# PANEL UNIT ROOT AND COINTEGRATION TEST OF PURCHASING POWER PARITY: A STUDY OF SELECTED AFRICAN COUNTRIE

**BY**

**AUWAL YAHAYA**

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## ABSTRACT

*The Purpose of this research is to test the validity of the purchasing power parity (PPP) theory in Africa. The theory is tested through the use of panel unit root and cointegration techniques. Based on the annual data covering the period of 1980-2012, panel unit root tests of Levin, Lin and Chu (2002) and Im, Pesaran and Shin (2003) are conducted on the real exchange rate of the studied countries. The results based on the unit root tests failed to validate the theory in its strong form. However, based on the Pedroni (1995, 1996) cointegration test of price indices and exchange rates, the results appeared remarkable in favor of long term applicability of PPP as a cointegration concept. Further test on the long run relationship revealed that domestic prices played a vital role in determining the equilibrium exchange rates (hence PPP) as far as this data is concern. As concerns major policy, based on this study, these countries could use the PPP theory to determine the equilibrium exchange rates. Even though, the strong form of PPP theory could not be attested given the unit root approach employed, the empirical results emphasized that there is weak evidence about the long run PPP hypothesis in these countries.*



**Keywords:** PPP, Real exchange Rate, Nominal exchange rate, Domestic Consumer Price Index (CPI), foreign Consumer Price Index (CPI*), Panel Unit Root and Panel Cointegration.

## ABSTRAK

*Tujuan kajian ini adalah untuk menguji kesahan teori kuasa beli pengguna (PPP)di Afrika. Teori ini diuji melalui penggunaan teknik data panel punca kuasa dua dan kointegrasi.Berdasarkan data tahunan ynag meliputi 1980-2012, ujian Levin, Lin dan Chu (2002) dan Im, Pesaran dan Shin (2003) panel punca kuasa dua dijlanakan keatas pertukaran asing benar di Negara yang dikaji. Keputusan berdasarkan ujian punca kuasa dua gagal mengesahkan teori tersebut dalam bentuknya yang kuat. Tetapi, berdasarkan Pedroni (1995, 1996 )ujian kointegrasi index harga dan kadar pertukaran, keputusan-keputusan tersebut menjadi luar biasa terhadap aplikasi PPP jangka masa panjang sebagai konsep kointegrasi. Ujian tambahan ke atas hubungan jangka panjang mendedahkan bahawa harga domestic telah memainkan peranan penting dalam menerangkan keseimbangan kadar tukaran (dan PPP) sejauh mana data ini diambil kira. Perhatian terhadap polisi penting, berdasarkan kajian ini, Negara-negara ini boleh menggunakan teori PPP untuk menentukan keseimbangan tukaran asing. Walaupun, bentuk teori PPP yang kuat tidak boleh disahkan apabila pendekatan punca kuasa dua digunakan, keputusan empirical menekankan terdapat bukti lemah terhadap hipotesis PPP jangka panjang di negara-negara ini.*



**Katakunci**: PPP, Kadar tukaran asing benar, Kadar tukaran semasa, Indeks Harga Pengguna Domestik (CPI), Indeks Harga Pengguna Asing (CPI*), Panel Punca Kuasa Dua dan Kointegrasi.

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| | |
|---|---|
| ADF | Augmented Dickey-Fuller |
| CPI | Consumer Price Index |
| CPI* | Foreign Consumer Price Index |
| EU | European Union |
| FMOLS | Fully Modified Ordinary Least Square |
| IPS | Im, Pesaran and Shin (2003) |
| IMF | International Monetary Fund |
| KPSS | Kwiatkoswski, Phillips, Schmidt & Shin test (1992) |
| LDCs | Less developed Countries |
| LLC | Levin, Lin and Chu (2002) |
| LM | Lagrange Multiplier |
| LOP | Law of One Price |
| MENA | Middle East and North African Countries |
| NER | Nominal Exchange Rate |
| OECD | Organization for Economic Cooperation and Development |
| PPP | Purchasing Power Parity |
| PPI | Producer Price Index |
| RER | Real Exchange Rate |
| SPM | Sequential Panel-Selection |
| SURKSS | Seemingly Unrelated Regressions Kapetanios-Shin-Snell(2009) |
| WPI | Whole Sales Price Index |

# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction

The theory of purchasing power parity as one of the oldest topics in international economics plays a central role in macroeconomic models in an open economy. It constitutes one of the oldest and the most practical relationships in the theory of exchange rates (the relationship between relative prices and exchange rate). Earlier versions of the theory can be traced back to the works of scholars dating to 15$^{th}$ up until 16$^{th}$ centuries. Though, the intellectual presentation of the theory began as far back as early 1800s, with the writings of Wheatly and Ricardo.

The series of debates on the collapse of world financial system and the necessary ways to restore it marked the modern origin of the theory of purchasing power parity (PPP). Before 1st World War, exchange rates between two countries were simply represented by their relative gold values. However, maintaining the relative gold standard after the end of the war was faced with lot of problems. Countries were highly concern about the possibilities of currency devaluation that could be easily adopted all in an effort to gain seignorage revenues. This let to abandoning of the gold standard (Rogoff 1996).

In a series of influential articles, Cassel (1921, 1922) advocated that PPP should be used to set gold parities. Even though, the theory of PPP had been given earlier discussion by the so-called classical economist, Cassel was really the first to digest and present it as a practical empirical theory.

Taking two countries, the general principle behind the theory is saying that; the nominal exchange rate between two countries should equal the ratio of their aggregate prices. Meaning, the purchasing power of their currencies should be same. Purchasing power parity assumes nominal exchange rates and price levels to have a smooth relationship for the economies concerned. Thus, we can say that, if goods market arbitrage which is regarded as the building block to the law of one price (LOP) enforces a wide equality in prices on a range of goods, then a correlation in aggregate price levels is expected, which definitely has the effect of equating price ratios with nominal exchange rate.

The present generation however, witnessed the use of different forms of PPP hypothesis in a wider range of applications. This could be selecting the exchange rate for a given newly independent nation, to making a forecast on the medium to long-term exchange rate (Rogoff 1996). We can in this way argue that not only PPP acts as benchmark to monitoring the general movement in prices and exchange rate, it gives a hint on the likely twin effect a policy that was designed to correct anomalies in general prices could have on exchange rates as well. Ultimately, there is no right PPP measure, the appropriate variation of PPP depends on the application (Rogoff 1996).

Being the theory behind PPP, the LOP states that, identical commodities should command the same price across different markets when barriers to trade as well as transaction costs were not present (Laurentiu, 2013). The law states:

$$P_{i,t} = S_t P^*_{it} \qquad i = 1, 2, 3,..., n \qquad (1)$$

$P$ Stands for the domestic price of good $i$ at time $t$, and $p*$ is the foreign price of good $i$ at time $t$. While $S$ here represents the nominal exchange rate (domestic price of a foreign currency at time $t$).

Though the LOP argue that goods should have the same price across countries if the prices are expressed in same currency of denomination, the theory is however, weakened by the presence of transportation costs and the so-called government intervention or restriction. This consequently would make it unprofitable to move items across different markets from different situated countries. Often, as a cost of moving goods and official trade restriction increase, the larger we expect exchange rate disequilibrium.

Observing from equation (1.1), it advocates similar to the law of Purchasing Power Parity with the only difference that LOP is representing only a case of single commodity and the former is for the aggregate prices of those goods which enter the market. Thus, one can say if law of one price should hold for every good, of course, PPP doctrine must also hold so long the concerned basket of goods that were taken into account in the overall price level in every country were same.

## 1.2 Statement of research problem

Many theoretical and empirical models of international finance were built on the assumption of the so-called doctrine of purchasing power parity. Though the topic has been researched so extensively, still the answer as to whether it holds in empirical life remains controversial. It remains an open argument that, a substantial deviation in PPP in the short-run is caused by financial factors, but still empirical

results on the long run validity remained contradictory. Shiller (2013) is of the view that, " the long run PPP validity is still subject to the particular currencies of study, or the form of price indices used, the particular time under investigation, and or the method of analysis employed". Efforts of early researchers have been unsuccessful with some researchers thinking that PPP theory is even empirically less relevant. Early studies on the theory include Darby (1983) and Roll (1979). Among the later works that specifically failed to reject the random walk hypothesis of the exchange rate was Huizinga (1987) . In fact, down to the year 2000, only little supports empirical studies were able to show on the long run PPP.

Noting that the failure of early researchers to validate PPP was due to a lack of power of the standard unit root test that was generally used by researchers (insufficient data sets), Frankel (1986) employed a bit long-horizon data covering 1986-1990. A more favorable result appeared that supported PPP as an equilibrium exchange rate policy. Studies employing long-horizon data sets became the fashion of researches in 1990s adopting different variety of statistical approaches. Studies such as Jorion (1990), Glen (1992) and Lai (1993) for example, get a similar results supporting long-run PPP. Using a long-frequency data, Lai (1993) obtained evidence of mean reversion for real exchange rates using wholesale price index (WPI) through 1900-1992.

Although with the application of long-horizon data researchers did find support for long-run validity of PPP, but because these studies were identified blending between fixed and floating exchange rate regimes, they were later been criticized on the ground of lacking econometric justification.

Another excellent alternative to addressing the low Power problem of the standard unit-root is to pool a range of cross-section of countries over a particular time period. Studies such as Frankel and Rose (1996) and Papell, D. and Theodoridis, H. (1998) obtained results that supported long-run validity of the theory using data from developed economies employing panel approach.

However, the common thread among all the above cited studies was that they concentrated extensively on industrial countries that are mostly characterized by relatively smooth and stable economy. While on the other hand, high inflation, exchange rate and trade controls, rapid growth in the money sector, capital flight, and real shocks are all among the dominant features that lived to make the validity of PPP in most less developed countries unsuccessful.

Coming down to Africa, studies have showed so many countries within the African region to have in one way or the other witnessed the adoption of World Bank and, or other IMF reform policies during 1980s. These were all meant for correcting the distortions in their foreign exchange rate markets, and improving the external competitiveness of their economies. It has been clearly stated in Nagayasu (1998) and Odedokun (2000) that; the basic guiding principle behind different exchange rate policy reforms in Africa is the assumption on the validity of PPP in the long run. Therefore, studies such as Nagayasu (2002), Kargbo (2003), Drine & Rault (2008) and Kalyoncu *et al* (2010) to mention but few find it motivating to examine the feasibility of PPP theory in Africa. Applying panel cointegration test on annual data for sixteen African countries, Nagayasu (1998) find a support for the long run PPP.

However, individual unit root and cointegration for the annual data at country level fails to show support for the PPP theory. Employing a non-linear approach, Su, *et al* (2012) and Pan *et al* (2012) get a weak form of mean reversion in exchange rate. Holmes (2000) could only get support for PPP applying panel unit root test, but his results for the individual countries were not supportive of the PPP hypothesis. However, in the work of Drine *et* al (2008), he concluded that in countries like Asia, Africa, Latin America and CEE, PPP gained no relevance in characterizing the behavior of real exchange rate in the long run, a point which called for more empirical justification.

