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Department of Economics Working Paper Series

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Working Paper: 2015-02
January 2015

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Assessment of Monetary Union in SADC: Evidence from Cointegration and Panel Unit Root Tests

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January 26, 2015

Abstract

In this paper we investigate the likelihood of a proposed monetary union in the Southern African Development Community (SADC) being successful from the viewpoint of the Generalised Purchasing Power Parity (GPPP) hypothesis and optimum currency area (OCA) theory. We apply Johansen's multivariate co-integration technique, panel unit root tests, Pedroni's residual cointegration test and error correction based panel co-integration tests. The findings from this study confirm that GPPP holds among SADC member countries included in this study on account of cointegration and stationarity in real exchange rate series. The South African rand normalised long run beta coefficients of all the real exchange rates are below one except in the case of the Mauritian rupee and all bear negative signs except in the case of the Angolan New Kwanza and Mauritian rupee. This evidence support monetary union in the region except for Angola and Mauritius. However, the absolute magnitudes of the short run adjustment coefficients of SADC countries' real exchange rates are low and bear positive signs in some cases. This finding implies that the observed slow speed of adjustment for the (log) real exchange rate of SADC member states might constrain the effectiveness of stabilization policies in the wake of external shocks, rendering SADC countries vulnerable to macroeconomic instability in the region. This result has important policy implications for the proposed monetary union in SADC.

Key Words: SADC, OCA, GPPP, real exchange rate, cointegration, panel unit root

JEL Classification: C32, E31, F15, F41

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1 Introduction

The Southern African Development Community (SADC) is the largest regional economic grouping in sub Saharan Africa (SSA) (Burgess, 2009). SADC's regional economic integration agenda is outlined in its Regional Indicative Strategic Development Plan (RISDP), adopted by member states in 2003. The RISDP plans for deepening regional integration over a 15-year period. The timeline for the plan include the creation of a free trade area by 2008, a customs union by 2010, a monetary union by 2016, and a single currency by 2018.

The formation of the European Union (EU) has inspired countless research papers on economic integration; specifically relating to monetary integration and optimum currency area (OCA) theory. It seems as if there is a sense of urgency in getting research results to policy makers to avoid a repeat of the EU financial crises in other regions. Recent research results are mixed about the economic and political feasibility of monetary integration in the SADC region and other regional economic communities in Africa. This paper sets out to achieve a number of objectives. The chief aim of this paper is to test generalised purchasing power parity (GPPP) in SADC as measure of real convergence, as OCA criterion, towards monetary union in the region.

This paper explores GPPP in SADC economies. The most important macroeconomic variable behind GPPP is the real exchange rate and its determinant factors. Stability of exchange rates along with other macro variables in the economy of potential currency union members, relative to other members, is one of the requirements for a group of countries to constitute an OCA and hence of adopting a single currency. This paper sheds light on the long run relationship among SADC constituent[1] economies to answer the question of whether SADC economies constitute an OCA. However, due to data limitations, four member countries are not included in the analysis. The motivation behind this study is to contribute empirical evidence towards the AU's agenda of economic integration with reference to SADC. Assessing criteria in the context of SADC and considering the lessons and practices from other regional integration initiatives on the continent will contribute to this end.

Studies carried out to test the validity of the PPP theory in the sub Saharan Africa (SSA) context fail to reject the null hypothesis of a unit root (Krichene, 1998; Nagayasu, 2002; Mkenda, 2001; Mokoena et al., 2009, Changet et al., 2010, and Olayungbo, 2011). This means that the real exchange rate series do not display mean-reverting behaviour in the long run. In some cases the results are not conclusive. To the best of our knowledge this paper is the first to test the GPPP hypothesis in SADC with a view of identifying countries in the region that may qualify as an OCA and may safely enter into a monetary union.

The remainder of the paper is organised as follows: section 2 adds contextual background, section 3 presents data and methodology, and section 4 presents empirical results and economic implications. The last section concludes the

[1] The fifteen countries forming SADC are Angola, Botswana, Democratic Republic of Congo, Lesotho, Malawi, Madagascar, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe.

paper.

2 The Relevance of GPPP in OCA Theory

OCA theory from the classic contributions by Mundell, 1961; McKinnon, 1963; Kenen, 1969; and Ingram, 1973 to its modern applications and revisions stresses that asymmetric, country specific shocks represent a key element in the choice of an exchange rate regime. Traditional OCA theory states that the requirements for suitable monetary unions are the *symmetry of shocks, the mobility of factors, the diversification of factors of production, the similarity of inflation rates, the flexibility of wages and prices and the capacity of risk sharing* (Tapsoba, 2009). In this section we attempt to explore the relevance of GPPP in explaining OCA theory. GPPP hypothesise that the real exchange rates between two countries comprising the domain of a currency area should be co-integrated. GPPP is also relevant in a multi-country setting. If GPPP holds among member courtiers that constitute an OCA, it implies that the fundamentals that drive the real exchange rates will exhibit common stochastic trends. Thus, real exchange rates in the currency area will also share common stochastic movements. Within the currency area, therefore, there should at least be one, at most n-1, linear combinations of various bilateral real exchange rates among member countries that is stationary.

The GPPP hypothesis is a variant of PPP theory. PPP theory is commonly regarded as one of the major pillars of international trade and finance theory. It has attracted considerable interest in the literature in the past and recently (Lau et al., 2011). However, puzzles associated with PPP and exchange rate economics make the theory debatable and without universal consensus (Taylor and Taylor, 2004; Mokoena, et al., 2009). Many recent studies taking advantage of econometric techniques confirm the positive contribution the theory has had. Furthermore, methodological improvements in addressing the limitations in the PPP theory are well documented (see Christopoulos and Leon-Ledesma, 2010; Lau et al., 2011). Recently, Snaith (2012) in a panel of 15 OECD countries using new panel root tests, which account for cross sectional interdependence among countries, finds that these panels produce more support for PPP theory using PPI indexes that represent a higher proportion of tradable goods.

