which can be obtained by using ϵ_{it}.[7] Therefore, L^{2}_{11i} can be also constructed using the off-diagonal elements of Ω_i ($L_{11i}=(\Omega_{11i}-\Omega^{2}_{21i}/\Omega_{22i})^{1/2}$). Since the off-diagonal of Ω_i is nonzero, it allows idiosyncratic feedback effects in the statistics. The term ϵ_{it} is the residual of equation (2) and is obtained from the nonparametric method, and ϵ^{*}_{it} the residual from the parametric model. Other terms are obtained as follows: σ^2 is a pooled, long-run variance for the nonparametric model ($\sigma^{2}=1/N\sum_{i=1}^{N} L_{11i}^{-2}\sigma_i^{2}$), and

[7]The appropriate lag length can be determined by the Newey-West method.

$\eta_i = 1/2(\sigma_i^2 - s_i^2)$. The term η_i is used to adjust for autocorrelation in parametric models, and σ_i^2 and s_i^2 are long-run and contemporaneous variances for individual, i which can, in turn, be obtained from v_{it}, where $\epsilon_{it} = \rho_i \epsilon_{it-1} + v_{it}$. Similarly, $\sigma*^2$ is the long-run variance for the parametric model and can be obtained as $\sigma*^2 = 1/N \sum_{i=1}^{N} s*_i^2$, and $s*_i$ is the individual contemporaneous variance obtained using the residuals of the parametric model.

Pedroni (1995) uses tests to examine the null hypothesis of non-co-integration against the alternative hypothesis of co-integration. The parametric and nonparametric t tests have the same asymptotic distribution, and a large negative value from the rho, the nonparametric and parametric stationarity tests suggests the rejection of the null. Pedroni (1995) tabulates the critical values for these statistics in the finite-sample case, and his Monte Carlo simulation suggests that the size distortion arising from his method is small as long as the moving-average coefficients are positive.

This panel co-integration technique is used in a number of areas in economics; Pedroni (1995) himself uses it to study the PPP hypothesis, examining the official exchange rates of 25 countries, most of which are middle-income or industrial countries.[8] His study provides evidence in support of the validity of the long-run PPP hypothesis. Canzoneri, Cumby, and Diba (1996) and Chinn (1996) have used panel co-integration tests to analyze the long-run relationship between the real exchange rate and productivity differentials in OECD countries. Pedroni (1997) also uses this technique to examine the long-term effects of human capital accumulation in the economic growth of developing countries.

V. EMPIRICAL RESULTS

Our study uses annual time series for the 16 African currencies listed in Table 1, and our sample period covers 1981-94. While we considered using higher frequency data to increase the number of observations, there is little to be gained by simply increasing the frequency of observations while maintaining the same time span (Shiller and Perron, 1985; Perron, 1989; DeJong and others, 1992; and Hakkio and Rush, 1991). The first three of these studies have examined the power of several unit root tests conducted with different data frequencies over fixed time spans. Hakkio and Rush (1991), meanwhile, have considered co-integration tests based on Monte Carlo simulations. The conclusions of all four studies are consistent: using different data frequencies in testing the long-term movements of the variable(s) has made little difference, as long as the time span of the data has been fixed.

Other variables include: parallel market exchange rates (end of period) which are expressed in terms of U.S. dollars and were obtained from the World Bank.[9] The consumer price indices (CPI) which are also based on the end of period, are from the *World Economic*

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[8]South Africa is the only African country included in his sample.

[9] Exceptions are the data of Mozambique in 1988 and 1990, which have been supplied by Banco de Moçambique.

