Purchasing Power Parity in Selected Sub-Saharan African Countries: Evidence from Panel Unit-Root Tests

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Abstract
This paper examined the validity of purchasing power parity (PPP) hypothesis and the degree of conformity to PPP in 16 selected sub-Saharan African countries for the period of 1980 to 2005 using a panel unit-root methodology. The conventional ADF unit-root was first carried to investigate the stationarity of the real exchange rate series. The univariate ADF unit-root test showed that real exchange rate series of all the selected sub-Saharan countries had unit root except for Ghana and Uganda with stationary exchange rate series. To have a robust conclusion, the panel unit-root test of both Im, Pesaran and Shin (IPS 2003) and Levin, Lin and Chu (LLC 2002) were explored to take power advantage of the extra information provided by the combination of the time-series and cross-sectional data. The panel unit-root estimation, however, failed to support evidence of PPP in the selected sub-Saharan African countries with the exclusion of Ghana and Uganda in the panel unit-root test. This paper, therefore, concludes that the degree of conformity to PPP is still relatively low in sub-Saharan African countries compared to other regions of the world.

Keywords: purchasing power parity, exchange rate series, panel unit-root test, sub-Saharan African countries.

INTRODUCTION
The purchasing power parity hypothesis (PPP) implies constant real exchange rates over time. PPP implies that the exchange rate has a mean-reverting behavior. It is achieved when a common basket of goods and services, denoted in a common currency, costs the same in all countries. For instance, if the Nigeria’s price level rises by 6% over a year while Ghanaian price level rises by 12%, then relative PPP suggests that the Nigerian naira will appreciate against the Ghanaian cedi by 6%. The naira appreciation against the Ghanaian cedi cancels the price differential.

Literature on this hypothesis is enormous. Most empirical works have used stationarity and co-integration techniques to test for the validity of PPP in OECD countries, Europe and Asian countries (see Cerrato and Serantis (2002), Taylor (2004), Lopez (2008), Chang and Song (2000) Kanas (2006) among others). However, the conclusions on the validity of PPP on empirical works have been mixed. Some studies which tested PPP using co integration techniques such as Corbae and Outliaris (1988), Taylor(1988), Kim (1990), Patel (1990), Layton and stark (1990), Ardeni and Lubian (1991), Telatar and Kazdagly (1998), Donganlar (1999) and Narayan (2007) have demonstrated that the long-run PPP does not hold. Kugler and Lenz (1993) and MacDonald (1993) however found evidence of PPP.


The concept of PPP is highly relevant for sub-Saharan countries given the move towards regional integration and the proposed African Union (AU). The ideal of PPP could be employed as a useful tool with which to select a common currency for a future currency union and for evaluating economic relationship among sub-Saharan African countries. The African Union (AU), which as a political African-wide body, is envisaged eventually having a common currency and central bank by 2025 (IMF, 2006). The degree of conformity to PPP would not only serve as a useful criterion for evaluating the economic relationship among sub-Saharan African countries but also to ascertain the possibility of the
investigated evidence of PPP for 16 sub-Saharan African countries. This paper, however, stated, most empirical works are on OECD countries, Europe and Asian countries. This paper, however, investigated evidence of PPP for 16 sub-Saharan African countries using panel unit-root test after the conventional univariate Augmented Dickey Fuller test. This paper is organized as follows. Section 1 deals with the introduction, section 2 contains the econometric model, section 3 discusses the data, and section 4 outlines the empirical results and discussions while section 5 concludes.

The Econometric Model

Under the purchasing power parity, the real exchange rate is the nominal exchange rates multiplied by the relative prices of trading countries. This is calculated as follows:

\[
RER = \text{NER} \times \frac{P^*_t}{P_t}
\]  

(1)

Where \(RER\) is the real exchange rate, \(\text{NER}\) is the nominal exchange rate, and \(P^*_t\) and \(P_t\) are the foreign and domestic prices respectively. In logarithmic form, equation (1) becomes:

\[
\text{LOG}(RER)_t = \text{LOG}(\text{NER})_t + \text{LOG}(P^*_t) - \text{LOG}(P_t)
\]

(2)