The failure of traditional PPP theory in explaining bilateral exchange rate behaviour does not rule out the possibility of the existence of a stationary relationship between real exchange rates in multi-country settings. When PPP fails, GPPP can be used to test whether a stationary relationship exists within a panel of countries which potentially constitute an OCA. This alternative view of the GPPP hypothesis was developed by Enders and Hurn (1994). The idea is that traditional PPP can fail because the fundamental macroeconomic variables determining real exchange rates, including national income, terms of trade and government consumption, etc. are non-stationary, and thus real exchange rates themselves tend to be non-stationary. Although bilateral real exchange rates are generally non-stationary, GPPP hypothesizes that bilateral real exchange rates can exhibit common stochastic trends if the fundamental macroeconomic determinants that affect real exchange rates are sufficiently interrelated. Therefore, the importance of the innovation of GPPP lies in the fact that it establishes a linkage among macroeconomic variables, real exchange rates and the concept of PPP (Gao, 2007).

Enders and Hurn (1994) first used the GPPP approach to assess the suitability of forming a currency union. If two countries qualify for the creation of a currency union the fundamental macroeconomic variables in the two countries must move together. In the context of GPPP, the fundamentals that drive real exchange rate will exhibit common stochastic trends. Within the currency area, therefore, there should at least be one linear combination of various bilateral real exchange rates that is stationary. Bilateral exchange rates are affected through both market conditions and intervention. Therefore, OCA theory helps explain the behaviour of bilateral exchange rates on the same grounds that decisions are taken whether or not to form a currency union. Such links arise because shocks to the foreign exchange market reflect OCA-related factors. Countries' bilateral exchange rates are stable relative to each other when the shocks they experience are similar. However, we should note that when potential members of a proposed monetary union belong to different exchange rate regimes it might have an impact on the speed of real exchange rate adjustment by different exchange rate regime countries, when exposed to similar shocks (see Annex 2 for SADC Currencies and Exchange Rate Regimes since 2004). Pooling real exchange rates from countries with different exchange rate regimes may therefore underestimate GPPP. When we consider the exchange rate regimes in the SADC region most of the countries in the region either have an independently floating or managed floating exchange rate regime. The rest are pegged to the South African rand which is independently floating. In the case of SADC however, we can assume that the exchange rate regimes are inherently uniform in the region.

3 Data and Methodology

3.1 Data

This study covers a sample of 11 SADC member countries. Four member states of SADC namely the DRC, Lesotho, Namibia, and Zimbabwe are not included in the sample given data limitations. Monthly data for the period January 1995 to August 2012 is used in this study. All data relating to consumer price indices (CPI) (based on 2005=100) and nominal exchange rates relative to the US dollar are taken from the IMF International Financial Statistics. Each of the consumer price index and nominal exchange rate series are transformed into natural logarithms before the econometric analysis. The PPP approach measures the real exchange rate as the price of foreign goods relative to that of domestic goods, where both prices are expressed in the same currencies. That is, it defines the real exchange rate as the nominal exchange rate adjusted for the relative price levels of the foreign and domestic economy. In its simplest form, under the assumption of purchasing power parity, the RER is the nominal exchange rate (NER) multiplied by the relative prices of trading countries i.e.

$$RER = NER\frac{P^*}{P} \tag{1}$$

where P^* and P are the foreign and domestic prices respectively.

Alternatively, we can express equation (1) in logarithmic form, such that the series of interest for country 'i' at time-'t', is given by the following equation:

$$r_{i,t} = s_{i,t} + p^*_{us,t} - p_{i,t} \tag{2}$$

where $r_{i,t}$ is the logarithm of the RER against the US dollar, $s_{i,t}$ is the logarithm of the NER against the US dollar, $p^*_{us,t}$ and $p_{i,t}$, are the logarithms of consumer price indices in the US and country 'i respectively'. Using equation 2 we compute the RER series for the countries included in this study. Table 1 presents the descriptive statistics of the SADC RER series (see all the tables at the end). Annex 1 provides a graphical illustration of RER series with non-mean reverting features at levels and show that the series are stationary in the second difference in line with literature reviewed; unit root test results are reported in Table 2.

3.2 Methodology

3.2.1 *Methodology on co-integration*

A time series of RER $\{\mathrm{r}_t\}$ is stationary if the following relation holds true under the assumption of linearity:

$$r_t = \alpha + \beta + \varepsilon_t < \beta < 1 \tag{3}$$

When β=1, equation (1) becomes a unit root process. It means the process does not allow the system to come back to equilibrium which limits the usefulness of PPP as a tool to assess monetary integration. However, the GPPP hypothesis can be employed in such conditions for the reasons discussed in section two. Following Enders and Hurn (1994) and succeeding literature - for example Wilson and Choy (2007); Beirne (2008) - GPPP can be described as follows: Assuming an $n-$country world, an m-country ($m \leq n$) currency area exists such that a long-run equilibrium relationship exists between the $m-1$ bilateral exchange rates of the form

$$r_{12t} = \alpha + \beta_{13t}r_{13t} + \beta_{14t}r_{14t} + \ldots + \beta_{1mt}r_{1mt} + \varepsilon_t \tag{4}$$

where r_{i1t} is the log of the bilateral RER in period t between country 1 and country i; α is the intercept term ; β_{i1t}'s are the parameters of the cointegrating vector, which represent the degree of comovement of the RERs; and is ε_t a stationary stochastic disturbance term.

