An Empirical Test of Purchasing Power Parity in Selected African Countries - a Panel Data Approach

Beatrice Kalinda Mkenda

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Department of Economics
Göteborg University

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Keywords: Purchasing Power Parity, Real Exchange Rate, Africa, Panel Data.

JEL Classification: C33; F44; O55.

Department of Economics
Göteborg University
Box 640
SE 405 30 Göteborg
E-mail Beatrice.Kalinda@economics.gu.se

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Beatrice Kalinda Mkenda
Department of Economics
P O Box 640
SE 405 30 Göteborg
SWEDEN.

Beatrice.Kalinda@economics.gu.se

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1 Introduction

This paper aims at testing one of the most controversial theories in international economics - Purchasing Power Parity (hereafter, *PPP*). The theory in its various versions relates the exchange rate between any two currencies to the relative price levels in the respective countries. The implication is that a country with inflation higher than that of her trading partners will tend to have a depreciating currency. Although at times *PPP* has often failed to stand empirical tests and its theoretical content of exchange rate determination has been questioned, it has continued to be pervasive in macroeconomic models. *PPP* is still implicit and also explicit in many models of exchange rate determination, and is also used as a yardstick of openness of an economy in macroeconomic models. On the policy front, *PPP*-based benchmarks have been used to assess levels of exchange rates in a bid to establish the need, extent and the direction of adjustment.

The pervasiveness of *PPP* in economics has gone hand in hand with the literature on the empirical tests of the theory. Most of these tests have been done in developed countries. Very few such studies have been done in Africa. This paper is an attempt at testing the theory on a panel of twenty African countries. In this regard, it is worth highlighting some striking features of the economies of the African countries included in our study.

The first feature is that virtually all the African countries rely on exporting primary products for foreign exchange earnings. The products are agricultural, such as coffee in the cases of Kenya and Tanzania, and cocoa in the case of Ghana; minerals, in the case of Zambia, Zimbabwe, and South Africa; and oil in the case of Nigeria. When these countries sell their products on the international market, individually, they do not command a large share of the market. As such, they are basically price-takers, who cannot influence the price of their products.

The second striking feature is that except for South Africa, and to some extent Zimbabwe, manufacturing activities, although they exist, are marginal. Most African countries, upon getting their independence invested in import-substituting industries that heavily relied on imported inputs. As foreign exchange earnings dwindled due to falling prices of their exports on the international market, their industries collapsed. Due to weak manufacturing industries, these countries rely on importing manufactured goods from industrialised countries. In the import market, African countries are also price-takers, but the difference is that they can decide not to buy products from countries where prices are higher. In some cases, however, when aid is tied to products from donor countries, they do not have much of a choice.

The third feature is that inter-country trade between African countries is small. Trade is not only hampered by small manufacturing activities, but also by lack of developed infrastructure to connect different countries, and other transaction costs. The high transaction costs and poor infrastructure lead to trade being regionally based as proximity to one another reduces some of the transaction costs. For example, in Table A in the appendix, we can identify some regional-based trade: West African countries such as Nigeria and Côte d'Ivoire feature prominently in trading with other West African countries; Kenya in East Africa trades with other East African countries, while South Africa dominates trade with other countries in Southern Africa.

The last feature pertains to exchange rate regimes. Tables B and C in the appendix classifies the exchange rate regimes that the countries pursued during the sample period. It is important to point out that most of these countries have changed regimes over time, although the current trend is that they are adopting more

flexible regimes (see also Nagayasu, 1998). We will not discuss the changes on a detailed level, but we shall merely point out the broad features.

Before the 1980s, most of the currencies were fixed and not convertible. As such, foreign exchange markets were dominated by controls and rationing. The most popular currency which they pegged their currencies to was the United States dollar. However, after mid 1980s, most of the countries undertook structural adjustment programmes to restructure their economies. One of the major policy recommendations of the programmes was that the countries had to devalue their currencies to make their exports more competitive. By the late 1980s and into the 1990s, most countries liberalised their economies, by moving towards market-determined exchange rates and by lowering tariffs in order to encourage more trade. However, although economic liberalisation seems to have swept the whole of Africa, there still remains some controls in some of the countries.

In light of these particular attributes of African countries, it is of interest to investigate the following issue:

- Given that African countries trade mostly with industrialised countries, to what extent are changes in the nominal exchange rates in African countries influenced by their price levels relative to that of their trading partners?

It should be noted that in the literature, *PPP* is more likely to hold among countries with similar consumption patterns. African countries and industrialised countries can hardly be said to have similar consumption patterns. On the other hand, African countries have tended to have high inflation, mostly two digits, compared to their main trading partners who have had low inflation. Generally, *PPP* has been found to hold in high inflation countries (Rogoff, 1996).

For a long period of time, most African countries pursued fixed and controlled exchange rate regimes. In other words, the exchange rates were fixed by decree of the state. Thus, rationing, rather than market forces, was used to deal with shortages. This seems to rule out any relevance of official nominal exchange rates in testing for *PPP*. However, these countries undertook occasional devaluations and it might be that these devaluations, even though overdue in almost all cases, were responsive to price differentials *vis a vis* the trading partners.

To examine this pertinent issue, the paper is structured as follows; the second section reviews the history and theory of the *PPP* doctrine. Section three dwells on the methodological issues involved in testing the *PPP* theory and the evidence on *PPP*. The results and empirical analysis are reported in section four, and section five summaries and concludes the paper.

2 Theoretical Framework of the Purchasing Power Parity Doctrine

As explained above, the essence of *PPP* is that the price levels in the respective countries influence the exchange rate between two currencies. The *PPP* theory's origin has been traced to the 16th century Salamanca School of Spain. During the nineteenth century, classical economists, including Ricardo, Mill, Goschen and Marshall, endorsed and developed more or less qualified *PPP* views. The theory, in its modern form, is credited to Cassel, a Swedish economist, who developed and popularised its empirical version in the 1920s (Rogoff, 1996).

Cassel's idea was that the nominal exchange rate should reflect the purchasing power of one currency against another. His proposal was that a purchasing power

exchange rate existed between any two countries, and it is measured by the reciprocal of one country's price level against another. Cassel wrote that:

> At every moment the real parity between two countries is represented by this quotient between the purchasing power of the money in the one country and the other. I propose to call this parity 'the purchasing power parity'. As long as anything like free movement of merchandise and a somewhat comprehensive trade between the two countries takes place, the actual rate of exchange cannot deviate very much from this purchasing power parity (Isard, 1995:58).

Cassel developed the idea after the collapse of the world financial system during World War I. Before the war, countries followed the gold standard, whereby their currencies were convertible to gold at fixed parities. This implied that relative gold values reflected the exchange rate between any two countries. However, after the war broke out, it was difficult to maintain the gold standard as speculators worried about countries that would devalue so as to gain seignorage revenues. The gold standard was thus abandoned, and countries had to decide how to reset exchange rates with minimal disruptions to prices and government revenues. Cassel thus promoted the use of *PPP* as a basis for setting relative gold parities. He suggested that cumulative inflation rates from 1914 be calculated, and then be used to calculate the exchange rate changes needed to maintain *PPP* (Rogoff, 1996; Dornbusch, 1994).

The Purchasing Power Parity theory is developed on the basis of *the law of one price* (*LOP*). The law states that once converted to a common currency, the same good should sell for the same price in different countries. In other words, for any good *i*,

$$\langle 1 \rangle \quad P_i = SP_i^*$$

where, P_i is the domestic price for good *i*, P_i^* is the foreign price for good *i*, and S is the domestic nominal exchange rate.

The *LOP* assumes that there is perfect competition, there are no tariff or other trade barriers, and no transportation costs. In practice, due to the existence of trade barriers and transportation costs that drive a wedge between prices in different countries, the law cannot hold exactly (Rogoff, 1996; Froot and Rogoff, 1995).[1]

Absolute purchasing power parity, *APPP*, is a generalisation of the law of one price. It postulates that given the same currency, a basket of goods will cost the same in any country. Formally,

$$\langle 2 \rangle \quad P = SP^*$$

thus;

$$\langle 3 \rangle \quad S = \frac{P}{P^*}$$

where, P and P^* are the prices of the identical basket of goods in the domestic and foreign countries respectively, and S is the exchange rate, or the domestic currency price of foreign currency.[2] Absolute purchasing power parity is unlikely to hold exactly for the same reasons that the law of one price fails to hold.

[1] Rogoff (1996) writes that the wedge depends on the tradability of the goods. For goods which are highly traded, such as gold, the law holds quite well, whereas for non-traded goods such as Big Macs, factors such as non-traded inputs, value-added taxes and profit margins militate against the law.

[2] In empirical tests however, no attempt is made to compare identical baskets of goods. Instead, different countries' *CPIs* and *WPIs* are used (Froot and Rogoff, 1995). The use of these indices to test for *APPP* can most definitely lead to results not supporting *APPP* because different countries use different compositions of goods in the baskets for constructing price indices. Also, since the weights assigned to goods are not necessarily standard, it makes it less likely that *APPP* measured in this way will hold.

