A Fast-Track East African Community Monetary Union? Convergence Evidence from A Cointegration Analysis

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Abstract

There is a proposal for a fast-tracked approach to the African Community (EAC) monetary union. This paper uses cointegration techniques to determine whether the member countries would form a successful monetary union based on the long-run behavior of nominal and real exchange rates, the monetary base and real gdp. The four variables are each analyzed for co-movements among the five countries. The empirical results indicate only partial convergence for the variables considered, suggesting there could be substantial costs for the member countries from a fast-tracked process. This implies the EAC countries need significant adjustments to align their monetary policies and to allow a period of monetary policy coordination to foster convergence that will improve the chances of a sustainable currency union.

Keywords: Monetary Union, Convergence, Cointegration, East African Community

1. Introduction

With the signing of an agreement for the establishment of the "Permanent Tripartite Commission for East African Co-operation" in 1993, the East African Community (EAC) has advanced its integration agenda rapidly. (Note 1) A treaty establishing the EAC was signed in 1999, a customs union treaty in 2004, and a Common Market Protocol (CMP) in 2009. (Note 2) The EAC has a stated objective to form a monetary union, with 2012 as the suggested target date in a fast-track currency union proposal. (Note 3) Article 5(2) of the EAC Treaty stipulates that "…the Partner States undertake to establish among themselves and in accordance with the provisions of this Treaty, a Customs Union, a Common Market, subsequently a Monetary Union and ultimately a Political Federation...". The 6th extra-ordinary meeting of the Summit of the EAC Heads of State decided that East Africa should move expeditiously towards establishing a monetary union by 2012, while the 11th ordinary summit directed that the preparation for the establishment of a monetary union be moved into high gear upon the coming into operation of the common market.

Macroeconomic convergence of member countries is crucial to the sustainability of a monetary union over the long term. Monetary policy convergence, exhibited mainly in similarity of inflation and interest rates among other indicators, is necessary to ensure a single monetary policy is optimal policy for all the union members. In an influential study Rose (2000) followed by others (a good summary is provided by Rose and Stanley, 2005), estimated that currency union enhances trade among member countries by two to three times. This boosts similarity of the demand patterns and price co-movements. Countries then could become more similar in a currency union than before currency union. If suitability for membership in a monetary union is endogenous, this suggests it may not be crucial for members to meet optimum currency area criteria before currency union. However recent assessment of the EMU experience (see Chintrakarn, 2008; Frankel, 2008) show a much smaller trade impact of the Euro of only about 15%. The endogeneity effect may even be smaller for African monetary unions. Carmignani (2009) and Tapsoba (2009) study the endogeneity effect of trade in African monetary unions and find that currency union increases synchronicity of business cycles but the effect is very small. While trade effects and endogeneity cannot be discounted, these subsequent results cautions against excessive optimism on the magnitude of the effects from an EAC monetary union. First, the trade effect benefits seem to be slow to achieve (about 15% from EMU nearly ten years later). Secondly, the EAC countries are starting from relatively low intra-EAC trade levels. Given the high dependency on primary product exports, the scope for increased trade is unlikely to be as great as more developed countries. (Note 4) Therefore this makes convergence before monetary union critical for the EAC to minimize any adverse effects from a loss of monetary policy for member countries.

No specific enforceable convergence targets have been laid down for eligibility in the proposed EAMU. It is however anticipated that the set of convergence criteria (exchange rates, inflation rates, long-term interest rates, and deficits) that formed the basis of eligibility in the European Monetary Union (EMU) would play a role in some form. With the signing of the CMP the focus is now shifting to the monetary union stage. (Note 5) A crucial question that needs to be answered at the start of this phase is to what degree the EAC countries' monetary policies and business cycles have converged.

