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Panel Data Analysis of the Proposed Monetary Union in the Southern African Development Community

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Abstract

This paper examines the sensibility of a proposed monetary union in the Southern African Development Community (SADC). The study hypothesizes that the majority of the economies in the SADC region are candidates for a monetary union. We test this hypothesis against one of the prime optimal currency area (OCA) theory criteria, namely economic homogeneity with reference to real exchange rates. The quantitative analysis encompasses monthly data of 11 SADC member countries over the period 1995-2016. We use first and second generation panel unit root tests and panel co-integration tests to test mainly for stationarity and cointegration of real exchange rate series for the group of SADC countries. The findings from this study confirm that there is stationarity and cointegration of the real exchange rate series among the 11 SADC member countries included in this study. These countries can be potential candidates to form the proposed monetary union in the SADC region. Economic homogeneity i.e. economies with common structural and institutional characteristics, is one of the requirements to be fulfilled prior to joining monetary union. It reduces the impact of asymmetric shocks to a group of countries forming a monetary union. Economic homogeneity is observed where real exchange rates of countries tend to move together and mean-reversion behaviour reveals how well real exchange rates adjust back to equilibrium after experiencing an asymmetric shock. This result has important policy implications for the proposed monetary union in the SADC region.

Key Words: Optimum Currency Area, Monetary Union, Real Exchange Rate, Panel Cointegration, Panel Unit Root test
JEL Classification: C32, E31, F15, F41

1. Introduction

Monetary union or a currency union is an agreement among members of the union (countries or other jurisdictions) to share a common currency and a single monetary and foreign exchange rate policy (Masson and Pattillo, 2005). However, the success of monetary union depends on the interplay of various political and economic factors. Furthermore, monetary union requires the ability to design and create strong supranational institutions i.e. a regional central bank, supervisory institutions, and regulatory bodies that are able to take into account political and economy wide constraints. For example, clashes between economic and political forces within the euro area (Darvas, 2012) and a sovereign debt crisis (Martin and Waller, 2012; Mongelli, 2013) have been among the biggest challenges in the formation of the European Monetary Union (EMU). Likewise monetary integration in Africa poses its own challenges before monetary union can be finalized and member countries reap tangible benefits from the union (Zerihun, et al., 2014).

The Southern African Development Community (SADC) is moving towards the creation of a monetary union by 2018 (Belle, 2010). However, there are mounting doubts about the economic and political feasibility of the monetary integration of SADC. Therefore, the current processes of integration on the African continent in general and in SADC[1] in particular should thus be gradual and slow; to allow for the consolidation of the progress attained with required convergence criteria and to provide sufficient time to learn how to deal with a fixed exchange rate regime as is the case in the EMU. Recent study by Bosco (2015) came up with promising findings on monetary union projects in Africa particularly with reference to a risk sharing arrangement and a welfare gains perspective. SADC is adamant that it would conclude monetary union by 2018. However, the proposed monetary union in the SADC region cannot afford a repeat of the type of financial and fiscal instability brought about by *ex-ante* structural economic differences and asynchronous business cycles as has been exhibited in the EMU.

In this study, we hypothesize that the majority of the economies in the SADC region are good candidates for a monetary union sometime in the not too distant future, if not in 2018. To test this hypothesis, this study seeks to answer whether some of the criteria stipulated by OCA theory as a pre-requisite for monetary union are fulfilled or not. To answer this question we use panel unit root tests as found in Im, Pesaran and Shin (IPS) (2003) and Levin Lin and Chu (LLC) (2002). Furthermore, we use Pesaran's cross-sectional augmented Dickey Fuller (CADF) test to supplement the results from the LLC & IPS tests and to take care of heterogeneity in the panel. The findings from this study confirm there is stationarity and cointegration in real exchange rate series among 11 SADC member countries included in this study. The other four member countries are not included in this study due to data limitations. These 11 countries can be potential candidates to form the proposed monetary union in the region. However, to ensure a deeper integration in the region; the member countries need to develop robust regional financial and capital markets, strengthen macroeconomic policy coordination and convergences in major policy variables.

The paper is organized as follows. Section two presents a brief literature review on OCA theory and experiences of economic integration in the SADC. The methodology and data sources of the research are presented in section three. Section four discusses the result of the analysis and the last section concludes the paper.

2. Brief Overview on OCA Theory and Experiences of SADC

2.1 OCA Theory in Brief

OCA theory has been evolving since Mundell (1961) and it is still under refinement (Pomfret, 2005, Zerihun et al., 2014). OCA theory has faced numerous challenges and criticisms which are well documented in the literature (see Goodhart, 1995; Schelkle (2001, 2013), among others). Moreover, both traditional monetary integration theory and its critiques are mainly designed for developed countries, referring predominantly to the euro area. Literature on

[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.

OCA approaches in the analysis of south-south integration (SSI) initiatives, such as SADC, is scarce.

Countries would form a currency area with the expectation that current and future benefits exceed costs. The theory of optimum currency areas (OCA) is the theoretical basis for analyzing associated costs and benefits of monetary union. OCA theory is a useful starting point for any discussion on regional integration. The theory addresses the central question of whether or not a monetary union is ideal. An OCA is a region where factors of production are internally mobile but internationally immobile so as to facilitate the intraregional redistribution of resources in response to demand shifts; common structural and institutional characteristics among candidate states is a prescription to reduce the impact of asymmetric shocks (Mundell, 1961; Asongu, 2014). These criteria outline a rigorous framework for monetary integration and provide a basis for the analysis of OCAs. Some of these criteria are outlined below.