Outlook database. These price series were chosen mainly because of their availability in African countries. The wholesale price index (WPI) may be a more appropriate approximation for prices when analyzing PPP but it is not readily available for most of the countries studied.[10] The average annual inflation of these 16 countries is 32 percent during our sample period, ranging from the lowest–Mauritius at 8 percent–to the highest–Uganda at 82 percent. Sierra Leone and Zambia have also experienced relatively higher inflation, at about 69 percent and 77 percent, respectively. Previous studies show that PPP may be a more relevant concept in higher-inflation countries, and thus the higher inflation rates in this region seem to promise support for the long-run PPP hypothesis. In Figure 1, the logs of the parallel exchange rates (s_t) and relative prices ($p_t - p_t^*$) are plotted for the 16 countries. As the data are raw, no inferences should be made as to whether the exchange rates were overvalued or undervalued during this period. However, a high correlation between these two variables is suggested, as well as a tendency for them to move in the same direction in the long run. One notable exception is Cameroon, whose currency did not respond to price movements from the mid-1980s to the early 1990s.

Our empirical results are summarized in Tables 2 and 3. Table 2 shows the results of individual and panel unit root tests aimed at establishing the order of integration of each variable. Engle and Granger (1987) argue the importance of understanding the order of integration of each time series before investigating the possibility of co-integration. In this study, ADF is implemented for the individual test; for the panel unit root test, the Im-Pesaran-Shin technique is used. The panel unit root is used to test the stationarity of a group of time series, such as exchange rates (s_t) and relative prices ($p_t - p_t^*$). Both individual and panel tests examine the null hypothesis of nonstationarity against the alternative of stationarity. More specifically, one of these tests, expressed as levels in Table 2, tests the null of I(1) against the alternative of stationarity, I(0); the other test, expressed as differences, tests the null of I(2) against the alternative of I(1). These tests also consider two combinations of the deterministic terms (constant, and constant and trend). The critical values for the individual ADF statistics have been obtained from MacKinnon (1991); the lag lengths are determined using the Schwarz information criterion and are presented in brackets in Table 2. Based on the individual unit root tests, many variables appear to be integrated at an order higher than one, since the null hypothesis in levels and differences cannot be rejected by the data. Our results suggest that 6 out of 16 exchange rates and 9 relative prices may be included in this group. However, these results may suffer from a finite-sample bias since T is only 14 for each individual series. We can draw a rather different conclusion from the panel unit root test, which examines the same hypotheses used in the individual unit root test. Under the panel test, the null hypothesis of I(2) can be rejected but the null of I(1) cannot be, implying that each group of variables is indeed I(1) (IPS (16) in Table 2). Furthermore, we have applied the panel unit root tests to a subset of five countries (The Gambia, Ghana, South

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[10] According to Officer (1976), Keynes (1930) claimed that using a WPI, which is heavily weighted by traded goods, is more likely to confirm the PPP hypothesis. The sensitivity of final results to the choice of the price index is reported by McNown and Wallace (1989), who fail to find a long-run relationship using the CPI but do find one when they employ the WPI.

Africa, Tanzania, and Uganda) whose time series, based on the individual ADF tests, seem to be I(1). However, under the panel unit root test, the results for the smaller group (IPS (5)) are the same as for the larger group. The different results obtained from the two different tests show the usefulness and the power of the panel tests, particularly, in the finite-sample context.

The co-integration results are summarized in Table 3. Here again, both individual and panel tests are conducted for purposes of comparison. The upper half of the table shows the results of applying the multivariate co-integration method (Johansen, 1988) to the individual PPP relationship. Johansen has proposed a method based on the maximum likelihood approach to ascertain the existence and number of long-run relationships in the system. In order to evaluate the number of such relationships, he proposes the use of two statistics, namely, maximal eigenvalue (*max*) and trace (*trace*) statistics. These tests are based on the restricted and unrestricted values of the maximized likelihood function; *Trace* can be used to examine the null of existence of "at most" r co-integrating vectors, and *Max* analyzes the null of existence of r co-integrating vectors.[11] Furthermore, in our study a small-sample correction is made to these statistics, as suggested by Reimers (1992).