The model of mean reverting real exchange rate is therefore:

\[
\text{LOG}(RER)_t = \alpha + \beta \text{LOG}(RER)_{t-1} + \epsilon_t
\]

(3)

Where \(\alpha\), \(\beta\) and \(\epsilon\) are the constant term, coefficient and the error term respectively. PPP means that the real exchange rates are stationary. The stationarity of the exchange rate indicates that any percentage changes in the price level between two countries would be offset by an equal depreciation or appreciation of the nominal exchange rate. If there is a unit-root in the real exchange rate this implies that shocks to real exchange rate are permanent and PPP does not exist between two countries (Kalyoncu and Kalyoncu 2008).

In this paper, the stationarity of countries’ real exchange rate series was first tested using the univariate Augmented Dickey-Fuller (ADF) unit-root test. Thereafter, we used the power advantage of panel data unit-root test. The superiority of the panel unit-root test is the combination of time-series and cross-sectional information which improve the power of standard unit root test as highlighted by Madala and Wu (1999). This paper, therefore, employed, Im et al (2003 hereafter IPS) and Levin et al (2002 hereafter LLC) basically in this work for the following reasons. Firstly, both IPS (2003) and LLC (2002) tests require the time-series to be reasonably larger than the cross-section. The sample used in this study satisfies this requirement with \(N = 16\) and \(T = 25\). Pesaran and Smith (1995) assert that with large cross-section (\(N\)) the homogeneity of the parameters is rejected. Also, the IPS (2003) test proposed a cross-section demeaning approach called cross-sectionally augmented IPS (CIPS) that assumes homogeneous cross-section dependence than other recent panel tests suggested by Chang (2002) for details on this, see Pesaran (2003). Furthermore, the homogeneous characteristics of sub-Saharan countries in their economies, apart from being developing countries, makes the choice of these panel tests relevant for this study. Lastly, both tests are employed for robustness and conclusion of results.

Let us assume a group of \(N\) real exchange rates, \(RER_{it}\), which have this time-series representation:

\[
\Delta RER_{it} = \beta_1 RER_{it-1} + \sum_{l=1}^{N} \beta_l DARE_{it-l} + \epsilon_{it}, t = 1, \ldots, T
\]

(4)

Levin Lin and Chu (2002) test

The LLC test examines:

\[
H_0 : \beta_1 = \beta_2 = \ldots = \beta_N = 0
\]

Against

\[
H_1 : \beta_l < 0, \text{ for some } l
\]

Where the appropriate lag order \(w_{It}\) from equation (4) must be determined. The conventional t-statistics for testing \(\beta_1 = 0\) is:

\[
t_{\beta_1} = \frac{\beta_1 - \bar{\beta}}{\hat{\sigma}(\bar{\beta})}
\]

(5)

The IPS adjusted t-statistic is expressed as:

\[
t_{\beta_1} = \frac{\beta_1 - \bar{\beta}}{\hat{\sigma}(\bar{\beta})}
\]

(6)

Im, Pesaran and Shin (2003) test

The IPS test also examines:

\[
H_0 : \beta_1 = \beta_2 = \ldots = \beta_N = 0
\]

Against

\[
H_1 : \beta_l < 0, \text{ for some } l
\]

Where the appropriate lag order \(w_{It}\) from equation (4) must be determined. The LLC statistic is:

\[
\text{CIPS}(N, T) = \frac{1}{T} \sum_{t=1}^{T} \epsilon_t (N, T)
\]

where \(\epsilon_t (N, T)\) is the cross-sectionally augmented ADF statistics (CADF) for the \(t\)th cross-section. Pesaran (2003) and Im and Pesaran (2003) have shown that this test has no size distortions and is more robust to cross-section dependence than other recent panel tests. The standardized IPS t-bar statistics is given by:

\[
t = \frac{\sqrt{N} (\bar{e} - \bar{e}) \sum_{t=1}^{T} \epsilon_t (N, T) - u}{\sqrt{\sum_{t=1}^{T-1} \epsilon_t (N, T) VAR (\epsilon_t (N, T))}}
\]
The null hypothesis for both test is that each of the series in the panel contains a unit root.

