Purchasing Power Parity for African Countries: The Impact of the 2007-2008 “Great Recession”

Christian Nsiah

Abstract

We investigate both the weak and strong forms of PPP between 33 African countries, the United States, Euro area, South Africa, and Nigeria. The study applies panel unit root tests, panel cointegration tests, panel granger causality test and the panel fully modified OLS models to quarterly CPI and nominal exchange rate data for the period 1995Q1-2014Q4. We find great support for the weak form of PPP and a persistent bi-causal relationship between the nominal exchange rates and the respective price differences between the African countries and reference countries. Support for a strong form of PPP occurs, however, in the post-recession era for the U.S. dollar and the British pound. When we break the data into pre and post-recession, we find a unidirectional causality for the South African rand, pound, and euro in some cases.

Key Words: Purchasing Power Parity, Consumer Price Index, Panel Unit Root, Panel Cointegration Test, Panel Granger Causality, Elasticity, Panel Fully Modified Ordinary Least Squares (PFMOLS), Africa

JEL Classification: F31, F37

1. Introduction

The law of one price (LOP) states that all goods should sell for the same price at all locations. Otherwise, arbitrage opportunities lead to price convergence in all locations. LOP constitutes the theoretical backing for the no arbitrage condition and the theory of Purchasing Power Parity (PPP), which was first presented in its modern form in the seminal work of Gustav Cassel (1918). PPP can be defined by its weak and strong forms. The strong form of the PPP hypothesis dictates that there is a one-to-one relationship between the nominal exchange rate (NER) of two country’s currencies and their aggregate price ratios. One theory advanced

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by Froot and Rogoff (1995), and Pedroni (2001a, 2001b & 2004) argues that this long run relationship between the NER and the price ratios that give rise to a weak form of PPP may in fact be stationary, but not unitary. This relationship between the nominal exchange rate and aggregate price ratios may thus move together in equilibrium, but need not necessarily be equivalent. Causes of this phenomenon may include the presence of transportation costs, tariffs, differences in the consumer baskets used to calculate average prices, and other market distortions. All of these factors may contribute to a weaker form of PPP than predicted. The analysis of PPP is necessary, because it has important implications to international trade. If PPP remains strong, the differential in inflation rates between two countries will be completely offset by changes in the exchange rates. Additionally, if the countries in question are under free exchange rate regimes, a strong PPP will ultimately affect a country’s competitive positions in world markets. Dornbusch (1985) further indicates that while monetary shocks may cause temporary deviations from the PPP, once the economy settles after the monetary disturbance, the PPP will stabilize. He summarizes that this same phenomenon exists in cases of changes in relative real income, productivity, and/or financial innovation. The resulting trend changes in velocity impact the relationship between money supply and prices as well as causes trend deviations from PPP.

Even though the brief literature review in the next section will reveal some evidence for the possibility of disturbances impacting PPP, based on our knowledge, none of the existing studies on PPP for African countries have analyzed the impact of disturbances such as global recessions and other types of shocks on the PPP for African countries and their trading partners. Further, the literature review will show that all the previous studies only evaluate African country’s PPP from the perspective of African currencies relative to the U.S. dollar. Studies ignore the fact that African countries have other major trading partners, such as some European, Asian, and in some cases other African countries, whose currency relationship does not mimic that between the U.S. dollar and the African currencies in question. As such, in order to present a more accurate analysis of the PPP for African countries, it is important to incorporate structural disturbances and the currencies of other major trading partners in the African PPP discourse and establishing conversion ratios.

Another point of contention is that of causation between nominal exchange rates and prices. In most PPP analyses, the assumption is implicitly made that rates adjust to relative prices. In the case of African countries and many developing and emerging markets, long-term contracts are virtually nonexistent. It is important, therefore, to check for the direction of causality between relative prices and nominal exchange rates, where alternate relationships may exist and domestic prices may adjust to nominal exchange changes. As many central banks around the world are moving toward setting rigid inflation targets, this analysis is very essential to the development of policies related to price stability.

This paper seeks to analyze both the weak and strong forms of the PPP theory for 33 African countries for the period 1995-2014. Our study contributes to the existing literature on PPP for African countries on three fronts. First, in order to test for both the weak and strong forms of PPP and the direction of causality between the nominal exchange rates and the price ratios, we employ recently developed panel unit-root tests the Westerlund (2007) cointegration test, panel granger causality test, and panel fully modified OLS models. Second, the recent 2007-2008 “Great Recession” provides a perfect laboratory to analyze the impact of economic disturbances in international markets as well the monetary and fiscal policies that shape the evidence of PPP trends for African countries or shape PPP trends for African countries. Lastly, unlike previous studies that used only the U.S. dollar as the reference currency, we use five different currencies, the U.S. dollar, British pound, euro, Nigerian naira, and South African rand, as the reference currencies for setting conversion ratios. The rest
of this paper is organized as follows: section 2 presents a brief literature review, section 3 discusses the applicable PPP models, the empirical methodologies, and data employed by this study, section 4 presents the empirical results, and finally section 5 presents our conclusions.