It is easy to see the intuition behind the *PPP* theory and why in practice it may not appear to hold. One way of circumventing the obstacles that make it impossible for *PPP* to hold in its absolute version is to resort to the rate of change of both the exchange rates and the national price levels. Despite transport costs and other trade barriers, the change in the exchange rate between two countries' currencies is likely to be influenced by the change in the price level of one country relative to the other country's price level, if indeed *PPP* is plausible. It is in this context that Relative Purchasing Power Parity, *RPPP*, another version of *PPP* was introduced. It states that the rate of growth in the exchange rate offsets the differential between the rate of growth in home and foreign price indices. Formally, this is represented by,

$$\langle 4 \rangle \quad \Delta P = \Delta S . \Delta P^{*}.$$

If the increase in domestic prices is faster relative to that of the foreign country, then the exchange rate will depreciate.

3 Empirical Evidence on Purchasing Power Parity

Even though *PPP* may be attractive because of both its simplicity and intuitive appeal, empirical tests have produced mixed verdicts. To a great extent, economists have tended to find weaknesses with the methodology employed in studies that have rejected *PPP*. Thus, they have seized every opportunity offered by new developments in econometrics to test *PPP*. Broadly, we can identify four classes of approaches that have been used in testing *PPP*.

The first approach is based on a simple test of *APPP* and *RPPP* using the following two equations;

$$\langle 5 \rangle \quad s_t = b_0 + b_1(p_t - p_t^*) + u_t$$

and

$$\langle 6 \rangle \quad \Delta s_t = b_0 + b_1(\Delta p_t - \Delta p_t^*) + u_t .$$

All variables are in logs and s is the nominal exchange rate, p and p^* are domestic and foreign price levels respectively, and t denotes time. In either equation, *PPP* holds if b_1 is statistically not different from one.

This approach has been employed in hyperinflationary countries in the 1920's, with results that supported *PPP*. However, attempts to apply the same test in the post-Bretton Woods era produced results which rejected *PPP* (Frenkel, 1981).

This approach has several shortcomings. The first one is that with the benefit of modern time series techniques, we know that regressions using the equations above should have involved running tests for stationarity in the variables and conducting cointegration analysis. Another shortcoming is that *PPP* does not define a causal direction between the exchange rate and the price level as implied by the models specified above. As such, any choice of a dependent variable is arbitrary and potentially susceptible to simultaneity bias.

The second approach for testing the *PPP* theory is built on the following premise; for various reasons, exchange rates fluctuate more than the price levels. Due to this, *PPP* can hardly hold at any particular instance. The only way that *PPP* can prove to hold is in its long-run behaviour. This will be manifested by a tendency of

a fluctuating exchange rate reverting towards a constant mean. Let the real exchange rate (e) be defined as;

$$\langle 7 \rangle \quad e = \frac{SP^*}{P}.$$

The test for *PPP* can be done indirectly; by testing the mean reversion of the real exchange rate. If the real exchange rate exhibits mean reversion, then we cannot reject the *PPP* hypothesis. If, on the other hand, the real exchange rate does not exhibit mean reversion, it means that it is not stationary. In this case, *PPP* is rejected. The following equation provides a framework for testing mean reversion:

$$\langle 8 \rangle \quad \Delta e_t = a + g e_{t-1} + u_t$$

where, u_t is a white noise error term. The null hypothesis is that the real exchange rate has a unit root, that is, $\gamma = 0$. Failure to reject the null hypothesis implies that the real exchange rate is not stationary, and thus does not exhibit mean reversion. In this case, *PPP* will be rejected.

Applied to industrialised countries during the floating exchange era, many studies failed to reject the hypothesis that real exchange rates follow a random walk (Rogoff, 1996). One reason given for this kind of result is that the small sample size of data employed did not render sufficient power to reject the null. Tests that employed "long-horizon" data sets (some of these data sets span centuries), for example, Frankel (1990) and Edison (1987), tended to give results in support of *PPP* (see Rogoff, 1996; and Froot and Rogoff, 1995). One caveat is in order; most of these studies made use of data sets from wealthy nations because of the availability of long-horizon data. This produces what has been called "survivorship" bias; countries that have been poor are not included, even though

inclusion of such countries could alter the results (Froot and Rogoff, 1995). Indeed, African countries are on average 40 years old as nations and thus are not capable of generating long-horizon data sets.

Cointegration analysis offers another approach for testing the *PPP* theorem. The world of economics is endowed with literature employing this approach, for example, Layton and Stark (1990), Fisher and Park (1991), Enders (1988), Kim (1990), Patel (1990), Taylor (1988), Ardeni and Lubian (1989), Liu (1992) and others (see Froot and Rogoff, 1995; Rogoff, 1996). Cointegration analysis can be used to test for the existence of a long-run equilibrium relationship between variables. This kind of analysis is particularly attractive in relation to the test of *PPP* because, for example, in case of the Johansen procedure, the need for "appointing" a dependent variable is dispensed off.

Cointegration analysis has also produced mixed results in testing for *PPP*. When a very large sample of data is used, for example, Kim (1990), *PPP* was supported and even parameter estimates were very close to the unit value predicted by *PPP*. On a small sample though, results have not been that good and at times, parameter estimates of implausible magnitude have been obtained (Froot and Rogoff, 1995).

The last approach, and the one we will use in this paper, involves panel data analysis. The panel data approach uses both time series and cross-sectional observations to increase the sample size. In this way, even "young" nations like African countries can be pooled to produce a reasonably large sample. Several studies have been conducted in this area with results that support *PPP*, that is, real exchange rates are mean reverting. These studies include Wu (1996), MacDonald (1996), Frankel and Rose (1995), Oh (1996), and Holmes (2000).

For a long time, one shortcoming in the use of panel data analysis for testing *PPP* was that the time series technique of unit root tests did not permeate the panel data analysis. However, of late, a number of procedures to test for unit roots in panel data have been developed. These procedures have been employed in testing for *PPP*, and in general, due to the increased power of the test arising from the cross-section dimension of the data sets used, the tests are supportive of long-run *PPP*. Below, we briefly review some of the studies that have employed the panel data unit root test.

One study by Papell (1997) used panel data analysis to test for long-run *PPP*. The main purpose of the study was to examine how much evidence there was against unit roots during the current float for industrialised countries. The following equation was estimated by Feasible Generalised Least Squares (*FGLS*);

$$\langle 9 \rangle \quad \Delta e_{jt} = m_j + a e_{jt-1} + \sum_{i=1}^{k} c_{ji} \Delta e_{jt-i} + e_{jt}$$

where, e is the real exchange rate, and j indexes the countries in the panel. Monte Carlo methods were used to compute exact finite sample critical values for the test statistics for the study. Papell's study found strong evidence against the unit root hypothesis for monthly data, but not for quarterly data.

Another study that employed a fairly new panel unit root test is the one by Coakley and Fuertes (1997). They used the Im *et al* (1997) panel unit root test, which is more powerful than the Levin, Lin and Chu (*LLC*) procedure, to analyse real exchange rate data for the G10 countries and Switzerland. They used monthly data for the period 1973-96 of bilateral rates and wholesale and consumer prices. Since

cross-sectional dependence[3] in disturbances is expected in panels on real exchange rates if a common currency such as the *US* dollar is used as a base, they allowed for this by using the demeaning adjustment proposed by Im *et al* (1997). The demeaning procedure involves subtracting cross-section means from the observed data, as follows; $e_{it} - \frac{1}{N}\sum_{i=i}^{N} e_{it}$. Their findings were that for the wholesale price series, the *t*-bar statistics rejected the null of a unit root in the real exchange rates at the 95 percent critical value, while for the consumer price series, the null was rejected at the 90 percent level only. They thus concluded that the real exchange rates in their panel are stationary in all cases, and hence rendered support for long-run *PPP*.

MacDonald's (1996) study used the *LLC* procedure to test for stationarity on two annual data sets for the post-Bretton Woods era, namely 17 *OECD* real exchange rates using wholesale price indices, and 23 *OECD* real exchange rates using consumer price indices. As a preliminary exercise, standard Augmented Dickey Fuller (*ADF*) tests were performed on the data sets. The standard *ADF* test indicated little evidence of rejection of the null of a unit root, with only three *WPI*-based real exchange rates and two *CPI*-based real exchange rates being stationary at 5 percent. When the panel unit root test was conducted on the panel, it was found that regardless of the chosen deterministic specification, that is, constant or

[3]O'Connell (1998) raised the issue of cross-sectional dependence, while acknowledging that these points were first noted by Hakkio, that cross-sectional dependence may arise due to the following: (1) by construction, bilateral real exchange rates may contain two parts (which can be induced by the choice of a numeraire country such as the *US*) namely, independent variation in the value of the dollar, and independent variation in *US* price index; and (2) by any economic shocks that influence prices or exchange rates. Cross-sectional dependence can have an impact on the statistical properties of panel unit root tests. O'Connell further showed how size and power could be affected when cross-sectional dependence is not accounted for; the power to reject the unit root was greatly diminished, raising significance levels of tests with nominal size of 5 percent to as much as 50 percent. The implication was that studies not accounting for cross-sectional dependence are likely to falsely reject a unit root.

constant plus trend, and price measure used, the real exchange rates were stationary.

Wu (1996) also used the *LLC* test to test for unit roots for 18 *OECD* countries. Pooled data on real exchange rates between the *US* and the *OECD* countries for the current float was used to test the hypothesis that each series contains a unit root against the alternative that the various series are stationary. When standard *ADF* and Phillips and Perron (*PP*) tests were done on monthly individual real exchange rates, the null was not rejected at conventional significance levels. However, when the panel-based test was performed, the null was rejected at the 1 percent level. The same conclusion was obtained for quarterly and annual data, providing further support for the validity of long-run *PPP* for the post-Bretton Woods period.