Beirne (2008) explains equation (4) as the spill-over effect due to real shocks in country i that are transmitted to other economies with high degrees of economic interdependence with country i. GPPP holds when at least one linear combination of bilateral RERs is observed. The existence of linear combinations implies that output shocks have a symmetrical effect on the RERs in a given area (Ogawa and Kawasaki, 2003; Beirne, 2008). Mathematically,

$$r_{i0t} = \sum \beta_j r_{j0,t} + \varepsilon_{GPPP,t} \tag{5}$$

where the residual term '$\varepsilon_{GPPP,t}$' is stationary.

In this paper we adopt the Johansen (1996) Multivariate Maximum Likelihood Estimation (MMLE) procedure because it assumes all variables to be endogenous and does not require the choice of a dependent variable. The Johansen method tests the restrictions imposed by co-integration of the unrestricted Vector Auto Regression (VAR) involving the series. To test whether the $n-1$ set of countries form an OCA, following Beirne (2008) we set up the *VAR (k)* in the following matrix notations:

$$z_t = A_1 z_{t-1} + \ldots + A_k z_{t-k} + \varepsilon_t \qquad \varepsilon \tilde{} IN(0, \Sigma) \tag{6}$$

where z_t is the log of the RER in the form of $(n \times 1)$ and A_i represents a matrix of parameters $(n \times n)$. In line with the Vector Error Correction Model (VECM), we can rewrite equation (6) as follows (in first-difference form):

$$\Delta z_t = \Gamma_1 \Delta z_{t-1} + \ldots + \Gamma_k \Delta z_{t-k+1} + \Pi z_{t-k} + \varepsilon_t \tag{7}$$

where short run information is given by Γ_i which represents $(I - A_1 - \ldots - A_i), (i = 1, \ldots, k-1)$, and long run information is provided by Π which represents $-(I - A_1 - \ldots - A_k)$. Thus the hypothesis to be tested is given by:

$$H_1(r) : \Pi = \alpha.\beta^{'} \tag{8}$$

Where α is the loading matrix known as the adjustment parameter in VECM and the reduced rank where, r is the number of co-integrating relationships. Granger's representation theorem indicates that if the coefficient matrix Π has a reduced rank $r < n-1$, there exists $(n-1) \times r$ matrices α and β each with rank r such that:

$$\Pi = \alpha.\beta^{'} \, and \, \beta^{'}.z_t \tilde{} I(0)$$

Finally, the Johansen method estimates the matrix from an unrestricted VAR and tests whether we can reject hypothesis 1 (in equation 8) on the reduced rank of Π. When the matrix is stable, there is a long-run relationship among $n-1$ real exchange rates whose countries can form an OCA (Sugimoto, 2008).

To test the hypothesis in equation (8) using the Johansen co-integration procedure we can have two specific test statistics; one relating to the trace[2] test and the other to the maximum Eigen-value test. Both tests yield the number of co-integrating vectors in the system. The null hypothesis is that there are

[2] Both trace and maximum eigenvalue tests are likelihood ratio type tests, however, both operate under different assumptions regarding the deterministic part of the data generation process. The trace test tends to have more distorted sizes whereas their power in some situations superior to that of the maximum eigenvalue tests (Lutvephol, 2000).

at most ‘r’ co-integrating vectors, i.e. (0 ≤ r ≤ n). The trace test statistics is computed as follows:

$$\lambda_{trace} = -N \sum\nolimits_{i} = r + 1^{n} \ln(1 - \lambda_i) \quad (9)$$

where λ_i are the (n-r) smallest squared canonical correlationsof z_{t-1} with respect to Δz_t corrected for lagged differences and N is the sample size. In the same way, the maximum Eigen-value test is computed as follows:

$$\lambda_{\max} = -N \ln(1 - \lambda_{N+1}) \quad (10)$$

With the maximum Eigen-value test, the null hypothesis is that there are ’r’ co-integrating vectors against the alternative that $r + 1$ exist. Thus, rejection of the hypothesis implies that a maximum of ’r’ contegrating vectors exist.

3.2.2 *Methodology on panel unit root tests*

Using the conventional wisdom in the literature, panel unit root tests are superior to time series unit root tests. Therefore, in this paper we use panel unit root tests as found in Im, Pesaran and Shin (IPS) (2003) and Levin Lin and Chu (LLC) (2002). Furthermore, we also use Pesaran’s cross-sectional augmented Dickey Fuller (CADF) test to supplement the robustness of LLC & IPS tests to take care of heterogeneity in the panel (see the result in Table 7).

From equation (4) we have the following panel unit root regression:

$$\Delta q_{i,t} = \alpha_i + \beta_i q_{i,t-1} + \sum\nolimits_{j=1}^{wij} \delta_{i,j} \Delta q_{i,t-j} + \varepsilon_{i,t}, i = 1, \ldots, N, \quad \text{and } t = 1 \quad (11)$$

LLC (2002) test

The LLC test examines:

$H_0 : \beta_1 = \beta_2 = ... = \beta_N = 0$ against $H_1 : \beta_i < 0$, for some i

$\mathbf{H}_0$ and $\mathbf{H}_1$ are the null and the alternative hypothesis respectively, where the appropriate lag order w_{ij} from equation (5) must be determined. The conventional t-statistics for testing $\beta_i = 0$ is:

$$t_{\beta i} = \frac{\hat{\rho}}{\hat{\delta}(\hat{\rho})} \quad (12)$$

The IPS adjusted t-statistic is expressed as:

$$t^*_{\beta i} = \frac{t_{\beta i} - NTS\hat{N}\sigma\varepsilon^{-2} STD\,(\hat{\sigma})\,\mu^* M\breve{T}}{\hat{\delta}(\hat{\rho}) M\breve{T}} \quad (13)$$