2. Literature Review

Since the seminal work of Cassel (1981), the literature on PPP has grown tremendously. Two main statistical directions have emerged from this growth of PPP analyses, including unit root-based tests to investigate real exchange rate stationarity, and cointegration type tests. These tests can be further broken down into two different econometric structures of data (time series and panel data). These studies have resulted in a myriad of findings ranging from PPP holding strongly (Fleissig and Strauss, 2000; Wu and Wu, 2001; Narayan, 2005; Narayan and Prasad, 2005), somewhat holding (Frenkel, 1981; Narayan, 2008; Bahmani-Oskoe and Hegerty, 2009; and Dutt and Ghosh, 2013), to not holding at all (Kravis and Lipsey, 1978; and Narayan, 2007). However, for several reasons including data availability issues, only a few studies on PPP specifically focus on African countries. Like PPP studies elsewhere, some of the previous studies have employed bilateral time series approach between an African country’s currency and the U.S. dollar. A few newer studies, which benefit from modern advancements in panel data econometric analysis, incorporate panel data options.

The most current African studies using the time series approach include Oguanobi et al. (2010), Bakare and Olubokum (2011), and Caporale and Gil-Alana (2015). Oguanobi et al. (2010), test for the validity of PPP in Ghana through the use of ADF unit-root tests for the period between 1970 and 2005. Even though they find the exchange rate and inflation to be both stationary, they fail to conduct cointegration tests and conclude that the two variables exhibited a long-run relationship and, therefore, fits in the category PPP “somewhat holding.”

Bakare and Olubokum (2011), using OLS multiple regression techniques and data for Nigeria and the USA for the period 1986-2010, find that a long-run relationship exists between the U.S. dollar exchange rate and the relative prices for Nigeria and the USA. More recently, using daily, weekly, and monthly data from January 1990 to December 2008, Caporale and Gil-Alana (2015) test for the validity of the PPP hypothesis for the South African Rand and the U.S. dollar real exchange rate. They conclude that the real exchange rate is highly dependent on an order of integration very close to one, regardless of the data frequency employed. Further, their data indicates a structural break with the unit-root null being rejected in favor of $d > 1$ for the periods before the break, but not afterwards. Thus, although the degree of dependence is lower after the break, no evidence of mean reversion is found. It follows that PPP does not hold, since the effects of shocks to the real exchange rate last forever.

On the other hand, several economists use a panel approach and non-linear tests to study PPP in the context of African countries. A study by Mkenda (2001), employs data for 20 African countries vis-à-vis the U.S. dollar using a panel approach. Mkenda argues that PPP holds when using import-based multilateral indices and bilateral indices, but is rejected when using trade-weighted multilateral indices. In the same spirit, Nagayasu (2002) tested the long-run PPP hypothesis for 17 African countries using panel cointegration tests and found support for the weak form of the PPP hypothesis. Finally, Bahmani-Oskooee and Gelan (2006) employ a unit-root test that incorporates non-linearity and a mean reverting process of a time series variable to test PPP for 21 African countries. They confirm that PPP is validated in 11 out of 21 African countries.

More recent studies that use panel and non-linear analysis include Olayungbo (2011) and Liu and Su (2011). Olayungbo (2011) employs data for 16 sub-Saharan countries from 1980
to 2005 using standard unit-root tests as well as panel unit-root tests. They uncovered little evidence of the PPP hypothesis for the countries concerned for the period under consideration. Rather, out of the 16 countries under consideration, only two exhibited the existence of long-run PPP. Using a non-linear cointegration analysis, Liu and Su (2011) tested the PPP hypothesis for 20 African countries in relation to the U.S. dollar using monthly data covering 1980 to 2008. Although, robust evidence supported the validity of long-run PPP for the countries in question, the tests studied countries individually. In another study, Bahmani-Oskooee, Kones, and Chang (2014) points to a lack of African data, which leads to a delay or lack of new methodological advances in analyzing PPP in Africa. They employ quarterly panel data from 1971 to 2012 for 20 African countries to test PPP using Kapitanios-Shin-Snell unit root tests for the real exchange rates for the African countries studied and the U.S. dollar. Their empirical results indicate that PPP is validated in only three of twenty African countries.

From the above summary of existing literature on PPP for African countries, one can conclude that all the well-known African studies have only used the U.S. dollar as the reference currency. They ignore PPP with currencies of other trading partners. Further, these studies have not provided much analysis on the impact of economic disturbances. The one exception is a study by Baharumshaha et al. (2008), which tests for the impact of economic disturbances such as recessions or currency crisis on PPP. Another finding worth noting is that none of the existing studies specifically address the issue of causality. Underpinning most of the previous literature is the assumption that exchange rates adjust to prices. However, there is some evidence that identifies exchange rate depreciation as the source of inflation in domestic markets (Madesha et al., 2013; Mandizha, 2014; Lado, 2015), especially for developing countries without many long-term contracts in place. Therefore, there is a possible endogeneity problem, which has not been explored for African countries.