Other studies that have employed panel data techniques and are supportive of long-run *PPP* are; Frankel and Rose (1996), Oh (1996), Lothian (1997), Jorion and Sweeney (1996) and Kuo and Mikkola (1998). Another study by Sarno and Taylor (1998) employed two multivariate unit root tests using panel data. The study provided support for *PPP* for the post-Bretton Woods period for which the validity of *PPP* has been most controversial. They employed the tests on monthly data on bilateral real dollar exchange rates among the G5 countries for the period 1973 to 1996. Both tests enabled them to find "unequivocal evidence of mean reversion in all of the real exchange rates examined."

In Africa, two recent studies have showed that *PPP* holds. Nagayasu (1998) examined the validity of long-run *PPP* using data for 16 African countries. The data used was annual, covering the period 1981-94. The study applied a panel cointegration technique that was pioneered by Pedroni (1995), and the panel unit root test developed by Im *et al* (1997) to the parallel market exchange rates

expressed in *US* dollars and *CPIs*. The findings of the study were that the test for unit root and cointegration in individual countries showed that *PPP* is invalid. However, more reliable results were obtained in the panel context, where the null of non-cointegration was rejected, confirming the semi-strong form of long-run *PPP* in the 16 African countries.[4]

The other study on African countries by Krichene (1998) used *PPP* to study exchange rate and price interdependence in five East African countries, namely Burundi, Kenya, Rwanda, Tanzania, and Uganda. The study employed monthly data of bilateral real exchange rates for the period covering 1979(1)-1996(12). The findings of the study were that bilateral real exchange rates revert to long-run equilibrium. Other findings of the study were that the tests for unit roots in bilateral real exchange rates rejected the null hypothesis of unit root, hence supporting absolute *PPP* in the cases of Burundi and Kenya, Burundi and Rwanda and Kenya and Rwanda. The result suggested that arbitrage and trade worked well due to the importance of bilateral trade, proximity of their markets, and rapid transmission of information on prices and profit opportunities. In the cases of Tanzania and Uganda, the null hypothesis of unit root could not be rejected for the whole sample period, owing to exchange rate misalignments. However, the null hypothesis was rejected when a sub-period covering 1986(1)-1996(12) was used.

Krichene (1998) also used a cointegration model to study the existence of unrestricted stationary relations linking bilateral nominal exchange rates and price levels by relaxing the homogeneity and symmetry assumptions of *PPP*. Overall, the findings were that the validity of the weaker version of *PPP* could not be rejected, implying that the nominal exchange rates and price levels tend to revert to a long-run equilibrium relation.

[4]The semi-strong form of *PPP* only requires a symmetry restriction on prices, unlike the strong form that requires parameter and homogeneity restrictions (Nagayasu, 1998).

Using the results of the study, Krichene (1998) concluded that nominal exchange rates in the five countries have adjusted to inflation differentials, and that intra-regional trade has played a key role in re-establishing competitiveness in the region. Furthermore, large real shocks have not had a lasting impact on competitiveness because of similar growth patterns and absence of persistent productivity differentials.

Our study differs from the two studies above in that besides using bilateral real exchange rates, we also use multilateral real exchange rate indices to test for *PPP*. The use of multilateral real exchange rate indices allows us to include more trading partners than bilateral indices. As such, multilateral indices are more broad and may be more relevant for policy evaluation than bilateral indices (see Edwards, 1989). Our study is, therefore, an improvement over other studies that only use bilateral rates. Furthermore, unlike Nagayasu (1998), our study accounts for cross-sectional dependence by demeaning (see O'Connell, 1998). Not accounting for cross-sectional dependence can lead to biased results that may give false support for *PPP*.

4 Empirical Analysis and Results

In this section, we present the data used in the analysis, the methodology, and the results.

4.1 The Data

The data used in this study is taken from the International Financial Statistics (*IFS*) Yearbook (1997) and the *IFS CD-ROM*. The exchange rate used is the period average. The data is annual, covering the period from 1965 to 1996, involving

twenty African countries. The countries and their exchange rate arrangements are given in Table C in the appendix. Four indices were constructed, namely, an export-based multilateral index, an import-based multilateral index, a bilateral index, using the *USA* as the numeraire country, and a trade-weighted multilateral index.

The construction of the multilateral indices of the real exchange rates was done as follows (see Edwards (1989) for different measures of the real exchange rate);

$$\langle 10 \rangle \quad MRER_{jt} = \frac{\sum_{i=1}^{k} a_i E_{it} P_{it}^{*}}{P_{jt}}$$

where, $MRER_{jt}$ is the multilateral real exchange rate index for country j in period t, E_{it} is the index of the nominal exchange rate between country i and country j in period t; $i = 1,\ldots,k$ denotes the k partner countries that are used in the construction of the index. In our case, the five largest trading partners on the export and import sides were considered for the export-based and import-based indices respectively, while the five largest trading partners for both exports and imports combined were considered for the trade-weighted index. The weight corresponding to partner i in the construction of the index is denoted by a_i, while P_{it}^{*} is the price index of partner i in period t. The price index of the home country in period t is given by P_{jt}. The multilateral indices were constructed using the trade weights for three years of trade data, that is, for 1975, 1985 and 1995. Table A in the appendix gives the trading partners used for the twenty countries in constructing the multilateral indices, and their export, import and trade weights.

The bilateral indices were constructed as follows;

$$\langle 11 \rangle \quad BRER_{it} = \frac{E_{iUSA} WPI_{USA}}{CPI_{it}}$$

where, $BRER_{it}$ is the bilateral rate for country i in period t; E_{iUSA} is the nominal exchange rate between country i and the USA; WPI_{USA} is the wholesale price index for the USA; CPI_{it} is the consumer price index for country i in period t.

Table 1 reports some descriptive statistics of the data set. The Pearson correlation coefficients show that the export-based and import-based indices have a high and positive significant correlation with the trade-weighted indices. Also, the export-based and import-based indices are positively correlated with each other. However, the Pearson correlation coefficients show that the bilateral indices are not linearly related to the export-based, import-based and trade-weighted indices. This confirms Edwards' (1991) view that bilateral rates and multilateral rates may not be related, and that they may even move in opposite directions.

Table 1: Summary Statistics and Correlation Analysis

Variable	Number of Observations	Mean	Standard Deviation	Minimum	Maximum
LMTRER	640	4.4151	0.4784	1.9607	6.2780
LMRERX	640	4.4226	0.4729	1.9650	6.5968
LMRERM	640	4.4139	0.4521	2.2192	5.9438
LBRER	640	3.6221	2.0894	-0.1084	7.5119

Pearson Correlation Coefficients

	LMTRER	*LMRERX*	*LMRERM*	*LBRER*
LMTRER	1.00000			
	(0.0)			
LMRERX	0.97462	1.00000		
	(0.0001)	(0.0)		
LMRERM	0.93307	0.86677	1.00000	
	(0.0001)	(0.0001)	(0.0)	
LBRER	-0.01316	-0.00982	0.05432	1.00000
	(0.7397)	(0.8041)	(0.1699)	(0.0)

Notes: RER - real exchange rate; LMTRER - Log of Trade-weighted RER; LMRERX - Log of Multilateral RER (export-based); LMRERM - Log of Multilateral RER (import-based); LBRER - Log of Bilateral RER.

4.2 The Panel Unit Root Test

In this study, we shall employ a panel unit root test to test for long-run *PPP* in our panel of twenty African countries. The test that we will use is the one developed by Im *et al* (1997).[5] It is conducted as follows. For a panel of N countries (i = 1,2,...,N), the real exchange rate can be written as an Augmented Dickey Fuller (*ADF*) regression of order p_i as;

$$\langle 12 \rangle \quad \Delta e_{it} = a_i + b_i e_{i,t-1} + \sum_{j=1}^{p_i} r_{ij} \Delta e_{i,t-j} + e_{it}, \qquad i = 1,...,N; t = 1,...,T.$$

In order to test for unit roots, the null and alternative hypotheses respectively, are given as;

$$\langle 13 \rangle \quad H_0 : b_i = 0 \quad \textit{for all } i$$
$$H_1 : b_i < 0, \quad i = 1,2,...,N_1, b_i = 0, i = N_1 + 1, N_1 + 2,...,N.$$

The way the alternative hypothesis is formulated in the test makes allowance for the fact that b_i can differ across groups. This formulation is more general than the homogeneous one, which is given by $b_i = b < 0$ for all i, and is used in the *LLC* test.

Using the above equation, a standardised *t*-bar statistic is calculated, based on the average of individual unit root *t*-statistics. The standardised *t*-bar statistic is used when the disturbances in the underlying *DF* regressions are not serially correlated.

[5]Other studies that have employed the test are by Coakley *et al* (1996), Coakley and Kulasi (1997), Coakley and Fuertes (1997), and Holmes (2000).

