



## **On the Validity of Purchasing Power Parity: Evidence from Energy Exporting Sub-Saharan Africa Countries**

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### **Abstract**

Substantial amount of studies have examined the validity of mean-reversion on the real exchange rate. However very limited studies of this nature have been conducted in Sub-Saharan Africa countries, particularly energy exporting countries, hence this study endeavors to find evidence for or against the mean-reversion of the real exchange rate. There is, however inadequate data required for the statistical significance for Sub-Saharan African currencies. Hence this study uses a panel of 5 energy exporting countries, i.e. South Africa, Mozambique, Congo Republic, Nigeria and Angola, to examine the validity of the purchasing power parity. Relying on the Im, Pesaran and Shin and the Fisher ADF proposed panel unit root tests the study fails to reject the null hypothesis of a unit root when small sample size is employed however by extending sample size and employing different price index, i.e. traded goods prices instead of GDP deflators the study reject the null hypothesis of a unit root and hence concludes the purchasing power parity holds in Sub-Saharan African energy exporting countries considered in the study.

**Keywords:** *Purchasing Power Parity, exchange rate, energy, unit root, Africa*

**JEL Classification:** F31

### **1. Introduction**

The term purchasing power parity (PPP, hereafter) was coined by a Swedish economist Gustav Cassel in 1918 (Kargbo, 2003). PPP hypothesis postulate that when rehabilitated to a single currency, goods should cost the same price in different nations and this could be loosely be referred to as the *law of one price* or rather an absolute purchasing power parity. The relative purchasing power parity holds that the rate of depreciation of one currency should be matched by the difference in the two countries general price inflation. The purchasing power parity received a number of criticisms after the World War I and was further criticised by Harbeler after the World War II, however it has remained pertinent (Balassa, 1964).

Such criticism has attracted interests in examining the validity of the PPP and researchers have had opposing views regarding the validity of the purchasing power parity. Taylor (2002) argues that the purchasing power parity has held for over 20 century, whereas Lopez et al. (2005) found weaker evidence using the data that was utilised by Taylor; however Lopez et al. employed different lag selection criteria. A

number of techniques have been put forward to scrutinise the validity of PPP and the most commonly used technique is unit root testing. A consensus that small sample size is the contributing factor towards the rejection of the purchasing power parity has emerged, (Meese and Rogoff 1983; Macdonald, 1996; Oh 1996 and Amano and van Norden, 1995). This consensus has thus led to endeavours to obtain a long sample size in order to evade false rejection of PPP. The one obvious attempt to obtain long sample though it is subject to some cons; is the use of panel dataset.

This paper therefore utilise the panel dataset for five Sub-Saharan Africa countries i.e. South Africa, Nigeria, Mozambique, Congo Republic and Angola containing 90 observations for the time period 1995-2013. Only energy exporting countries are being selected; however because of data unavailability some were dropped. The choice of Sub-Saharan Africa as an area of study is justified by several reasons. Firstly, the existing literature on PPP has focused on developed countries where data are easily available and thus neglecting emerging countries as an area of study. PPP hypothesis has proved to be more applicable for high inflation countries with low economic growth (Kargbo, 2006 and Arize et al. 2010) and thus this *inter alia* justifies the choice of Sub-Saharan Africa as an area of study. Chen and Rogoff (2003) and Chen *et al.* (2008) argued the value of a currency is more likely through terms of trade to be determined by the value of a commodity which contributes larger proportion of total exports. Frankel (2007) and Dauvin (2014) supported the argument by establishing that South African rand is a commodity currency i.e. its value is determined by prices of minerals and coal exports. African countries are well endowed with both mineral and energy resources, thus their case appear to be interesting, such that shock in energy or mineral prices is expected to deviates exchange rate from its equilibrium, and the effect may be permanent if purchasing power parity does not hold. Therefore proper analyse of the PPP are vitally important for policy makers so as to eschew future disequilibrium (Ghiba and Sadoveanu, 2012). The study applies two tests i.e. the test developed by Im *et al* (2003) and the Fischer Augmented Dickey fuller test to examine the validity of the purchasing power parity. Both the Fischer ADF and Im *et al* test suggests that when sample size is small and GDP deflators are used exchange rate contains a unit root therefore resulting to the rejection of the purchasing power parity hypothesis. Simply put, the rejection of the null hypothesis signals the failure of the purchasing power parity to hold. However, when traded goods prices and large sample size are used the null hypothesis of a unit root is rejected at all levels of significance above 5%. Hence consistent recent African studies PPP does hold for energy exporting countries included in the sample.