Trade factors are an important addition to the theory of OCAs; the influence of openness in a currency area demonstrates that considerations of a country‘s trade behaviour are integral to determining optimality (McKinnon, 1963). On the issue of homogeneity, intraregional diversification serves as a buffer to economic shocks (Mundell, 1973; McKinnon, 2004; Zerihun et al., 2016). In addition, OCA criteria include the mobility of labour and other factors of production, price and wage flexibility, diversification in production and consumption, similarity in inflation rates, fiscal integration and political integration (Mongelli; 2002, 2008; Asongu, 2016).

2.2 Experiences of Economic Integration in the SADC

The main reasons for the economies of most African countries to remain detached from each other are overlapping membership of various Regional Economic Communities (RECs) and a lack of investment in the institutions and systems required for integration (UNECA, 2010; Jovanovic, 2006). In spite of these problems, the Southern African Development Community (SADC) is moving towards the creation of a monetary union by 2018 (Belle, 2010). However, there are mounting doubts about the economic and political feasibility of the monetary integration of SADC. Macroeconomic stability is important in promoting regional economic integration and *a sine qua non* to develop robust regional financial and capital markets. Maintaining stability will require strengthened policy coordination and macroeconomic convergence, which over time and with varying speed, depending on the sub region, can become building blocks toward deeper integration and monetary unification.

The recent economic developments in SADC economies have been affected by global uncertainty and financial turmoil in the Euro Area. In response to the global economic slowdown, SADC performance indicators point to a decline in economic activity. Given rising food prices, most member countries experienced a rise in domestic inflation rates. This underscores the need for sound fiscal and monetary policies in order to sustain macroeconomic stability and robust economic growth. Moreover, it creates the need for extensive reforms to unlock the region’s productive potential and promote trade and financial sector development as buffers to mitigate the disruptive effects associated with an uncertain global environment.

As shown in Table 1, SADC economies have adopted *Maastricht* type convergence criteria on their major macroeconomics variables. Except during the years of global financial crisis most of the member states have achieved those criteria. However, when we perceive these achievements from the EMU experience, meeting those criteria does not guarantee successful monetary union. On average, the main macroeconomic convergence indicators show a small deterioration in 2011. Budget deficit to GDP and public debt to GDP ratios experienced a slight increase, while reserves import cover (in months) were somehow reduced. Nevertheless, budget deficit and public debt to GDP convergence targets were met in this period. In line with an uncertain international environment, SADC countries generally adopted soft economic policies as a general strategy to prompt growth. In general, the region has exhibited modest achievements in terms of convergence among major macroeconomic variables (UNECA, 2010).

Table 1: Maastricht type macroeconomic convergence goals of SADC

Criteria	*2008*	*2012*	*2015*	*2018*
Inflation	<10%	5%	5%	3%
Budget deficit, % GDP	≤ 5%	3% as an anchor, proportion1%	3% as an anchor, proportion1%	3% as an anchor, proportion1%
Foreign debt, % GDP	< 60%	< 60%	< 60%	< 60%
Foreign reserve/ covered by exports	≥ 3 month	> 6 month	> 6 month	> 6 month
Central bank debt	< 10% of the previous year tax revenue	< 10% of the previous year tax revenue	< 5% of the previous year tax revenue	< 5% of the previous year tax revenue

Source: Kumo (2011)

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 November 2016 is used in this study. All data relating to consumer price indices (CPI) and nominal exchange rates (NER) relative to the US dollar are obtained from the IMF's International Financial Statistics. Each of the consumer price index and nominal exchange rate series are transformed into natural logarithms before the econometric analysis.

Using the convention 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 the LLC & IPS tests to take care of heterogeneity in the panel.

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, following Chinn (2006) we can express equation (1) in logarithmic form, such that the series of real exchange rate for country 'i' at time't', is given by the following equation:

$$q_{i,t} = s_{i,t} + p^{*}_{us,t} - p_{i,t} \quad (2)$$

where $q_{i,t}$ is the logarithm of the RER against the US dollar, $s_{i,t}$ is the logarithm of the NER against the US dollar, and $p^{*}_{us,t}$ and $p_{i,t}$ respectively, are the logarithms of consumer price indices in the US (i.e. the foreign country) and domestic country '*i*'. Using equation (2) we computed the RER series for the 11 countries included in this study. Table 2 presents the descriptive statistics and normality test of SADC real exchange rate. The Jarque-Bera test result in the last column of Table 2 presents test statistics for the null hypothesis of a univariate normal distribution. Except for Malawian real exchange series in the rest of the series the null hypothesis of a univariate normal distribution is rejected at 1 percent level of significance, however, the level of significance for Botswana real exchange series is just at 10 percent.

Table 2: Descriptive statistics and normality test of SADC (log) real exchange rate

Country	*Mean*	*Median*	*Max.*	*Min.*	*Std. Dev.*	*Skewness*	*Kurtosis*	*Jarque-Bera*
Angola	5.36	5.20	8.66	4.64	0.64	2.05	9.78	688.10***
Botswana	2.42	2.42	2.70	2.25	0.09	0.30	2.64	5.42*
Madagascar	8.14	8.11	8.64	7.90	0.13	0.91	3.28	37.37***
Malawi	5.45	5.46	6.35	4.73	0.32	0.12	3.18	1.04
Mauritius	3.86	3.86	4.06	3.70	0.08	0.24	2.13	10.89***
Mozambique	3.84	3.82	4.37	3.57	0.14	0.67	3.74	25.72***
South Africa	2.16	2.14	2.80	1.82	0.19	0.67	3.28	20.41***
Seychelles	2.71	2.62	3.21	2.42	0.19	0.41	1.86	21.76***
Swaziland	2.58	2.57	3.11	2.31	0.14	0.80	3.71	33.75***
Tanzania	7.57	7.60	7.87	7.24	0.15	-0.33	2.11	13.67***
Zambia	2.30	2.31	2.79	1.87	0.26	0.03	1.40	28.22***

Source: own computation from sample data (1995m1-2016m11)

Note: *, **, and*** indicate significance at the 10%, 5% and 1% levels, respectively.