3. Purchasing Power Parity, Empirical Methodologies, and Data

3.1 PPP Model

According to the PPP theory, the exchange rate between two countries is in equilibrium when their purchasing power is the same in both countries. As presented in Equation 1 below, the absolute form of the PPP states that the nominal exchange rate is equal to the ratio of prices between two trading partners.

\[ S_t = \frac{P_t^A}{P_t^F} \]  

(1)

Here \( S_t \) denotes the nominal exchange rate defined in indirect terms as how many African country currency units (ACCU) are needed to buy one unit of the reference currency (for example US $). The \( P_t^A \) and \( P_t^F \) signifies the price levels in the African country and that of the reference country respectively. Equation 1 indicates that if the price level of an African country goes up relatively more than that of the reference country, it follows that the nominal exchange rate will depreciate (more ACCU’s will be needed to buy the reference currency). Taking the natural logs of both sides of the equation and adding a constant term, Equation 1 can be transformed into a log linear model as \( \ln S_t = \ln P_t^A - \ln P_t^F \), which can then be restated to arrive at the real exchange rate (henceforth known as RER) presented in equation 2.

\[ R_t = S_t - P_t^A + P_t^F \]  

(2)
where $R_t$ denotes real exchange rate. Therefore, we can state that the RER is equal to the nominal exchange rate minus home country price level plus the foreign country price level. We can empirically test for PPP by estimating Equation 3 below, which is another version of Equation 2,

$$S_t = \alpha + \beta(P_t^A - P_t^F) + \mu_t$$  

(3)

where $\alpha$ is a constant term denoting differences in units of measurement and $\mu_t$ is the error term. The absolute version of the PPP states that the RER presented in Equation 2 should equal one, indicating that the logarithm of RER should be equal to zero. The relative version of PPP states that while the RER is constant, it is not necessarily equal to one. The stationarity of the RER indicates that the nominal exchange rate and the relative price levels move together and is sufficient proof of the weak form of PPP. Further, from Equation 3, we can test if $\beta$ is positive and significant as a necessary condition for the weak form of the PPP. To validate the strong form of PPP, the real exchange rate should be stationary, plus the conditions of $\alpha = 0$ and $\beta = 1$ should hold.

In order to test for the weak form of PPP, we use the newly developed panel unit root and panel cointegration tests. The test for the strong form of PPP requires the best fitting model in order to check for the direction of causation and apply models that account for endogeneity, if necessary. Finally, we employ the panel fully modified OLS (PFMOLS) model to estimate the long-run elasticities of our model and test for the strong form of PPP.

### 3.2 Empirical Methodologies

#### Unit Root Tests

We follow Drine and Rault (2007), Olayungbo (2011), Cheng et al. (2008) and Robertson et al. (2014) in applying the recently developed panel unit-root tests to analyze the stationarity of our real exchange rate. While there are many types of panel unit-root tests presented by Stata (see xttunitroot command documentation), we chose to apply the Im-Pesaran-Shin (2003), henceforth known as IPS, and the Fisher-Type (Choi 2001) ADF unit root tests. These tests best fit our data, because they allow for both the unbalanced panel and the autoregressive parameter to be panel-specific. The other tests assume all panels share the same autoregressive parameter. Panel unit-root tests have been widely used in recent times to examine the stationarity of real exchange rates. For instance, Fleissig and Strauss (2000), Wu and Wu (2001), and Sarno and Taylor (2002) demonstrate that real exchange rates follow a stationary process. Using a panel unit-root test, Wu and Chen (1999) and Engel (1999) conclude that real exchange rates follow a unit-root process.

We thus apply the panel unit root tests (xtunitroot) presented by Stata, the general form of which can be written for our RER as presented in Equation 4.

$$R_{it} = \rho_i R_{i,t-1} + z_{it}' Y_t + \epsilon_{it}$$  

(4)

where $i$ and $t$ indexes our panels and time respectively and $R_r$ denotes the real exchange rate. Further, $z_{it}$ can denote panel specific means, time trend, or nothing, depending on the options defined. By default $z_{it} = 1$ so that the term $z_{it}' Y_t$ represents panel-specific means or fixed effects. Here, we test for null of $\rho_i = 0$ for all $i$'s, versus the alternate that $\rho_i < 1$. Note that depending
on the test method selected the alternate may hold for one $i$, a fraction of all $is'$, or all $is'$, which is the most restrictive.