Section 2 briefly review the literature of the purchasing power parity, followed by section 3 which simple and concisely spells out the specification of the exchange rate and the data sources. Section 4 provides the results of the study and lastly section 5 provides concluding remarks and policy implications

## **2. Review of Related Studies**

In the absence of trade barriers, transportation costs, imperfect competition, etc. when expressed in a single currency tradable goods should cost the same price across countries, such that

$$P_{h,t} = E_t P_{f,t} \quad (1)$$

(Rogoff, 1996). Hence the exchange rate is determined by the relative price between two nations;

$$E_t = \frac{P_{h,t}}{P_{f,t}} \quad (2)$$

$E_t$  Denotes the nominal exchange rate between countries, at time period  $t$ , and  $P_{h,t}$  and  $P_{f,t}$  are domestic and foreign prices, respectively. However this kind of relationship i.e. the law of one prices have long been argued not to hold because of the above mentioned reasons and merely because in the short-run prices tend to be sticky and hence the law of one price is hindered in the short-run. A situation of no trade restrictions, perfect competition, etc. is hard to find in real world. Hence focus has shifted from testing the short-run PPP and the absolute version to long-run relationship and the relative version of PPP.

The PPP has been reduced to testing for unit root on the real exchange rate such that stationary real exchange rate implies that PPP parity does hold vice versa, and hence equation (2) can be re-arranged to yield:

$$RER_{it} = \frac{E_t P_{f,t}}{P_{h,t}} \quad (3)$$

$RER_{it}$ , represents real exchange rate for country  $i$  at time period,  $t$ . Equation (3) simply states that ceteris paribus an increase in domestic price level and an increase foreign price level depreciates and appreciates the real exchange rate, respectively and nominal exchange rate appreciation results to a real exchange rate appreciation.

Purchasing power parity is one of the most essential concepts in international economics and hence substantial amount of interest has been paid on to validating the concept. Unfortunately the results are mixed; some authors have found evidence of purchasing power whereas others have not, amongst others Roll (1979) and Cushman (2008) failed to find evidence for PPP whereas Kargbo (2006) and Taylor (2002) managed to provide evidence for purchasing power parity. There is growing consensus that failure to find evidence for PPP owes to the use of insufficient data and thus researchers have turned to using panel data as opposed to time series so that the power of the tests can be improved (see, Macdonald, 1996 and Frank and Rose, 1996).

Earlier studies which relied mostly on traditional time-series econometric techniques and data failed to find evidence supporting purchasing power parity. Amongst others, Roll (1979) found no evidence for PPP. The conclusion that PPP does not hold was also reached by Frenkel (1981, 1981). Darby (1981), Mishkin (1984) and Piggott and Sweeney (1985) also failed to find evidence for PPP. However, because the data which they used dated back to the periods to which exchange rate were not flexible

and economies were not as open as they are in nowadays, one would expect that PPP be hindered by the inflexibility of exchange rate and disintegration of economies.

It is for these reasons *inter alia* why recent studies shifted focus from traditional time-series to panel data and most of the recent literature using new panel econometric techniques have managed to find evidence for purchasing power parity (Chiu, 2002). Wu (1994) applied unit root testing approach to survey the validity of PPP and he strongly rejected the null hypothesis of a unit root on the real exchange rates and thus concluding that purchasing power parity does hold. Confirming that indeed traditional unit root testing technique have low power to reject the null hypothesis of a unit root on the real exchange rate; Wu (1996) employed both the traditional Dickey-Fuller and Phillips and Perron unit root test, he failed to reject the null hypothesis of a unit root. He concluded that, the failure to find evidence for PPP in earlier studies owes to the choice of econometric modelling i.e. traditional unit root test have low power to reject the false null hypothesis of a unit root. These assertions were supported by Wei and Parsley (1995), Macdonald (1995), Pappell (1995), Oh (1996), Lothian (1997), and Pedroni (2004).