Table 3 (top half) presents the number of lags used in our specification of the Johansen test, as well as the results. In this specification, we have applied the co-integration tests to the same five countries that are used in our unit root tests. Using the critical values tabulated in Osterwald-Lenum (1992), our results show that the long-run PPP hypothesis is invalid for all of the selected countries. The null hypothesis of non-co-integration cannot be rejected for any country.[12] The absence of a long-run relationship implies that the PPP concept is irrelevant, even in the long-run context, for all these countries. Our results are contrary to those of Krichene (1998) who studies the individual pairs of PPPs and confirms the existence of cointegration(s) among five East African countries in the long-run context. These different results seem to be mainly attributable to the fact that his study is based on a pair of African countries' exchange rates vis-à-vis the other African rates.

However, a more reliable result can be obtained in the panel context. The bottom half of Table 3 presents parameters for each country and results from our panel co-integration tests. Here, at most two lags are introduced to the testable specification. The results show that all statistics (the rho, parametric, and nonparametric t tests) are negative and large enough to reject the null using the data of the 16 countries. Therefore, our study provides evidence in favor of the semi-strong form of the long-run PPP hypothesis. Furthermore, we have conducted the same test using the five countries studied in our previous analysis. Our results remain unchanged and so confirm the previous results. Therefore, the semi-strong form of long-run PPP is empirically supported in the panel context regardless of a change in the composition of the country group.

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[11] See Hamilton (1994), for instance, for further details of the Johansen method.

[12] Note that the constant term is treated as unrestrictive in the vector autoregression (VAR).

Table 1. Exchange Rate Regimes of 16 African Countries (As of March 31)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Botswana	Other---													--->
Burundi	US$---			--->	SDR---								--->	Other--->
Cameroon	FF---													--->
Gambia, The	UKP---					--->	More flx---							--->
Ghana	More flx--->	Flx limit---				--->	US$--->		More flx---					--->
Kenya	SDR---							--->	Other---					---> More flx
Malawi	SDR---			--->	Other---									---> More flx
Mauritius	SDR---		--->	Other---										--->
Mozambique	Other---						--->	US$---		--->	More flx--->	Other--->	More flx---	--->
Nigeria	More flx---													---> US$
Sierra Leone	SDR---		--->	More flx--->	US$--->	SDR---		--->	More flx--->	US$---		--->	More flx---	--->
South Africa	More flx---													--->
Tanzania	Other---													---> More flx
Uganda	SDR--->	More flx---					--->	US$---		--->	Other---		---> More flx---	--->
Zambia	SDR---			--->	Other--->	More flx---		--->	US$--->	SDR---		--->	More flx---	--->
Zimbabwe	Other---													--->

Notes: The classification of exchange rate regimes is based on the IMF's Exchange Arrangements and Exchange Restrictions (1981-85) and International Financial Statistics (1986-94). FF stands for French franc, SDR for Special Drawing Rights, UKP for pound sterling, and US$ for U.S. dollar. The category "Other" is other currency composites to which the exchange rates of African countries are pegged. The "more flx" category is consistent with the "More flexible" exchange rate regime in the IMF classification while the "Flx limit" category corresponds to the "Flexibility limited in terms of a single currency or group of currencies".