3.2 Methodology on panel unit root tests

First generation panel unit root test

As a common accord 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). From equation (2) we have the following panel unit root regression:

$$\Delta q_{i,t} = \alpha_i + \beta_i q_{i,t-1} + \sum_{j=1}^{wij} \delta_{i,j} \Delta q_{i,t-j} + \varepsilon_{i,t}, \ i = 1, \ldots, N, \text{ and } t = 1 \quad (3)$$

Using equation (2) LLC (2002) test and IPS (2003) test are carried out, respectively. *LLC (2002) test*- The LLC test examines:

H_0: $\beta_1 = \beta_2 = ... = \beta_N = 0$ (no cointegration) against;

H_1: $\beta i < 0$, for some *i* (there is cointegration)

H_0 and 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:

$$t_{\beta i} = \frac{\widehat{\rho}}{\widehat{\delta}(\widehat{\rho})} \quad (4)$$

The IPS adjusted t-statistics is expressed as:

$$t^*_{\beta i} = \frac{t_{\beta i} - NTS\widehat{N}\sigma\varepsilon^{-2} STD\left(\hat{\widehat{\sigma}}\right)\mu^* M\breve{T}}{\widehat{\delta}(\widehat{\rho}) M\widehat{T}} \quad (5)$$

Note that the IPS test also examines similar null and alternative hypothesis as specified in LLC test.

Second generation panel unit root test

Here we follow the basic framework developed by Im et al. (2003) and Ucar and Omay (2009). Let q_{it} be pane exponential smooth transition autoregressive process of order one (PESTAR(1)) on the time domain $t = 1.2, ..., T$ for the cross section units $i = 1.2, ..., N$. Consider q_{it} follows the data generating process (DGP) with fixed effect (heterogeneous intercept) parameter α_i :

$$\Delta q_{it} = \alpha_i + \phi_i q_{i,t-1}\left[1 - \exp(-\theta_i q^2_{i,t-1})\right] + \varepsilon_{i,t} \quad (6)$$

where $d \geq 1$ is the delay parameter and $\theta > 0$ implies the speed of mean reversion for all *i*.

Setting $\phi_i = 0$ and $d = 1$, Ucar and Omay (2009) drive the following specific PESAR (1) model:

$$\Delta q_{it} = \alpha_i + \gamma_i q_{i,t-1}\left[1 - \exp(-\theta_i q^2_{i,t-1})\right] + \varepsilon_{i,t} \quad (7)$$

To make a plausible test of stationarity for the nonlinear panel data series Ucar and Omay (2009) approximate the PESTAR (1) model around $\theta_i = 0$ for all i using first-order Taylor series approximation to obtain the following auxiliary regression:

$$\Delta q_{it} = \alpha_i + \delta_i q_{i,t-1}^3 + \varepsilon_{i,t} \tag{8}$$

where $\delta_i = \theta_i \gamma_i$

Based on regression (8) the hypothesis for unit root testing can be established as follows:

$$\begin{aligned} &H_0 : \delta_i = 0, \text{for all i, (linear nonstationarity)} \\ &H_1 : \delta_i < 0, \text{for some i, (nonlinear stationarity)} \end{aligned} \tag{9}$$

Going further, Ucar and Omay (2009) propose panel unit root tests computed through taking the average of individual KSS[2] statistics. The KSS statistics for the i th individual is simply t-ratio of δ_i in equation (8) defined by:

$$t_i NL = \frac{\Delta q_i^{'} M_\tau q_{i,}^3 - 1}{\sigma_{i,NL}\left(q_{i-1}^{'} M_\tau q_{i-1}\right)^{3/2}} \quad \text{and} \tag{10}$$

$$\overline{t_{NL}} = \frac{1}{N}\sum_{i=1}^{N} t_{i,NL} \tag{11}$$

For details and proof on equations 6-11 refer Ucar and Omay (2009).

Moreover, following (Pesaran, 2007), a cross sectional augmented version of the IPS (CIPS) test statistics is computed as follows:

$$CIPS(N,T) = \frac{1}{N}\sum_{i=1}^{N} t_i(N,T) \tag{12}$$

where $t_i(N,T)$ is the cross-sectional augmented ADF statistics (CADF) for the i^{th} cross section. Similarly, the standardised IPS t-bar statistics is given by:

[2] KSS stands for Kapetanios, Shin and Shell who introduced the concept of nonlinear unit root test to the economics literature. KSS test is applied to test equation by adding the index of the transfer function to test nonlinear adjustment characteristics (Liu and He, 2010).

$$t_{ips} = \frac{\sqrt{N}(t-1)/N\sum_{t=1}^{N} N\bar{E}[t_i, t]\beta_i = 0}{\sqrt{N-1\sum_{t=1}^{N} VAR[t_i, t]\beta_i = 0}} \tag{13}$$

3.3 Methodology on Fisher-Johansen Combined Individual Tests

In addition to Johansen's trace statistics and the maximum Eigen-value test statistics; Maddala and Wu (1999) use Fisher's result to propose an alternative approach to testing for cointegration in panel data by combining tests from individual cross-sections to obtain at test statistic for the full panel. Following Anagnostou, et al. (2016) we can write the combined individual test as stated in equation (8).

$$-2\sum_{i=1}^{N}\log(\pi_i) \rightarrow \chi^2 2N \tag{14}$$

where N= three variables; real exchange rate (RER), nominal exchange rate (NER) and consumer price indices (CPI). The χ^2 values based on Mackinnon–Haugh Michelis (1999) p-values for Johansen's cointegration trace and maximum Eigen value tests are reported in Table 6.