It is clear from the background to the study of this thesis that the validity of long run Purchasing Power Parity has remained inconclusive. Therefore, different conclusions concerning the validity of the theory both at the theoretical and empirical levels provide the background motivation for this study. This is because further study on this topic using these eleven less developed African countries` data would provide a clearer view that may help policy makers in planning decisions for these countries, and also provide additional evidence on the support or otherwise to the PPP theory.

## 1.3 Objectives of the Study

### 1.3.1 General Objective

The study is an attempt to examine the existence of the validity of purchasing power parity in the long run within these eleven selected less developed African countries.

### 1.3.2 Specific Objectives

**1.** To examine the long run validity of strong form of purchasing power parity theory.

**2.** To examine the long run co-integration among nominal exchange rate, domestic and foreign consumer price indexes.

**3.** To examine the effects of each of the independent variables on the equilibrium exchange rate in the long run.

## 1.4 Significance of the Study

Based on theoretical arguments, PPP is treated as an international long run parity condition, which most of the macro-economic predictions of open economies are built up on. Hence, it is been argued that, the open-economy dynamics models hinge on the rejection or otherwise of the null of random walk assumption of real exchange rates.

The theory can serve as a means through which long run exchange rates can be predicted, and also determine whether or not a countries` currencies are undervalued or overvalued (Holmes 2001 and Sarno 2005). However, this is much relevance to countries with wide gap between the foreign and domestic inflation rates which developing countries like Africa are not exception.

Testing the validity of long-run PPP is important because, a more accurate and convenient comparisons of living standards in poor and labor endowed economies is achieved with the notion of PPP than is possible when incomes are measured in dollars for instance.

Therefore, confirming the existence of this theory and determining the necessary variables acting as engine to long-run adjustments in equilibrium exchange rates will provide a hint on whether the theory of PPP should be used as a guiding principle in decision making process.

## 1.5 Scope of the Study

This research focused on testing the validity of purchasing power parity theory using two approaches of panel unit root and cointegration techniques. Time series data for the sample countries on real exchange rate, nominal exchange rates and CPI were employed, covering the period of 1980-2012. The study is limited to examining the validity of the theory in these selected sample countries of Africa, where US is taking as the base country of comparison. And for the method of analysis, the panel unit root of Levin, Lin and Chu (2002) and Im, Pesaran and Shin (2003) were employed. Under the second approach, the Pedroni (1995, 1996) panel cointegration and Fully Modified Ordinary Least Square (FMOLS) techniques were used.

## 1.6 Organization of the Study

This work is organized as follows: chapter two provides a review of previous studies conducted on the validity of PPP especially in LDCs and Africa in particular. Chapter three discussed the methods of analysis used in the study with some econometric tests illustrated. In chapter four, the findings of the various estimations and their interpretations were discussed. And lastly, chapter five constitutes conclusion and policy recommendations based on the discussed findings.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

Chapter two focused on the theoretical review of the theory in general, and after which the empirical literatures reviewed on the validity of the theory either as a short-run or long-run phenomenon were presented. This hence provides the framework for testing the validity of PPP in the long run.

## 2.2 Theoretical Framework

### 2.2.1 Purchasing power parity

The doctrine of purchasing power parity is about determining the equilibrium that is said to exist between exchange rates and prices of goods and services in particular countries of analysis. As the theory of long run equilibrium exchange rate, PPP has two alternative versions used in practice depending on the circumstances at hand. The two versions of the theory are: absolute purchasing power parity and the Relative purchasing power parity.

### 2.2.2 The Absolute Purchasing power parity

The absolute version of the hypothesis assumes nominal exchange rate between any two currencies should equal the price ratios for the countries. As it has been put forward in the words of Bela (1964) that; " absolute PPP calculated as a ratio of consumer goods prices for any pair of countries would tend to approximate the

equilibrium rates of exchange". The absolute version of PPP is said to hold when the nominal foreign exchange rate between two countries is in a manner which equalizes the domestic purchasing power of a particular currency with its foreign counterpart, once they (currencies) are converted in the same rate (Laurentiu, 2013).

Absolute purchasing power parity is based on the notion of law of one price (LOP). The law requires equality in the prices of identical commodities under different set of markets. Assuming for any commodity, say *i*;

$$P_i = \mathrm{E}.P_i^* \qquad (2)$$

Where *P*, *P** represent commodity *i`s* price levels for the domestic and foreign currency respectively. While E here stands for the domestic price of the foreign currency, that is;

$$\mathrm{E} = {}^{P}/_{P^*} \qquad (3)$$

However, the LOP holds under some strict assumptions that no barriers to international trade, goods market should be perfectly competitive (meaning with perfect information to the individual agents of the countries). Moreover, the international delivery of commodities should be freely, costless and with no any delay. Therefore, in a situation where by the LOP fails to take place, then we say arbitrage occurs. An instance describing a circumstance in which the prices of some identical goods are not equal at different country`s market. This will then give the arbitrageurs chance to import from the markets with low prices to sell at more profitable markets. And due to increase in supply, prices will fall in the expensive markets all things being equal, while rise in the cheaper markets as a response to

increase in demands. Hence, the prices of these commodities will tend towards each other and latter equalize in both markets as the process continues.

Given that the LOP is referring to a single commodity only, taking the general price level indices of two countries with the same basket of goods, and assuming equal weight to each of the goods, we are said to establish a relationship called the "absolute PPP"; like:

$$P = E.P^* \quad (4)$$

Where P, $P^*$ are now general price indices (referring not only to a single good as in the LOP) in domestic as well as foreign country, and E is as earlier defined.

It can be seen that equation (4) is almost same with (2) with the only difference that, the latter equation (4) is implying to broad baskets of goods in the countries of study. Thus, impliedly, absolute PPP advocates that nominal exchange rate between two countries should equal the ratio of national price levels.

### 2.2.3 Relative purchasing power parity

This holds when the percentage change in the exchange rate over a given period just offsets the difference in inflation rates in the countries concerned over the same period. It states that the changes in exchange rate should equal the difference in inflation rates (changes in prices). Bela (1964) described relative version of PPP saying that; "in comparison to a period when equilibrium rates prevailed, changes in relative prices would indicate the necessary adjustments in exchange rates". Meaning that, the real exchange rate should be constant over time (but not necessarily one). In this way, the purchasing power of a unit of the domestic currency in the domestic

economy relative to its purchasing power in the foreign economy when converted at the going exchange rate is the same at the end of the period as at the beginning of the period.

The relative PPP hypothesis is thus implying that the exchange rate should bear a constant proportionate relationship to the ratio of national price levels. In particular;

$$S = k^{P}/_{P^*} \qquad (5)$$

Where *k* is a constant parameter proxy for the trade obstacles such as transportation costs, tariffs etc., (Sulku 2001).

Because either of the two variants implies a constant real exchange rate, taking the logarithms of both sides of equations (4) and (5), it will thus be:

$$s = c + p^* - p \qquad (6)$$

where s, $p^*$and $p$ are the logarithms of $S, P^*, P$; while $c = \ln(k) = 0$ in the case of absolute PPP. Thus under either of the variants, a change in the ratio of price levels implies a proportionate change in the nominal exchange rate. Hence;

$$\Delta s = \Delta p^* - \Delta p \qquad (7)$$

Equat. (7) Implies that the percentage change in the nominal exchange rate is equal to the difference between inflation rates in the domestic and foreign country.

With difficulties faced in measuring the reality of absolute PPP across different economies, researchers opted for the test of relative PPP version of the theory. Among the many issues that failed the validation of the absolute parity condition

include absent of a special general price index in countries which compose of internationally standardized basket of goods and have equal weights for each of the commodities. Also there is difficulty to finding the same baskets of goods to compare absolute PPP across countries. Furthermore, the equilibrium price of any given good may not be the same in different locations because of market imperfections such as transportation costs and other trade obstacles in international trade like quotas, tariffs.

All things being equal, in theory, any deviation from PPP should result in an immediate change in prices/or the exchange rate in such a way that the parity still holds. But due to barriers and other imperfections just mentioned, PPP does not hold perfectly in practice. However, going by the theoretical arguments of PPP, these deviations are expected to be temporary so that at last the prices converge to one another in the long run. Thus, any short run deviations from equilibrium exchange rate that might occur either due to changes in price or nominal exchange rate should allow the exchange rate to return to its initial mean level in the long run. The extent to which mean reversion takes place is sometimes measured by half-life which represents the amount of time that elapses before the gap that is between the PPP level and the current exchange rate is half its current size.

Therefore, empirically the PPP theory can be tested based on examining the random walk behavior of the real exchange rate through implementing unit root tests or by performing co-integration test to a linear combination of exchange rate and the domestic-foreign price levels. And if the PPP holds, then inter-country commodity arbitrage acts as error correction mechanism. And therefore, divergence from the

linear combination of the nominal exchange rate and the domestic foreign price levels should revert back to equilibrium. Or the real exchange rate should be stationary when unit root test is conducted.

## 2.3 Empirical framework

It has been repeatedly proved and presented by the early researchers on the invalidity of PPP in the short-run. But, whether the hypothesis is valid in the long run remains an important and open empirical debate that has implications for both the sources of disequilibrium to real exchange rates and for models of exchange rate determination.

### 2.3.1 Early Studies based on Short-horizon data

Given that Purchasing Power Parity theory remains very important in exchange rate modeling and international macroeconomics in general, researchers have been identified with efforts in testing for its validity especially with the recent sophistication in the estimation techniques.

The early studies on the theory were based on the models testing the validity of the absolute version of purchasing power parity. Although Frankel (1978) was able to obtained estimates of β and $\beta^*$ close to +1and -1, yet several tests conducted by researchers failed to show support for the absolute version of the theory especially in a stable monetary economy. Early studies have showed that the failure to take into account the non-stationarity of residuals rendered most previous studies misleading.

The conventional unit root tests of PPP have been criticized in the early 1980s due to the random walk nature of the exchange rates and also due to the less power of the

test on small samples data. In finite samples, conventional unit root techniques inevitably have a limited power against the alternative hypothesis with highly persistent deviations from equilibrium. And considering the fact that most of the empirical works that have been done using the conventional unit root tests were before 1990s employing data of less than 20 years, researchers have related the failure of these studies to reject the random walk hypothesis of exchange rates to the short-horizon nature of their data, or we can equally say; lack of power.

### 2.3.2 Empirical Studies based on Long-horizon data

In reaction to the low power problem, researchers like Edison and Klovland (1987) used an error-correction model on a long-horizon data. Analyzing dollar/pound data for 1890 to 1978, their empirical results showed a weaker rejection of PPP. More modern empirical methods were employed in the latter period of 1990s; ranging from fractional integration, variance ratios, co-integration and error correction models on the long-horizon data. This development in the latter period lends a support to the long run validity of purchasing power parity.