The Data
The annual data were taken from the World Development Indicator, (WDI 2007) database. The data was from 1980 to 2005. The US dollar was used as the as the exchange rate for each countries. The real exchange rates are constructed defining relative prices as the ratio of each country’s CPI to US CPI. All the series were in logarithmic form. This work made use of 16 countries from sub-Sahara Africa. These countries are Burundi, Cameroun, Central Africa Republic, Congo, Cote d’Ivoire, Gabon, Gambia, Ghana, Lesotho, Mali, Nigeria, Sierra Leone, South Africa, Togo, Uganda, and Zambia. The result of the traditional Augmented Dickey Fuller (ADF) test is presented in Table 1

Table I: Univariate Augmented Dickey-Fuller test of the real exchange rate

<table>
<thead>
<tr>
<th>Country</th>
<th>ADF Intercept</th>
<th>ADF Trend and Intercept</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burundi</td>
<td>-0.4532 (0)</td>
<td>-2.5363 (0)</td>
</tr>
<tr>
<td>Cameroun</td>
<td>-1.2629 (1)</td>
<td>-2.1680 (1)</td>
</tr>
<tr>
<td>Central Africa Republic</td>
<td>-1.2950 (1)</td>
<td>-1.5948 (1)</td>
</tr>
<tr>
<td>Congo</td>
<td>-1.6247 (0)</td>
<td>-2.212 (0)</td>
</tr>
<tr>
<td>Cote d’Ivoire</td>
<td>-1.9515 (1)</td>
<td>-2.1402 (1)</td>
</tr>
<tr>
<td>Gabon</td>
<td>-0.7005 (1)</td>
<td>-1.7953 (1)</td>
</tr>
<tr>
<td>Gambia</td>
<td>-0.2920 (2)</td>
<td>-1.7953 (2)</td>
</tr>
<tr>
<td>Ghana</td>
<td>-3.9336 (1)</td>
<td>-3.1015 (1)</td>
</tr>
<tr>
<td>Lesotho</td>
<td>-1.7172 (0)</td>
<td>-1.5866 (0)</td>
</tr>
<tr>
<td>Mali</td>
<td>-0.9760 (1)</td>
<td>-3.9783 (2)</td>
</tr>
<tr>
<td>Nigeria</td>
<td>-1.4448 (0)</td>
<td>-1.4131 (0)</td>
</tr>
<tr>
<td>Sierra Leone</td>
<td>-1.2656 (1)</td>
<td>-2.3807 (1)</td>
</tr>
<tr>
<td>South Africa</td>
<td>-2.2615 (1)</td>
<td>-2.8368 (1)</td>
</tr>
<tr>
<td>Togo</td>
<td>-1.7357 (1)</td>
<td>-1.5762 (1)</td>
</tr>
<tr>
<td>Uganda</td>
<td>-4.0327 (0)</td>
<td>-3.5986 (0)</td>
</tr>
<tr>
<td>Zambia</td>
<td>-2.8778 (1)</td>
<td>-2.3742 (1)</td>
</tr>
</tbody>
</table>

The numbers in the parentheses are lags (k) and k was determined using Schwarz criterion. 1%, 5% and 10% critical values ADF intercept are -3.7343, -2.9907 and -2.6348 respectively, while the ADF trend and intercept for 1%, 5% and 10% critical values are -4.3942, -3.6118 and -3.2418 respectively.

EMPIRICAL RESULTS AND DISCUSSIONS
The analysis is started by carrying out the Augmented Dickey-Fuller (ADF) test, which is the classical unit-root test. The ADF test is based on the null hypothesis that the time-series has unit root. The unit-root with intercept was first performed, followed by the unit-root with trend and without trend. The inclusion of time trend is to account for the Balassa-Samuelson effect. The Balassa-Samuelson hypothesis postulates that as the process of economic growth unfolds the effect of relatively higher productivity growth in the tradable sector raises the price of the non-tradable to tradable sector within a country (Balassa, 1964). This, in turn, has implications for the real exchange rate across countries. Therefore, allowing for time trend takes care of this effect. The optimal lag lengths were chosen using Schwarz Information Criteria (BIC).