4. Empirical Results and Discussions

Prior to and panel unit root and cointegration test analysis it is customary to carry out conventional unit root tests. The unit root tests are presented in appendix A-1.

4.1 First Generation Panel Unit Root Test Results

The results from our panel unit root tests are subject to inclusion or exclusion of a time trend. The optimal lag lengths are chosen using Schwarz Information Criteria (BIC). Table 3 present panel unit root tests according to LLC and IPS respectively. As shown in Table 3, 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 3 shows that the panel of (log) real exchange rate series is stationary at the 1 percent level of significance only when the time trend is included in the analysis; otherwise it is a unit root. From these two panel unit root tests we can safely generalise that the panel of real exchange rates is stationary, hence the real exchange series of the whole panel of SADC countries is mean reverting considered jointly and when the time trend is included in the panel analysis.

Table 3: Levin-Lin-Chu and Im-Pesaran-Shin panel unit root test for SADC real exchange rate series

Panel unit root test: Summary
Sample: 1995M01 2016M11
Automatic lag length selection based on SIC: 0 to 1
Newey-West automatic bandwidth selection and Bartlett kernel

Series: lnRER (level)			D(lnRER) (first difference)	
Result with individual effects			With individual effects and individual linear trends	
Method	Statistic	Prob.**	Statistic	Prob.**
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	0.01715	0.5068	-74.2175	0.0000
Breitung t-stat	-	-	-36.8750	0.0000
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-1.99758	0.0229	-56.7750	0.0000
ADF - Fisher Chi-square	34.6222	0.0424	1362.93	0.0000
PP - Fisher Chi-square	33.8463	0.0509	1399.90	0.0000

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

4.2 Second Generation Panel Unit Root Test Results

The second generation panel unit root test results are based on the linear IPS test of Im et al. (2003) and the non-linear UO test of Ucar and Omay (2009). The results are provided in Table 4. The results in Table 4 shows that the linear IPS test rejects the null of a unit root at the 10 level of significance with intercept included in the regression and the non-linear UO test rejects the null hypothesis at a 1 percent level of significance.

Table 4: Linear and non-linear panel unit roots for SADC (log) real exchange rate series

Variable	IPS test				UO test			
	Intercept		Intercept & trend		Intercept		Intercept & trend	
	W-stat	t-stat	W-stat	t-stat	W-stat	t-stat	W-stat	t-stat
RER	-1.507*	-1.911*	-1.127	-2.456	-1.1473	-1.9244	-1.2956***	-2.4523***
***, * signify rejection of the null of unit root at 1% and 10% level of significance using bootstrap p-values Maximum of 12 lags were used.								

To supplement the robustness of the IPS test we also carried out Pesaran's cross-sectional augmented Dickey Fuller (CADF) test. As shown in Table 5 Pesaran's CADF test also rejects the null hypothesis of *'all series are non-stationary'* at the 5 percent level of significance, supporting the results obtained by the LLC and IPS panel unit root tests above.

Table 5: 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	-2.430	-1.924	0.027	**

Source: own computation from sample data (1995m1-2016m11)

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

4.3 Results from Fisher-Johansen Combined Individual Tests

Table 6 reports unrestricted cointegration rank tests of trace and maximum Eigen value tests and individual cross section test results. Both rank tests confirm that there are three cointegration relationships at the 1 percent level of significance among the 11 real exchange series of SADC countries included in this study as a panel. The individual cross section results also reveal the same evidence as the rank test statistics except for real exchange rates of South Africa and Tanzania. These two countries are not conforming with the rest of the group in the region.

Table 6: Johansen Fisher Panel Cointegration Test Result

Johansen Fisher Panel Cointegration Test Result
Series: lnRER, lnCPI, lnNER
Sample: 1995M01 2016M11
Included observations: 2893
Trend assumption: Linear deterministic trend
Lags interval (in first differences): 1 1

Unrestricted Cointegration Rank Test (Trace and Maximum Eigenvalue)

Hypothesized No. of CE(s)	Fisher Stat.* (from trace test)	Prob.	Fisher Stat.* (from max-eigen test)	Prob.
None	166.5	0.0000	151.5	0.0000
At most 1	57.62	0.0000	49.66	0.0007
At most 2	41.63	0.0069	41.63	0.0069

Individual cross section results

Cross Section	Trace Test Statistics	Prob.**	Max-Eign Test Statistics	Prob.**
Hypothesis of no cointegration				
Angola	97.6926	0.0000	58.0989	0.0000
Botswana	41.0831	0.0017	31.0006	0.0015
Madagascar	51.5732	0.0000	34.1134	0.0005
Malawi	36.2325	0.0079	30.9502	0.0015
Mauritius	45.5439	0.0004	32.4886	0.0008
Mozambique	66.2453	0.0000	57.3007	0.0000
South Africa	20.2496	0.4061	13.0605	0.4467
Seychelles	44.6358	0.0005	31.2703	0.0014
Swaziland	28.4066	0.0717	18.9672	0.0978
Tanzania	22.4453	0.2744	14.0717	0.3592
Zambia	48.3746	0.0001	32.4050	0.0009

* Probabilities are computed using asymptotic Chi-square distribution.
**MacKinnon-Haug-Michelis (1999) p-values

Lastly, as shown in Table 7, we also computed the error correction based co-integration (ECM) tests for the panel of SADC (log) real exchange rate series to check the robustness of the results. We followed Persyn and Westerlund (2008) in estimating the ECM since it accounts for the loss of power in the case of residual-based panel unit run and panel co integration tests carried out in this paper. In ECM 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). As shown in Table 7 the findings reject the null hypothesis of no cointegration for the panel as the whole at the 1 percent level of significance. However, with the group mean statistics the estimation fail to reject the null hypothesis. This implies that there is no co-integration for at least one of the cross-sectional units. 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).