Table 2. Unit Root Tests for 16 African Countries

	Individual Unit Root Tests							
	Parallel Exchange Rates (s)				Relative Prices ($p - p^*$)			
	Level		Difference		Level		Difference	
	Constant	Constant + trend	Constant	Constant + trend	Constant	Constant + trend	Constant	Constant + trend
Botswana	-1.180 [3]	-2.852 [3]	-2.564 [0]	-2.653 [0]	2.182 [0]	-0.736 [0]	-2.065 [1]	-4.198* [1]
Burundi	-0.493 [0]	-2.009 [0]	-2.784 [1]	-2.835 [1]	-0.272 [0]	-2.786 [0]	-3.512* [1]	-3.311 [1]
Cameroon	-1.194 [0]	-0.815 [0]	-0.846 [2]	-1.118 [2]	-2.074 [0]	-1.922 [0]	-1.630 [1]	-0.871 [1]
Gambia, The	-1.805 [0]	-2.248 [0]	-5.946* [0]	-6.480* [0]	-1.314 [0]	-0.845 [0]	-0.994 [3]	-4.445* [3]
Ghana	0.949 [1]	-3.047 [1]	-3.917* [1]	-3.591 [1]	-1.273 [0]	-2.698 [0]	-7.567* [1]	-6.245* [1]
Kenya	-0.932 [0]	-2.112 [0]	-3.156* [0]	-3.253 [0]	1.332 [0]	-0.565 [0]	0.539 [2]	-0.315 [2]
Malawi	1.805 [0]	-0.177 [0]	0.147 [2]	-0.943 [2]	1.592 [0]	-0.903 [0]	-2.584 [0]	-3.093 [0]
Mauritius	-2.070 [0]	-2.734 [0]	-3.003 [1]	-2.883 [1]	0.824 [0]	-0.809 [0]	-2.381 [1]	-2.821 [1]
Mozambique	-1.749 [0]	-1.892 [0]	-3.151* [0]	-3.247 [0]	0.126 [1]	-2.670 [1]	-2.941 [0]	-2.842 [0]
Nigeria	-0.736 [0]	-2.694 [0]	-1.219 [2]	-1.332 [2]	2.713 [0]	0.425 [0]	-1.074 [1]	-2.634 [1]
Sierra Leone	-1.189 [0]	-1.186 [0]	-4.535* [0]	-5.048* [0]	-1.642 [1]	-1.179 [1]	-1.739 [1]	-1.878 [1]
South Africa	-2.044 [1]	-2.573 [1]	-3.999* [1]	-2.772 [1]	-1.350 [1]	-1.627 [1]	-1.930 [2]	-4.847* [2]
Tanzania	-1.386 [0]	-1.873 [0]	-4.974* [0]	-5.358* [0]	-1.119 [2]	-2.242 [2]	-5.723* [0]	-5.777* [0]
Uganda	-2.764 [1]	-1.604 [1]	-1.717 [2]	-5.602* [2]	-3.403* [2]	-1.487 [2]	-1.218 [3]	-8.262* [3]
Zambia	-0.432 [0]	-2.988 [0]	-5.546* [0]	-5.372* [0]	-1.099 [1]	-2.169 [1]	-1.620 [0]	-0.709 [0]
Zimbabwe	-1.195 [0]	-2.689 [0]	-3.903* [1]	-3.878 [1]	-1.584 [0]	-0.419 [0]	-2.029 [0]	-2.307 [0]
	Panel Unit Root Tests							
IPS(16)	1.951	0.261	-6.900*	-5.771*	4.472	3.059	-3.694*	-5.414*
ISP(5)	0.220	-0.233	-5.905*	-6.042*	-0.515	0.732	-4.441*	-8.371*

Notes: The statistics that are significant at the 5 percent level are denoted with * and numbers with [ ] indicate the lag length. IPS(16) is the Im-Pesaran-Shin test applied to all 16 countries, and IPS(5) is the test applied to 5 countries (the Gambia, Ghana, South Africa, Tanzania, and Uganda). The null hypothesis of the unit root test indicated by "Level" is that the time-series are I(1) against the alternative hypothesis of stationary, and that denoted by "Difference" examines the null of I(2) against I(1).

Table 3. Co-integration Tests

Individual Test

	Null (max)		Null (trace)		
	r == 0	r <= 1	r == 0	r <= 1	Lags
Gambia, The	3.721	2.659	6.380	2.659	[3]
Ghana	7.439	0.001	7.441	0.001	[3]
South Africa	6.574	1.891	8.465	1.891	[3]
Tanzania	7.150	1.504	8.654	1.504	[1]
Uganda	13.93	1.329	15.26	1.329	[1]