IPS (2003) test

The IPS test also examines:

H$_0$: $\beta_1 = \beta_2 = ... = \beta_N = 0$ Against H_1: $\beta_i < 0$, for some i

The IPS statistics is: $CIPS(N,T) = \frac{1}{N}\sum_{i=1}^{N} t_i(N,T)$ where $t_i(N,T)$ is the cross-sectionally augmented ADF statistics (CADF) for the ith cross section. Similarly, the standardised IPS t-bar statistics is given by

$$t_{ips} = \frac{\sqrt{N}(t-1)/N\sum_{t=1} NE[t_i,t]\beta_i = 0}{\sqrt{N-1\sum_{t=1}^{N} VAR[t_i,t]\beta_i = 0}} \tag{14}$$

4 Empirical Results and discussions

Prior to cointegration and panel unit root test analysis it is customary to carry out conventional unit root tests. In this study we performed the following four unit root tests; the Dickey–Fuller test with generalised least squares (DF-GLS), Augmented Dickey Fuller (ADF) test, Philipps-Perron (PP), the test proposed by Ng and Perron (NG-MZ$_\alpha$) (2001), and the Kwiatkowski-Philips-Schmidt-Shin (KPSS) test. The test results confirm that the series are non-stationary at level. See the results of unit root tests in Table 2.

4.1 Cointegration Test Results

4.1.1 *Johansen's test for cointegration*

The co-integration rank is determined by assessing the Trace and Maximum Eigen-value test statistics. As shown in Table 3 the Trace statistics indicate three cointegrating relationships while the Maximum Eigen-value shows one cointegrating equation at the 1% level. The Eigen-values in Table 3 are less than unity which implies that the system as a whole is stable and the co-integration results are reliable (Chiemeke, 2010). Given these findings there are more than one co-integrating vector for SADC (log) real exchange rate in support of GPPP hypothesis in the SADC region for the sample period. To supplement the result presented in Table 3 we also carried out the Pedroni (Engle-Granger-based) residual cointegration test for the series of real exchange rate (RER), nominal exchange rate (NER) and CPI. The Pedroni cointegration test is robust enough to allow for heterogeneous dynamics across individual members of the panel (Pedroni, 2005). The findings in Table 4 are in support of the findings in Table 3 (For methodological aspects of the Pedroni cointegration test see Pedroni, 2004). The results shown in Table 4 further strengthen the assertion of cointegration in the RER series in the SADC region by rejecting the null hypothesis of no integration in all of the statistics.

4.1.2 *Speed of short run adjustment and long run elasticity coefficients*

The alpha (α) coefficients in Table 5 provide the estimates of the short run adjustment of each of the real exchange rates towards the long run equilibrium. The alpha coefficients of SADC countries in Table 5 are all below one and the standard errors of the estimation are very low. These are good indications of

RER stability in the region. However, all the coefficients are positive except in the case of the Angolan new kwanza, Mauritian rupee, Seychelles rupee, and Zambian kwacha. The coefficients can be interpreted as a measure of how quickly each of the RERs converges to GPPP (Beirne, 2008). Considering the absolute magnitude of the alpha coefficient in Table 5, the Angolan new kwanza has highest value of -0.94 which implies that the (log) RER of the Angolan new kwanza expressed against the dollar adjusts at the rate of 94% per month towards the long run equilibrium whereas the Zambian kwacha adjusts at a rate of -0.0088 or only 0.88% per month towards the long run equilibrium. The rest of the coefficients can also be interpreted likewise.

The absolute magnitude of the adjustment coefficients of SADC countries' real exchange rate is low. The lower the absolute magnitude of the 'α' coefficient, the slower becomes the speed of adjustment towards long run equilibrium. This finding implies that the observed slow speed of adjustment for (log) real exchange rate of SADC member states might constrain the effectiveness of stabilization policies in the wake of external shocks, rendering SADC countries vulnerable to macroeconomic instability in the region. Though the magnitudes of the alpha coefficients are low, they are all significantly different from zero at a 1 percent level of significance. Therefore, the problem of weak exogeneity[3] is not observed for the countries included in this study during the study period.

The beta (β) coefficient in Table 6 reflects the interrelationships among SADC real exchange rates in terms of the log run elasticities. The real exchange rates based on the South African rand expressed against dollar is used to obtain the normalized equations in Table 6. When using the South African RER to obtain the normalised cointegrating equations, the results of adjustment coefficients (α) and long run coefficients (β) become much better than using other currencies in the region. The results are statistically significant at the 1 percent level of significance for the bilateral real exchange rates. The sign and the magnitude of the parameters of the co-integrating vectors of countries in the sample reflect common policy connections and coordination that exist among member countries (Beirne, 2008). The magnitude of the beta coefficients of all the real exchange rates are below one except in the case of Mauritius and they all bear negative signs except in the case of Angola and Mauritius. We can take this evidence as supportive of monetary union in the region excluding Angola and Mauritius. These two countries may exhibit asymmetry in response to external shocks, disqualifying them from a SADC OCA. The interpretation goes with Table 6. Thus, a 1 percent increase in the real exchange rate of the South African rand per US dollar (i.e. a devaluation of rand) will induce a 0.818%, 0.137%, 0.558%, 0.387%, 0.083%, 0.779% , 0.445% and 0.156% decrease in the real exchange rates of the currencies of Botswana, Malawi, Madagascar, Mozambique, Seychelles, Swaziland, Tanzania, and Zambia per US dollar, respectively.