Though some literatures still discourage the application of long-horizon data, but Glen (1992) and Lai (1993) have both in different studies found a support for the long run mean reversion in the real exchange rates of post-Bretton Woods high frequency data. In another different study, Salehizadeh & Taylor (1999) used co-integration techniques in accessing 27 selected developing countries against the US dollar, covering periods of 1975- 1997. Using co-integration technique, the empirical findings gave a relatively strong support for PPP in 14 out of the 27 sampled countries. However, the speed of convergence was relatively high.

Present as well as early researchers of the theory suggested that the presence of obstructions (constituting the presence of transportation cost and non-traded goods) to the free flow of goods across international borders means absolute PPP must be rejected. However, Crownover, Pippenger, & Steigerwald (1996) preferred that absolute PPP be treated as an empirical relation of study. Observing 15 country pairs, they found support for relative PPP in 8 countries with 4 of the remaining countries supporting for absolute PPP. This however, contradicted most of the studies of different researchers indicating the puzzle present in the study of PPP.

In relation to the studies of Crownover et al., (1996), Charles Engle and John H. Roggers (2001) studied the causes and welfare costs of deviations from purchasing power parity. Introducing another different border effects; real barriers effect (which resulted from various impediments to market integration) and sticky price plus volatile exchange rate effects impliedly showed deadweight in the welfare of consumers by their findings. But, they hinted although the first effect was significant, but the second effect can be controlled through intervention of adopting fixed exchange rates.

In line with studies such as that of Salehizadeh & Taylor (1999), Faust, Rogers, & H. Wright (2003) among others were of the view that non-linear models should be used in examining the relationship that exist between nominal exchange rate and other macro-economic variables. In quest of that, the authors explores whether the evidence of asymmetric may go a long way to explaining the difficulties faced in examining the long run real exchange rates. Their findings suggest that non-linear models are indeed a plausible solution for the inability to reject the hypothesis of unit

root in the exchange rate series. Their results not only support the argument that exchange rate are predictable, but rationalizes the unwillingness of foreign exchange traders to depend on economic fundamentals like relative prices.

Although it is of the interest to foreign traders a short term mean conversion forecast of less than six months, Kilian & Taylor (2003) find no evidence to support for improved forecasts shorter than six months instead, at 2-3 years horizon.

Investigating the validity of long run PPP, Lopez, Murray, & Papell, (2005) re-examined the same countries studied by Taylor (2002). Though, Taylor (2002) was able to get 11 out of the 16 countries in his study to show support to the validity of PPP, but Lopez *et al*. (2005) instead showed that Taylor only rejected the unit root in exchange rate due to sub-optimal lag selections he applied. Applying a method that has a better lag selection technique, only 9 out of the 16 industrialized countries in their samples supported for the long run PPP.

In a bit to see channels through which exchange rate reached equilibrium in the long run, Cheng (1999) advances his study by re-examining the PPP literature through examining exchange rates, prices and interest rates for Japan and the US. Adopting Hsiao`s Granger causality technique, he showed exchange rate to adjust to changes in price levels in ensuring long run equilibrium. Further tests revealed prices responds via interest rate to correct disequilibrium in PPP.

But applying same technique, Islam & Ahmed (1999) reported a partial evidence favoring long-run PPP for Korea covering a period of 1971:1 to 1996:1, but with

short run dynamics and speed of convergence somewhat slower. While accounting for the unidirectional causality obtained by their study, the authors lamented that it was because most of the periods covered in their study fall under exchange rate control regime.

A thorough re-examination to the study of Taylor (2002) and Lopez *et al.* (2005) was also given by Pradon (2006). Because *Lopez et al.* (2005) finds only 9 out of the 16 countries studied by Taylor (2002) that favored either trend or level stationarity in the real exchange rate at 5%, Pradon (2006) investigated two alternative versions (reversion to a constant mean as argued by Cassel or reversion to a constant trend as in the spirit of Balassa-Samuelson) of PPP for the remaining seven countries. They obtained evidence in support of PPP for five of the seven studied countries. Meaning that, additional five countries were found to show support to the long run PPP with either trend or constant mean reversion.

Motivated by the writings of Nagayasu (1998) recently researchers find it exciting examining the faith of the PPP in African economic atmosphere. Using parallel exchange rate market and CPI, Kargbo (2003) tested the validity of PPP in some selected 30 African countries with a strong support for the theory.

Inspired by trade cost models (non-linear models of exchange rates), Shintani (2006) was among the researchers that adopted a simple non-parametric procedure on annual historic data. Estimating the model on first set of the data used, his findings revealed a lesser half-life with more than 2 year difference if compared to the linear

estimates of 4.84 years. While a 1year reduction was obtained on the linear estimates when the model was estimated using the current floating data.

Sophocles, Dimitris, & Fragiska (2004) conducted an empirical study that aimed at examining bias that may likely results from policy making, and the behavioral nature of markets` participants in affecting any effort meant for testing the acceptance of PPP. Using data from France and Greece for Post Bretton Wood`s period, omission of policy effects appeared significant in the case of Greece, meaning, any prior study conducted on Greece without taking policy effects into cognizance could appeared misleading.

Observing the mixed results generally produced by previous researches on the properties of real exchange rates data for most of Asian countries, Tsong (2010) was motivated to use international data of 15 developing economies. Using the covariate stationary test of Janson (2004), he obtained a strong support for PPP unlike weak support showed when a nonlinear unit root test was applied.

Among the most recent and unique papers that examine the validity of PPP in African countries with emphasis given to the half-life of exchange rate deviations was the work of Arize et al. (2010). Using the Johansen and, Harris and Inder (1994) procedure, they rejected the random walk hypothesis of exchange rate in these 14 African countries. They reported an average half-life shorter than what was reported in the work of Rogoff (1996) for the period of 1973: 4 through 2007.

In another effort to uncover the effects of exchange rate regime on the behavior of long run exchange rate equilibrium, Sulku (2010) observed 16 different less developed economies from different angles of the world. Combining both flexible as well as fixed exchange rate regimes in his study, he obtained almost equal evidence in favor of the theory in every of the two studied regimes. Therefore, his conclusion was that; failure to reject the hypothesis of unit root in exchange rates should be attributed to other factors (e.g other market regulations), but not the particular exchange rate regime employed by a country.

Slightly different from the findings of Kargbo (2003) and Arize *et al*. (2010) among others; Chang, Lu, Tang, & Liu (2011) could get only 4 of his 22 sampled African countries to support PPP theory using Engle-Granger test that is based on symmetric adjustments. However, applying threshold co-integration procedure of Enders and Siklos (2001), about 17 out of the 27 countries appeared to support PPP hypothesis. A result that substantiates the arguments of L. Sarno & Peel (2001) among others, that non-linear adjustment in the nominal exchange rate could go a long way in explaining the PPP puzzle.

Reinvestigating the properties of the log real exchange rates in the nine transition economies, Chang & Tzeng (2011) applied Enders and Siklos (2001) threshold co-integration approach. Using data between 1995 to December 2008, Engle-Granger symmetric adjustments test showed only 6 of the 9 countries to support the long run PPP. But applying the asymmetric methods, their findings revealed strong evidence in favor of PPP for the entire sample. Employing the same Enders and Siklos (2001) threshold co-integration technique, Chang, Lee, Chou, & Tang (2011) in another

different study rejected the unit root assumption of exchange rates for all G-7 countries except Canada.

Contrary to the study of Chang & Tzeng (2011); Lin, Chang, & Chang (2011) examined the data of the nine transition economies studied by Chang & Tzeng (2011). However, only weak support was seen for the long run PPP when Fourier stationary test proposed by Beckler *et al.* was applied. Their results thus is in conformity with the conclusions of Halpern and Wyplosz (1997) and Li (2007) that PPP will be suited more to low volatile economies which Lithunia happens to be the only country with low volatile currency among these sampled economies.

In a recent study, Güney, Öge, Telatar, & Hasanov M. (2012) use data for some emerging and African economies to examine the validity of long run PPP. His study was an extension to the previous works of Chang *et al*. (2010). Employing a different unit root test which allows both structural changes and non-linearity in the data generating process, their empirical findings suggest the validity of PPP in majority of the sample.

Another recent study that used co-integration approach to test for PPP was Shiller (2013). Conducting a unit root on the real exchange rates, and also the long run relationship between US dollar, UK pound sterling, French Franc, German Mark, and Japanese yen; he argued that PPP has generally failed. Although the unit root test as well as long run co-integration favors PPP for UK, yet he maintained that the result is weak to attest the validity of PPP. Similar to his findings was the work of Laurentiu (2013). Using four key currencies of Canada, Euro zone, Japan and UK, all

as his domestic countries, while US dollar as the base, he examined PPP based on "pre-crisis" and the "full-sample" periods. But as far as his findings, he concluded in favor of the non-stationarity of real exchange rates.

Sarno & Passari (2011) were motivated to research on deviations from LOP (doctrine behind the existence of PPP). Their paper only focuses mainly on internationally tradable goods that seem to receive less attention by scholars. A careful study of the properties confirmed evidence on PPP for broad range of tradable goods. Departures from the law of LOP were shown to be transitory, indicating the existence of the law for wide range of tradable commodities for different set of currencies, and hence PPP.

In another effort to addressing the need for suitable modeling of structural breaks and non-linearity in exchange rate adjustment for developing economies, *Öge Güney et al.*, (2012) examined the data of some emerging markets and African countries. Empirical results of their study confirmed for long run PPP in majority of the sampled countries. But applying a linear unit root test, only few cases supported the long run PPP, an indication proving the nonlinear nature of exchange rate adjustments.

In their determination to revisit the presence of PPP in developing nations, Hoque & Banerjee, (2012) employed a data for a sample of 55 years for Bangladesh, India, Pakistan and Srilanka. Given their findings, neither the linear nor the nonlinear unit root of Kwiatkowski, Phillips, Schmidt and Shin (1992) (KPSS) tests prove to give a clear support for stability in the real exchange rate. Moreover, the authors

incorporated single as well as multiple breaks in the models, but the real exchange rates for all of the sampled countries were indistinguishable from I(1) processes. Therefore, conclusions based on this indicated that purchasing power parity for the studied countries is not valid with government intervention and also trade restrictions. Meaning these factors was identified to be the genesis of the deviations.

### 2.3.3 Studies based on Panel Approach

We can see that the consensus among the long-horizon data is remarkable; they were however subjected to so many criticisms. One obvious drawback with these studies was mixing both fixed and flexible exchange rate data at a study, while it is clear that not only the exchange rate but sometimes the whole economy is subjects to so many changes in the long run. This problem if not carefully handled may leads to conclusions that are based on spurious findings. A convincing test was then regarded necessary so as to provide a correct modeling and estimates of the real exchange rate, especially within the recent floating period.