Panel Test

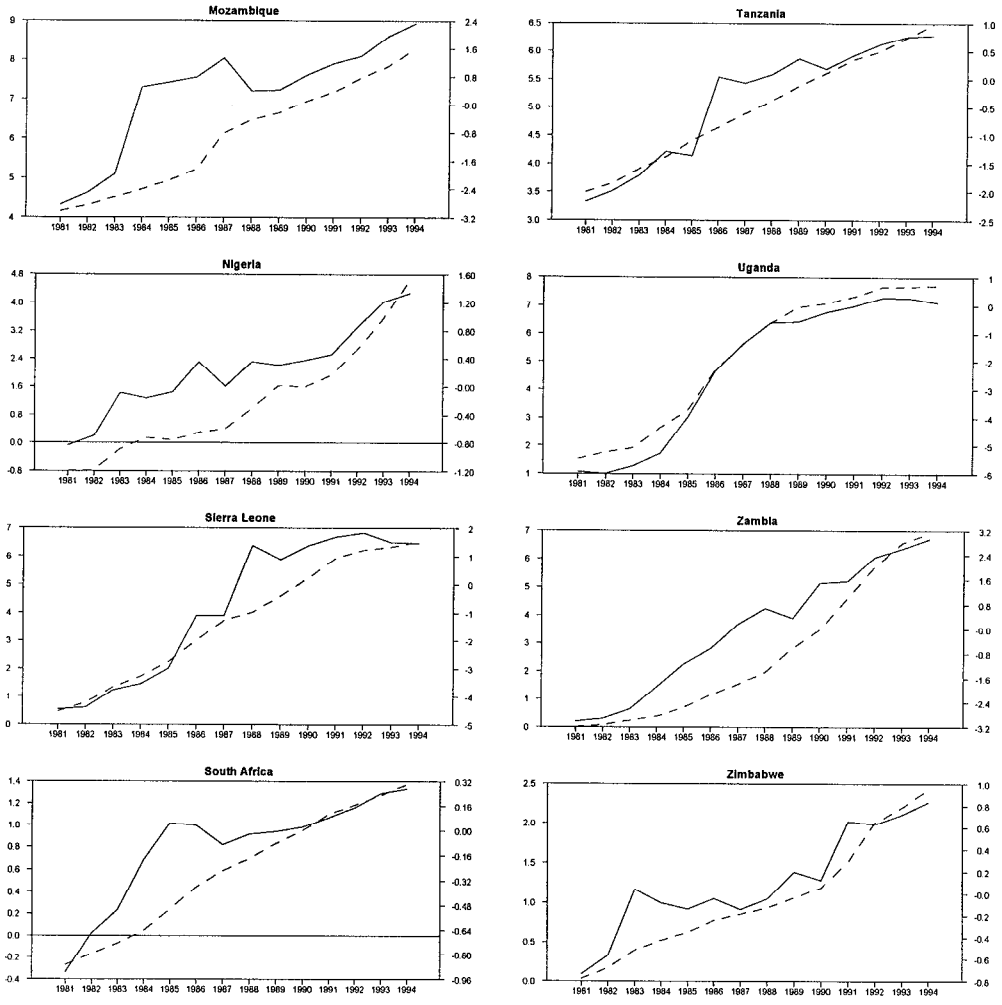
Parameters	α_i	γ_i		α_i	γ_i
Botswana	0.785	0.977	Mozambique	7.800	0.745
Burundi	5.414	2.591	Nigeria	2.406	1.469
Cameroon	5.822	0.130	Sierra Leone	5.635	1.127
Gambia, The	2.147	0.895	South Africa	1.071	1.071
Ghana	6.135	0.908	Tanzania	5.656	1.041
Kenya	3.268	1.173	Uganda	6.674	1.042
Malawi	1.395	0.984	Zambia	4.293	0.944
Mauritius	2.741	0.996	Zimbabwe	1.304	1.142

Number of Countries	16	5	7 (parallel)	7 (official)	7(parallel & official)
Z(rho)	-43.787*	-27.682*	-25.250 *	-18.748	-14.210
Z(t)	-14.511*	-8.373 *	-40.076 *	-7.993 *	-5.496
Z(pp)	-12.292*	-7.551 *	-12.746 *	-6.687	-4.777