No studies have rigorously examined the current state of monetary policy convergence for the EAC. This paper attempts to fill this gap. Our contribution is to provide empirical evidence on the state of convergence for the five EAC member countries with respect to nominal and real exchange rates, the monetary base and real gdp. This paper thus provides convergence evidence from a range of both nominal and real variables. To achieve this, we apply multivariate cointegration. The monetary base is included as an indicator of monetary policy convergence in absence of consistent long term interest rate data. The monetary aggregate is preferred over other broader aggregates because it is less diluted by intervention by other agents in the financial system, and better able to capture the central bank's policy stance. Indicators of fiscal convergence, such as the debt ratios, are important factors not considered in this paper due to lack of consistent data. Empirical evidence on the state of convergence will help policy-makers in setting realistic convergence targets and a frame–work to monetary union. Knowledge of the current state of convergence becomes even more crucial given the very short time left for monetary policy coordination if the target union date is to be achieved.

Multivariate cointegration analysis has been applied by a number of authors to test convergence especially for the European Monetary Union (EMU) and accession countries. Haug *et al*. (2000) uses cointegration techniques (on data that spans the period 1979 to 95), to analyze which of the European Union (EU) countries would form a successful monetary union based on the nominal convergence criteria laid down in the Maastricht treaty. Their results indicated that not all the 12 original countries could all form a successful EMU over time unless countries made significant adjustment. Brada and Kutan (2002) compare the convergence of monetary policy of the Balkan and Mediterranean candidates for EU membership with those of Germany as a proxy for the European Central Bank (ECB). They interpret cointegration of base money with those of Germany as implying an ability of the country to follow policy leadership of the ECB. They found that among the Balkan transition economies and in Turkey, the ability to follow the policies of the Bundesbank was weak or nonexistent for some countries.

Some authors have examined monetary policy convergence by testing the uncovered interest parity (UIP). The premise is that the difference between domestic and foreign interest rates should correspond to the expected exchange rate change plus a risk premium. When reaching monetary integration this risk premium should disappear. Kasman *et al.* (2008) test this type of convergence between EU (using Germany as reference country), the new Central and Eastern member countries, and several candidate countries. The results suggest UIP holds for Estonia, Croatia and Turkey.

A limited number of studies assess the feasibility of the proposed EAC monetary union. Buigut and Valev (2005) use a VAR to assess the symmetry of structural shocks. The results suggest the demand and supply shocks are generally asymmetric. However the speed and magnitude of adjustment seem similar across the member countries. Buigut (2006) uses a cluster analysis to assign countries in the East and Southern Africa (ESA) region into the most suitable monetary union based on a set of real and nominal convergence criteria. The conclusion of this analysis is that the ESA is not converged enough for an ESA- wide monetary union. However the EAC shows up as a relatively converged subgroup within the ESA.

2. Methodology

2.1 Data

This article analyzes several criteria (viz nominal exchange rates, real exchange rates, and inflation rates, monetary base and real output) for convergence among the EAC countries. A multivariate cointegration frame-work (Johansen, 1994; Johansen, 1995) is used to test the existence of long-run relationships that tie together variables in each criterion across the EAC countries. Because convergence implies co-movements of specific variables over time, the cointegration approach is well-suited to assess the feasibility of the proposed EAC monetary union. Quarterly data from the International Financial Statistics (IFS) CD – ROM (International Monetary Fund, 2009) is used, except for the real output where annual data is used. The nominal exchange rate variable (in national currency per US dollar) spans the period 1997Q1-2008Q4. The period average spot rate (line rf in the IFS CD) is used. The inflation rate is calculated from the CPI (line 64 of IFS) as $\ln(cpi_{t+1} / cpi_t)$, and covers the period 1997Q4 – 2009Q1. The real exchange rate is obtained from (eP^* / P), where e is the nominal exchange rate (national currency per US dollar), P^* is the US CPI, and P is the national CPI. The period covered is 1997Q3-2008Q4. The monetary base is the narrowest form of money and better able to capture the central bank's policy than broader money aggregates (Brada *et al*., 2005). This variable is used in the absence of interest rates. The monetary base data covers the period 2001Q1 - 2009Q1 (line 14 of the IFS CD). (Note 6) For the real gdp quarterly data is not available and annual data covering the period 1981 to 2005 is used. The real gdp is obtained from nominal gdp deflated by the consumer price index. We do not study the fiscal deficits and interest rates because of data availability problems.