A reasonable approach to addressing these problems was increasing the power of the unit-root tests by employing a long-horizon data which is free from combining different exchange rate regimes. Faced with data limitations, a pooled cross-section time series was considered the best option for generating the powerful unit root test needed. The most influential studies were Livin, Lin & Chu (2002), and Im, Pesaran, & Shin (2003), which we intend to employed in this regard. Other panel co-integration procedures were also applied by different researchers all in effort to remedy the low power of the traditional techniques used previously.

Among the early works that employed panel data for the study of PPP in the 1990s were Philippe & Niso (1990) who showed the power of their test using monticalor experiments after pooling the data in a system of univariate auto- regressions. Covering longer period than other recent studies, yet their empirical results proved inconclusive, with the speed of adjustment around 3 years.

Wu (1996) employed the famous Levin and Lin test while testing for eighteen (18) developed countries from 1974 through April 1993. His empirical outcomes showed that the hypothesis of unit root in exchange rates during post-Bretton Woods period can be rejected. His result was robust for it cares not on the price indices chosen or the frequency of observations in the samples. Frankel & Rose (1996) verified the validity of PPP hypothesis by examining a panel of 150 countries and 45 annual observations. Lothian (1996) also looked into the PPP theory by examining a panel data for the United States and 22 Organization for Economic Cooperation and Development (OECD) number countries for the year 1974-1990. Despite the short-horizon of their data, the results verified PPP puzzle in a much better way than is commonly assumed.

A robust and comprehensive study was also conducted by Andrian and Jack Strauss (2000) which examined the effect of price indexes believed to have differed in their traded and non-traded components. Their study entails a four different unit root tests in panel framework for OECD economies using the recent floating period. Empirical findings from their research showed a quick convergence in real exchange rates deflated by WPI compared to those that were based on CPI. And they also confirmed a slower mean reversion for panel unit root tests that imposed homogeneity in the

samples compared to panel unit root procedures with heterogeneous first order autoregressive process. And for the half-life; it converges with a much better speed to the mean level (1.124 to 2.855years) after removing the series containing different autoregressive processes than for the full panel (1.105 to 3.68 years). In fact, using different powerful panel unit root procedures, their results justified why we have different conflicting results in different broad of studies.

Jointly testing for both developed as well as developing economies in a pooled of cross-section study, Chiu (2002) applied different panel statistic procedures capable of either correcting patterns of serial correlation in the error terms, to bias correction terms and de-trending to examine a selection of 45 developed, and developing economies over the period of 1980-1999. Empirical findings in their study give a support to PPP theory. Taylor (2002) moved to give a more explanations on the long run PPP as well as its historical evolution. In doing so, he used a long panel data of its history for a group of twenty countries over a hundred years. Using multivariate in line with univariate tests of higher power, his findings showed a support for the validity of long run PPP. Even though, further tests suggest larger deviations from PPP during the floating exchange rate regime, but Taylor (2002) does not attribute it to such a regime but he proposes the presence of large shocks in such episodes. He hence concluded that most of the deviations observed in PPP should be attributed to monetary phenomenon instead.

Among the few but famous panel studies conducted on sub-Saharan Africa was Nagayasu (2002). Adopting panel co-integration procedure on bilateral exchange rate markets for 17 different countries; his results support a weak form of PPP. While

examining the Asian countries of Korea, Malaysia, Thailand and Indonesia; Salah (2003) applied ADF, Phillips Perron as well as KPSS tests. However, of the six countries, only Singapore and Korea showed no support for the validity in PPP theory.

Most of the excited recent panel studies were conducted within the context of developed economies, but Alba & Park (2003) applied a data from a more heterogeneous developing countries. These are countries believed to be prone to frequent shocks and disturbances in one time or the other making deviations from PPP a frequent phenomenon, and suggesting different results as to the validity of PPP depending on the time examined. To explore more on the bias that might results from the differences in time periods and other economic circumstance prevailing within these economies, they divide their period of study to 10 year periods starting from 1976-1985 up to 1990-1999. The countries were classified into 14 different groups based on inflation, GDP real per capita, openness, and Growth rate. With 15 moving periods, a total of 210 unit root tests were performed, but only 14 out of the 210 cases support for the long run PPP, suggesting a weak form of PPP.

Coakley, Flood, Fuertes, & Taylor (2005) conducted a research based on a large data set for 1970:1 to 1998:2 period comprising 19 OECD member countries; and other 26 developing countries using CPI and PPI indexes. Testing for the generalized relative PPP, a panel regression technique that allows for heterogeneity in the countries, cross sectional dependence as well as non-stationary disturbances was developed. By allowing movement in the long run equilibrium real exchange rate,

but at same time testing for long run unit elasticity of the nominal exchange rate with relative prices, the results have testified on the presence of general relative PPP.

Examining the purchasing power parity version of Balassa-Samuelson, Zhang & Lowinger (2006) applied ADF test which confirmed the rejection of unit root hypothesis for only South Africa and Pakistan at 5% level. And for the other samples of Egypt, India, Indonesia, Mexico, South Korea, Philippines, Thailand and Turkey, he could not reject the unit root hypothesis; a result in line with Pradon (2006). However, plausibly by pooling these countries together as a panel, the enhancement of the tests power seems to improve the result by obtaining a weaker form of PPP. For the half-life of the deviations, 2.04 and 1.50 years were recorded for both of the tests conducted respectively.

In their attempt to explore an explanatory essay which supposed to give more hint on the arguments attributing PPP to low inflationary countries, a particular exchange rate regime or even the particular type of data used, Drine & Rault (2008) employed 80 different countries comprising both developed and developing nations with different exchange rate regimes as well as inflationary levels. Though, a concrete evidence favoring long run PPP was obtained for OECD countries, only weak support was seen for Middle East and North African countries (MENA) respectively. In countries like Asia, Africa, Latin America and CEE, PPP gained no relevance in characterizing the behavior of real exchange rate in the long run.

A unique explanation that has been put forward by the authors was saying that; investigations proved exchange rates regimes matters not on the validity of PPP as it

was suggested in some studies. Also countries with a little higher inflation show a support to the theory contrary to studies relating its validity to low inflationary environments. Further, their study rejects the validity of PPP in developing economies, a point which called for more empirical justifications.

The pattern of grouping countries into different unique characteristics is considered interesting by so many researchers in an effort to present a most plausible explanation on the PPP puzzle.

Chang, Zhang, & Liu (2010) used the recent Seemingly Unrelated Regression (SUR) Kapetanios-Shin-Snell (KSS) tests put forward by Wu and Lee (2009). In order to accomplish their study, a group of 8 Association of South East Asian Nations was studied. Conducting different forms of panel Unit-root tests confirmed no support in favor of PPP. However, applying the sophisticated nonlinear SURKSS tests, PPP was found to hold for 2 (4) of the sampled countries if U.S dollar (Japanese-yen) is used as the base currency. Empirical findings of their study revealed a correlation between the presence of purchasing PPP and the currency used as the base year, an issue that may be attributed to the fact that US may not be the major trade partner to some of these economies but Japan. In another different study, Chang, Liu, Yu, & Kang (2010) applied also the nonlinear SURKSS approach to study the PPP theory. Half of the sample countries they studied supported the long run existence of PPP. However, as they argued no encouraging outcome was seen when linear models were used.

In a study that incorporated data from Africa and other developing countries, Huseyin Kalyoncu (2010) utilized the LM unit root test which endogenously determine structural breaks both at level and trend. Using both official and bilateral exchange rates, result favoring the validity of PPP emerged but at 10% for all the studied 13 countries except for Tunisia, Syria and Iran. The study of Pan *et al*., (2012) was also identified with applying another unique approach of Sequential-panel-selection method (SPM) put forward by Chortereas & Kepetani`os (2009), to study PPP in 18 African economies. This unique technique has the advantage of grouping a panel into stationary and non-stationary series, hence more appropriate than the common panel based unit root tests used in most of the panel studies. However, empirical results from their study showed PPP holds only for Tanzania, Madagascar, Sierra Leone and morocco. This result, therefore is re-confirming the claims that non-linear methods seem to work poorly for PPP in African countries.

In the same vein, Su *et al*., (2012) used different nonlinear approach (SURKSS) in examining the validity of long run purchasing power parity for some fifteen (15) African economies. After they failed to get support for PPP theory applying univariate as well as panel-based unit-root tests, the non-linear approach obtained support for purchasing power parity in 4 out of these 15 studied countries.

Covering a unique and homogeneous period (the EU floating regime) of the Czech Republic, Hungary, and Poland; Karabulut, Bilgin, & Gozgor (2013) focused on the currencies of the largest trading partners of these countries to evaluate the presence of long run PPP. Conclusion reached based on their findings was that, US seems not to be the major trading partner to the sampled countries. Thus, any previous study

conducted on same countries with US as the base country might have generated a misleading empirical finding. Empirical results showed deviations from equilibrium in the long run exchange rates of Czech and Poland are non-mean reverting, that is, invalidating the PPP theory with respect to the two countries. Nevertheless, using the panel unit root test of Breitung (2000), a weak form of mean reversion was obtained for the Czech Republic, while only limited empirical support was obtained between Hungary's major trading partners.

On a different set of data samples, Lin *et al*., (2011) extended the use of recent panel (SURKSS) test that was proposed by Wu and Lee (2009). Focusing their study to the nine transition economies` data, the nonlinear test favored the theory with a weak form of evidence for only Estonia and Hungary. Their findings have in another way strengthened the work of Karabulut *et al.*, (2013) for Hungary. In their controversial findings, Ilhan & Ali (2010) could not reject the null hypothesis of unit root in exchange rates for Transition economies given ADF and KPSS unit-roots tests. However, after incorporating for structural breaks in the model, a support of mean reversion in exchange rates was confirmed but only for Bulgaria and Romania.

Therefore, based on the mixed results provided in the above different reviewed studies, the validity of PPP especially in African countries is far from being resolved. Thus, it would be concluded that this research may appear relevant in contributing to the literature on the validity of PPP in Africa.

# CHAPTER 3

# METHODOLOGY AND DATA

## 3.1 Introduction

This chapter generally presents the methodology as well as the prescriptions of the data used in the study. Section 3.2 contained the model specification for PPP in panel framework, while the data and its sources are shown in 3.3. The methods of analyses and other techniques applied are detailed in section 3.4.

## 3.2 Model specification

In this section, the methodology and the testable hypothesis for the long run Purchasing Power Parity (PPP) are presented. There have been basically three stages in testing for PPP as put down in Rogoff and Froot (1995).