[3] An economic variable tends to be weakly exogenous if its speed of adjustment coefficient is not statistically different from zero (Harris, 1995). Such a variable has no explanatory power with respect to the long run coefficients.

4.2 Panel Unit Root Test Results

The results from our panel unit root tests are subject to inclusion or exclusion of a time trend. The inclusion of a time trend is to account for the Balassa-Samuelson effect. The optimal lag lengths are chosen using Schwarz Information Criteria (BIC). Table 6&7 present panel unit root tests according to LLC and IPS respectively. As shown in Table 7, the LLC panel unit root test rejects the null hypothesis of a unit root at the 1 percent level of significance when a time trend is included in the estimation. It also rejects the null hypothesis of a unit root in the panel at a 10 percent level of significance when a time trend is not included.

The IPS unit root test result in Table 8 shows that the panel of (log) real exchange rate series is stationary at a 1 percent level of significance only when the time trend is included in the analysis; otherwise it is unit root. From these two panel unit root tests we can safely generalise that the panel of real exchange rates is stationary, hence there is GPPP when the whole panel of SADC countries is considered jointly and when the time trend is included in the panel analysis. The other two variables in this study, the panel series of the logarithm of nominal exchange rate and CPI are also stationary with and without the trend. These results are not reported here. To supplement the robustness of IPS test we also carried out Pesaran's cross-sectional augmented Dickey Fuller (CADF) test. As shown in Table 9 Pesaran's CADF test also rejects the null hypothesis of *'all series are non-stationary'* at 5 percent level of significance, supporting the results obtained by the LLC and IPS panel unit root tests.

4.3 Robustness Check

Lastly, as shown in Table 10, we also computed the error correction based co-integration tests for the panel of SADC (log) real exchange rate series to check the robustness of the results. In these tests there are two statistics; *group mean statistics* (i.e.G_α and G_τ) and the *panel statistics* (i.e. P_α and P_τ). In this test we reject the null hypothesis of no co-integration for the panel as the whole at the 1 percent level of significance. However, with the group mean statistics we fail to reject the null hypothesis. This implies that there is no co-integration for at least one of the cross-sectional units. This result is in line with our normalised co-integrating equations' long run coefficients reported in Table 8. Here it should be noted that the (log) real exchange rate series of Mauritius and South Africa behave differently from the rest of the group. It is important to again emphasise that the panel tests have the highest power since they are based on pooled least square estimators of the co-integration coefficients (Persyn and Westerlund, 2008).

5 Conclusions

The aim of this paper was to establish whether SADC countries form an OCA by using the GPPP framework. For the analysis the Johansen multivariate co-integration technique, LLC and IPS panel unit root tests and error correction based panel co-integration tests were used. A panel of the logarithm of SADC real exchange rates, nominal exchange rates, CPI, and CPI of the US as a base country for the period of 1995 to 2012 are employed in the analysis.

Consistent with the previous studies in developing regions across the globe, all the conventional unit root tests confirm that the panel series in this study have unit roots. We also employed panel unit root tests for RER series which confirmed stationarity with a high level of significance with a time trend included in the estimation. Johansen's multivariate co-integration test has two specific test statistics: the trace and the maximum Eigen-value. In this paper the trace statistics indicate the existence of three co-integrating relationship among SADC real exchange rates while the maximum Eigen-value shows one cointegration relationship. The Eigen-values obtained in the analysis of these two statistics are less than unity which implies that the systems of equations are stable and hence the results from the estimations are reliable. Therefore, the conclusion from these findings implies that GPPP holds in the SADC region.

In addition to Johansen's co-integration analysis, Pedroni's residual cointegration test and error correction based panel co-integration tests are also performed. Both tests confirm that there are cointegrating relationships among SADC real exchange rate series. However, the absolute magnitudes of the short run adjustment coefficients of SADC countries' real exchange rates are low. The lower the absolute magnitude of the alpha coefficient, the slower becomes the speed of adjustment towards long run equilibrium. This finding implies that the observed slow speed of adjustment for (log) real exchange rate of SADC member states might constrain the effectiveness of stabilization policies in the wake of external shocks, rendering SADC countries vulnerable to macroeconomic instability in the region. The magnitude of the long run beta coefficients of all the real exchange rates are below one except in the case of Mauritius and they all bear negative sign except in the case of Angola and Mauritius. We can take this evidence as supportive of monetary union in the region excluding Angola and Mauritius. These two countries may exhibit asymmetry in response to external shocks, disqualifying them from a SADC OCA. Similar findings are reported by Zerihun et al. (2014) that states that not all countries in SADC conform to OCA criteria judged by both asymmetrical business cycles and weak co-movements in business cycles.

In general the study concludes that the GPPP hypothesis holds for SADC economies given the stationary panel of RER series and cointegrating relationships amongst the system of RERs. This implies that the region is potentially an OCA that could proceed with monetary integration. However, the slow speed of adjustment towards long run equilibrium sounds a warning for the possible ineffectiveness of policy to defend these countries against external shocks. We recommend that policy makers should not focus only on the dynamics of RER in the SADC region and consider alongside this result more OCA criteria for meaningful policy formulation as SADC moves toward the proposed monetary integration in the region.