Notes: The statistics that are significant at the 5 percent level are denoted with *. Maximal (max) and trace (trace) statistics are adjusted for a small sample following the method developed by Reimers (1992). Z(rho), Z(t), and Z(pp) are residual based rho, parametric, and nonparametric tests, respectively. The set of seven countries (using more flexible exchange rate regimes during 1989-94) comprises the Gambia, Ghana, Mozambique, Nigeria, Sierra Leone, South Africa, and Zambia. The panel test (7(parallel)) examines the relationship between parallel exchange rates and prices, 7(official) analyzes that between official exchange rates and prices, and 7(parallel & official) considers that between parallel and official exchange rates.

The critical values for 5 panel co-integration tests (16, 5, 7(parallel), 7(official) and 7(parallel & official)) are based on Pedroni (1995). The critical values, -31.89 (N = 20, T = 10) for the Z(rho) statistics and -11.43 (N = 20, T = 10) for Z(t) and Z(pp), are applied to our study with 16 countries, and -19.90 (N = 5, T = 10) for the Z(rho) and -6.90 (N = 5, T = 10) for the Z(t) and Z(pp) are used for the other 4 tests.

Figure 1. Parallel Market Exchange Rates and Consumer Price Differentials for 16 African Countries (concluded)



In addition, we have examined whether the recent shift to more flexible exchange rate regimes may bring official exchange rate movements closer to those of the economic fundamentals. Looking at only recent data (1989-94), we have constructed a panel of seven countries -- the Gambia, Ghana, Mozambique, Nigeria, Sierra Leone, South Africa, and Zambia -- that have used more flexible exchange rate regimes for a considerable portion of this sample period. Furthermore, the relationship of relative prices to both official and parallel exchange rates is examined for purposes of comparison. These results are also presented in Table 3; they suggest that the null hypothesis of non-co-integration can be rejected for parallel exchange rate PPP using all tests, which is consistent with our previous results. In contrast, we have found that only the parametric *t* test can reject the null hypothesis for the official exchange rate PPP. Because of the substantial reduction in the number of countries and observations, the final results should be interpreted with caution; nevertheless, this outcome seems to suggest that parallel exchange rates better reflect the economic fundamentals, in this case, price movements. Thus, the parallel rate movements may be worthwhile investigating for these countries even though the official exchange rates have become more flexible.

The significant difference between the official and parallel exchange rates is also implied by our results from testing the existence of the long-run relationship between the official and parallel exchange rates. The statistics of this test are presented under the title "7(parallel & official)" and the same 7 countries mentioned above are employed here. Three statistics, rho, t and pp, are used to evaluate the null hypothesis of non-co-integration. Our results show that there is no long-run relationship between the official and parallel exchange rates: all three tests fail to reject the null hypothesis. Therefore, this also raises some evidence that there is a significant discrepancy between these two types of exchange rates.

VI. CONCLUSION

This paper explores the validity of the PPP hypothesis using recent data from African countries. It avoids the potential problems of small samples by using panel data. Panel data co-integration tests seem to provide significantly more robust results than do individual country tests. Using individual-country data for 16 countries, we fail to obtain any empirical support for the existence of a long-run relationship between the exchange rates and prices. However, by using the more powerful panel co-integration test, the null hypothesis of non-co-integration is clearly rejected. Therefore, our results confirm the semi-strong form of long-run PPP in these 16 countries. It is also worth noting that our PPP model imposes a symmetry restriction, which is a stronger form of the PPP hypothesis than is tested for in some alternative models. In addition, the paper examines whether the recent shift toward more flexible exchange rate regimes has brought official exchange rate movements close to those of relative prices in the long run. The number of countries and observations available in our study is small, and therefore one needs to interpret the results cautiously; nevertheless, we have confirmed that there is a stronger long-run relationship in the parallel exchange rate-price relationship than in the official exchange rate-price relationship and that a significant long-run discrepancy exists between the official and parallel exchange rates. Finally, one extension of our study will be to incorporate other factors in the determination of nominal