**IPS Test**

The IPS test can be expressed as a set of Dickey-Fuller regressions presented below in Equation 5.

$$\Delta R_{it} = \phi_i R_{i,t-1} + \gamma_i Y_t + \epsilon_{it}$$

IPS assumes that the error term is independently distributed normal for all $is'$ and $ts'$ and $\epsilon_{it}$ has heterogeneous variances across panels. In our model, we allow for serially correlated error terms, and we use the AIC method to choose the number of lags. We follow LLC (2002) and remove cross-sectional averages from the data to help control for this type of correlation in the calculation of our W-t-bar test statistics for IPS unit root. The null hypothesis for our IPS test is that all panels contain a unit root ($\phi_i = 0$), against the alternative and that at least a fraction of the panels follows a stationary process.

**Fisher-type Tests**

The IPS test described above links evidence of unit-root analysis from N cross-section units into one value. In a sense, the Fisher-type tests operationalize this process by employing meta-analysis, which combines the p-values from independent tests to create an overall unit-root test statistic, and, as proposed by Choi (2001), combines the four panel-specific unit-root tests. These tests include inverse chi-squared (P), inverse normal (Z), inverse-logit transformation ($L^*$) of p-values, and the modified inverse chi square-squared (Pm). Choi (2002) suggests that the inverse normal Z statistic offers the best trade-off between size and power and recommends its use in applications. We perform this test with lags and also remove the cross-sectional averages. The null hypothesis here is that all panels contain a unit root, whereas, the alternate hypothesis is that at least one panel is stationary.

**Cointegration Tests**

As a second step to check for long-run relationship between nominal exchange rate and relative prices, we follow Cheng et al. (2008) and employ the error-correction model for cointegration tests of panel data, as described by We sterlund (2007). Unlike models based on residual dynamics (such as Pedroni, 2004), this model proposes four new panel tests of the null hypothesis of no cointegration. These tests are based on the structural, rather than the dynamics, and, therefore, they do not impose common factor restrictions. Two of the tests are designed to test the alternative hypothesis that the panel is cointegrated as a whole group (panel tests), while the other two test the alternate hypothesis that there is at least one individual member of the panel that is cointegrated (group tests). In a nutshell, if the null hypothesis of no error correction is rejected, then the null hypothesis of no cointegration is also rejected. We note here that the error-correction tests assume the following data-generating process:

$$\Delta S_{it} = \delta_i d_t 1 1 \alpha_i (S_{i,t-1} \beta' x_{i,t-1}) + \Sigma \gamma_{it} A x_{i,t-j} + \epsilon_{it}$$

where $t = 1, \ldots, T$ and $i = 1, \ldots, N$ denotes the time-series and cross-sectional units respectively; $d_t$ contains the deterministic components for which there are three possible cases
that can occur including: (1) $d_t = 0$. Thus, equation (1) has no deterministic terms, (2) $d_t = 1$, thus, $\Delta S_t$ is generated with a constant, and (3) $d_t = (1,t)$, thus, is generated with both a constant and a trend. Note that $S_t$ and $X_t$ denotes the nominal exchange rate and the relative price differences respectively.

Equation 6 can be rewritten as an error correction process as follows:

$$\Delta S_{it} = \delta_d l_t 1 \alpha_i l_i \lambda r_i l_{i-1} + \sum_{j=1}^{p_i} \alpha_{ij} l_i r_{i-j} + \sum_{j=1}^{p_{i-1}} \gamma_{ij} l_i X_{i-j} + \varepsilon_{it}$$

(7)

where $\lambda = -\alpha_{i} \beta_{i}$. The parameter $\alpha_{i}$ determines the speed at which the system $r_{i-j} - \beta_{i} l_i X_{i-1}$ corrects back to the equilibrium relationship after a sudden shock. If $\alpha_{i} < 0$, then the model is an error-correcting, implying that $S_t$ and $X_t$ are cointegrated. If $\alpha_{i} = 0$, then there is no error correction and, thus, no cointegration. We can, therefore, state the null hypothesis of no cointegration as $H_0: \alpha_{i} = 0$ for all $i$. The alternative hypothesis depends on what is being assumed about the homogeneity of $\alpha_{i}$. Westerland (2007) proposes four statistical tests including two group-mean tests and two panel-mean tests. The group-mean tests do not require the $\alpha_{i}$’s to be equal and as such allow one to test the null hypothesis against the alternative hypothesis of $H_g: \alpha_{i} \neq 0$ for at least one $i$. In the case of the panel-mean statistic, we test the null against the alternative hypothesis of $H_p: \alpha_{i} = \alpha = 0$ for all $i$. (see Persyn and Westerlund, 2008). The postulated relationship between our variables of interest allows for a linear time trend:

$$\ln(S_{it}) = u_i + \tau_i t + \beta_i \ln(X_{it}) + \varepsilon_{it}$$

(8)

We perform the cointegration tests using AIC to choose an optimal lag and lead lengths for each series and with the Bartlett kernel window width set according to $4*(T/100)^{2/9} \sim 3.8$. Since part of our interest lies in investigating the possible impact of possible structural break caused by the great recession, we present the cointegration test results for not only the overall sample and also for the pre and post 2007 recession periods. The results of these tests are presented in Table 4.