When there is serial correlation in the disturbances,[6] as was the case in our panel, a *modified* version of the *t*-bar statistic is calculated, which is expressed as follows:

$$\langle 14 \rangle \quad y_{\bar{t}} = \frac{\sqrt{N}\left\{\bar{t}\,NT(p,r) - \frac{1}{N}\sum_{i=1}^{N} E\left[t_{iT}(p_{i,}0)\middle| b_i = 0\right]\right\}}{\sqrt{\frac{1}{N}\sum_{i=1}^{N} Var\left[t_{iT}(p_{i,}0)\middle| b_i = 0\right]}}$$

where,

$$\langle 15 \rangle \quad \bar{t}\,NT(p,r) = \frac{1}{N}\sum_{i=1}^{N} t_{iT}(p_i, r_i).$$

In equation 15, $t_{iT}(p_i,r_i)$ is the individual *t*-statistic for testing $b_i = 0$, and in equation 14, the values $E[t_{iT}(p_i,0) \mid b_i=0]$ and $Var[t_{iT}(p_i,0) \mid b_i=0]$ are tabulated by Im *et al* (1997). The values are evaluated by stochastic simulations for various lags, time periods, and with and without time trends. Under the null hypothesis of a unit root, the modified *t*-bar statistic has a standard normal distribution.

In our estimation, the appropriate lag length was selected by a procedure recommended by Enders (1994). We started by choosing a relatively long lag length and then pared down the model by using the *t*-test statistic. That is to say, if the *t*-statistic on the highest lag was insignificant, we dropped the lag length by one, and then we re-estimated the equation. The process was repeated until the lag was significant.

[6] Im *et al* (1997) have also devised a standardised *LM*-bar statistic and its modified version in case of serially correlated disturbances. In this paper however, we only use the modified *t*-bar statistic since it performs better than the *LM*-bar test (Im *et al*, 1997).

4.3 The Results

Table 2 reports the results of the unit root tests for individual countries. The results show that for the import-based index, three out of the twenty countries' real exchange rates are stationary, while for the export-based and trade-weighted indices, only one out of the twenty is stationary. For the bilateral index, the null hypothesis of a unit root was rejected only for one country.

Table 2: Individual Unit Root Tests

Country	Multilateral Index (Export-based)		Multilateral Index (Import-based)		Multilateral Index (Trade-weighted)		Bilateral Index	
	b_i	*ADF/DF*	b_i	*ADF/DF*	b_i	*ADF/DF*	b_i	*ADF/DF*
Burkina Faso	-0.361(0)	**-2.233**	-0.233(0)	**-1.547**	-0.263(0)	**-1.705**	-0.631(2)	**-2.950**
Burundi	-0.161(2)	**-2.048**	-0.052(0)	**-0.716**	-0.154(2)	**-2.131**	-0.107(0)	**-1.208**
Congo Rep.	-0.331(0)	**-2.442**	-0.744(0)	**-4.033**	-0.584(0)	**-3.400**	-0.389(0)	**-2.648**
Côte d'Ivoire	-0.240(0)	**-1.756**	-0.393(1)	**-2.867**	-0.424(1)	**-2.558**	-0.259(0)	**-2.086**
Egypt	-0.288(1)	**-2.725**	-0.293(1)	**-2.774**	-0.294(1)	**-2.780**	-0.330(1)	**-2.903**
Ethiopia	-0.085(0)	**-0.727**	-0.061(0)	**-0.522**	-0.082(0)	**-0.673**	-0.083(0)	**-0.706**
Gabon	-0.147(0)	**-1.197**	-0.087(0)	**-0.762**	-0.122(0)	**-1.035**	-0.225(0)	**-1.812**
The Gambia	-0.122(2)	**-1.580**	-0.649(0)	**-3.626**	-0.128(2)	**-1.601**	-0.273(2)	**-2.141**
Ghana	-0.125(1)	**-1.808**	-0.132(1)	**-1.663**	-0.123(1)	**-1.781**	-0.123(1)	**-1.794**
Kenya	-0.200(0)	**-1.985**	-0.398(0)	**-2.242**	-0.554(0)	**-2.908**	-0.188(0)	**-1.727**
Madagascar	-0.048(0)	**-0.774**	-0.046(0)	**-0.770**	-0.265(3)	**-2.413**	-0.056(0)	**-0.845**
Mauritius	-0.052(0)	**-1.182**	-0.074(0)	**-1.614**	-0.054(0)	**-1.353**	-0.178(1)	**-2.040**
Morocco	-0.030(0)	**-1.078**	-0.090(0)	**-1.669**	-0.066(0)	**-1.573**	-0.127(1)	**-1.772**
Niger	-0.200(0)	**-1.554**	-0.497(1)	**-3.136**	-0.440(1)	**-2.854**	-0.145(0)	**-1.430**
Nigeria	-0.204(1)	**-2.392**	-0.213(1)	**-2.493**	-0.207(1)	**-2.432**	-0.186(1)	**-2.226**
Sierra Leone	-0.266(0)	**-2.262**	-0.221(0)	**-2.303**	-0.262(0)	**-2.487**	-0.424(0)	**-2.995**
South Africa	-0.693(3)	**-3.637**	-0.811(3)	**-3.601**	-0.834(3)	**-3.806**	-0.539(3)	**-2.834**
Tanzania	-0.146(1)	**-2.128**	-0.130(1)	**-1.981**	-0.131(1)	**-2.023**	-0.092(1)	**-1.596**
Zambia	-0.389(0)	**-2.642**	-0.226(0)	**-1.939**	-0.404(0)	**-2.659**	-0.247(0)	**-2.023**
Zimbabwe	-0.113(0)	**-1.574**	-0.126(0)	**-1.569**	-0.126(0)	**-1.570**	-0.174(0)	**-1.807**

Note: The figures in parentheses are lag lengths

However, a more reliable panel unit root test was performed, and the results are reported in Table 3. The results show that the null hypothesis of a unit root is rejected for three indices, namely the multilateral import-based index, the bilateral index, and the trade-weighted multilateral index at the 95 percent significance

level.[7] This means that these three real exchange rate indices are stationary, implying that *PPP* holds. However, the null hypothesis is not rejected for the export-based multilateral index.

Table 3: Panel Unit Root Tests (The Im et al Test)

	Modified t-bar Statistic ($j_{t\text{-}bar}$)	
	Original Data	*Demeaned Data*
Export-based *RER*	-1.513	-
Import-based *RER*	-1.913**	-2.338**
Trade-weighted *RER*	-2.163**	-0.476
Bilateral *RER*	-1.682**	-2.414**

Notes: ** *Significant at 95 percent. The 95 percent critical value is –1.65.*

The fact that the panel unit root test produced different outcomes for the import- and export-based multilateral indices can probably be explained as follows. Most African countries rely on primary products (that is, agricultural products, mineral resources, and other raw materials) for exports. The world market mostly determines the prices of export products. The volume of exports of these products is therefore unlikely to be influenced by the domestic price levels of these African countries. In short, export proceedings are not directly influenced by the relative price levels of exporting and importing countries, at least in the short to medium term. On the other hand, imports to most of these African countries are to some extent, dependent on the purchasing power of the people. That is to say that both the domestic price level and the price level of the trading partner are likely to influence the demand for foreign exchange through import demand. In this situation therefore, it is more likely that *PPP* would hold.

[7]For the bilateral index however, the null hypothesis was barely rejected at the 95 percent level.

We next performed the demeaning adjustment on the indices for which the null hypothesis of a unit root was rejected. We did this in order to remove the effect of cross-sectional dependence, which, according to O'Connell (1998), may cause the test to falsely support *PPP*. But before performing the demeaning adjustment, we tested for the significance of the time effects (λ_t), given that the individual effects (μ_i)[8] are not absent ($\lambda_t=0 \mid \mu_i \neq 0$). We found that the null hypothesis that time effects are absent given that individual effects are not, was rejected at 5 percent – the observed values for the bilateral index, import-based and trade-weighted multilateral indices are 4.112, 2.011, and 1.701 respectively, while the critical value is 1.46.[9] This means that the time effects are significant, and if they are not incorporated in the model to be estimated, as is the case in the panel unit root test, their effect is captured or retained in the error term. The presence of time effects in the error terms causes the variance-covariance matrix of the disturbance term to be non-diagonal. In order to remove their effect, a demeaning adjustment is recommended. The demeaning procedure involves subtracting cross-section averages from the observed data.

The results of the unit root test for individual countries for the demeaned indices are in Table D in the appendix.[10] These results are used for the panel unit root test, and are reported in Table 3. The null hypothesis of a unit root is rejected at 5 percent for the import-based index and the bilateral index. As for the trade-weighted index, the null hypothesis is not rejected. This implies that after

[8]Time effects (λ_t) are unobservable variables introduced through a dummy to capture the effects that are specific to each time period but are the same for all cross-sectional units, while individual effects (μ_i) are the time-invariant individual specific variables, that are also captured by a dummy (see Baltagi, 1995; or Hsaio, 1986).

[9]The *F-test* statistics for testing whether time effects are absent for the import-based and trade-weighted multilateral indices are smaller in absolute terms. This could indicate that the construction of a multilateral index reduced cross-sectional dependence to some extent, although not completely.

[10]The *F-test* statistics for testing whether the time effects are absent after demeaning showed that cross-sectional dependence was accounted for, as the time effects were insignificant.

demeaning, that is, accounting for cross-sectional dependence, *PPP* does not hold for the trade-weighted index, but it holds for the import-based and bilateral indices. The failure to reject the null hypothesis of a unit root in the trade-weighted multilateral index is due to the influence of exports. As we have seen above, for the export-based index, *PPP* did not hold. It is worth noting that before removing cross-sectional dependence, the null hypothesis of a unit root was rejected at the 5 percent level for the trade-weighted index. The fact that the removal of cross-sectional dependence made it impossible to reject the null hypothesis of a unit root is consistent with the observation that the presence of cross-sectional dependence makes it easier for panel unit root tests to accept *PPP* (O'Connell, 1998).