2.2 Cointegration models.

If X is an n dimensional column vector of I(1) variables a VAR(p) model can be reformulated into vector error correction model (VECM) of the form;

$$\Delta X_t = \pi X_{t-1} + \sum_{i=1}^{p-1} \pi_i \Delta X_{t-p} + \mu_0 + \mu_1 t + \varepsilon_t \qquad (1)$$

$\pi = \alpha\beta'$, where α represents the speed of adjustment to disequilibrium and β is a matrix of long-run coefficients, both full rank $n \times r$ matrices. The μ_0 and μ_1 are $n \times 1$ vectors of constant and trend coefficients, ε_t is a $n \times 1$ error vector assumed multivariate normal, mean zero and variance Ω that is independent across time periods. If the rank is zero ($r = 0$) then $\pi = 0$, which means there is no linear combination of X_t that is stationary. If the rank of π matrix is equal to n then X_t is a stationary process. In the intermediate case, $0 < r < n$, there are r stationary linear combinations of the elements of X_t and $n - r$ stochastic trends (Haug, *et al*. 2000). Given $\pi = \alpha\beta'$, the relation between α and the deterministic term, $\mu_t = \mu_0 + \mu_1 t$, is crucial for the properties of X_t process. Five submodels are commonly derived (see Johansen 1994; Haug *et al*., 2000; Koukouritakis and Michelis, 2008) from this interaction. We consider the five submodels following the ordering in Haug *et al.* (2000) and Koukouritakis and Michelis (2008) from the most to least restrictive:

Model 0: $\mu_t = 0$, X_t has no deterministic terms and all stationary components have zero mean. (Note 7)

Model 1*: $\mu_t = \alpha\beta_0$, X_t has neither a quadratic trend nor a linear trend. But both X_t and the cointegrating relation $\beta' X_t$ are allowed a constant term.

Model 1: $\mu_t = \mu_0$, X_t has a linear trend, but $\beta' X_t$ does not.

Model 2*: $\mu_t = \mu_0 + \alpha\beta_1 t$, X_t has no quadratic trend but has linear trend that is present in the cointegrating relations.

Model 2: $\mu_t = \mu_0 + \mu_1 t$, allows for quadratic trend in X_t but $\beta' X_t$ has only a linear trend.

Testing for cointegration amounts to finding the number of $r \le (n-1)$ linearly independent columns in π (i.e. the rank of π). The trace statistic (λ_{trace}) (Johansen and Juselius, 1990) tests the null hypothesis that the number of distinct cointegrating vectors is less than or equal to r against a general alternative that rank (π) $= n$. This value is equal to zero when all the eigenvalues, λ_i, are zero. The further away the estimated roots (eigenvalues) are from zero the more negative is $\ln(1 - \hat{\lambda}_i)$ and the larger the trace statistic.

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} \ln(1 - \hat{\lambda}_i) \tag{2}$$

An alternative test, the maximum eigenvalue statistic ($\lambda_{\max}$), tests the null that the number of cointegrating vectors is r against the alternative of $r + 1$ cointegrating vectors.

$$\lambda_{\max}(r, r+1) = -T \ln(1 - \hat{\lambda}_{r+1}) \tag{3}$$

where $\hat{\lambda}_i$ are the estimated values of the eigenvalues (characteristic roots) obtained from the π matrix, and T is the number of usable observations.

In interpreting the results we claim, (as in Hafer and Kutan, 1994; Haug *et al*., 2000), complete convergence of monetary policy among the set of n countries if we find $n-1$ cointegrating vectors and therefore a single shared common trend. If $0 < r < (n-1)$ then we claim only partial convergence, or partial interdependence among the policies. In this case, maintaining a monetary union would be difficult since policy measures have not converged to one common long run path.

3. Results.

Before carrying out any cointegration tests, we test each time series variable for unit root using the Augmented Dickey-Fuller (ADF) test. The results are presented in Table 1. As can be seen from column two, the test fails to reject unit root, in levels, for the nominal exchange rate for only three (Kenya, Rwandan, and Tanzania) of the five countries. We also test for a second unit root using the first difference. This hypothesis was rejected in all cases (column three). The conclusion is that the nominal exchange rate is I(1) for three countries (Kenya, Rwandan, and Tanzania), but this variable is I(0) for Burundi and Uganda. Therefore only the three countries are included in the cointegration analysis for this variable. The ADF results suggest the real exchange rate is I(1) for all the five countries, thus we use the full set of five countries when analyzing cointegration of this variable. The inflation rate is I(0) for all the five countries. Cointegration analysis is not carried out for this variable. Instead the CPI is used to generate the real exchange rate and real gdp as discussed in Section 2.1. The monetary base is I(1) for four countries (data is not available for Rwanda) and are included in the cointegration tests. The results suggest real gdp is I(1) for all the five countries, and we use the full set of five countries when analyzing cointegration of this variable.