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Table 1: Descriptive Statistics and Normality Test of SADC (Log) Real Exchange Rate

Country	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera[1]
Angola	4.460	4.479	5.627	1.966	0.551	-0.867	5.800	95.768***
Botswana	1.714	1.696	2.129	1.493	0.143	0.743	2.945	19.527***
Madagascar	7.438	7.453	7.894	7.171	0.152	0.114	2.155	6.767**
Malawi	4.629	4.680	5.107	4.083	0.215	-0.910	3.432	30.886***
Mauritius	3.300	3.335	3.492	3.093	0.111	-0.262	1.833	14.453***
Mozambique	3.118	3.104	3.457	2.874	0.146	0.559	2.463	13.603***
South Africa	1.909	1.884	2.528	1.592	0.193	0.975	3.992	42.273***
Seychelles	1.798	1.733	2.263	1.558	0.158	1.054	3.212	39.619***
Swaziland	1.949	1.911	2.580	1.581	0.207	0.832	3.416	25.979***
Tanzania	6.911	6.937	7.161	6.635	0.118	-0.470	2.462	10.357***
Zambia	8.476	8.601	9.066	7.904	0.316	-0.284	1.481	23.240***

Source: own computation from sample data (1995m1-2012m8)
Note: ** and*** indicate significance at the 5% and 1% levels, respectively.

Table 2: Univariate Unit Root Tests of SADC (Log) Real Exchange Rate Series

(Log) Real Exchange Rate Series	**DF**(GLSdetrended)	**ADF** (Level)	**PP** (GLSdetrended)	MZ_α (GLS detrended)	**KPSS** (Trend Stationary)
Angola	-0.770(8)	-1.477(8)	-0.523(8)	-0.298(8)	0.239(14)***
Botswana	-1.350(2)	-2.090(8)	-3.712(2)	-3.685(2)	0.236(10)***
Madagascar	-1.699(1)	-2.428(1)	-6.703(1)	-6.665(1)	0.233(11)***
Malawi	-1.699(5)	-1.510(5)	-5.085(5)	-5.051(5)	0.217(13)***
Mauritius	-1.166(7)	-1.5348(7)	-2.967(7)	-2.949(7)	0.316(14)***
Mozambique	-1.532(7)	-1.481(7)	-4.321(7)	-4.293(7)	0.223(14)***
South Africa	-0.995(2)	-2.404(8)	-2.184(2)	-2.158(2)	0.237(14)***
Seychelles	-0.653(1)	-1.235(5)	-1.2801(1)	-2.076(1)	0.254(14)**
Swaziland	-1.215(3)	-1.420(8)	-3.309(2)	-3.283(3)	0.233(14)***
Tanzania	-1.122(8)	-1.299(6)	-2.269(8)	-2.296(8)	0.229(12)***
Zambia	-0.578(1)	-0.441(8)	-1.280(1)	-1.272(1)	0.242(14)***

Source: own computation from sample data (1995m1-2012m8)

Note: For ADF we used one-sided (lower tail) test of H_0: Non-stationary vs. H_1: Stationary and 1%, 5%, 10% critical values (T=100) = -3.510 -2.890 -2.580, respectively.
5% Crtical Value for ADF, PP, MZ_α and DF-GLS test is -8.350.

Figures in parentheses are optimal lag lengths selected by appropriate lag criteria. For KPSS test maximum lag of 14 is chosen by Schwert criterion and the autocovariances weighted by Bartlett kernel. Critical values for Ho: real exchange rate is trend stationary are: 10%:**0.119**, 5%:**0.146**, and 1%:**0.216**.

[1] This results present test statistics for the null hypothesis of a univariate normal distribution.

Table 3: GPPP Test using Johansen multivariate co-integration test on SADC (Log) RER

(Base currency =US$)
Sample (adjusted): 1995M08 2012M10
Null hypothesis: no integration
Included observations: 207 after adjustments
Trend assumption: Linear deterministic trend
Series: RERSA RERA RERB RERMA RERMD RERMU RERMO RERSC RERSW RERTA RERZA
Lags interval (in first differences): 1 to 4

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	1 % Critical Value	Max-Eigen Statistic	1 % Critical Value
None***	0.418328	**395.8688**	293.44	**112.1628**	75.95
r≤ 1***	0.268538	**283.7060**	247.18	64.73099	69.09
r≤ 2***	0.248888	**218.9750**	204.95	59.24356	62.80
r≤ 3	0.190979	159.7314	168.36	43.86950	57.69
r≤ 4	0.152646	115.8619	133.57	34.28672	51.57
r≤ 5	0.125896	81.57520	103.18	27.85303	45.10
r≤ 6	0.090721	53.72216	76.07	19.68641	38.77
r≤ 7	0.070556	34.03575	54.46	15.14602	32.24
r≤ 8	0.047670	18.88973	35.65	10.11057	25.52
r≤ 9	0.030071	8.779158	20.04	6.320142	18.63
r≤ 10	0.011809	2.459016	6.65	2.459016	6.65
Note: *** denotes rejection of the null hypothesis.		*Trace test indicates 3 cointegrating equation(s) at the 1% level.*		*Max-Eigen test indicates 1 cointegrating equation(s) at the 1% level.*	

Source: own estimation

Table 4: Pedroni Residual Cointegration Test Result

Series: lnRER lnNER lnCPI				
Sample: 1995M03 2012M10				
Included observations: 2332				
Cross-sections included: 11				
Null Hypothesis: No cointegration				
Trend assumption: Deterministic intercept and trend				
User-specified lag length: 1				
Newey-West automatic bandwidth selection and Bartlett kernel				
(within-dimension)	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	12.73971	0.0000	10.60199	0.0000
Panel rho-Statistic	-3.523916	0.0002	-3.389909	0.0003
Panel PP-Statistic	-2.947256	0.0016	-2.840992	0.0022
Panel ADF-Statistic	-7.917885	0.0000	-7.861144	0.0000
(between-dimension)				
Group rho-Statistic	-2.129851	0.0166		
Group PP-Statistic	-2.305456	0.0106		
Group ADF-Statistic	-8.001912	0.0000		