In connection to the above empirical results, a few conclusions can be drawn. Firstly, given that *PPP* holds in the import-based and bilateral indices shows that at least *PPP* cannot be completely written off.

Secondly, the fact that *PPP* seems to hold in the bilateral index and import-based multilateral index suggests that devaluations were probably influenced by the price differentials between African countries and their trading partners. As noted earlier, most of the countries in our study had devalued their currencies during the time their exchange rates were fixed. This could have been necessitated by the widening price differentials with their trading partners, the industrialised countries.

Lastly, we have seen that *PPP* holds between African countries and industrialised countries that trade with them. It is plausible, as pointed out above, that in the import-based index, *PPP* is more likely to hold than in the export-based index because individually, each of the countries is a price-taker for the primary good it exports. As such, individually, they are not able to influence export prices, and also, given that the export prices are fixed, the price differentials do not directly influence the exchange rates of African countries.

5 Summary and Conclusions

The *PPP* hypothesis is an important assumption in most models in international economics. Although its validity has at times failed to pass empirical tests, *PPP* does however, highlight the plausible factors that are behind exchange rate movements (Krugman and Obstfeld, 1997). It has also been used as a basis for assessing levels of exchange rates, and in comparing income levels between countries. This continuing importance of *PPP* in economics merits further tests to establish its validity. As econometric methods undergo more development and refinement, better techniques for undertaking empirical tests of *PPP* become available. This study employs one of the latest techniques, the panel unit root test, for testing *PPP* in African countries.

A number of methods for testing for long-run *PPP* have evolved over time. However, of late, panel-based tests seem to have dominated the literature. Panel-based tests that have been done by most researchers have tended to offer support for long-run *PPP*, unlike cointegration tests, which are criticised for having low power. Panel-based tests are the best choice for African countries because it is hardly 40 years since most of these countries gained their political independence. Therefore, the relevant data are available for, at best, 40 years. Panel data, however, boosts the number of observations by including a cross-section dimension. Moreover, as pointed out by O'Connell (1998), panel data provides a more powerful test for long-run *PPP*.

In testing for long-run *PPP*, we formulated three multilateral real exchange rate indices, namely, import-based, export-based, and trade-weighted. We also constructed a bilateral index. We decided to construct multilateral indices because of the argument in the literature that bilateral indices, by construction, can introduce cross-sectional dependence in the error term. Cross-sectional

dependence, if not controlled, can lead to biased results, mostly leading to tests rejecting the null too frequently, hence giving false support for *PPP* (Kuo and Mikkola, 1998). Thus, in a bid to eliminate the problem of cross-sectional dependence, we formulated the three multilateral indices. However, the *F-test* indicated that cross-sectional dependence was present in the multilateral indices. This is due to the fact that the trading partners are similar across the countries (see Table A in the appendix).

In this paper, we sought to test the *PPP* hypothesis in twenty African countries using a fairly new technique – the Im *et al* (1997) panel unit root test. While the most widely used panel unit root test is the *LLC* test, we chose to use the Im *et al* (1997) test due to a number of advantages it has over the *LLC* test. These are; firstly it is more powerful than the *LLC* test, (Coakley and Fuertes, 1997), and as such, it performs better (Im *et al*, 1997). Secondly, the Im *et al* (1997) test allows for some of the individuals in the panel to have unit roots under the alternative hypothesis (*cf.* equation 13). The *LLC* test, on the other hand, assumes that all individuals are identical with respect to the presence and absence of a unit root, thus rendering it more restrictive (Levin *et al*, 1997). The third advantage is that while both tests acknowledge cases where disturbances may be correlated, the Im *et al* (1997) test explicitly sets out a way of dealing with correlated errors across groups – the demeaning procedure, while the *LLC* test does not.

In our study, the Im *et al* (1997) test was able to reject the null of a unit root for three indices, namely the multilateral import-based and trade-weighted indices, and the bilateral index, while it was unable to reject the null for one index, the multilateral export-based index. It appears therefore that *PPP* based on the import-based and trade-weighted multilateral indices, and the bilateral index holds in the selected African countries. However, after demeaning, we found that the null hypothesis was not rejected for the trade-weighted multilateral index. Probably the

reason why *PPP* did not hold in the export-based multilateral index is that most African countries rely on primary products for exports, whose prices are determined in the world market. As such, domestic price levels in Africa have little, if any, influence on the volume of exports in the short-run. The fact that *PPP* was found to hold in the import-based index is an indication of some extent of price elasticity of imports.

Although the *PPP* framework has certain limitations, there is no doubt that it is still appealing as a starting point for quantitative exercises regarding assessing the appropriate level for new parities of exchange rates (Isard, 1995). Thus, *PPP* can help policymakers to assess the appropriateness of exchange rate levels in Africa, or as Isard (1995) puts it,

> if used intelligently, along with other approaches to assessment, *PPP* calculations can have significant diagnostic value.

Besides using a fairly new panel unit root test, this study has also used multilateral indices to test for *PPP*. Most studies on *PPP* use bilateral indices, with the *US* chosen as a base country. The use of multilateral indices is more desirable in terms of policy evaluation. As Edwards (1989) remarked, a failure to use a broad multilateral real exchange rate index can result in misleading and incorrect inferences.

Appendix

TABLE A: COUNTRIES INCLUDED IN CONSTRUCTION OF INDICES AND THEIR IMPORT, EXPORT, AND TRADE SHARES

	Export-based	**Import-based**	**Trade-based**
BURKINA FASO	1975: Côte d'Ivoire (.58), France (.23), Italy (.08), UK (.07), Germany (.04); 1985: France (.60), Italy (.15), Spain (.07), Germany (.10), Japan .(07); 1995: France (.38), Italy (.25), Thailand (.17), Portugal (.11), Indonesia (.09).	1975: France (.56), Côte d'Ivoire (.26), USA (.09), Germany (.05), Netherlands (.03); 1985: Côte d'Ivoire (.39), France (.38), USA (.13), Netherlands (.06), Germany (.04); 1995: France (.48), Côte d'Ivoire (.34), Nigeria (.07), Japan (.06), USA (.05).	1975: France (.49), Côte d'Ivoire (.34), USA (.07), Germany (.05), UK (.04); 1985: France (.42), Côte d'Ivoire (.36), USA (.12), Netherlands (.05), Germany (.05); 1995: France (.52), Côte d'Ivoire (.31), Nigeria (.06), Japan (.06), USA (.05).
BURUNDI	1975: USA (.56), Germany (.27), France (.08), Belgium (.05), Netherlands (.04); 1985: Germany (.41), Finland (.39), USA (.08), Belgium (.07), UK (.05); 1995: UK (.54), Switzerland (.21), Kenya (.09), Tanzania (.09), Germany (.07).	1975: Belgium (.44), Germany (.18), France (.16), UK (.13), USA (.09); 1985: Iran (.25), Belgium (.25), France (.20), Germany (.19), Japan (.11); 1995: Belgium (.35), France (.22), Germany (.18), Japan (.13), Netherlands (.12).	1975: USA (.29), Belgium (.27), Germany (.22), France (.13), UK (.09); 1985: Germany (.32), Belgium (.20), Finland (.18), Iran (.17), France (.13); 1995: Belgium (.28), UK (.27), France (.18), Germany (.16), Kenya (.11).
CONGO REPUBLIC	1975: France (.36), Italy (.34), USA (.17), UK (.09), Germany (.04); 1985: USA (.62), Spain (.19), France (.11), Italy (.04), Belgium (.04); 1995: USA (.35), Italy (.24), Netherlands (.19), France (.14), Spain (.07).	1975: France (.68), Germany (.11), Gabon (.10), USA (.07), Netherlands (.04); 1985: France (.69), Italy (.11), USA (.07), Germany (.07), Spain (.06); 1995: France (.57), USA (.17), Netherlands (.12), Italy (.07), Belgium (.07).	1975: France (.53), Italy (.21), USA (.13), Germany (.07), UK (.06); 1985: USA (.46), France (.29), Spain (.15), Italy (.06), Germany (.04); 1995: USA (.30), France (.28), Italy (.19), Netherlands (.17), Spain (.06).
CÔTE D'IVOIRE	1975: France (.43), Netherlands (.17), USA (.16), Germany (.14), Italy (.10); 1985: Netherlands (.29), France (.28), USA (.20), Italy (.16), UK (.07); 1995: France (.32), Denmark (.23), Netherlands (.23), Italy (.13), Germany (.09).	1975: France (.63), USA (.12), Germany (.09), Italy (08), Nigeria (.08); 1985: France (.51), Nigeria (.20), USA (.12), Japan (.09), Germany (.08); 1995: France (.54), Nigeria (.21), USA (.10), Germany (.08), Japan (.07).	1975: France (.54), USA (.14), Germany (.12), Netherlands (.11), Italy (.09); 1985: France (.38), Netherlands (.23), USA (.18), Italy (.13), Nigeria (.08); 1995: France (.44), Denmark (.17), Netherlands (.16), Nigeria (.12), Italy (.11).
EGYPT	1975: Italy (.40), Netherlands (.20), France (.14), UK (.13), Saudi Arabia (.13); 1985: Italy (.45), France (.29), Netherlands (.10), Greece (.08), Japan (.08); 1995: USA (.35), Italy (.30), Germany (.14), Netherlands (.11), Spain (.10).	1975: USA (.39), France (.22), Germany (.17), Italy (.12), UK (.09); 1985: USA (.31), Germany (.23), Italy (.18), France (.16), Japan (.12); 1995: USA (.44), Germany (.21), Italy (.14), France (.14), Netherlands (.07).	1975: USA (.37), France (.22), Germany (.17), Italy (.14), UK (.10); 1985: Italy (.26), USA (.24), France (.20), Germany (.19), Japan (.11); 1995: USA (.42), Germany (.19), Italy (.18), France (.13), Netherlands (.08).