Next is to carry out the cointegration analysis. A separate VECM is set up for each variable. To select the appropriate lag length, the Akaike Information Criterion (AIC) and the Hannan-Quinn Information Criterion (HQIC) are used. For each VECM, the five submodels (model 0, 1*, 1, 2*, and 2) described in Section 2.2 are considered. However in an attempt to identify which of the submodels is most appropriate to use, the five submodels are tested against each other using likelihood ratio (LR) tests. For the nominal exchange rate, the best model seems to be the model 1. For the real exchange rate the better model seems to be model 2, model 2* for the monetary base, and model 1 for the real gdp. The results of cointegration tests for nominal exchange rate, real exchange rate, and monetary base variables based on the λ_{trace} and λ_{max} statistics for the submodels identified by LR are provided in Tables 2, 3, and 4 respectively. Further we show the results for all the five submodels in Tables 5, 6 and 7 for these variables. Table 8 provides the cointegration results for the real gdp from the five submodels.

Consider Table 2 which presents the results for model 1 for the nominal exchange rate variable. Both the λ_{trace} and λ_{max} test statistics suggests one cointegrating equation for this variable at the 5% significance level. The results for the real exchange rate (Table 3) based on model 2 also suggest one cointegrating equation at the 5% significance level. For the monetary base two cointegrating equations are identified at the 5% level based on model 2*. Next we turn to the results for all five submodels shown in Tables 5, 6 and 7. For brevity only the number of cointegrating equations suggested by the λ_{trace} and λ_{max} test statistics are shown for each submodel at the 1% and 5% significance levels. Take the nominal exchange rate variable results provided in Table 5 for example. Both the λ_{trace} and λ_{max} suggest one cointegrating equation at the 5% level for model 0, 1*, and 1. The results in Table 5 indicate the highest number of cointegrating equations obtained is one for any submodel. Since only three countries are included in the analysis ($n = 3$) convergence would be complete if there were two cointegrating equations such that there is only one common trend shared by all the three countries. Because there is at most only one cointegrating equation identified, there are at least two shared stochastic trends. Hence we can only claim partial convergence of the nominal exchange rate. Next consider the real exchange rate. Five countries are included in the analysis. The highest number of cointegrating equations obtained is two (Table 6) at the 5% significance level, suggesting at least three shared stochastic trends. The real exchange rate has not followed one common trend for the EAC countries. So again we can only claim partial convergence with respect to this variable. For the third variable, the monetary base, four countries are included and the number of cointegrating equations identified (Table 7) at the 5% level is at most two. This suggests at least two shared stochastic trends. This implies as of now there are at least two independent monetary policy trends followed by these countries. For the real gdp, five countries are included in the analysis. The highest number of cointegrating equations obtained is three (Table 8) at the 5% significance level, suggesting at least two shared stochastic trends.

For all the four variables analyzed (nominal exchange rate, real exchange rate, monetary base, and real gdp), the empirical results from all the five submodels considered suggest only partial convergence of policies of the EAC. These results imply there are some EAC countries that follow policies that are independent of the policies that are followed by other EAC countries. From a policy perspective the lack of complete long-run equilibrium suggests the EAC countries will need to make significant adjustments to align their policies for the currency union to be viable. A direct implication of these results is that the EAC countries need a period of monetary policy coordination prior to monetary union. The results puts into serious question the suggested date of 2012 as it is unlikely to provide adequate time for effective policy coordination for member countries. A clearly defined convergence period, with clear targets to be achieved by all member states would need to be a part of any negotiated framework to monetary union. The EAC currently does not have an autonomous supranational monetary institution that can be tasked with the implementation of the coordination phase. Therefore there is need for the creation of such an institution (call it an East African Monetary Institute - EAMI) would be necessary at the start of this phase. The EAMI's task would be to encourage cooperation between the national central banks of the member states of the EAC and oversee the convergence process. Such an institution could be the precursor to the East African Central Bank.