Frank and Rose (1996) applied OLS to examine the validity of PPP and found that the coefficient on the real exchange rate is 0.97 which closer to 1 as stated in theory of PPP that exchange rate should be constant (i.e. equal to 1) for PPP to hold, however owing to construction of price indices one expect that the coefficient would not be necessarily be equal to 1, but should be closer to a unit. Therefore they concluded that PPP does hold and this was supported by a number of tests they conducted. The validity of PPP was further confirmed by Coakley and Fuertes (1997), in their study they found that indeed the long-run PPP parity does hold. Taylor (2002) argued that prices do not adjust linear thus deterring real exchange rate from adjusting linear; if non-linearity is not taken into account it could plague the results. Hence he applied nonlinear unit root test to examine the stationarity of the real exchange rate using data for over 20 centuries. Taylor (2002) strongly rejects the null hypothesis of a unit root and concludes that PPP has held for over 20 centuries. This therefore implies that indeed Gustav Cassel's (1918) postulations were correct, at some point prices does converge across nations. Consistent with Taylor (2002), Kim and Moh (2010) employed nonlinear unit root test to survey the nonstationarity on the real exchange rate using a sample of 16 countries. They found strong evidence against unit root in the real exchange rate for 14 out of 16 countries included in their sample. Kim and Moh (2010) concluded that PPP does hold; however nonlinearity is not accounted for, one may incorrectly reject the validity of PPP hypothesis. Using a battery of panel unit root tests Chiu (2002) found evidence for purchasing power parity and stressed the importance of taking intercountry dependence into account for more robust results. Accounting for structural breaks, Akinboade and Makina (2006) surveyed mean reversion of the South African real exchange rate, and found that exchange rates do revert to their mean hence PPP holds.

Arize *et al.* (2010) surveyed PPP for African countries using multivariate-error correction model; they found that PPP does hold for Africa countries. Similar conclusions were reached by Kargbo (2006) using black market exchange rate. Relying on Johansen cointegration approach and error correction model, he found that purchasing power parity does hold for African countries. He *et al.* (2013) used SPSM approach which is able to classify the panel into group of stationary and nonstationary series while taking structural break, nonlinearity and cross-sectional dependence into account. Consistent with recent panel evidence, they concluded that indeed PPP does

hold. Using Gregory and Hansen (1996) and Hatemi-j (2008) cointegration approaches which are able to take structural break into account; Dimitriou and Simos (2013) examined the strong and weak form of PPP between Japan and United States (JPY/USD). They found evidence for both the strong and the weak form of PPP; however strong form of PPP was rejected in period before subprime crisis. Chen and Wu (2000) re-surveyed PPP for Japan and Taiwan, allowing for nonlinear adjustment. They argued that failure for strong form to hold in the period before crisis owes to the incongruous use of monetary policy. Testing for linearity they rejected the linear framework in support of an exponential smooth transition autoregressive process (ESTAR). Chen and Wu concluded that previous studies have failed to find evidence for PPP merely because they failed to allow for nonlinear adjustment of PPP deviations.