Table A continued…			
ETHIOPIA	1975: USA (.32), Saudi Arabia (.21), Germany (.19), Egypt (14), Japan (.14); 1985: Germany (.31), USA (.22), Japan (.20), Italy (.16), France (.11); 1995: Germany (.50), Japan (.18), Italy (.15), USA (.10), UK (.07).	1975: Saudi Arabia (.23), Japan (.22), Italy (.20), Germany (.19), Iran (.16); 1985: Italy (.32), Germany (.22), UK (.19), Japan (.13), France (.13); 1995: Italy (.31), USA (.23), Germany (.17), Japan (.16), UK (.13).	1975: USA (.23), Saudi Arabia (.23), Germany (.20), Japan (.19), Italy (.15); 1985: USA (.32), Italy (.22), Germany (.20), UK (.13), Japan (.12); 1995: Germany (.27), Italy (.26), USA (.19), Japan (.17), UK (.11).
GABON	1975: France (.44), USA (.33), UK (.10), Germany (.07), Italy (.06); 1985: France (.42), USA (.34), Spain (.17), UK (.04), Morocco (.03); 1995: USA (.75), France (.15), Japan (.05), Portugal (.03), Morocco (.02).	1975: France (.81), Belgium (.05), USA (.05), Germany (.04), Netherlands (.04); 1985: France (.65), USA (.14), Germany (.08), Japan (.07), UK (.06); 1995: France (.67), USA (.10), Netherlands (.09), Japan (.07), UK (.07).	1975: France (.57), USA (.25), UK (.07), Germany (.06), Italy (.05); 1985: France (.50), USA (.28), Spain (.13), UK (.05), Germany (.04); 1995: USA (.60), France (.28), Japan (.06), Netherlands (.04), Portugal (.02).
GAMBIA, THE	1975: UK (.55), Netherlands (.23), France (.09), Italy (.07), Portugal (.06); 1985: Ghana (.66), Switzerland (.15), France (.07), UK (.06), Belgium (.06); 1995: UK (.44), France (.38), USA (.06), Netherlands (.06), Spain (.06).	1975: UK (.57), Japan (.13), Germany (.12), Italy (.09), Netherlands (.09); 1985: UK (.30), France (.23), USA (.22), Germany (.13), Netherlands (.12); 1995: UK (.29), Côte d'Ivoire (.28), France (.16), Belgium (.14), Germany (.13).	1975: UK (.59), Netherlands (.18), France (.09), Italy (.08), Germany (.06); 1985: Ghana (.46), UK (.18), France (.16), USA (.12), Italy (.08); 1995: UK (.33), Côte d'Ivoire (.23), France (.20), Belgium (.13), Germany (.11).
GHANA	1975: UK (.27), USA (.21), Netherlands (.20), Switzerland (.16), Germany (.16); 1985: UK (.33), USA (.25), Japan (.18), Germany (.14), Netherlands (.09); 1995: UK (.29), Germany (.24), USA (.23), France (.16), Japan (.08).	1975: USA (.29), UK (.27), Germany (.20), Nigeria (.12), Japan (.12); 1985: UK (.43), Germany (.18), USA (.15), Japan (.12), Nigeria (.12); 1995: UK (.33), Nigeria (.31), Germany (.15), USA (.11), Netherlands (.10).	1975: UK (.30), USA (.27), Germany (.20), Japan (.14), Switzerland (.09); 1985: UK (.40), USA (.20), Germany (.17), Japan (.15), Netherlands (.08); 1995: UK (.37), Germany (.22), USA (.18), France (.12), Netherlands (.10).
KENYA	1975: Italy (.28), UK (.23), Tanzania (.21), Germany (.19), USA (.09); 1985: UK (.38), Germany (.25), USA (.16), Pakistan (.13), Netherlands (.08); 1995: UK (.30), Germany (.24), Tanzania (.18), Pakistan (.15), Netherlands (.13).	1975: UK (.34), Iran (.25), Japan (.15), Germany (.13), Saudi Arabia (.13); 1985: UK (.32), Japan (.22), Germany (.18), USA (.15), Saudi Arabia (.13); 1995: UK (.29), Japan (.20), RSA (.19), India (.18), Germany (.14).	1975: UK (.35), Germany (.17), Iran (.20), Italy (.15), Japan (.13); 1985: UK (.38), Germany (.23), USA (.17), Japan (.14), Saudi Arabia (.08); 1995: UK (.34), Germany (.19), Japan (.17), RSA (.16), India (.14).
MADAGASCAR	1975: France (.44), USA (.25), Germany (.15), Malaysia (.08), Japan (.08); 1985: France (.48), USA (.18), Japan (.14), Indonesia (.10), Germany (.09); 1995: France (.58), USA (.13), Germany (.13), Japan (.08), Italy (.08).	1975: France (.68), Germany (.14), USA (.07), Japan (.06), Italy (.05); 1985: France (.62), Germany (.12), USA (.11), UK (.08), Saudi Arabia (.07); 1995: France (.68), Japan (.09), Singapore (.09), Germany (.07), Iran (.07).	1975: France (.60), Germany (.14), USA (.14), Japan (.07), Italy (.05); 1985: France (.58), USA (.15), Germany (.11), Japan (.10), Netherlands (.06); 1995: France (.64), Germany (.11), USA (.10), Japan (.09), Italy (.06).

Table A continued…			
MAURITIUS	1975: UK (.82), USA (.06), France (.06), Canada (.04), Germany (.02); 1985: UK (.49), France (.23), USA (.17), Germany (.07), Italy (.04); 1995: UK (.43), France (.26), USA (.19), Germany (.07), Italy (.05).	1975: UK (.33), RSA (.18), Iran (.17), France (.17), Japan (.15); 1985: France (.32), RSA (.22), UK (.20), Japan (.15), Germany (.12); 1995: France (.29), RSA (.25), India (.19), UK (.15), Japan (.11).	1975: UK (.67), France (.11), RSA (.08), Iran (.07), Germany (.06); 1985: UK (.41), France (.28), USA (.14), Germany (.09), RSA (.08); 1995: UK (.34), France (.30), USA (.15), RSA (.12), Germany (.09).
MOROCCO	1975: France (.44), Italy (.15), Belgium (.14), UK (.14), Germany (.13); 1985: France (.51), Spain (.16), India (.12), Italy (.12), Belgium (.09); 1995: France (.51), Spain (.16), India (.14), Italy (.10), Japan (.09).	1975: France (.56), Germany (.15), USA (.14), Spain (.08), Italy (.07); 1985: France (.40), Saudi Arabia (.25), Spain (.12), Netherlands (.12), USA (.11); 1995: France (.45), Spain (.17), USA (.13), Germany (.13), Italy (.12).	1975: France (.55), Germany (.15), Italy (.11), USA (.10), Spain (.09); 1985: France (.46), Saudi Arabia (.19), Spain (.14), Netherlands (.12), Italy (.09); 1995: France (.49), Spain (.18), Italy (.11), USA (.11), Germany (.11).
NIGER	1975: France (.71), Nigeria (.24), USA (.03), UK (.01), Germany (.01); 1985: France (.80), Nigeria (.13), USA (.04), Italy (.02), Japan (.01); 1995: France (.80), Greece (.10), Canada (.04), Nigeria (.03), Turkey (.02).	1975: France (.57), USA (.23), Germany (.09), Netherlands (.06), UK (.05); 1985: France (.47), Nigeria (.20), Italy (.14), Côte d'Ivoire (.11), UK (.08); 1995: France (.50), USA (.21), Côte d'Ivoire (.16), Germany (.06), Netherlands (.06).	1975: France (.65), Nigeria (.17), USA (.11), Germany (.04), UK (.03); 1985: France (.63), Nigeria (.17), Italy (.08), Côte d'Ivoire (.06), USA (.05); 1995: France (.67), USA (.14), Côte d'Ivoire (.10), Greece (.05), Germany (.04).
NIGERIA	1975: USA (.40), UK (.19), Netherlands (.15), France (.15), Netherlands Antilles (.11); 1985: USA (.33), Germany (.23), France (.18), Italy (.17), Spain (.09); 1995: USA (.61), Spain (.14), France (.09), India (.08), Germany (.08).	1975: UK (.35), Germany (.22), USA (.16), Japan (.15), France (.12); 1985: UK (.35), USA (.20), Germany (.19), France (.16), Japan (.10); 1995: UK (.27), USA (.24), Germany (.21), France (.17), Netherlands (.11).	1975: USA (.32), UK (.27), Germany (.15), France (.14), Netherlands (.12); 1985: USA (.29), Germany (.22), France (.17), UK (.17), Italy (.15); 1995: USA (.54), France (.12), Germany (.12), Spain (.12), UK (.10).
SIERRA LEONE	1975: UK (.59), Netherlands (.14), USA (.13), Japan (.08), Germany (.06); 1985: Belgium (.36), Germany (.21), UK (.17), USA (.15), Netherlands (.11); 1995: Belgium (.59), USA (.19), Spain (.12), UK (.06), Germany (.04).	1975: UK (.48), Nigeria (.16), Germany (.13), Japan (.12), USA (.11); 1985: Nigeria (.32), UK (.28), Germany (.21), Japan (.10), Netherlands (.09); 1995: UK (.36), India (.19), Côte d'Ivoire (.18), USA (.16), Netherlands (.11).	1975: UK (.55), USA (.12), Netherlands (.12), Japan (.11), Germany (.10); 1985: Belgium (.26), UK (.24), Germany (.22, Nigeria (.15), USA (.13). 1995: Belgium (.38), UK (.23), USA (.19), India (.10), Côte d'Ivoire (.10).
SOUTH AFRICA	1975: UK (.37), Japan (.20), Germany (.18), USA (.18), Switzerland (.07); 1985: USA (.29), Japan (.26), UK (.20), Netherlands (.13), Switzerland (.12); 1995: UK (.30), Japan (.19), USA (.18), Germany (.16), Zimbabwe (.16).	1975: UK (.27), Germany (.26), USA (.25), Japan (.16), France (.06); 1985: Germany (.29), USA (.24), UK (.21), Japan (.17), France (.08); 1995: Germany (.31), USA (.22), UK (.20), Japan (.19), Iran (.08).	1975: UK (.32), Germany (.23), USA (.22), Japan (.17), France (.06); 1985: USA (.27), Japan (.22), Germany (.22), UK (.21), Netherlands (.08); 1995: Germany (.27), UK (.25), USA (.21), Japan (.19), Italy (.08).