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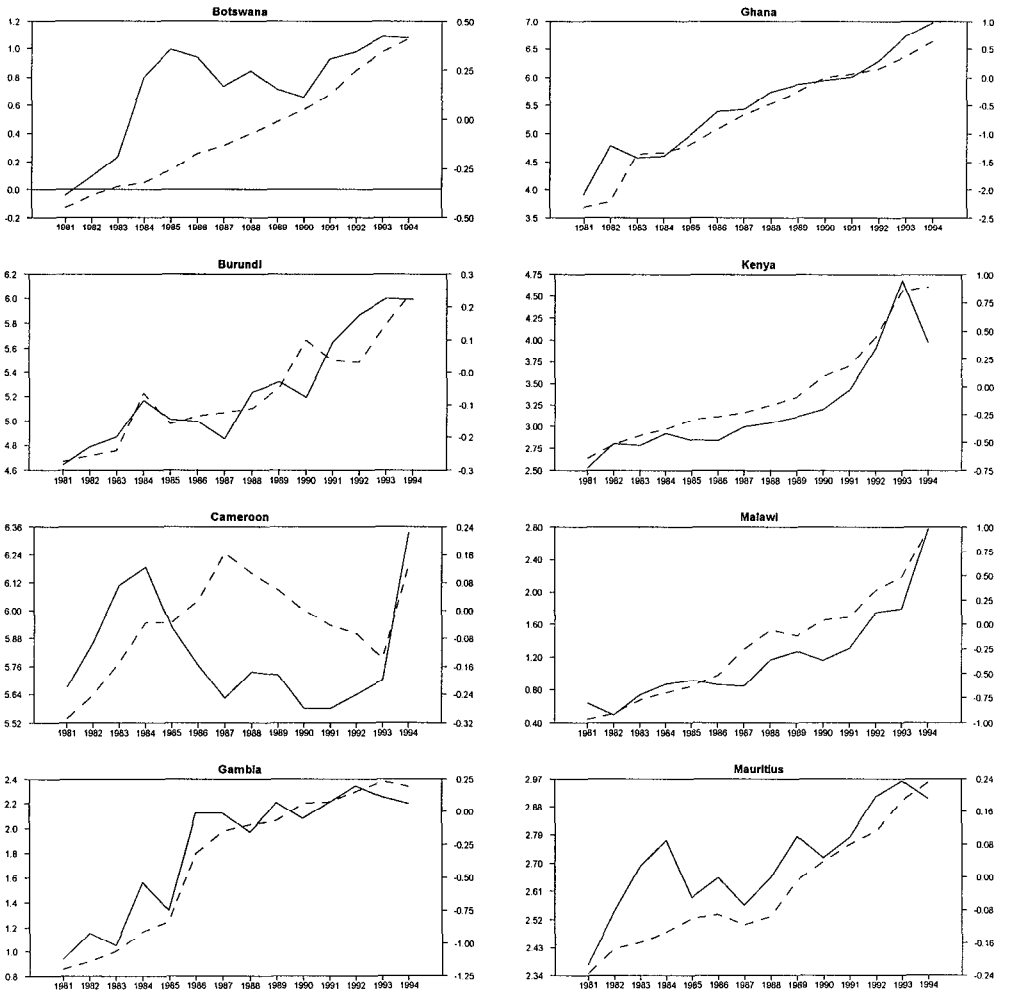
Figure 1. Parallel Market Exchange Rates and Consumer Price Differentials for 16 African Countries
___ Local Currency per U.S. Dollar (s_t) (left scale)
---- Consumer Price Differential ($p_t - p*_t$) (right scale)



Note: All our data are based on the end of period (December 31); however, when the price data is not availabe, the data of November is used.

exchange rates since individual African countries show no evidence of co-integration under the stronger form of the PPP hypothesis. Possible candidates include supply-side factors, such as productivity differentials (or the Balassa-Samuelson effect), oil prices, and terms of trade, while the demand-side factors could include government expenditures (deficits). These additional terms may help us understand better African exchange rate movements.

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