Source: own computation

Note: *The null hypothesis of 'no cointegration' is rejected in all the seven statistics as shown above.*

Table 5: Short-run Adjustment Coefficients (α)

RER series	Adjustment coefficients (α)	Standard Error
D(South African rand)	0.016662	0.03318
D(Angolan new kwanza)	-0.941522	0.12886
D(Botswana pula)	0.037468	0.02376
D(Malawian kwacha)	0.086315	0.03880
D(Malagasy ariary (MGA))	0.107311	0.02685
D(Mauritian rupee)	-0.024887	0.01444
D(Mozambique metical)	0.042243	0.02391
D(Seychelles rupee)	-0.016641	0.05774
D(Swazi lilangeni)	0.016270	0.03557
D(Tanzanian shilling)	0.022810	0.01770
D(Zambian kwacha)	-0.008818	0.03676

Source: own computation from sample data (1995m1-2012m8)

Table 6: SADC (Log) Real Exchange Rate Normalised long run Cointegrating Equations (β- Coefficients)

RER series (1 Cointegrating Equation: Log likelihood 4852.518)	Normalised Long run Cointegrating Equations (β- Coefficients)	Standard Error
South African rand	1.000	
Angolan new kwanza	0.160	0.031
Botswana pula	-0.818	0.345
Malawian kwacha	-0.137	0.075
Malagasy ariary (MGA)	-0.558	0.154
Mauritian rupee	1.616	0.252
Mozambique metical	-0.387	0.131
Seychelles rupee	-0.083	0.135
Swazi lilangeni	-0.779	0.273
Tanzanian shilling	-0.445	0.177
Zambian kwacha	-0.156	0.087

Source: own computation from sample data (1995m1-2012m8)

Table 7: Levin-Lin-Chu panel unit root test for SADC (Log) Real Exchange Rate Series

	t-statistics		p-value	
	Without time Trend	With time Trend	Without time Trend	With time Trend
Unadjusted t	**-6.5519**	**-8.7189**	**0.0628**	**0.0002**
Adjusted t*	**-1.5314**	**-3.6077**		

Notes:
Ho: Panels contain unit roots
H_1: Panels are stationary

AR parameter: Common
Panel means: Included
Number of panels = 11
Number of periods = 212

Asymptotics : N/T → 0
LR variance: Bartlett kernel, 19.00 lags average (chosen by LLC)

Source: own computation from sample data (1995m1-2012m8)

Table 8: Im-Pesaran-Shin panel unit root test for SADC (Log) Real Exchange Rate Series

t-statistics			p-value		Fixed-N Exact Critical Values		
	Without time trend	With time trend	Without time trend	With time trend	1%	5%	10%
t-bar	**-1.5066**	**-2.1323**	**0.5265**	**0.0086**	**-2.040**	**-1.890**	**-1.810**
t-tilde-bar	**-1.4935**	**-2.1063**					
z-t-tilde-bar	**0.0665**	**-2.3823**					

Notes:
Ho: Panels contain unit roots
H_1: Some panels are stationary
AR parameter: Panel-specific
Panel means: Included
Number of panels =11
Number of periods =212
Asymptotics : T,N $\rightarrow \infty$ sequentially

Source: own computation from sample data (1995m1-2012m8)

Table 9: Pesaran CADF Test for (log) Real Exchange Rate

t-bar test, N,T=(11,212) Obs. = 2277
Augmented by 4 lags (average)
Ho: All series are non-stationary
H_1: Some panels are stationary

t-bar	cv10	cv5	cv1	Z[t-bar]	p-value
-2.312	-2.150	-2.250	-2.430	-1.924	0.027**

Note:
Cross-sectional average in first period extracted and extreme t-values truncated
Deterministic chosen: constant

Source: own computation from sample data (1995m1-2012m8)

Table 10: ECM Panel Cointegration Test for the panel of SADC (log) real exchange rate series

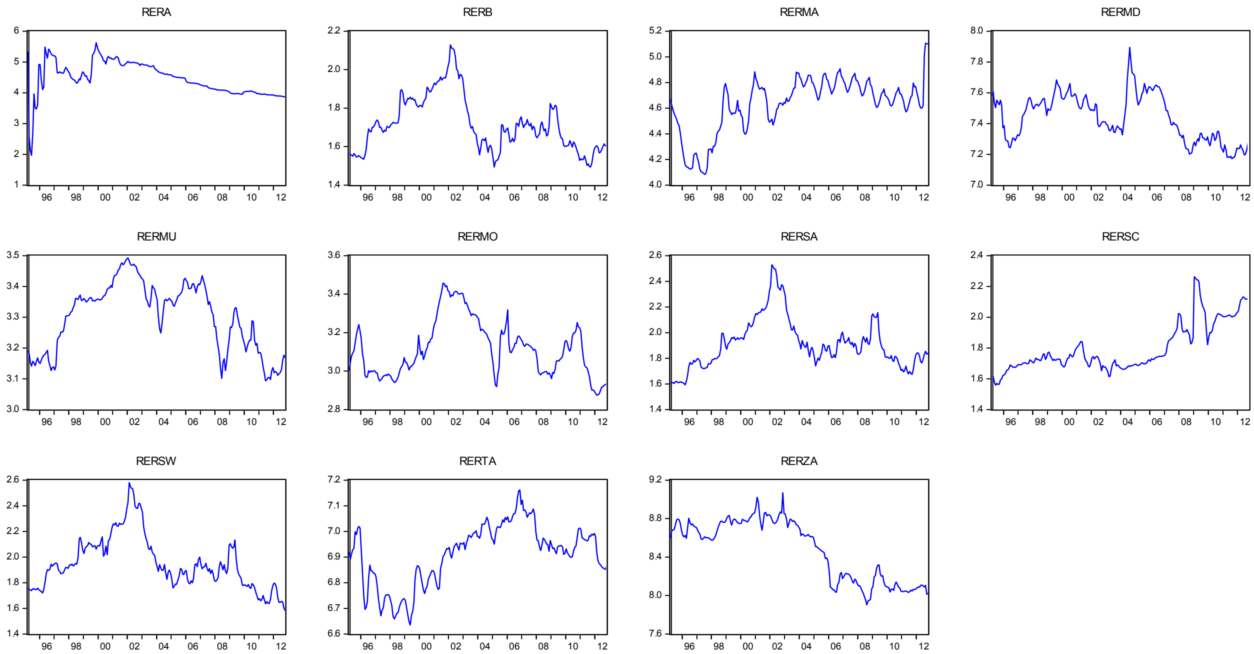
Results for $\mathbf{H_0}$: no cointegration with 11series and 3 covariates