The first stage was based on testing regressions with the form of the following equation;

$$S_{it} = \beta_0 + \beta\ (P_{it} - P_{it}^{*}\ ) + \varepsilon_{it} \qquad (8)$$

And $S$ is the log of nominal exchange rate while $\beta_o$ is a constant term. $P$ and $P^*$ are the logs of domestic and foreign price levels respectively; $\varepsilon_t$ is the error term. The main interest of researchers in the early (first) stage was to investigating on whether $\beta$ is close to one or not.

In the second stage of examining PPP, the researchers are only interested on the properties of the log of *q*:

$$q_{it} = S_{it} - (P_{it} - P_{it}^{*}) + \varepsilon_{it} \quad (9)$$

here *q* represents real exchange rate, *S*, *P* and $P^{*}$ are as defined in equation (8). In this setting, the theory of PPP is assumed to hold if *q* is stationary.

While for the third stage, testing PPP deals with co-integration test of long run PPP in the context of both univariate and multivariate framework. As t has been adopted from the study of Nagayasu (2002), the Panel cointegration model will be;

$$S_{it} = \beta_0 + \beta_i(P_t - P_t^{*}) + \varepsilon_{it} \quad (10)$$

For the above cointegration equation, we assumed the values of $\beta_i$(i.e. $\beta_1$ & $\beta_2$) not to change proportionately in the presence of measurement errors, transportation costs, barriers to trade, etc, (Arize *et al*. 2010). Testing PPP based on equation (10) tests whether the equation is stationary for the error term ε. Thus, there exists long run equilibrium between nominal exchange rate and prices.

Therefore, for the purpose of this study, the validity of PPP is been examined in the long run for these sample countries based on the unit root test on *q*, that is, equation (9). Hence:

$$q_{it} = S_{it} - (P_{it} - P_{it}^{*}) + \varepsilon_{it}$$

and to the lesser extent of co-integration among nominal exchange rate, domestic and foreign price levels. Thus:

$$S_{it} = \beta_0 + \beta_i(P_t - P_t^{*}) + \varepsilon_{it}$$

However, as it has been the saying of researchers; that Purchasing Power Parity (PPP) hypothesis does not hold in the short run, while its acceptance as a long run phenomenon remains an empirical argument. The best way to test for the long run PPP is through examining the state of real exchange rates, that is, whether it is a stationary (mean reverting) stochastic process or not. Though the most frequently used unit root procedure in univariate framework is Dickey and Fuller (1979, 1981), but in a bit to solve the Purchasing power parity puzzle, researchers now put more emphasis on the adoption of panel unit root technique, an approach put forward by Levin and Lin (1993). The test was latter named, Levin and Lin test after which it was further reviewed together with Chu in (2002). Levin-Lin & Chu (2002) proposes the act of pooling a cross sectional data in a bit to add more power to the unit root test. The test was designed in such a way that it assumes each individual in the panel has non-stationary residuals with the alternative hypothesis that all individual cross sections have stationary residuals.

Another widely used alternative is the Im., Pesaran & Shin (2003) unit root test. But in this case, their test relaxed the homogeneity restriction in the alternative hypothesis imposed by Levin, Lin & Chu (2002). And the test is also run on any separate individual cross section of the panel, contrary to the panel as a whole.

The above two must use panel unit root tests are considered to check for stationarity in RER as well as other variables of study. While for the cointegration section of the study, the panel co-integration test of Pedroni (1995, 1996) is employed in a bid to examine the long run co-integration relationship between nominal exchange rate and

CPI for the sampled countries. In the same vein, fully modified ordinary least square of Pedroni is also applied to determine the long run coefficients of our parameters.

## 3.3 Estimation of the Procedures

Panel unit root test emanated from the unit root test in time series analysis. However, the main difference between the two tests is that one has to consider the asymptotic behavior of the time series dimension T, and the cross sections N in terms of the panel analysis. The way in which N and T converge to infinity is critical if one wants to determine the asymptotic behavior of estimators and tests used for non-stationary panels. Like we have earlier stated, the two panel unit root tests to be applied in this work are; Levin-Lin and Chu (2002), and Im-Pesaran and Shin (2003). These are discussed in the following sub-sections.

### 3.3.1 Levin-Lin and Chu (2002) Test

Though testing for unit root has become a standard procedure in time series analysis, it has been faulted for its lack of power in rejecting the null hypothesis of unit root. Levin, Lin and Chu (henceforth called LLC in this work) published a thorough discussion on a panel unit root test in 2002, after the work of Levin and Lin (1993). They suggested the following hypothesis:

$H_0$: each time series contains a unit root

$H_1$: each time series is stationary

where the lag order *p* is permitted to vary across individuals. The procedure works as follows:

**i-** First we run augmented Dickey-Fuller (ADF) for each cross-section on the equation:

$$\Delta y_{it}=\rho_i y_{i,t-1}+\sum_{L=1}^{pi}\phi_{iL}\Delta y_{it-L}+\emptyset_{mi}d_{mt}+\varepsilon_{it} \quad (11)$$

where $d_{mt}$ stands for the vector of deterministic variables, while $\propto_{mi}$ is the corresponding vector of coefficients for model $m = 1,2,3$. To be précised, $d_{1t} = \{\text{empty set}\}$, $d_{2t} = \{1\}$ and $d_{3t} = \{1, t\}$. And the lag order $\rho_i$ is permitted to vary across individuals.

For given *T* (time), choose a maximum lag order $\rho_{max}$ and then use $\hat{\theta}_{iL}$ to determine if a smaller lag order is preferred. Under null hypothesis $\theta_{iL}= 0$, both when $\rho_i = 0$ and when $\rho_i < 0$.

Two auxiliary regressions are run after determining the $\rho_i$ to *orthogonalized* the residuals:

1. $\Delta y_{it}$ on $\Delta y_{it-L}$ and $d_{mt}$ to obtain the residuals $\hat{e}_{it}$ and
2. $y_{i,t-1}$ on $\Delta y_{it-L}$ and $d_{mt}$ to get residuals $\overset{\Lambda}{v}_{i,t-1}$

However, someone is also required to perform standardization of the residuals so as to control for variability across *i*.

$$\tilde{e}_{it}=\hat{e}_{it}/\hat{\sigma}_{\varepsilon i} \quad \text{and} \quad \tilde{v}_{it-1}=\hat{v}_{it}/\hat{\sigma}_{\varepsilon i} \quad (12)$$

with $\hat{\sigma}_{\varepsilon i}$ standing for standard error from each ADF regression and for *i= 1,…, N.*

**ii**- The second step involves estimation of the ratio of long-run to short run standard deviations. It was estimated in the first place the long-run variance of Equation (11) by: $\hat{\sigma}_{yi}^2 = \frac{1}{T-1}\sum_{t=2}^{T}\Delta y_{it}^2 + 2\sum_{L=1}^{\overline{K}} w_{\overline{K}L}\left[\frac{1}{T-1}\sum_{t=2+L}^{T}\Delta y_{it}\Delta y_{i,t-L}\right]$ (13)

Where $\overline{K}$ is a truncation lag that can be data-dependent and it must be obtained in manner that ensures the consistency of $\hat{\sigma}_{yi}^2$. For a Bartlett Kernel, $w_{\overline{K}L} = 1 - (\frac{L}{\overline{K}+1})$. For each cross section *i*, the ratio of long run standard deviation to the innovation standard deviation is estimated by, $\hat{s}_i = \frac{\hat{\sigma}_{yi}}{\hat{\sigma}_{\varepsilon i}}$.

The average standard deviation is estimated by:

$$\hat{S}_N = \frac{1}{N}\sum_{i=1}^{N}\hat{s}_i \quad (14)$$

And finally, the pooled OLS regression is run as;

$$\tilde{e}_{it} = \rho\tilde{v}_{it-1} + \widetilde{\varepsilon_{it}} \quad (15)$$

Based on $N\tilde{T}$ observations where $\tilde{T} = T - \bar{\rho} - 1$. $\tilde{T}$ is the average number of observations per individual in the panel with $\bar{\rho} = \sum_{i=1}^{N}\rho_i/N$. Then $\bar{\rho}$ is the average lag order of individual ADF regressions. The conventional *t*-statistics for $H_0$: ρ = 0 is $t_\rho = \frac{\hat{\rho}}{\hat{\sigma}(\hat{\rho})}$ .

#### 3.3.1.1 Other features of LLC

i. The cross dimension N in LLC test is a monotonic function of time dimension T (the necessary condition for the test is $\sqrt{N_T}/T \rightarrow 0$, while sufficient condition would be; $N_T/T \rightarrow 0$ and $N_T/T \rightarrow k$).

ii. The test performed better when N lies between 10 and 250 and T lying between 5 and 250. If T is very small, the test is undersized and has low power.

iii. Among the weaknesses of the test is that it assumed cross-sectional independence.

iv. The null hypothesis that all cross sections have a unit root is very restrictive. That is it does not allow for the intermediate case where some individuals are subject to a unit root and some are not.

v. If T is very large, the authors suggest individual unit root time-series test.

### 3.3.2 Im, Pesaran and Shin (IPS, 2003) Test.

The Im, Pesaran and Shin (2003) test is not as restrictive as the L.L.C (2002), given that it allows for heterogeneity in the model. The model is;

$$y_{i,t} = \alpha_i + \rho_i y_{i,t-1} + \varepsilon_{i,t} \qquad (16)$$

$$t = 1, 2, \ldots, T$$

The null hypothesis is that all individuals follow a unit root process:

$$H_0: \rho_i = 0 \ \forall \ i$$

The alternative hypothesis allows some (but not all) of the individuals to have unit roots:

$$H_1: \begin{cases} \rho_i < 0 \; for \; i = 1, 2, \; \ldots, N_1 \\ \rho_i = for \; i = N_1 + 1, \ldots, N \end{cases}$$

The t-statistics suggested by Im, Pesaran and Shin is given as;

$$\bar{t} = \frac{1}{N} \sum_{i=1}^{N} t_{\rho i}, \qquad (17)$$

where $t_{\rho i}$ is the individual t-statistic for testing the null hypothesis: $\rho_i$ = 0 for all *i*.

In the general case where the lag order $\rho_i$ may be nonzero for some cross-sections, IPS show that a properly standardized $\bar{t}$ has an asymptotic N(0,1) distribution. It is known that for a fixed N,

$$\mathrm{t}_{\rho_i} \Rightarrow \frac{\int_0^1 \mathrm{W_{iZ}} \mathrm{dW_{iZ}}}{\left[\int_0^1 \mathrm{W_{iZ}^2}\right]} = \mathrm{t_{iT}} \qquad (18)$$

as

T→∞ where √ W(r) dr denotes a Wiener intergral with argument r suppressed in. They also assume that $\mathrm{t_{iT}}$ are i.i.d and have finite means and variance. Monto Carlo simulations revealed that the small sample performance of the Im, Pesaran-Shin is better than Levin-Lin-Chu test.

Their test requires N/T → 0 for N → ∞. If either N is small or if N is large relative to T, then both Im-Pesaran-Shin and Levin-Lin-Chu show size distortions. And the test also tends to have little power if deterministic terms are included in the model.