Albeit evidence for PPP has grown in the literature and it has not gone un-criticized and undisputed. PPP is one of the longest surviving theory and one of the most researched. However, it has remained controversial and unsettled matter. Lopez *et al.* (2005) employed the nonlinear unit root test and the data that was used by Taylor (2002) to examine validity of PPP. Lopez *et al.* (2005) however changed the lag selection criteria and found unit root on the real exchange rate. Hence they concluded that PPP has never held and Taylor's findings are sensitive to lag selection criteria. Lopez *et al.* (2005) findings' were backed by Cushman (2008) who argued that PPP "has apparently not survived a passage of time" Cushman (2008:10). Cushman (2008) in a 3 country analysis (Germany, United States and Japan) applied Johansen cointegration approach to examine validity of PPP and failed to find evidence for PPP. Same conclusion was reached by Ghina (2012), examining PPP in Romania using Engle-Granger cointegration approach. Using 4 unit root tests Acaravci and Ozturk (2010), examined PPP in 8 transition countries namely, Bulgaria, Croatia, Czech Republic, Hungary, Macedonia (FYR), Poland, Romania and Slovakia Republic. ADF and KPSS unit root test reject stationarity for real exchange rates thus implying that PPP is invalid for these 8 transition countries. However when allowing for structural break using Lee and Strazicich (2004) proposed test they found that PPP holds for only two countries i.e. Romania and Bulgaria, but does not hold for the other 6 transition countries. Using cointegration technique Doganlar *et al.* (2009) found no cointegrating relationship between prices and nominal exchange rate for emerging economies including South Africa and Brazil; hence they rejected the validity of purchasing power parity for emerging economies included in their sample except for Mexico and Peru.

### **3. Research Method**

The study uses two different panel datasets for 5 selected Sub-Saharan Africa, covering the period of 1995-2013 and 1980-2013. The initial sample size is small and it uses GDP deflators which includes non-trade goods, the inclusion of non-traded goods may and therefore thwarting PPP from holding. Hence the second sample is quite large and it uses traded good prices thus allows one to have robust results. Following Xu (2003) and Dimitriou and Simos (2013) the traded goods price are constructed as follows:

$$P_t = \left( \frac{X_t}{M_t + X_t} \right) XP_t + \left( \frac{M_t}{M_t + X_t} \right) MP_t \quad (4)$$

Where  $X_t$  and  $M_t$  are exports and imports levels, respectively.  $XP_t$  And  $MP_t$  are the export and import prices, correspondingly. Data for export and import levels and export and import prices have been extracted from the world development indicators. Due to non-availability of real effective exchange rate, the study uses bilateral exchange rate. The data for the nominal exchange rate comes from the world development indicators as well. The data for GDP deflators is extracted from World Economic Outlook IMF 2014 database.

This study considers the basic panel-data model;

$$RER_{it} = \gamma_i RER_{i,t-1} + X'_{it} RER_i + \varepsilon_{it} \quad (5)$$

Where  $i=1, \dots, N$  indicates panels,  $t=1, \dots, T$  indexes time,  $RER$  represent the variable of interest i.e. the real exchange rate and  $X'$  are the panel specific means and since time trend is not included then  $X'_{it} = 1$  thus it represents fixed effect i.e. those effect that are time invariant. For simplicity, equation (5) is transformed to yield;

$$\Delta RER_{it} = \rho_i RER_{i,t-1} + X'_{it} RER_i + \varepsilon_{it} \quad (6)$$

The null hypothesis reads  $H_0: \rho_i = 0$  for all panels and alternative hypothesis reads  $H_1: \rho_i < 0$  for some panels. Failure to reject the null hypothesis implies that purchasing power parity does not hold whereas the rejection of a null hypothesis implies that long-run PPP holds.

The issue of cross-sectional dependence has been raised in the panel data literature (Breitung and Pesaran, 2008). Pesaran (2007) and Pedroni (1999) suggests that in order to eschew the bearing of cross-sectional dependence in the panel regression setting, one must subtract cross-sectional averages  $\bar{Y}_t = N^{-1} \sum_{i=1}^N Y_{it}$  (demean the data) from the data so that “all common factors over cross-sectional dimensions will be reduced through mathematical cancellation” Solberger (2011;252). Owing to the use of US dollar as a numeraire currency and other unknown common factors, the presence of cross-sectional dependence is expected and hence data has been demeaned as suggested by Pedroni (1999). Arize et al (2010) and Kargbo (2006) neglected the impact of cross-sectional dependence in their PPP validity surveys in Africa so to fill the gap in the recent literature this study will take cross-sectional dependence into account. Furthermore, removing cross-sectional averages justifies the use of Im et al (2003) and Fischer ADF unit root test which are based on the assumption of no cross-sectional dependence.