Table 7: ECM based panel cointegration test for the panel of SADC real exchange rate series Results for H_0: no cointegration with 11series and 3 covariates

Results for 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 cointegration 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 cointegration for the panel as the whole.*
	P_α	96.902	-48.648	0.000	

Source: own estimation from sample data (1995m1-2016m11)

The ECM-based panel cointegration test result in Table 7 is in line with Johansen Fisher panel cointegration test result that exhibits overall cointegration for the real exchange rate series in the panel as the whole, however, member countries like South Africa and Tanzania have exhibited no cointegation for the study period.

4.4 Robustness Check

Following the suggestion from the anonymous reviewers we estimate variance ratio statistics, vector error correction estimates, impulse response functions (IRFs), and variance decomposition (VDC) on based on the Cholesky factor[3]. The results from these tests are reported in Appendix A-2. The vector error correction estimates show that there are linear combinations of interrogated variables that are stationary. The variance ratio statistics for the real exchange rate series of SADC countries lies in the interval implying that the series are stationary i.e. mean reverting. In line with the result from variance ratio statistics, the IRFs die out to zero and asymptote to some (non-zero) constant again implying stationary series in the analysis. The VDC also exhibits the same evidence as the IRFS. In general, the quantitative analysis in this study is robust enough to confirm the hypothesis that the majority of the SADC countries included in this study are candidates for a monetary union.

5. Conclusion and Policy Implications

In this paper the objective was to examine whether SADC countries form an optimal currency area (OCA) by analysing real exchange rate behaviour of a panel of SADC countries. In particular, panel unit root tests can reveal if a panel of exchange rate series exhibit mean reverting behaviour (i.e. the stationarity of the series). If they do, it simply means that for the panel as a whole, the purchasing power parity criterion of OCA is fulfilled. The second objective was to ascertain if the panel of real exchange rate series is cointegrated in the long run. This we did by using cointegration analysis. If the series of real exchange rates are cointegrated, it would point to the fact that the countries in the panel behave similar to common exogenous shocks and can therefore form the proposed monetary union.

[3] Cholesky factor imposes a recursive causal structure from the top variables to the bottom variables but not the other way around. EViews software provides built-in functions for generating the Cholesky decomposition.

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. Findings from first and second generations of panel unit root tests for RER series confirm stationarity with a high level of significance with a time trend included in the estimation. In addition to panel unit root tests, error correction based panel co-integration tests are also performed. Both tests confirm that there are cointegrating relationships among SADC real exchange rate series.

Even though the majority of countries included in this study are candidates to form the proposed monetary union in the region, to ensure deeper integration in the region the member countries need to develop robust regional financial and capital markets, strengthen macroeconomic policy coordination and convergence in major policy variables. In this regard much more integration efforts should be expected from South Africa and Tanzania as these two countries do not exhibit individual cointegration among cross sections as reported in Fisher-Johansen combined individual tests.

Overall findings from this study confirm there is cointegration and stationarity in real exchange rate series among 11 SADC member countries included in this study. This implies that the region is potentially an OCA that could proceed with monetary integration and adoption of a common currency. We recommend that policy makers should consider not only the dynamics of real exchange rates in the SADC region. In order not to repeat the type of financial and fiscal instability brought about by *ex-ante* structural economic differences and asynchronous business cycles as has been exhibited in the EMU, policy makers in region, alongside this result, should consider more OCA criteria. Furthermore, additional studies on the effects of fiscal policies on the structural and institutional characteristics among candidate countries are imperative for meaningful policy formulation as SADC moves toward the proposed monetary integration.

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Appendix A-1: Univariate unit root tests of SADC real exchange rate series

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_{α}) (2001), and the Kwiatkowski-Philips-Schmidt-Shin (KPSS) test. The test results confirm that the series are non-stationary at level.

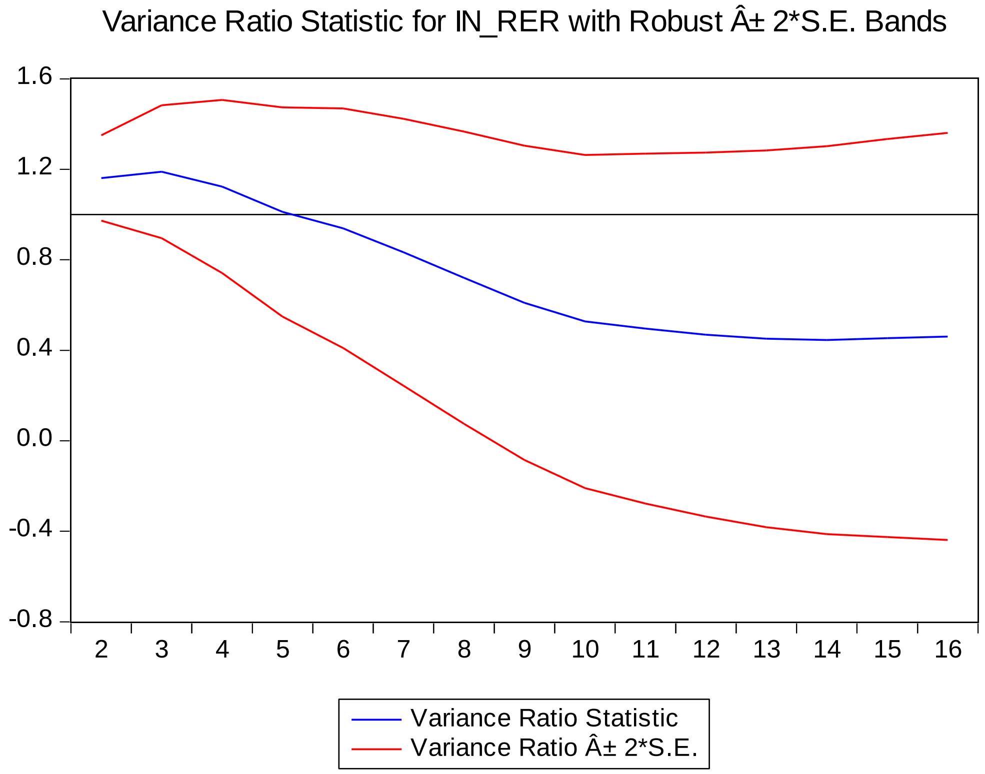
(Log) Real Exchange Rate Series	***DF*** *(GLS de-trended)*	***ADF*** *(Level)*	***PP*** *(GLS de-trended)*	MZ_{α} ***(****GLS de-trended)*	***KPSS*** *(Trend Stationary)*
Angola	-0.770(8)	-1.477(8)	-0.523(8)	-0.298(8)	0.239(14)***
Botswana	-1.350(2)	-2.090(8)	-3.712(2)	-3.685(2)	0.236(10)***
Madagascar	-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)	-1.534(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 (1995m1-2016m11)