#### 3.3.2.1 Other features of Im-Pesaran-Shin (2003)

i. The test assumes that T is the same for all cross-section units and hence E($t_{i,T}$) and V($t_{i,T}$) are the same for all *i*, so the IPS test is applied only for balanced panel data.

ii. In the case of serial correlation, IPS proposed using the ADF t-test for individual series. Hence E($t_{i,T}$) and V($t_{i,T}$) will have to vary as the lag length included in the ADF regression varies.

## 3.4 Panel Co-integration

The next step and also the second part of this research is the test for the long-run validity of PPP which test for the existence or presence of a long-run relationship among the nominal exchange rate, domestic consumer price index and the foreign consumer price index with US taken as the foreign country. For the panel co-integration, the Pedroni (1995, 1996) co-integration technique is adopted. This Panel co-integration technique has allowed for estimation and test of hypothesis for common co-integrating vectors that are in line with the degree of heterogeneity assumed in the adopted panel unit root tests and co-integration studies. Being identified with accommodating a considerable heterogeneity across members of the panel, Pedroni panel methodology allows researchers to extract the long run information contained in the panel while permitting the short run dynamics and fixed effects to be heterogeneous among different members of the panel.

Extending the two step strategies of Engle and Granger (1987) to panels while relying on ADF and PP principles, the Pedroni test make use of seven panel statistics. In practice, the co-integrating equation is first estimated separately for

every individual panel, and then the residuals are subjected to a unit root test. The residuals are pooled either along the within or the between dimension of the panel, which thus form the panel and group mean statistics. Thus, long run co-integration or equilibrium exchange rates exist if the null hypothesis of no co-integration is rejected.

The methodology proposed by Pedroni makes use of the estimated residuals from the hypothesized long-run regression of the following form:

$$y_{i,t} = \alpha_i + \delta_i t + \beta_{1i} x_{1i,t} + \beta_{2i} x_{2i,t} + \ldots + \beta_{Mi} x_{Mi,t} + e_{i,t} \qquad (19)$$

$t = 1, \ldots, T;\quad i = 1,\ldots,N;$ and $m = 1, \ldots, M,$

with T number of observations over time, N number of cross-sections and M taken as regressors included in the model. While $\alpha_i$ is representing fixed effects parameter which assumed to vary across individual cross-sections. And $\delta_i t$ is the slope coefficient and specific time effect for any member.

The null hypothesis test of no co-integration is tested based on whether residuals (errors) $e_{it}$ are stationary processes or not. Thus;

$\rho_i = 1$ given

$$\hat{e}_{it} = \rho_i \hat{e}_{it-1} + v_{it}$$

Pedroni has presented seven different tests grouped into two co-integration statistics. They are designed to test the null hypothesis of no co-integration between the variables in model (19) above, against the alternative hypothesis of co-integration.

The first category of the four statistics is what Pedroni labels as within-dimension statistic or Panel *t*-statistic which includes a variance ratio statistic, a non-parametric Philips and perron type $\rho$-statistic, a non-parametric Phillips and Perron type *t*-statistic and a Dickey-Fuller type *t*-statistic. They involved testing the hypothesis:

$$H_0 : \rho = 1,$$

$$H_1 : \rho < 1$$

While the second category are the three panel cointegration statistics defined as a between-dimension statistic or Group *t*-statistic including a Phillips and Perron type $\rho$-statistic, a non-parametric Phillips and Perron type *t*-statistic and finally an Augmented Dickey-Fuller type *t*-statistic which also tests:

$$H_0 : \rho_i = 1,$$

$$H_1 : \rho_i < 1 \qquad \text{for all } i.$$

The seven co-integration statistics of the Pedroni Panel analysis are given as follows:

a. Panel *v*-statistic:

$$T^2 N^{3/2} Z_{\hat{v},N,T} = T^2 N^{3/2} \left( \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{e}_{i,t-1}^2 \right)^{-1} \tag{20}$$

b. Panel $\rho$-Statistic:

$$T\sqrt{N} Z_{\hat{\rho}N,T-1} = T\sqrt{N} \left( \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{e}_{i,t-1}^2 \right)^{-1} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \left( \hat{e}_{i,t-1} \Delta \hat{e}_{i,t} - \hat{\lambda}_i \right) \tag{21}$$

c. Panel *t*-Statistic (non-parametric):

$$Z_{tN,T} = \left( \tilde{\sigma}^2_{N,T} \sum_{I=1}^{N} \sum_{T=1}^{T} \hat{L}^{-2}_{11i} \hat{e}^2_{i,t-1} \right)^{-1/2} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}^{-2}_{11i} \hat{e}^2_{i,t-1} \left( \hat{e}_{i,t-1} \Delta \hat{e}_{i,t} - \hat{\lambda}_i \right) \tag{22}$$

d. Panel t-Statistic (parametric):

$$Z^*_{tN,T} = \left( \tilde{s}^2_{N,T} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}^{-2}_{11i} \hat{e}^{*2}_{i,t-1} \right)^{-1/2} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}^{-2}_{11i} \hat{e}^*_{i,t-1} \Delta \hat{e}^*_{i,t} \tag{23}$$

e. Group $\rho$-Statistic:

$$TN^{-1/2} \tilde{Z}_{\hat{\rho}N,T^{-1}} = TN^{-1/2} \sum_{i=1}^{N} \left( \sum_{t=1}^{T} \hat{e}^2_{i,t-1} \right)^{-1} \sum_{t=1}^{T} \left( \hat{e}_{i,t-1} \Delta \hat{e}_{i,t} - \hat{\lambda}_i \right) \tag{24}$$

f. Group *t*-Statistic (non-parametric);

$$N^{-1/2} \tilde{Z}_{tN,T^{-1}} = N^{-1/2} \sum_{i=1}^{N} \left( \sum_{t=1}^{T} \hat{e}^2_{i,t-1} \right)^{-1/2} \sum_{t=1}^{T} \left( \hat{e}_{i,t-1} \Delta \hat{e}_{i,t} - \hat{\lambda}_i \right) \tag{25}$$

g. Group t-Statistic (parametric):

$$N^{-1/2} \tilde{Z}^*_{tN,T} = N^{-1/2} \sum_{i=1}^{N} \left( \sum_{t=1}^{T} \hat{s}^{*2}_i \hat{e}^{*2}_{i,t-1} \right)^{-1/2} \sum_{t=1}^{T} \hat{e}^*_{i,t-1} \Delta \hat{e}^*_{i,t} \tag{26}$$

where the residuals $\hat{\mu}_{i,t}$, $\hat{\mu}^*_{i,t}$, and $\hat{\eta}_{i,t}$ are obtained from the regressions of the following:

$$\hat{e}_{i,t} = \hat{\gamma}_i \hat{e}_{i,t-1} + \hat{\mu}_{i,t} \quad (27)$$

$$\hat{e}_{i,t} = \hat{\gamma}_i \hat{e}_{i,t-1} + \sum_{k=1}^{K_i} \hat{\gamma}_{i,k} \Delta \hat{e}_{i,t-k} + \hat{\mu}^*_{i,t} \quad (28)$$

$$\Delta y_{i,t} = \sum_{m=1}^{M} \hat{b}_{mi} \Delta x_{mi,t} + \hat{\eta}_{i,t}$$

Rescaling the above seven statistics, they are thus distributed as standard normal. For the standardization of the co-integration statistics, it is expressed as;

$$\frac{K_{NT} - \mu\sqrt{N}}{\sqrt{v}} \Rightarrow N(0,1) \quad (29)$$

Where $K_{NT}$ is the standardized form of the test statistics with respect to *N* and *T*.

### 3.5 Fully Modified OLS (FMOLS) Panel Estimates

The panel test suggested by Pedroni (1995 & 1996) proposed several tests for the null hypothesis of co-integration in a panel data that allows for a considerable heterogeneity. His test can be classified into two categories. The first category is similar to the panel tests of Kao (1999) and McCoskey and Kao (1999) that involved averaging tests statistics in the time series across cross-sections. While for the second set, the averaging is done in pieces so that the limiting distributions are based on limits of piecewise numerator and denominator terms.

Estimation based on this technique is there to accommodate the heterogeneity that existed in transitional serial correlation dynamic and in the long run co-integration relationship. Thus, the advantage of using this estimation is; correcting the standard OLS bias caused by the endogeneity and serial correlation of the regressors.

The starting point in the Pedroni co-integrating system for panel analysis starts with;

$$y_{it} = \alpha_i + x'_{it}\beta + e_{it} \tag{30}$$

and where

$$x_{it} = x_{i,t-1} + \varepsilon_{it} \tag{31}$$

where $\xi_{it} = [e_{it}, \varepsilon'_{it}]$ is taken to be stationary with covariance matrix of $\Omega_i$. The estimator $\beta$ will be consistent when the error process $\omega_{it} + [e_{it}, \varepsilon'_{it}]'$ satisfies the assumption of cointegration between $y_{it}$ and $x_{it}$. FMOLS Pedroni's estimator is constructed as follow:

$$\hat{\beta}_{FM} - \beta = \left( \sum_{i=1}^{N} \hat{\Omega}_{22i}^{-2} \sum_{t=1}^{T} (x_{it} - \hat{x}_t)^2 \right)^{-1} \sum_{i=1}^{N} \hat{\Omega}_{11i}^{-1} \hat{\Omega}_{22i}^{-1} \left( \sum_{t=1}^{T} (x_{it} - \bar{x}_t) e_{it}^* - T\hat{\gamma}_i \right) \tag{32}$$

$$\hat{e}_{it}^* = e_{it} - \hat{\Omega}_{22i}^{-1} \hat{\Omega}_{21i}, \qquad \hat{\gamma}_i = \hat{\Gamma}_{21i} + \hat{\Omega}_{21i}^0 - \hat{\Omega}_{22i}^{-1} \hat{\Omega}_{21i} \left( \hat{\Gamma}_{22i} + \hat{\Omega}_{22i}^0 \right) \tag{33}$$

where the covariance matrix can be decomposed as $\Omega_i = \Omega_i^0 + \Gamma_i + \Gamma_i$ where $\Omega_i^0$ is the contemporaneous covariance matrix, and $\Gamma_i$ is a weighted sum of autocovariances. Also, $\hat{\Omega}_i^0$ denotes an appropriate estimator of $\Omega_i^0$.

However, in most studies researchers report both the group as well as the individual FMOLS results so as to enable them comparability. But given the objective of this research is not to analyze these countries on separate grounds, only the overall group FMOLS are reported to enable examining the effect and magnitude of this impact on the dependent variable of the independent variables.