Statistics		Value	z-value	p-value	Remark
Group mean	G_τ	0.080	5.796	1.000	*There is no cointegartion for at least one of the cross-sectional units.*
	G_α	0.000	4.148	1.000	
Panel	P_τ	-14.956	-8.079	0.000	*There is strong cointegtaion for the panel as the whole.*
	P_α	96.902	-48.648	0.000	

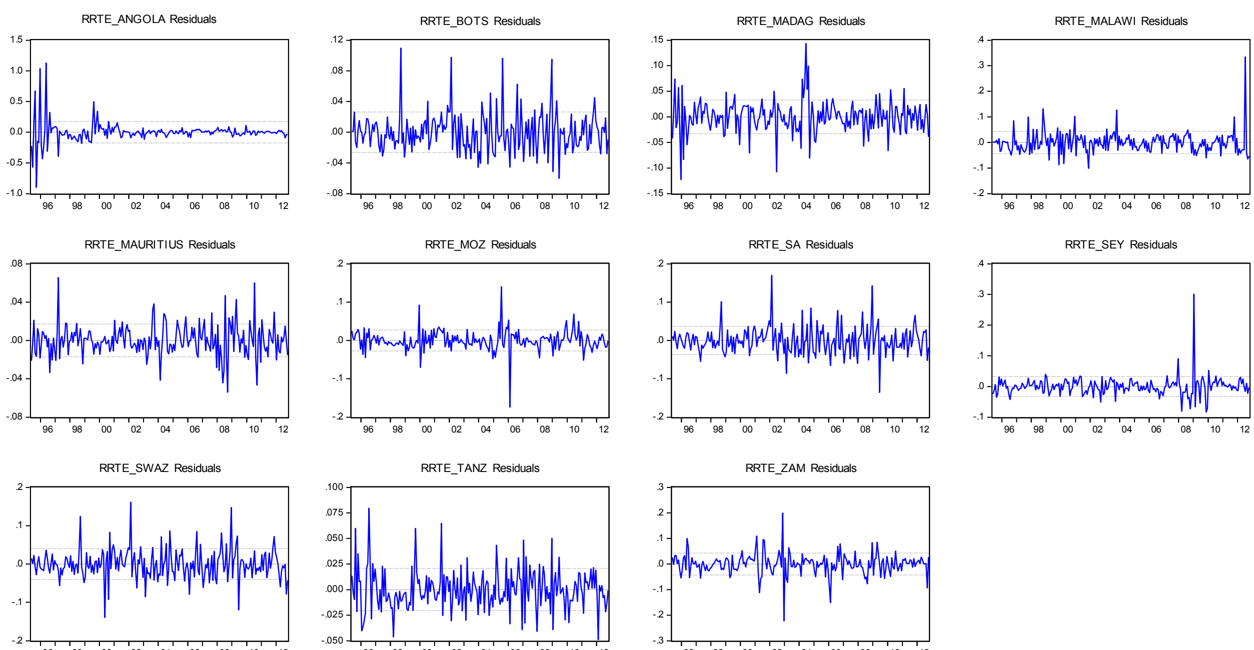
Source: own computation from sample data (1995m1-2012m8).

Annex-1: (Log) Monthly Real Exchange Rates-SADC Countries in the sample, 1995:03-2012:10

a) RER-at Level



b) RER-Residuals



Annex 2: SADC Currencies and Exchange Rate Regimes since 2004

Country	Currency	Exchange Rate Regime
Angola	New Kwanza	Managed floating
Botswana	Pula	Conventional fixed peg to a basket
DRC	Franc Congolais	Independently floating.
Lesotho	Loti	Conventional fixed peg to ZAR
Malawi	Kwacha	Independently floating
Madagascar	Malagasy ariary	Independently floating
Mauritius	Mauritian rupee	Managed floating
Mozambique	Metical	Managed floating
Namibia	Namibian dollar	Conventional fixed peg to ZAR
Seychelles	Seychelles rupee	Conventional fixed peg to ZAR
South Africa	Rand	Independently floating
Swaziland	Lilangeni	Conventional fixed peg to ZAR
Tanzania	Tanzanian Shilling	Independently floating
Zambia	Kwacha	Managed floating
Zimbabwe	Zimbabwe dollar	Managed floating

Source: SADC Central Banks (various issues)