**Granger Causality Test**

While many of the previous PPP make the assumption of a uni-directional causal relationship running from the price ratio to the nominal exchange rate, as mentioned above, some previous literature indicates that causality can be bi-directional or uni-directional. Bi-directional causation supports the case for correcting for endogeneity or to use models that accounts for endogeneity in estimating long-run imports.

Love and Zicchino (2006) present a Stata program that estimates panel vector autoregressive regression (PVAR), which accounts for individual country heterogeneity. Their program alleviates the issue of biased coefficients when using standard mean-differencing simultaneously with fixed effects and dependent lags in the VAR. Following Arellano and Bover (1995), PVAR allows untransformed lagged regressors to be used as instruments, because the variables are forward mean differenced and the coefficients can be estimated by a system of generalized method of moments (GMM). The standard errors are drawn from a Monte Carlo simulation. Abrigo and Love (2015) expand the suite of routines for the original PVAR developed by

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2 We followed Newey and West (1994)
3 PVAR fits a multivariate panel regression of each dependent variable on lags of itself, lags of all other dependent variables and exogenous variables. The estimation is by generalized methods of moments (GMM).
Love and Zicchino (2006) to include sub-routines to help implement Granger causality tests and optimal moment and model selection, developed by Andrews and Lu (2001). We apply the PVAR routine with Granger causality post-estimation test options (pvargranger) to help us identify the direction of causality between price differences and the nominal exchange rate. The pvargranger performs Granger causality Wald tests for each equation of the underlying PVAR model. The result of this analysis is presented in Table 5.

Panel Fully Modified OLS Model

Having verified the long-run relationship between nominal exchange rate and relative price differences, we now turn to the estimation of the long-run elasticity of the price difference on nominal exchange rate using the Panel Fully Modified Ordinary Least Squares Method (PFMOLS). Once the PFMOLS model is estimated, we run a post-estimation test for the strong form of PPP. For example, if we were using Equation 2, we test $H_0: \beta = 1$. We employ an autoregressive distributive lag (ARDL) dynamic panel specification in the following form:

$$S_t = \sum_{j=1}^{p} \gamma_j S_{t-j} + \sum_{j=0}^{q} \delta_j x_{it-j} + \mu_i + \epsilon_{it} \tag{9}$$

where $S_{it}$, $i = 1,...,N$, $t = 1,...,T$, denotes the nominal exchange rate for the $i$th country in period $t$, respectively. $X_{it}$ is a $K \times 1$ vector of explanatory variables; $\mu_i$ and $\epsilon_{it}$ are scalars and a $K \times 1$ vector of coefficients. If the variables in equation (9) are I(1) and cointegrated, then the error term is an I(0) process for all of our groups $i$. An important feature of variables that are cointegrated is their responsiveness to deviations from the long-run state. This suggests an error-correcting model, where the short-run dynamics (shocks) of our variables will adjust to the long-run equilibrium, which are influenced by deviations from long-run equilibrium. This allows us to re-parameterize Equation 9 into an error correction model written as:

$$\Delta y_{it} = \phi_i (y_{it-1}(\theta, X_{it}) + \sum_{j=1}^{p} \gamma_j \Delta y_{it-1} + \sum_{j=0}^{q} \delta_j \Delta x_{it-j} + \mu_i + \epsilon_{it} \tag{10}$$

where denotes the error-correcting speed of adjustment term. If $\phi_i = 0$, then there is no evidence for a long-run relationship between the dependent variable and our regressors. The parameter is expected to be significantly negative under the previous assumption that the variables return to a long-run equilibrium. The vector is of particular importance because it contains the long-run relationships (elasticities) between nominal exchange rate and our explanatory variable (relative price difference).\(^4\)

The procedure described above has two key advantages over other commonly used estimators in the literature. Compared to the static fixed-effects estimator, the PFMOLS estimator allows for dynamics, while the static fixed-effects model does not. Another pertinent advantage is that the underlying auto-regressive distributed lag (ARDL) structure dispenses with the importance of the unit root pre-testing of the variables in question. As long as there is a unique vector which defines the long-run relationship among our variables of interest, it is of no consequence if the variables are either I(1), or I(0), since the model estimates of an ARDL specification will yield consistent estimates. Another point worth noting is that reverse causality is not a problem if the variables are I(1). In this case, there exists the superconsistent property. The command comes with 3 possible estimation procedure options including PMG, MG, and DFE options. Due to the make-up of our data and our computational power needed, we are only able to apply the DFE procedure. The DFE procedure estimates the dynamic fixed effects model where all parameters, except intercepts, are constrained to be equal across panels. The result of this analysis is presented in Table 6.