### 3.6 Data description and it sources

The purchasing power parity theory is tested in this study using the real and nominal exchange rates, and inflation rates (CPI) for the selected sample countries, with U.S as the base (foreign country). The data is obtained from the world development indicators and the IMF online data base. This therefore, testified on the relative reliability of its sources. The validity of Purchasing Power Parity is studied taking the sample of eleven different African countries from different regions of the continent. These countries are; Algeria, Cameroon, Cot` devour, Gabon, Gambia, Ghana, Malawi, Nigeria, Niger, South Africa, Togo and Uganda with the US serving as the base country.

In a bit to avoid the possibility of misleading result that may originate from bias caused by country homogeneity in the panel, the sample countries were choose randomly from different regions of the continent. This would also enable examining the argument raised by Shiller (2013) relating the validity of PPP to particular countries of study.

The research includes annual observations of real exchange rates and CPI starting from 1980 to 2012 (with 2010 taken as the base year). To accomplish the task of estimating for the long run co-integration, data on nominal exchange rates for the sampled countries from 1980-2012 was also obtained. These data thus contained 32 observations for each country for all the three different variables used.

# CHAPTER 4

# EMPIRICAL ANALYSIS AND FINDINGS

## 4.1 Introduction

The validity or evidence of PPP can be tested through conducting a unit root test on the real exchange rate $q$ data for the countries studied. If it was found to be stationary then PPP is said to occur and if otherwise, the validity of the theory under the first approach (i.e. the unit-root test of PPP) is rejected. It has been mentioned also earlier that this research will adopt both the unit-root approach of testing for PPP, coming down to the test of a weaker form of PPP through testing for the long-run co-integration among the nominal exchange rate, domestic as well as foreign consumer price indexes.

## 4.2 Panel Unit Root Test Results

Data estimation in the first stage of this work is done by conducting the two mentioned unit-root tests of LLC (2002) and Im, Pesaran and Shin (2003). Given that Levin-Lin and Chu panel unit-root test is criticized on being a common (homogeneity assumption) unit root test process, it has been employed together with it the heterogeneous Panel unit-root test of Im, Pesaran and Shin (2003) to handle the individual unit root test for the panel. Thus, the study is therefore expected to present a robust unit-root test of PPP given the two different panel unit-root tests employed.

The first step taken was the unit-root test on the real exchange rate data for the whole cross-sections of these sampled countries. Table 4.1 below has presented the various results for both LLC and IPS.

As it will be observed, the unit-root tests were conducted under two different scenarios; that is a test that includes linear trend in the estimations and that which does not. Plotting the whole series individually before the estimations provided an information that the whole series have a linear trend in them. That is, a trend is needed to be included while choosing the options for estimations if a correct model specification is to be used. However, it was also decided to run for the same unit roots without including the trend so as to see how the empirical results may behave. Therefore, as Table 4.1 contained unit-root results without linear trend, while the unit-root results that incorporated linear trend are presented in Table 4.2 below.

**Table 4. 1: Panel Unit-Root Test Results without Linear Trend**

| Variables | Levin-Lin & Chu Test | | Im- pesaran & Shin Test | |
|---|---|---|---|---|
| | Level | First Diff | Level | First Diff |
| LogRER | -4.17185*** | - | -2.15665*** | - |
| LogNER | 7.22579 | -3.87862*** | 8.06493 | -7.54672*** |
| LogCPI | 10.9358 | -2.66031*** | 13.4075 | -3.60304*** |
| LogCPI* | -0.27986 | -11.9455*** | -0.18606 | -5.29630*** |

Note: (***), (**) and (*) indicate the rejection of the hypothesis of unit-root at 1%, 5% and 10% significance level respectively.

If a careful study is to be given to the above presented panel unit-root results, the first plausible glance one can have is seeing that the real exchange rate to be stationary process. Given the two unit root tests applied, if one was to test the model without

including a linear trend, one would be said to believe that *RER* is a stationary process, a result that could prove strong evidence in favor of PPP. However, for the *NER, CPI and CPI** all the two tests (LLC and IPS) provide a picture indicating that all the series are I(1`s) processes even though no linear trend was included to the model. Hence, this therefore may serve as another clue on the long-run co-integration that could be obtained when model (10) was to be estimated.

**Table 4. 2: Panel Unit-Root Test Results with Linear Trend**

| Variables | LLC Test | | Im, Pesaran & Shin | |
|---|---|---|---|---|
| | Level | First Diff | Level | First Diff |
| LogRER | 0.3348 | -7.78715*** | 2.06687 | -4.56646*** |
| LogNER | 2.81149 | -8.17383*** | 2.1079 | -8.42097*** |
| LogCPI | 4.93180 | -4.74480*** | 5.88426 | -4.82077*** |
| LogCPI* | 0.58894 | -9.67526*** | -2.54903 | -5.23542*** |

Note: (***), (**) and (*) indicate the rejection of the hypothesis of unit-root at 1%, 5% and 10% significance level respectively.

Contrary to the unit-root results obtained when a linear trend was not included, a different look of things was seen after conducting a different unit root tests that incorporated a linear trend in the model. As one can observed, all of the other variables that were shown to be an I(1) processes previously do not change except for the *RER*. The slight difference is that a close study of their empirical results showed a little improvement in their probabilities even though, yet they appeared not to be stationary processes.

Taking the *RER* on to the stage, inclusion of linear trend does not favor the result which in this case proving that real exchange of these countries of study are not mean reverting. That is, *RER* appeared non-stationary in this respect. This result is hence similar to that obtained by Nagayasu (2002) whose study appeared sensitive to the inclusion of time dummies or its absence. He pointed out that he was only able to reject the null hypothesis of the unit-root when he includes time dummy in his estimations.

The inclusion of the trend in the model was necessitated as pointed earlier when one should have visual look at the graphical plots of the whole series. These series all exhibited a trend in their natures; hence it became necessary when choosing the right option in the estimation to take into cognizance the trend. Therefore, based on the second table representing estimates with trend, it has been concluded that all the series including real exchange rates are non-stationary processes. Consequently, the result thus is invalidating the evidence on the strong form of PPP theory.

However, one needs not to worry by the nature of the results obtained by including the linear trend. This is because looking at the individual country results given in the Im, Pesaran and Shin which as it was stated takes the unit root in form of individual cross-sections. Apart from real exchange rate for Ghana and Uganda, no any other country seems stationary at country level. Table 4.3 presents the individual cross sections result for each country with or without including the linear trend.

Therefore, looking into the individual results obtained for every country, it testifies that the conclusion derived on the overall non-stationarity of the real exchange rate

of these countries is something to take home about. No any cross section of country if not Ghana and Uganda has validated the existence of PPP at its country level. However, even the stationarity obtained in respect of the two countries was due to non-inclusion of the linear trend. But after including trend in the model, the whole cross sections result proved non-stationary.

**Table 4. 3: Individual Cross-Sections for Im, Pesaran and Shin Unit Root Test Results**

| Cross sections | Without Trend | | With Trend | |
|---|---|---|---|---|
| | t- statistics | Prob. | t-statistics | Prob. |
| Algeria | -1.5564 | 0.4927 | -0.1612 | 0.9912 |
| Cameroon | -2.198 | 0.1722 | -2.0663 | 0.5441 |
| Cote d'Ivoire | -2.3198 | 0.1722 | -2.0663 | 0.5441 |
| Gabon | -2.3198 | 0.1722 | -2.0663 | 0.5441 |
| Gambia, The | -1.9292 | 0.3152 | -2.4373 | 0.3546 |
| Ghana | -3.2332 | 0.0271*** | -1.2492 | 0.8824 |
| Malawi | -0.3568 | 0.9050 | -2.0173 | 0.5694 |
| Nigeria | -1.6672 | 0.4378 | -0.8873 | 0.9453 |
| S. Africa | -2.4365 | 0.1402 | -1.6947 | 0.7302 |
| Togo | -2.3198 | 0.1722 | -2.0663 | 0.5441 |
| Uganda | -2.6781 | 0.0892* | -1.4684 | 0.8189 |

Note: (***) , (**) and (*) indicate significance level at 1%, 5% and 10% respectively.

Nevertheless, since the scope of this research has includes the test of weak form of PPP hypothesis, then the research is allowed with the last option of testing to see if this theory would be acceptable in this side of the coin; which proponents of the theory termed as a weak form of PPP.

## 4.3 Panel Co-integration Test Results

Prior to testing for the long-run co-integration among these variables, one has to be sure that they are all integrated of order one, that is *i* (1) processes. As it has been shown in Table 4.1, the nominal exchange rate, domestic and the foreign price levels are integrated of order one. This hence provides the opportunity to estimate the long-run model.

For the panel estimation of the long-run co-integration equation, the Pedroni (1995 & 1996) test is applied. The Pedroni test gives seven different long-run statistics which have to be significant before one can assume the long-run relationship in the variables. The relationship can be tested via Panel V- Stat, Panel Rho- Stat, Panel PP- Stat, Panel Adf- Stat, Group Rho- Stat, Group PP- Stat and Group Panel PP-Stat. If these statistic values are found to be statically significant (meaning the null hypothesis of no co-integration is rejected), then the model is said to have a long run relationship. The test statistics are in panel and individual statistics as well. A common AR coefficient within dimension in the panel statistics is the same way saying that our model is co-integrated. Thus, the null hypothesis is stating that there is no common AR coefficient within the dimension, which in the same vein meaning the absent of long-run relationship in our model. While in the group statistics, the AR coefficient is allowed to vary across the cross-sections. By rejecting the null hypothesis, co-integration thus is said to be present. Table 4.4 below has presented the seven different panel co-integration statistics.

**Table 4. 4: Pedroni Residual Co-integration Test Results**

| Panel coint. statistics(within-dimension) | With Linear Trend | Without Lear Trend |
|---|---|---|
| Panel v-statistic | 0.999262 | 0.791158 |
| Panel Rho-statistic | -1.315844* | -1.65488** |
| Panel PP-statistic | -2.907462*** | - 3.456161*** |
| Panel ADF-statistic | -2.983530*** | -3.612347*** |
| Group mean cointegration statistics (between-dimension) | | |
| Group PP-statistic | -10.170004 | -0.495475 |
| Group PP-statistic | -2.615493*** | -3.011547*** |
| Group ADF-statistic | -3.617295*** | -3.604000*** |

Note: (***), (**) and (*) are indicating rejection of the hypothesis of no co-integration at 1%, 5% and 10% significance level.

Out of the four statistics in the panel co-integration statistics, only the panel V-statistics is found not be significant even at 10%. And likewise for the group means co-integration statistics, group PP-statistics was found not also to be significant.

From the Panel co-integration results in Table 4.4 above, a strong support to reject the null hypothesis of no co-integration in five out of the seven embedded statistics was shown in the Pedroni panel co-integration technique. Though, a strong support for mean reversion in real exchange rates for the sampled countries could not be obtained, but testing for the long run relationship revealed evidence portraying that in the long run these series tend to move together, suggesting a weak form of purchasing power parity theory. This result can said to be in line with the findings obtained in Nagayasu (2002) who also could only finds a weak support for the theory as he studied some selected African nations.