Table A continued…			
TANZANIA	1975: UK (.31), Germany (.21), Singapore (.20), Kenya (.14), USA (.14); 1985: Germany (.39), UK (.28), Indonesia (.12), Singapore (.11), Netherlands (.10); 1995: Germany (.25), Japan (.22), India (.22), Belgium (.17), UK (.14).	1975: UK (.26), USA (.25), Saudi Arabia (.21), Germany (.14), Kenya (.13); 1985: UK (.27), Japan (.19), Italy (.19), Germany (.19), Iran (.15); 1995: UK (.26), Kenya (.25), Japan (.19), Saudi Arabia (.17), India (.13).	1975: UK (.29), USA (.23), Germany (.17), Saudi Arabia (.16), Kenya (.15); 1985: UK (.29), Germany (.25), Italy (.17), Japan (.17), Iran (.12); 1995: UK (.25), Japan (.22), Kenya (.20), India (.17), Germany (.16).
ZAMBIA	1975: UK (.30), Japan (.23), Germany (.19), Italy (.17), France (.11); 1985: Japan (.47), Italy (.18), France (.14), USA (.12), India (.09); 1995: Japan (.33), Saudi Arabia (.24), Thailand (.24), India (.09), Singapore (.09).	1975: UK (.33), USA (.21), Saudi Arabia (.19), Japan (.15), Germany (.12); 1985: UK (.30), Saudi Arabia (.28), Japan (.16), USA (.16), Zimbabwe (.10); 1995: RSA (.43), UK (.18), Zimbabwe (.14), Japan (.14), USA (.11),	1975: UK (.36), Japan (.22), Germany (.17), Italy (.14), USA (.11); 1985: Japan (.37), UK (.20) USA (.16), Saudi Arabia (.15), Italy (.12); 1995: Japan (.30), RSA (.24), Thailand (.17), Saudi Arabia (.17), UK (.12).
ZIMBABWE	1975: RSA (1); 1985: UK (.27), RSA (.23), Germany (.21), USA (.17), Italy (.12); 1995:RSA (.29), UK (.23), Germany (.19), Japan (.18), Italy (.11).	1975: RSA (1); 1985: RSA (.37), UK (.21), USA (.20), Germany (.14), Japan (.08); 1995: RSA (.73), UK (.08), USA (.07), Japan (.07), Germany (.05).	1975: RSA (1); 1985: RSA (.30), UK (.24), USA (.19), Germany (.17), Italy (.09); 1985: RSA (.58), UK (.13), Japan (.11), Germany (.10), USA (.08).

Source: Compiled from Direction of Trade Statistics Yearbook, IMF, various issues.

TABLE B: CLASSIFACATION OF EXCHANGE RATE REGIMES*

	BF	BR	CG	CD	EG	ET	GB	GM	GH	KE	MD	MT	MR	NR	NG	SL	SA	TZ	ZM	ZB
1965	na	US$	na	na		US$	na	UK£	UK£	UK£	FF	UK£	FF	na	UK£	UK£	UK£	UK£	UK£	Other
1966																				
1967											MF									
1968																				
1969											FF									
1970																				
1971					US$															
1972									US$	US$					US$		US$	US$	US$	
1973													MF				UKS			
1974															Other					
1975										SDR							MF			
1976												SDR						SDR	SDR	
1977					MF															
1978																SDR				
1979																				
1980																		Other		
1981									MF											
1982											Other									
1983												Other				MF				
1984		SDR														US$			Other	
1985															MF	SDR				
1986								MF	US$										MF	
1987																MF				
1988									MF	Other						US$			US$	
1989																			SDR	
1990																				
1991																MF		MF	MF	
1992																				
1993																				
1994		Other								MF		MF			US$					
1995																				
1996																				

*Notes: Format adapted from Nagayasu (1998). See Table C in the appendix for an abridged account of the exchange rate regimes; FF – French Franc, SDR – Special Drawing Rights; UK£ - Pound Sterling, US$ - US Dollar, MF – More Flexible exchange rate regime, Other – Other currency composites to which the exchange rates are pegged; *Refer to Table C in the appendix for the full names of countries.*

TABLE C: LIST OF COUNTRIES IN THE SAMPLE AND THEIR EXCHANGE RATE ARRANGEMENTS*

COUNTRY	EXCHANGE RATE ARRANGEMENTS
BURKINA FASO (BF)	NA
BURUNDI (BR)	1964: The Burundi Franc (FBu) linked to Belgian Franc; Multiple rate existed; 1965: Link to Belgian Franc broken, set to USD; devaluation in gold terms; multiple rate terminated; 1970: FBu pegged to USD; 1971: Floating of USD – de facto devaluation; 1973: Devaluation of USD, FBu realigned; 1976: Gold content fell; 1983: FBu peg to USD broken, now linked to SDR – controlled floating effective rate; 1986-91: FBu devalued and several other devaluations occurred in stages; 1992: link to SDR broken, now linked to basket of currencies, but it continued to depreciate.
CONGO REPUBLIC (CG)	NA
CÓTE D'IVOIRE (CD)	NA
EGYPT (EG)	1962 and 1971: The Egyptian Pound (LE) devalued; semi-official rate for tourists; 1973: USD devalued, LE realigned; Parallel market rate (PM) absorbed tourist rate; 1974: PM placed on controlled floating basis; 1975-76: PM devalued and depreciated; 1979: exchange structure revised, PM became official rate; 1981; three rates existed; 1984: LE devalued; 1986-88; several revisions and devaluation; 1990: devaluation; 1991: exchange rate system simplified to eliminate black market rate.
ETHIOPIA (ET)	1976: Name changed from Ethiopian Dollar to Birr (Br); official rate pegged to USD; adjustments made in buying and selling rate; 1992: devaluation of 58.6%.
GABON (GB)	NA
GAMBIA, THE (GM)	1971: de facto devaluation of USD appreciated the Gambian Dalasi (D); 1972: Dismantling of Sterling Area – depreciated the D, effective put on controlled floating basis; 1984: Link to £ changed; 1986: Link to £ broken; unit floated according to demand and supply; inter-bank market rate established, all foreign exchange controls ended; 1990: Foreign exchange bureaus permitted to operate.

Table C continued …	
GHANA (GH)	1972: The New Cedi (NC) replaced the Ghana Cedi (C), up-valued to new rate per USD; break up of Sterling Area; 1973: Devaluation of USD, NC realigned; 1977: Resident Travel Rate split into two; 1978: NC's link to USD severed, placed on controlled floating rate basis; de facto devaluation; 1979: Currency reform – travel rates merged, and devalued; 1981-86: Several devaluations; 1986 – exchange rate system revised – dual rate system; 1987: all business on auction rate; 1988: bureaus allowed to operate – eliminated black market rate; 1990: auction and bureau rate unified.
KENYA (KE)	1966: THE Kenya Shilling (KSh) replaced East African Shilling; 1971: de facto devaluation of USD, KSh appreciated; broke with £ and attached to USD; 1972: Break up of Sterling Area; 1973: USD devalued, KSh devalued in terms of gold; 1974; KSh devalued; 1975: KSh ties to USD severed, unit linked to SDR, placed unit on controlled floating basis, de facto devaluation; 1977: Break up of East African Currency Area. 1981-84: KSh cut seven times; 1985 – cumulative depreciation; 1986: KSh cut twice; 1987-88: Link to SDR severed, unit linked to basket of currencies; small devaluations effected. 1992: Free Market Export Rate established.
MADAGASCAR (MD)	1963: The Malagasy Franc (FMG) replaced CFA Franc at par; 1967: all foreign exchange controls abolished; 1968: controls re-instituted gradually; 1969: FMG cut; 1971: Dual system introduced, and realigned following de jure devaluation of USD; 1973: USD devaluation, official rate adjusted; withdrawal from French Franc Area, but still linked to Paris unit; Dual rate abolished; 1982: Unit's peg to French Franc broken, and attached to basket of currencies, effective rate managed flexibly – periodic devaluations and depreciations effected.