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**.

Appendix A-2: Additional Test Results

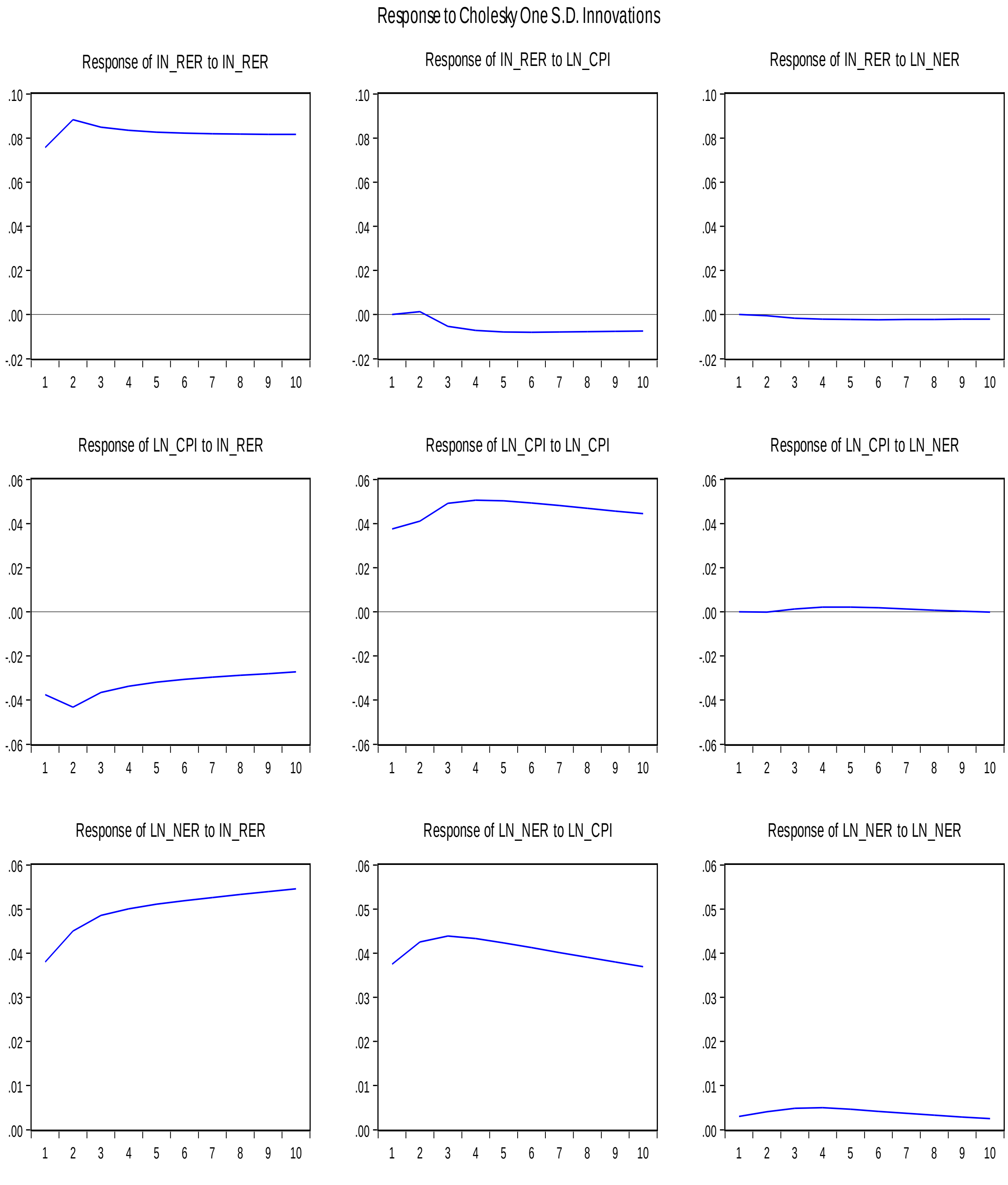


Vector Error Correction Estimates
Date: 07/17/17 Time: 23:09
Sample (adjusted): 1995M04 2016M11
Included observations: 2860 after adjustments
Standard errors in ( ) & t-statistics in [ ]