\(^4\) $\phi = -1 - \sum_{j=1}^{p} \gamma_j, \theta = \frac{\sum_{j=1}^{p} \delta_j}{(1-\sum_{j=1}^{p} \gamma_j)}, \phi_j = \sum_{j=1}^{p} \delta_j, j = 1,..., P - 1, and \delta_j = - \sum_{j=1}^{q} \gamma_j, j = 1,..., q - 1.$
3.3 Data

We employ quarterly data from Q1 1995 to Q4 2014 for 33 African countries in our analysis (see the appendix for the list of countries). We follow previous studies in using the consumer price index (CPI), which we get from the World Development Indicators (WDI) as our aggregate price measures. For our nominal exchange rate, which we define as how many Africa currencies units (ACU’s) one needs to obtain one foreign currency unit, we use the U.S. dollar exchange rate obtained from the WDI to also calculate the cross exchange rate between the ACU’s and the British pound, euro, South African rand, and the Nigerian naira.

Owing to the fact that WDI data are fraught with too many missing observations, we use panel multiple imputation techniques to fill in the missing observations, dropping from our analysis variables and countries with more than 15 percent missing observations for the period under consideration. The summary statistics of these data points are presented in Table 1 below. Please note that we also divide our data into two periods to account for the period before and after the initial occurrence of our recent past “Great Recession” of 2007.

4. Empirical Results

4.1 Unit Root Tests

The results of our IPS and Fisher type unit root tests are presented in tables 2 and 3 below respectively.

As mentioned in the description of the IPS tests, we estimated our model in both levels and first difference. The results presented in Table 2 indicate that our real exchange rates are
stationary both in levels and first difference at the 1% level of confidence for the whole sample and also for the periods before and after the recession.

Table 3 presents the estimation results for the Fisher-type unit root test. For the overall sample, we find that the real exchange rates under consideration are all stationary in levels and first difference apart from the euro real exchange rate which is only stationary in first difference. We find that most of this is driven by the fact that the euro RER is not stationary in levels for the pre-recession period. We find that while the RER is stationary in both levels and first difference for all the tests for the post-recession period, it is not the case for the pre-recessionary period. However, as mentioned earlier, Choi (2002) suggests that the inverse normal Z statistic offers the best trade-off between size and power and as such should be used in applications. In our case the Z statistic is significant in both levels and first difference for all of our RER’s in the pre-recession era, except for the case of the Euro RER which none of the four statistics is significant in levels, but significant in first difference.

These results present a very strong case for the stationarity of our real exchange rates, thus, providing compelling support for the sufficient condition for the weak form of PPP generally for the African countries under consideration, and also for the pre and post-recession periods respectively.

4.2 Cointegration Test Results

Table 4 presents our empirical results for the Westerlund (2007) error-correction model. As previously mentioned, if a model is adjudged to be error-correcting, it follows that the variables in the model are cointegrated and as such have a long-run relationship.

As the results show, all the four test statistics indicate rejection of the null hypothesis of no error-correction for the post-recession period in the case of the dollar, euro and the pound. This is not the case for the pre-recession period and the overall sample for the aforementioned currencies. We can thus conclude that while we find strong evidence for a long-run relationship between the nominal dollar, pound and euro exchange rates and the respective price differences for the post-recession period.-Weak mixed results further support a long-run relationship for the euro and the pound and no long-run relationship for the dollar in the pre-recession period as well as for the whole sample period. In the case of the South African Rand, we find strong
evidence of a long-run relationship with the price difference for the overall sample and for the pre-recession period, however, we obtained mixed results for the post-recession period. The Nigerian Naira exhibits mixed results for the whole sample as well as for both periods. We can conclude that albeit it not being the same for all currency and price difference combination, we, at a minimum, found a weak case of error-correction for all of our currency combinations for the overall sample and for the different time periods, except in the case of the U.S. dollar, which did not exhibit any long-run relationship across all four statistics in the pre-recession era.

### Table 3: Panel Unit Root Tests (Fisher-type ADF).

<table>
<thead>
<tr>
<th>Real Exchange Rate</th>
<th>Overall</th>
<th>Pre-Recession</th>
<th>Post-Recession</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Levels</td>
<td>Difference</td>
<td>Levels</td>
</tr>
<tr>
<td>USD</td>
<td>P</td>
<td>86.7733 **</td>
<td>716.9469 ***</td>
</tr>
<tr>
<td></td>
<td>Z</td>
<td>−2.0552 **</td>
<td>−22.9388 ***</td>
</tr>
<tr>
<td></td>
<td>L*</td>
<td>−2.0625 **</td>
<td>−34.4979 ***</td>
</tr>
<tr>
<td></td>
<td>Pm</td>
<td>1.8081 **</td>
<td>56.6577 ***</td>
</tr>
<tr>
<td>GBP</td>
<td>P</td>
<td>86.7578 **</td>
<td>717.0381 ***</td>
</tr>
<tr>
<td></td>
<td>Z</td>
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<td>−22.9402 ***</td>
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<tr>
<td></td>
<td>L*</td>
<td>−2.0612 **</td>
<td>−34.5023 ***</td>
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<td>56.6656 ***</td>
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<td>−22.9404 ***</td>
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<td>−22.9427 ***</td>
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<td>Z</td>
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<td>L*</td>
<td>0.7656</td>
<td>−45.9097 ***</td>
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<td></td>
<td>Pm</td>
<td>−0.7602</td>
<td>77.2784 ***</td>
</tr>
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Note: the models were ran in logs using the Fisher-type tests with Dicky Fuller, and demean options, with two lags. ***, **, and * denotes significance at the 1%, 5% and 10% levels respectively.
4.3 Panel Granger Causality Test Results