Given their advantages of competing tests such as the Levin, Lin and Chu (2002) (LLC, hereafter) both the Im *et al* (2003) proposed and the Fischer ADF unit root tests will be utilised in this study to test the null hypothesis specified in above (i.e. nonstationarity for all member, against the stationarity for some members of the panel). Most of panel unit root tests such LLC mentioned above assume that panels share a mutual autoregressive parameter, however country specifics such as culture,

institutional settings makes it difficult for this assumption to hold in practice. Therefore Im *et al* (2003) developed a set of test that shy away from the assumption of common autoregressive panel, also the IPS test does not necessarily require a balanced panel data. Im, Pesaran and Shin allow the error term to have a heterogeneous variance across panels and also assume that error terms are independently and identically distributed across the panels. So ultimately the IPS fits each panel to equation 6 and put the resulting t-statistics together rather than pooling the data like Levin, Lin and Chu (2002) thus implying a heterogeneous autoregressive parameter.

In order to obtain a solid conclusion in biostatistics and medical sciences they generally use a Meta-Analysis i.e. combining results from different studies that test the same hypothesis, and this is exactly what Fisher type unit root test does. The Fisher ADF test simply performs a unit root test separately on each series and then combine all the p-values to determine if the panel series contain a unit root or not. This is a bit similar to the IPS except that the Fisher ADF is more explicit than the IPS.

#### 4. Findings of the Study

Validity of purchasing power parity has been reduced to testing for real exchange rate stationarity, such that if exchange rate are found to be stationary it can thus be inferred that PPP does hold, vice versa. Validity of PPP carries essential implications for both policy making (Kargbo, 2006) and international macroeconomic theories such as the monetary/asset approach to exchange rate determination which assumes that PPP does hold (Donbursch 1985).

**Table 1**  
IPS Real exchange rate unit root test based on GDP deflators

<b>Im, Pesaran and Shin (2003) Panel Unit root test results: Real exchange rate (GDP deflators)</b>				
	<b>Statistic</b>	<b>Exact Critical Values</b>		
		1%	5%	10%
t-bar	-1.3886	-2.500	-2.190	-2.040
t-tilde-bar	-1.286			
Z-t-tilde bar	0.2137 (0.5846)			

Corresponding *P*-values are reported in parenthesis.

PPP hypothesis is extremely essential for policy decisions and forecasting. If PPP does hold it can serve as a useful predictor of future exchange rate whereas if it does not hold it is irrelevant i.e. it cannot be used anywhere. For Sub-Saharan Africa particularly energy exporting country whom are very vulnerable to exchange rate

shocks via terms of trade, it is essential to know if PPP does holds or not so that they will understand if exchange rate shocks are prolonged or not. Irrespective of the cause, disequilibria are shown in prices. If the price of goods in the United States surpasses the exchange rate and shipping cost adjusted price of similar goods abroad then U.S. goods are said to be overvalued (Magee and Rao, 1980).

**Table 2**

IPS Real exchange rate unit root test based on traded goods prices

<b>Im, Pesaran and Shin (2003) Panel Unit root test results: Real exchange rate (traded-good prices)</b>				
	<b>Statistic</b>	<b>Exact Critical Values</b>		
		1%	5%	10%
t-bar	-2.1658	-2.430	-2.160	-2.020
t-tilde-bar	-2.0142			
Z-t-tilde bar	-1.5941 (0.0555)			

Corresponding *P*-values are reported in parenthesis.