The result of the ADF in Table 1 indicates that the series for all the selected countries are non-stationary at 5% except for Ghana and Uganda for both trend and without trend. This result implies that the real exchange rate for the selected countries have unit root at the 5% level and except for Ghana and Uganda. This outcome suggests that ADF test does not support PPP for the selected sub-Saharan African countries within the study period. Hamilton (1994) affirms that univariate and single equation econometric methods for testing unit-roots can have low power test and can also give imprecise point estimates when working with small sample sizes. This limitation of the univariate ADF unit-root test motivated the use of the recently proposed panel unit-root tests of Im, Pesaran and Shin (IPS) and Levin, Lin and Chu (LLC) panel unit root test for both trend and without trend. The results of the panel tests are presented in Table 2 and 3.1 In the appendix.

The IPS and LLC panel unit-root results in table 2 and 3 indicate that real exchange rates series were stationary for all the selected countries, which is in support of the validity of PPP. In other to be certain of our conclusion, we excluded Ghana and Uganda whose real exchange rates were found to be stationary using the traditional ADF test as reported in Table 1. However, with the exclusion of these two countries, we found out that evidence of PPP no longer holds using panel unit-root test for both trend and without trend.

IMPLICATIONS AND CONCLUSION
This paper examined the validity or otherwise of PPP hypothesis for 16 sub-Saharan African countries for the period of 1980 to 2005. In this paper, I tested the stationarity of real exchange rates for the selected countries using the univariate ADF unit-root test. The ADF unit-root test showed that real exchange rate series of all the selected sub-Saharan countries had unit root except for Ghana and Uganda. I further applied the panel unit-root test of IPS (2003) and LLC (2002) to take advantage of the extra information provided by the combination of time-series and cross-sectional data and the power advantages of panel data unit-root tests. The outcome suggested that the real exchange rates among sub-Saharan African countries are stationary, which is in favor of validity of PPP. However with the exclusion of Ghana and Uganda’s real exchange series in the panel unit-root tests, the evidence of PPP vanished. This is an indication that the exchange rate series of

1 There are other Panel Unit root tests such as Chang (2002), (2004), Choi (2004) and Hadri (2000) which assume heterogeneous, dependent and larger cross-sections. These panel tests are not adopted in this paper due to inapplicability of their econometric and theoretical assumptions to our sample selection.
both Ghana and Uganda are strong and dominating. This implies that the degree of conformity to PPP is still relatively low in sub-Saharan Africa compared to other regions like Europe, OECD and Asia, and also, the idea of African Union (AU) and common currency may not be feasible now. However, the results need to be interpreted with care and caution due to the short annual data employed and the numbers of sub-Saharan countries included in the study.

REFERENCES


Sarno L., Taylor M.P. 2002. Purchasing power parity and the real exchange rate. IMF Staff


**APPENDIX**

<table>
<thead>
<tr>
<th>Method</th>
<th>IPS (Statistic)</th>
<th>IPS (Probability)</th>
<th>LLC (Statistic)</th>
<th>LLC (Probability)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All countries</td>
<td>-3.57599</td>
<td>0.0002</td>
<td>-4.72862</td>
<td>0.0000</td>
</tr>
<tr>
<td>All countries except Ghana and Uganda</td>
<td>0.26864</td>
<td>0.6059</td>
<td>-0.86370</td>
<td>0.1939</td>
</tr>
</tbody>
</table>

H0: each series contains unit-root.

<table>
<thead>
<tr>
<th>Method</th>
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<th>LLC (Statistic)</th>
<th>LLC (Probability)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All countries</td>
<td>-4.86279</td>
<td>0.0000</td>
<td>-5.89519</td>
<td>0.0000</td>
</tr>
<tr>
<td>All countries except Ghana and Uganda</td>
<td>0.33624</td>
<td>0.6317</td>
<td>-0.86370</td>
<td>0.6565</td>
</tr>
</tbody>
</table>

H0: each series contains unit-root.

2 Based on the evidence from OECD countries, Li (1999) draws a similar conclusion on the inappropriateness of the univariate unit root test for the PPP hypothesis due to low power problem. Exploiting both the time series and cross-section dimension through panel tests have been shown to overcome this problem (see Taylor 2004 for details)