## 4.4 Fully Modified Ordinary Least Square (FMOLS)

With the evidence on the long-run relationship among these variables of concern, it is now safe to estimate the long run parameters of the model employing the FMOLS technique. As provided by Pedroni (1995 & 1996), the FMOLS corrects the endogeneity and serial correlation biases of the regressors in OLS. It does not only provide asymptotically unbiased estimators, but produces a nuisance parameter with free standard normal distribution. Though Panels composed of aggregate national data are prevalent with a considerable degree of short run heterogeneity, but applying the FMOLS, inferences can be made while the short run heterogeneity effects are corrected. The elasticity or the sensitivity of exchange rates to any movement or changes in either domestic or foreign prices (CPI or CPI*) is relevant to understanding the appropriate channel to a correct exchange rate modeling and necessary steps to be taken if corrections are meant in any economy. Therefore, the FMOLS is estimated to see which of the two independent variables is said to affect exchange rate significantly.

Table 4.5 below has provided the results for the group mean FMOLS estimators. It was decided to report only the group mean without reporting the individual FMOLS results for the model. This is because the scope of this research only concerns the final coefficients of the variables for the panel as a whole, but does not intend to make any comparison between the group mean FMOLS and the reported individual FMOLS estimates.

**Table 4. 5: Fully Modified OLS Estimates**

| Variables | Coefficients without Time Trend | Coefficients with Linear Time Trend |
|---|---|---|
| LogCPI | 0.701141*** | 0.851321*** |
| | (8.38094) | (15.89328) |
| LogCPI* | 0.226591 | -0.645695* |
| | (0.975262) | (-1.707686) |

Note: (***), (**) and (*) shows levels of significance at 1%, 5% and 10% respectively.

The FMOLS results of the regression equation with *NER* as the dependent variable illustrates that the coefficient of *CPI* is positive and significant even at 1% significance level. By implication, based on the estimated FMOLS results, any change or policy targeted at the domestic price levels may affect the exchange rates by about 85%. This result does not therefore deviate from macro-economic theories postulating changes in domestic prices to affect any changes in exchange rates in the long run.

But for the *CPI**, the coefficient is negative at the same time insignificant. The probability is seen to be very high that we can only accept that *CPI** affects exchange rate in the long run at 10% level of significance. But because the probability is above 10%, it is now concluded that *CPI** does not affect exchange rate as far as this model is concern.

# CHAPTER 5

# CONCLUSIONS AND POLICY IMPLICATIONS

## 5.1 Introduction

This chapter presents the discussion of the major findings which include the summary of the three different tests conducted and their results. Section 5.2 contained the discussions of the major findings of the research. And section 5.3 represents the overall summary, while policy implications shown in section 5.4. Concluding remarks is presented in section 5.5.

## 5.2 Discussions of Major Findings

The validity of long run PPP is analyzed using two approaches of Panel unit root tests (LLC (2002) and IPS (2003) ) and Panel co-integration technique of Pedroni (1995, 1996).

Based on the t-statistics and their corresponding probability levels, the data provide some sort of support to a weak form of PPP in the long run. In the absence of linear trend in the model, a support for a strong form of PPP given both the two unit root tests employed was seen. However, even on this specification, when one looks at the IPS unit root test result representing the individual cross sections, only two countries of Ghana and Uganda seem to support the PPP theory at the country level. Including the linear trend, under both the two test the null hypothesis of the unit root in real exchange rates of these samples could not be rejected. And because of the reason stated earlier, the correct specification of the model should be with a linear trend;

hence, the first approach adopted in this research fails to support the strong version of PPP theory. This is however, not contrary to results obtained in so many different researches which Alba & Park (2003), Nagayasu (2002) and Pan *et al*. (2012) are inclusive. Their studies could only get weak support to PPP either by employing a unit root approach with symmetric models, or unit root approaches and co-integration with asymmetric models. Also Su *et al.* (2002) could only get support of PPP in four of the 15 African countries he studied using a non-linear approach.

Panel co-integration however, showed that PPP holds in the long run for a group these selected African countries. Applying the Panel co-integration technique, a t-statistic big enough to reject the null hypothesis of no co-integration was obtained. And this is feasible even when the model with linear trend is to be considered. Impliedly, it would be said that a long run relationship is established between the variables of study. As stated by M. Azali *et al.* (2001), not only strengthen the power of the test, Panel study of PPP provides more informative data with more variability and degrees of freedom. Hence the result is much similar or same when other studies conducted either on Africa or even developed countries were to be analyzed. As stated, the study of Nagayasu (2002) on African countries supported the co-integration form of PPP in his study. Studies such as that of Taylor and Taylor (2002), Wu (1996) and the likes could serve as examples in developed nations.

Employing the Fully-Modified OLS technique, the results for the coefficients of the long run model was obtained. The empirical results are suggesting that the coefficient of *CPI* is positive and significant at 1%, that is, exchange rates is influenced largely by domestic changes in prices rather than by inflation in the US.

## 5.3 Conclusions

Almost since early to mid-1980s African countries witnessed the implementation of different macro-economic and other structural adjustment programs with exchange rate policies as the focal issue (Su *et al*. 2012). This gives light on how relevant examining the validity of PPP in Africa would be. Kargbo (2003) stated that, most of the exchange rate policy modifications implemented in Africa were on the assumption of purchasing power parity validity. Therefore, a study like this should be considered relevant to providing useful information especially to policy making in the particular countries of analysis.

The research investigated the purchasing power parity theory selecting a group of eleven developing countries of Africa ranging through 1980-2012. The official exchange rates and price levels for these countries were used with the US as foreign country. Two approaches of Panel unit root and Panel co-integration were applied. Though the unit root test failed to attest for a strong PPP in this research, however, applying the Panel co-integration technique showed a remarkable result.

It has been argued that the presence of PPP is likely to be weakened by a high volatility in external financial flows of a particular country, in view of this study; empirical results give a support to the existence of long run PPP upon different constraints facing these countries. Studies such as that of Holmes (2000), Drine & Rault (2008) have all found that PPP is in most cases accepted in high and moderate inflation countries. In general, the out-come in this research is said to be in line with the theoretical predictions relating the acceptance of purchasing power parity to a more inflationary economies.

As it has being written in the words of Chang *et al* (2011), countries with high monetary growth and inflation might be faced with deviations from purchasing power parity in the short run, but in the long run, PPP should hold where prices and nominal exchange rates are expected to compensate each other. Given this research, it is therefore concluded that prices especially the domestic price levels are found to be the major determinants to the exchange rates equilibrium. This has gone with what Cheng, (1999), Kargbo (2003) and Arize *et al*. (2010) showed in their papers. In A.C Arize *et al* (2010), 10-37% of the ahead forecast error variance in exchange rates was found to be accounted for by domestic prices. While Cheng (1999) suggested that if the two countries (Japan & U.S) in his study can maintain stable price between them, then impliedly PPP would be feasible in the long-run.

In conclusion, even though, a support for the strong PPP based on the panel unit root conducted could not be obtained, results from the co-integration estimates does indicate support for a weak form of PPP theory. Meaning there is hope for prices and exchange rates to adjust in the future towards long run equilibrium. Empirical findings indicate that based on the studied data, price adjustments are sufficient to revert back the real exchange rates to stability point. And given the non-stationarity of real exchange rates at level, the respective currencies of these countries are found not to be tied rigidly to the US dollar. Likewise, closely observing the individual unit root test results presented by IPS, one might simply belief that these findings are in line with the economic theory and other major studies attributing purchasing power parity to a highly inflationary economy. Thus, it is more common to reject the unit root hypothesis of exchange rates for countries with high and moderate inflations.

Lastly, this research work could be said to add to the existing literatures validating the theory of purchasing power parity in Africa as a region. Even though, a strong support was not obtained, but evidence in favor of weak form of PPP was seen given the long run cointegration results.

## 5.4 Policy Implications

Based on the conclusions derived in the previous sections of this research, the below important policy implications are deemed presented. Haven the purchasing power parity theory to be valid in the long run, the theory could now be used as a benchmark to determining equilibrium exchange rates in the future. Purchasing power parity theory may therefore, be used as a guide towards a better exchange rate policies. However, the unbounded gains reaped from arbitraging in trade seems unfeasible given that prices are expected to equalized at a point in the future, which may hence left the arbitrageurs unprofitable.

Moreover, because studies have showed most of African countries in recent years adopted different IMF and World Bank trade policies, one would expect to see more plausible evidence to parity conditions as openness to trade and price liberalization become intensified. However, a serious precaution should be taken when designing these policies. The fact still remained; real exchange rate may likely appreciate due to a large and continuous capital inflows. And this could either come from more foreign direct investment, or capital account liberalization.

As it was made clear in the work of Drine & Rault (2008), trade liberalizations appear to be a common phenomenon in developing countries in particular, but with

respect to our sample countries more is requested to put on grown. One would not expect to see the presence of tariff and non-tariff trade barriers still in this part of the world, given the advocated trade policies embarked up on in the region. A complete openness and abolishing of all sorts of trade barriers could improve the living standards of populace.

## 5.5 Limitations of the Study

Among the limitation of this study was that the long run coefficients of the model were only obtained through estimating the FMOLS without including any variable that may possibly affect exchange rate behavior. This therefore means that the result of the long run parameters might have likely suffered from multicollinearity. Even though, domestic price levels were obtained to significantly affect the long run equilibrium in exchange rates, the result could be misleading due to the likely multicollinearity problem.

Although number of researchers have been using official exchange rate in testing PPP, yet there is a considerable difference in what is considered most appropriate. It has was stated by Bahmani-Oskooee & Hegerty (2009) that, tests of PPP base on bilateral exchange rates would reflect the actual supply and demand pressures within a certain economy. Therefore, testing PPP in that context may show the efficiency or not of the markets for the foreign currency. In this regard, this study is said to be limited to using the official exchange rate for it`s easier source and convenience in terms of estimations and comparisons.

Plethora of literatures argued that, testing PPP using the whole sale price index (WPI) should give results that empirically do better on validating the theory. This is to the reason that it has includes greater proportion of traded goods than CPI, (Froot & Rogoff 1996) and Bela (1964). Therefore, due to the presence of non-tradable goods in CPI indices, researches basing their analysis on it may likely suffer from spurious inferences. Thus, it is now also made clear that this particular study is limited to applying CPI rather than the prepared WPI.

## 5.6 Suggestion for Future Studies

Although this research is able to see the existence of prices adjusting in the long run to revert back equilibrium in the exchange rates, it did not cover to show how long it would take to comeback to equilibrium (half-life). A lot is needed in that area because only few studies were able to visit the section especially coming to Africa as a study ground. In the same way, a further research is expected to be conducted in the future which is capable of suggesting to individual countries in this research a possible ways the suggested better exchange rate policies could be achieved.

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