The previous section analyzed the long-run relationship between the nominal exchange rates and our price differentials from which we can conclude that there is some evidence of a long-run relationship between the nominal exchange rates and their related price differences. However, we were not able to determine the magnitude and/or the direction of this long-run relationship. In an attempt to discover the direction of causality between our infrastructure indices and economic growth, we employ the panel vector autoregression model (PV AR) with panel Granger causality option presented by Abrigo and Love (2015). The results of this analysis are presented in Table 5.

From Table 5, we can deduce that the nominal exchange and the price difference exhibit bi-causal relationship for the overall sample and for the pre and post-recession periods, except in the case of the ZAR, GBP, and the euro, which exhibit unidirectional causality. Here, the causal relationship runs from price difference to the nominal exchange rates for ZAR and GBP during the pre-recession periods respectively, whereas it runs from the nominal exchange rate to the price difference for the euro during the pre-recession era. These findings indicate that apart from a few cases, the price differences are most likely endogenous. Therefore, we should take into consideration the issue of endogeneity in deciding on our choice of models in estimating the long-run elasticities and subsequently checking for the strong form of PPP.
4.4 Panel Fully Modified OLS Model Estimation Results

Having established that the variables are stationary, exhibit long-run cointegration, and the direction of causality in the previous sub-sections, we now estimate the long-run impact of the infrastructure indices on the economic growth of African countries using the PFMOLS estimator. The choice of the PFMOLS over Ordinary Least Squares (OLS) estimators is based on the fact that it has the dual advantage of correcting for both serial correlation and potential endogeneity problems that arise when the OLS estimators are used. Remember that the PFMOLS provides three possible estimation procedures options including PMG, MG, and DFE, however, due to the nature of our data, and computational power we are only able to apply the DFE version. The results for the DFE estimation are presented in Table 6.

The negative and significant values of the parameter for all of our models indicate that there is a long-run relationship between nominal exchange rates and their related price difference. For the U.S. dollar and the British pound, we find that the price difference significantly positively impacts the nominal exchange rates for the overall sample and also for the post-recession era, whereas pre-recession period doesn’t exhibit a significant positive impact. We subsequently test for the strong PPP by testing the null that the price difference coefficient is equal to 1. Since we are only able to not reject the null for these two currencies in the post-recession era, we can conclude that for the dollar and the pound the strong form of PPP only holds after the recession. In the case of the euro, rand and the naira, we did not find any evidence of the strong form of PPP holding in any instance.
5. Conclusion

The economies of African countries are an important component of the global economy, however, these economies are the least studied due to a myriad of reasons. The purpose of this paper is to contribute to the existing literature on African economies by investigating the long-run weak and strong forms of purchasing power parity for African countries and three of their major trading counterparts (USA, Great Britain, and the Euro area) as well as two of