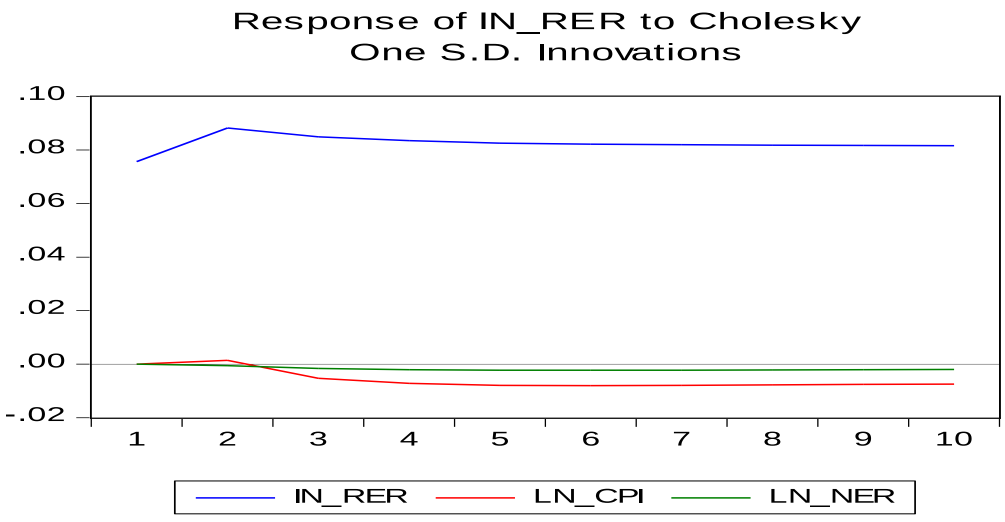
Cointegrating Eq:	CointEq1		
IN_RER(-1)	1.000000		
LN_NER(-1)	-0.994816 (0.00547) [-182.017]		
LN_CPI(-1)	0.709759 (0.01133) [62.6622]		
C	-3.348043		
Error Correction:	**D(IN_RER)**	**D(LN_NER)**	**D(LN_CPI)**
CointEq1	0.002016 (0.00578) [0.34882]	0.064159 (0.00409) [15.6963]	0.062201 (0.00406) [15.3255]

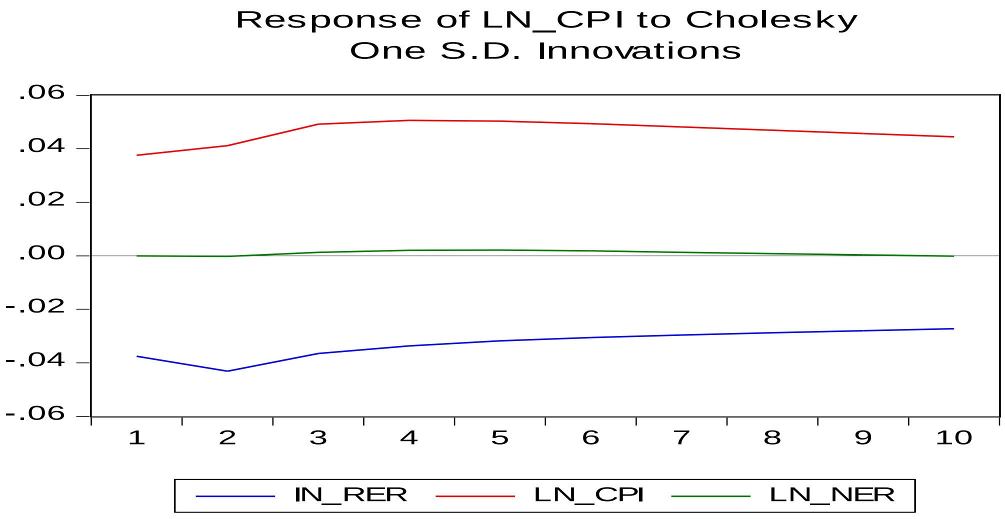
D(IN_RER(-1))	0.368930	-0.253086	-0.022848
	(0.45493)	(0.32168)	(0.31941)
	[0.81095]	[-0.78676]	[-0.07153]
D(IN_RER(-2))	0.031839	-0.119151	-0.394739
	(0.45430)	(0.32124)	(0.31897)
	[0.07008]	[-0.37092]	[-1.23755]
D(LN_NER(-1))	-0.184019	0.412377	-0.005421
	(0.45515)	(0.32183)	(0.31956)
	[-0.40431]	[1.28134]	[-0.01696]
D(LN_NER(-2))	-0.198136	0.157145	0.598208
	(0.45480)	(0.32158)	(0.31931)
	[-0.43566]	[0.48866]	[1.87341]
D(LN_CPI(-1))	0.221265	-0.260933	0.117278
	(0.45587)	(0.32234)	(0.32007)
	[0.48537]	[-0.80949]	[0.36642]
D(LN_CPI(-2))	0.009948	-0.120657	-0.371612
	(0.45561)	(0.32216)	(0.31989)
	[0.02183]	[-0.37452]	[-1.16170]
C	0.001198	0.008964	0.008918
	(0.00174)	(0.00123)	(0.00122)
	[0.68818]	[7.28534]	[7.29935]
R-squared	0.040335	0.190310	0.247876
Adj. R-squared	0.037979	0.188322	0.246030
Sum sq. resids	16.32154	8.160517	8.045742
S.E. equation	0.075649	0.053491	0.053114
F-statistic	17.12422	95.76211	134.2752
Log likelihood	3329.346	4320.591	4340.846
Akaike AIC	-2.322620	-3.015798	-3.029962
Schwarz SC	-2.305953	-2.999131	-3.013295
Mean dependent	5.58E-05	0.010222	0.011960
S.D. dependent	0.077128	0.059373	0.061169
Determinant resid covariance (dof adj.)		7.37E-11	
Determinant resid covariance		7.31E-11	
Log likelihood		21201.45	
Akaike information criterion		-14.80731	
Schwarz criterion		-14.75105	