Table 1 and Table3 left column reports both the Im et al. (2003) proposed and the Fischer ADF panel unit root and both tests fail to reject the null hypothesis of unit root on the real exchange rate when GDP deflators and small sample is applied. This finding is indeed consistent with the existing literature and assertions (see Beko and Borsic, 2007; Levin *et al.* 2002 and Acaravci and Ozturk, 2010). It has been well established that small sample size has limited power to reject a false null hypothesis of unit root (see Rogoff, 1999; Gagnon and Melick, 1997; Frank and Rose, 2006 and Macdonald, 1995). Further the use of GDP deflators has long been argued to lead to bias and inconsistent results, because of the inclusion of non-traded goods in their construction. There is no reason to believe that non-traded goods prices will be equalized across countries since their prices are independently determined by domestic and foreign market forces. Hence the failure to reject the null hypothesis is justified.

**Table 3**

Fischer ADF real exchange rate unit root test based on GDP deflators

<b>Fisher ADF Panel Unit root test results: Real exchange rate</b>		
	<b>GDP Deflators</b>	<b>Traded Goods prices</b>
	<b>Statistic</b>	<b>Statistic</b>
Inverse Chi-Squared (10) p	14.3389	17.869*
Inverse normal z	0.1522	-2.1309**
inverse logit t(29) L*	-0.0628	-1.9979**
Modifies inv. Chi-squared pm	0.9702	1.7596**

\*, \*\*, \*\*\* denote levels of significance 10%, 5% and 1% respectively.

However, applying traded-good price and large sample size the null hypothesis on the real exchange rate is rejected by both the Im *et al.* (2003) and the Fischer ADF unit root test. The unit root test results for traded-goods prices are reported in table 2 and right hand side column of table 3, Im *et al.* (2003) and Fischer ADF, respectively. These findings are consistent with recent empirical literature on the validity of PPP, amongst others Taylor and Taylor (2004), Frank and Rose (2006), Kargbo (2006) and Arize *et al.* (2010). The validity of purchasing power parity carries essential implications for policy-makers. Stationarity of real exchange rate implies that there is a long-run association between nominal exchange rate and price levels, hence PPP, could be utilised to determine long-run equilibrium exchange rate. Further the findings suggest that monetary approach to exchange rate determination was and is non-controversial since PPP does hold, (Rogoff, 1999).

The findings of the study are consistent with the view that PPP is expected to hold perfectly for high inflation and open economies (McNown and Wallace, 1989). Relatively to the supposedly trading partner (U.S.), African countries have extremely high levels of inflation and they are becoming more and more open to trade thus removing trade barriers which hinder PPP from holding (Rogoff, 1996). Hence it is therefore expected that because of international arbitrage their price levels should converge to U.S. price level, thus compelling PPP to hold.

## 5. Conclusion

Using panel data for period 1980-2013 and 1995-2013 for five Sub-Saharan African energy exporting countries; South Africa, Nigeria, Mozambique, Congo Republic and Angola we assess the validity of the purchasing power parity. The findings of the study are consistent with existing African and international literature. Kargbo (2006) employed black market exchange rate to examine validity of PPP and found that PPP does hold in Africa similar conclusions are presented by Arize *et al.* (2010). When small sample size and GDP deflators were employed the study (both the IPS and Fisher ADF) fails to reject the null hypothesis of a unit root. The failure to reject the unit root when sample size is smaller is consistent with what has been established in the literature (see Frank and Rose, 1996). Because of sticky price adjustment small sample size is more likely to fail to provide evidence for purchasing power parity. Further GDP deflators includes non-traded goods whereas the PPP theory states that when converted to a single currency traded goods should cost the same price. Hence the inclusion of non-traded goods may impede PPP from holding and can lead to bias and inconsistent results, (He *et al.* 2013). When moderate sample size and traded good price are employed the study rejects the null hypothesis of a unit root all levels above 5% levels of significance.

It can therefore be inferred that because of slow price adjustment and demand inertia, testing for the validity of purchasing power parity requires that data covers long period of time, otherwise one might falsely reject the validity of PPP. The second conclusion that can be drawn from the initial sample is that exchange rate(s) constructed using traditional price indices such as CPI, GDP deflators which includes non-traded goods should be interpreted cautiously.

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