Table 6: Panel Fully Modified Ordinary Least Squares Model (PFMOLS).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Description</th>
<th>Overall</th>
<th>Pre- Recession</th>
<th>Post- Recession</th>
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<td>pdusa</td>
<td>Price difference vs. USA</td>
<td>0.4228 ***</td>
<td>0.2208</td>
<td>0.9596 ***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.1150)</td>
<td>(0.4355)</td>
<td>(0.1239)</td>
</tr>
<tr>
<td>Φ</td>
<td>Speed of Error-Correction</td>
<td>-0.0662 ***</td>
<td>-0.0643 **</td>
<td>-0.1981 ***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0185)</td>
<td>(0.0284)</td>
<td>(0.0525)</td>
</tr>
<tr>
<td>test pdsa = 1</td>
<td></td>
<td>25.2100 ***</td>
<td>3.2000</td>
<td>0.1100</td>
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<tr>
<td>pduk</td>
<td>Price difference vs. UK</td>
<td>0.3415 **</td>
<td>0.4124</td>
<td>1.1112 ***</td>
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<tr>
<td></td>
<td></td>
<td>(0.1713)</td>
<td>(0.3248)</td>
<td>(0.2030)</td>
</tr>
<tr>
<td>Φ</td>
<td>Speed of Error-Correction</td>
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<td>-0.0765 **</td>
<td>-0.2011 ***</td>
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<tr>
<td></td>
<td></td>
<td>(0.0203)</td>
<td>(0.0378)</td>
<td>(0.0446)</td>
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<tr>
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<td>3.2700</td>
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<td>0.4417 ***</td>
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<td></td>
<td></td>
<td>(0.1400)</td>
<td>(0.2034)</td>
<td>(0.1896)</td>
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<tr>
<td>Φ</td>
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<td>-0.1084 ***</td>
<td>-0.1391 ***</td>
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<tr>
<td></td>
<td></td>
<td>(0.0200)</td>
<td>(0.0349)</td>
<td>(0.0174)</td>
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<tr>
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<td>15.9000 ***</td>
<td>5.4600 **</td>
<td>9.0800 ***</td>
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<td>pdng</td>
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<td>0.3278 ***</td>
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<td></td>
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<td>(0.0815)</td>
<td>(0.0936)</td>
<td>(0.2630)</td>
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<tr>
<td>Φ</td>
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<td>-0.0727 ***</td>
<td>-0.0778 ***</td>
<td>-0.1067 **</td>
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<td></td>
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<td>(0.0086)</td>
<td>(0.0099)</td>
<td>(0.0502)</td>
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<tr>
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<td>65.1000 ***</td>
<td>51.5500 ***</td>
<td>20.9400 ***</td>
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<tr>
<td>pdeu</td>
<td>Price difference vs. Europe</td>
<td>-0.2626 *</td>
<td>-0.6449 ***</td>
<td>0.5915 ***</td>
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<td></td>
<td>(0.1593)</td>
<td>(0.1626)</td>
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<tr>
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<td>(0.0134)</td>
<td>(0.0410)</td>
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<tr>
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<td></td>
<td>2.7200 *</td>
<td>15.7200 ***</td>
<td>9.0400 ***</td>
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</table>

Note: *, **, *** denotes significance at the 1%, 5% and the 10% levels of confidence respectively. The numbers in parenthesis are the standard errors. The dependent variables are the nominal exchange rates.
Africa’s leading economies (Nigeria and South Africa). We first test for the stationarity of the real exchange rate between the African countries and the aforementioned countries. Second, we test for existence of a long-run relationship between the nominal exchange rate and the applicable price differences through cointegration analysis. Third, we analyze the direction of causality between the nominal exchange rates and their relative price differences. Finally, we use dynamic panel fully modified OLS model to estimate long-run elasticities and test for the strong form of the PPP. We also test for the impact of PPP in African economies during the 2007-2008 recession.

We find that the real exchange rate is largely stationary in both levels and difference in relation to price differences. This indicates that the real exchange rate is mean reverting, thus, satisfying the sufficient condition for the weak form of the PPP for all periods under consideration. Turning our attention to our analysis of the long-run relationship between the nominal exchange rates and the price differences, we find mixed results from the Westerlund (2007) error-correction model, with the dollar, euro and pound nominal exchange rate exhibiting long-run relationships mainly only after the recession, whereas the rand and naira largely exhibiting strong long-run relationship with their associated price difference prior to the recession. However, the long run relationship is confirmed in the PFMOLS model for all periods and all currency/price combinations by the strong confirmation of the error-correction process. From the PFMOLS model we are able to estimate long-run elasticities and the test for the strong form of the PPP. We find that the strong form of the PPP only holds for the dollar and the pound after the great recession.

The findings from the Westerlund error correction models and that of the PFMOLS models confirm a structural break in the long-run relationship between the nominal exchange rates and their associated price differences caused by the global impacts of the great recession. This could be due to the effects of the quantitative easing policy pursued by the Federal Reserve Bank, the decline in oil prices, fiscal policy, and/or even changes in trade patterns caused directly by the recession or indirectly through associated policies and their impacts. It is not surprising that the strong form of the PPP does not hold for the case of the rand and the naira. Even though many African countries may share borders, they may not trade much because of the lack of quality infrastructure to link them due to high transaction costs.

Another important finding with serious policy implications is the bi-directional causality between the relative prices of the African countries and their trading partners and their relative nominal exchange rates. As the central banks of many African countries, including Botswana, Ghana, Kenya, Malawi, Mozambique, Nigeria, South Africa, Uganda, and Zambia, adopt inflation targeting as their monetary policy tool, if their country’s price levels can be impacted by exchange rate changes, strictly adhering to their set targets may have unintended negative consequences. For example, the domestic economy may be stable, but depreciation of the domestic currency of these countries may lead to increases in the domestic prices in the case of bi-causal relationship between relative domestic prices and inflation. A hard set inflation target environment will force the central banks to pursue contractionary monetary policies, which will slow down the economy, when a contractionary policy may not have been warranted. This means that in the presence of a bi-causal relationship between domestic prices and nominal exchange rates, hard-set inflation targets may not be the best policy. Rather, a target with fundamental discretion may be the more prudent policy approach. Central banks aspiring to implement inflation targeting policies must also analyze the direction of causality of their currency’s value and their relative domestic prices before determining what type of inflation targeting to implement.
References


## Appendix

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