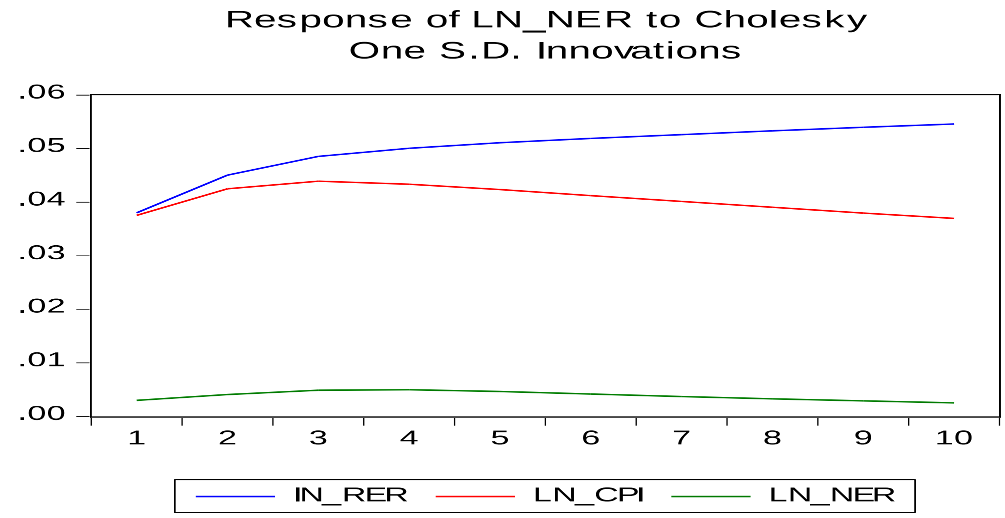
Impulse response function

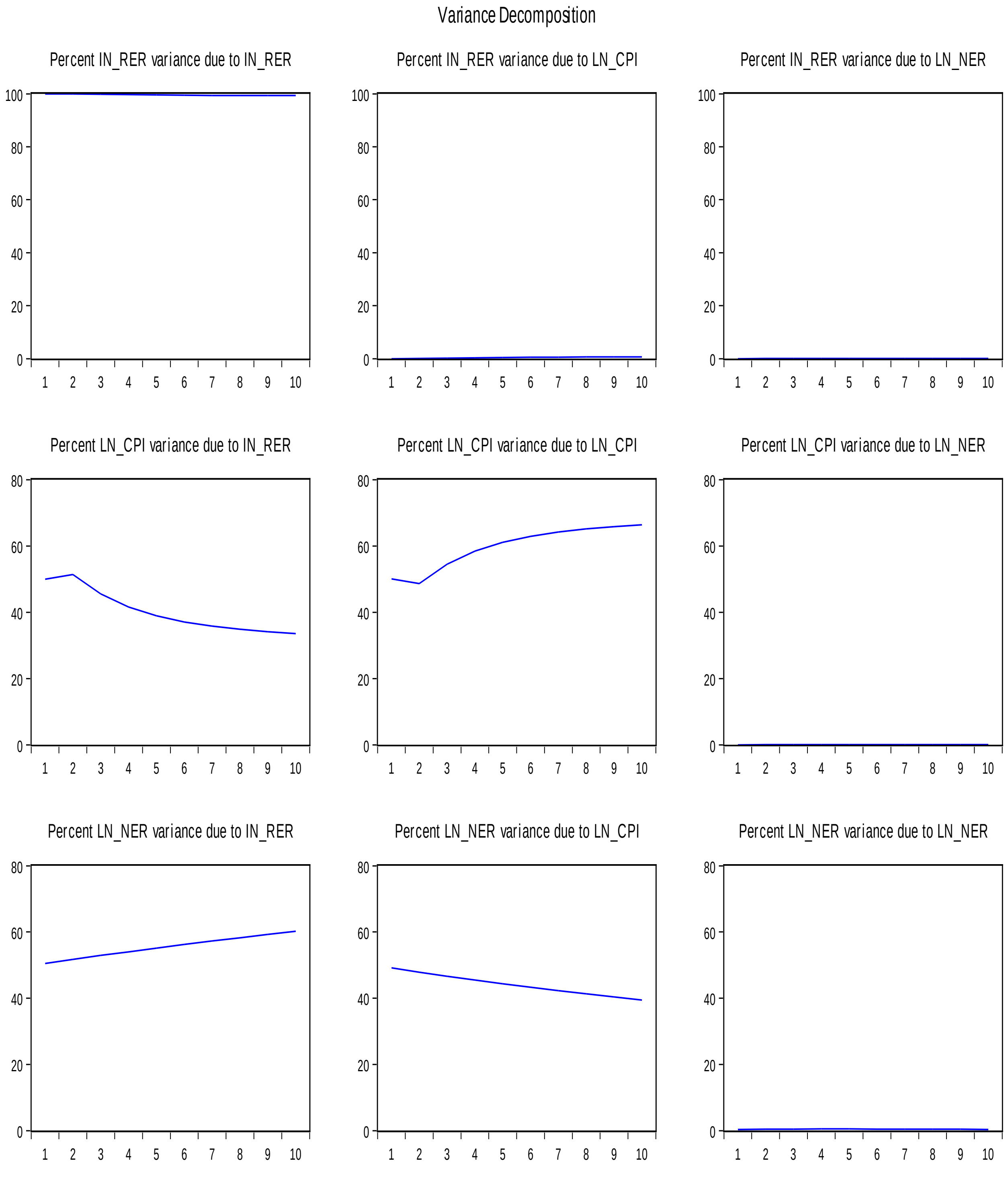


Combined graphs








Variance Decomposition
Percent IN_RER variance due to IN_RER
Percent IN_RER variance due to LN_CPI
Percent IN_RER variance due to LN_NER
Percent LN_CPI variance due to IN_RER
Percent LN_CPI variance due to LN_CPI
Percent LN_CPI variance due to LN_NER
Percent LN_NER variance due to IN_RER
Percent LN_NER variance due to LN_CPI
Percent LN_NER variance due to LN_NER

Combined graph