Table C continued …	
MAURITIUS (MT)	1934: The Mauritian Rupee (MauRe) became independent unit linked to £; 1949: devalued along with £; 1967: devaluation paralleling £; 1971-72; USD floated, Rupee appreciated; Sterling Area dissolved, Rupee allowed to float with £ - controlled floating rate; 1973: USD devaluation, unit realigned; 1976: unit's link to £ broken, linked instead to SDR; 1979: unit depreciated; dual system introduced, unit depreciated further, dual system dissolved; 1983: Unit's peg changed to trade weighted basket of currencies.
MOROCCO (MR)	1959: The Moroccan Dirham (DH) created when MF was devalued; 1961: DH became effective monetary unit; exchange fixed per French unit despite French devaluation; 1971: USD float – unit realigned to USD with 4.5% fluctuation range; 1973: USD devaluation – official rate realigned; effective rate floated in tandem with French unit; link to French Franc broken and placed on controlled floating basis; 1978: Supplementary Premium rate created – devalued unit;; 1980: Premium rate terminated; 1982-1984: changed to 5% premium; fixed percentage changed to one which changed from bank to bank, and then abolished in 1986; 1990: effective rate for unit devalued.
NIGER (NR)	NA
NIGERIA (NG)	1973: The Nigerian Naira (N) replaced £N, gold content fell paralleling USD devaluation; 1974; Unit put on controlled floating basis – rate adjusted in relation to basket of currencies; currency reforms decreed, borders closed; foreign exchange controls; 1986: Two-tier official rate established – auction rate and one set by central bank; 1987: the two rates merged, but dual system still existed – auction rate and inter-bank rate; 1988: Biweekly auctions ended; 1989: dual system officially ended; unified system – devaluation of 32%; official foreign exchange bureau rate existed; 1990: Dutch auction system used for allocations of foreign exchange; 1991; exchange rate system revised – central rate determined by central bank; 1992: exchange rate system revised – Naira free to float, effective rate devalued.

Table C continued …	
SIERRA LEONE (SL)	1964-1967: The Sierra Leonean Leone (Le) replaced West African £; unit devalued following £ devaluation; 1971: USD devaluation – unit appreciated due to link with £; 1972: End of Sterling Area – unit depreciated against USD, and rate put on controlled floating basis; 1973: USD devaluation – unit realigned; 1978: Unit's peg to £ broken, and linked to SDR; 1982: Dual exchange rate announced; 1983: Dual rate abolished, peg to SDR broken, and linked to USD; 1985: Unit linked to SDR – devalued; 1986: Rate structure scrapped in favour of flexible exchange rate system, but later abandoned and pegged to USD and re-valued later; 1988-89: Unit adjusted on several occasions; 1990: Unit reduced sharply, exchange rate system revised, and link to USD broken; effective rate determined by average of weekly commercial bank transaction, and official rate based on supply and demand in market; 1991: Licensed foreign exchange bureaus permitted to operate.
SOUTH AFRICA (SA)	1961: The South African Rand (R) replaced South African £; 1971: Floating of USD – de facto devaluation as R's link to £ was severed and pegged to USD; Later re-linked to £; 1972: Following floating of £ and dismantling of Sterling Area, Rand remained linked to £, de facto devaluation; 1973: USD devaluation, official rate realigned, R up-valued in terms of gold; 1974: effective rate established, R placed on controlled floating basis – de facto devaluation; 1975: R devalued, two-tier exchange rate system established – commercial and financial R; 1983: Two rate abolished and merged into unified floating effective rate – de facto devaluation; 1985: dual system re-established;
TANZANIA (TZ)	1966: The Tanzania Shilling (TSh) replaced east African Shilling; 1971: Floating of USD – Tanzania severed her link with £ - attached to USD – de facto devaluation; gold content of TSh reduced; 1972: Floating of £, and Sterling Area dismantled; 1973; USD devaluation, TSh devalued in gold; temporary effective rate established; and gold content later increased – up-valued official rate; 1974: TSh devalued following Kenya and Uganda; 1975: effective rate established as ties to USD were severed, and linked to SDR instead – currency placed on controlled floating basis – de facto devaluation; 1977: Break up of East African Community; 1979; effective rate devalued ad link to SDR was broken; Unit depreciated and attached to basket of currencies; 1990-91: controlled effective rate downgraded several times; 1992: licensed foreign exchange bureaux allowed to operate.

Table C continued …	
ZAMBIA (ZM)	The Zambian kwacha (K) replaced the £Z; devalued by 50%.; 1971; USD de facto devaluation – K was fixed through link to £, it began to appreciate; Unit's link to £ broken, and attached to USD – de facto devaluation; K's gold content fell, allowed to fluctuate within 4.5% range; 1972: Dismantling of Sterling Area; 1973: USD devaluation – official rate realigned; 1976: effective rate established, as K's ties to USD are severed, and linked to SDR – placed unit on controlled floating basis – de facto devaluation: 1978: link of effective rate to SDR cut to new exchange value; 1983: effective rate devalued; link to SDR broken and unit attached to basket of currencies; 1985: Rate determined by marginal clearing bid at weekly auction; 1987: Auction system discontinued; K pegged to basket of currencies, and rate to move in range 8-11US$; dual system re-introduced; exchange rate system unified and K pegged to USD; 1988: K devalued and pegged to SDR; 1989: K devalued, new bank notes; 1990: dual rate reinstated; 1991: Dual rates merged at market rate, Market rate pegged to SDR and rate against USD adjusted frequently to reflect demand and supply conditions; 1992: foreign exchange bureaux began operating.
ZIMBABWE (ZB)	1965-79: UDI – dual exchange rate was in place, the Zimbabwe Dollar ($Z) was put in fixed relation with the South African Rand, with adjustments effected at irregular intervals; 1980: Dual system abandoned; 1980-1993: Unit pegged to a trade-weighted basket of currencies.

*Note: *The exchange rate arrangements for five countries are not available; NA – Not available.*
Source: Cowitt, P.P. et al, (ed.), (1996), World Currency Yearbook.

TABLE D: Individual Unit Root Tests (Demeaned Data)

Country	Multilateral Index (Import-based) *ADF/DF*		Bilateral Index *ADF/DF*		Multilateral Index (Trade-weighted) *ADF/DF*	
	b_i	*ADF/DF*	b_i	*ADF/DF*	b_i	*ADF/DF*
Burkina Faso	-0.144(0)	**-1.318**	-0.251(0)	**-2.014**	-0.136(0)	**-1.261**
Burundi	-0.157(0)	**-1.556**	-0.328(0)	**-2.344**	-0.142(0)	**-1.500**
Congo Rep.	-0.129(0)	**-1.321**	-0.105(0)	**-1.154**	-0.136(0)	**-1.359**
Côte d'Ivoire	-0.254(1)	**-2.574**	-0.139(1)	**-2.674**	-0.260(1)	**-2.479**
Egypt	-0.333(1)	**-3.088**	-0.299(1)	**-2.932**	-0.349(1)	**-3.161**
Ethiopia	-0.246(0)	**-1.624**	-0.318(3)	**-1.978**	-0.216(0)	**-1.616**
Gabon	-0.281(1)	**-2.455**	-0.200(3)	**-2.932**	-0.300(1)	**-2.484**
The Gambia	-0.201(0)	**-1.959**	-0.198(0)	**-1.840**	-0.104(2)	**-1.406**
Ghana	-0.163(1)	**-1.899**	-0.152(1)	**-2.010**	-0.148(1)	**-1.972**
Kenya	-0.143(0)	**-1.643**	-0.413(0)	**-2.606**	-0.160(0)	**-1.743**
Madagascar	-0.679(3)	**-2.982**	-0.429(0)	**-2.672**	-0.100(0)	**-1.254**
Mauritius	-0.106(0)	**-1.396**	-0.114(0)	**-1.239**	-0.109(0)	**-1.369**
Morocco	-0.152(1)	**-1.795**	-0.123(1)	**-1.568**	-0.113(0)	**-1.431**
Niger	-0.313(1)	**-2.719**	-0.282(0)	**-1.978**	-0.417(1)	**-3.284**
Nigeria	-0.278(1)	**-2.751**	-0.272(1)	**-2.623**	-0.249(1)	**-2.551**
Sierra Leone	-0.135(0)	**-1.503**	-0.345(0)	**-2.585**	-0.226(0)	**-2.112**
South Africa	-0.246(3)	**-2.126**	-0.252(3)	**-2.064**	-0.258(3)	**-2.139**
Tanzania	-0.176(1)	**-2.432**	-0.190(1)	**-2.546**	-0.175(1)	**-2.455**
Zambia	-0.199(0)	**-1.731**	-0.278(0)	**-2.142**	-0.206(0)	**-1.822**
Zimbabwe	-0.113(0)	**-1.509**	-0.602(3)	**-2.679**	-0.115(0)	**-1.523**

Notes: The figures in parentheses are lag lengths.

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