The EMU experience suggests that the integrity of fiscal policy is also crucial to the overall long term success of monetary union. Several member countries have failed to live up to the agreed upon fiscal policy restrictions. As Kočenda *et al.* (2008) notes, monetary unions do not necessarily encourage fiscal convergence for its members. This failure could undermine the credibility of macroeconomic polices in Europe. Neck and Holzmann (2006) have suggested that the detrimental effects of high and increasing public debt threaten the stability of EMU. Hence this experience suggests the EAC would need, in addition to monetary coordination, a fiscal coordination program prior to monetary union and the ability to enforce these restrictions post-monetary union to ensure fiscal integrity is maintained.

4. Conclusions

This paper applies multivariate cointegration analysis to provide empirical evidence on the state of convergence for the five EAC member countries with respect to four variables; the nominal and real exchange rates, the monetary base, as well as the real gdp. The motivation for this investigation is the stated objective of the five-member EAC to fast track the establishment of the proposed monetary union. This is despite the fact that no specific monetary or fiscal policy coordination program is currently in place to promote convergence. However, with the common market negotiations drawing to a successful conclusion, the focus is now beginning to shift to the monetary union stage. To help policy-makers set up a realistic time frame for the monetary union process, one important question that needs to be answered at the start of this phase is the current state of convergence of the EAC countries' policies.

Using cointegration techniques we test the existence of long-run relationships that tie together variables in each criterion across the EAC countries. The results we find support a gradual approach caution against a fast-track EAC monetary union process. The empirical results for all the four variables from all the five submodels considered indicate only partial convergence of the EAC policies. These results imply there are some EAC countries that follow policies that are independent of the policies that are followed by other EAC countries. Hence the EAC countries need to make significant adjustments to align their monetary policies for the currency union to be viable. Given the relatively small endogeneity effects suggested by literature (such as Carmignani (2009) and Tapsoba (2009)), prudence would suggest that the EAC countries allow for a period of monetary policy coordination prior to monetary union to promote further convergence and improve the chances of a credible and sustainable monetary union.

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Notes

Note 1. The EAC comprises 5 countries (Kenya, Tanzania, Uganda, Rwanda and Burundi).

Note 2. The common market protocol was signed November 20, 2009 at the 11th ordinary summit of heads of state in Arusha. This is expected to be ratified and implemented in 2010. [Online] available: http://www.eac.int/component/content/342.html?task=view (Accessed November 21, 2009).

Note 3. This would seem an ambitious target date and though there is a likelihood it may not be achieved, it may be construed as an indicator of the political will to pursue this agenda.

Note 4. Only 11.17% of Burundi exports go to EAC countries. The corresponding numbers for the other EAC countries are 23.69% for Kenya, 2.23% for Rwanda, 4.42% for Tanzania, and 17.44% for Uganda. Source: Calculated from Direction of Trade Statistics (IMF, 2009). These numbers are an average for 2007 and 2008.

Note 5. Consultations on the proposed establishment of the East African Monetary Union (EAMU) got underway September 2009 with various stakeholders in Kigali, Rwanda. [Online] available: http://www.eac.int/component/content/308.html?task=view (Accessed September 20, 2009).

Note 6. All nominal exchange rates, real rates, and monetary base are expressed in natural logs.

Note 7. This is termed trend (none) in Stata10 program. The other submodels that follow are termed restricted constant, unrestricted constant, restricted trend, and unrestricted trend for models 1*, 1, 2*, and 2 respectively in stata.

Table 1. Augmented Dickey Fuller unit root tests

Country	Nominal Exchange Rate		Real Exchange Rate		Inflation Rate		Monetary Base		Real GDP	
	Level	First difference[a)]	Level	First difference	Level	First difference	Level	First difference	Level	First difference
Burundi	-3.31 (0.02)[b)]	-5.48 (0.00)	-2.68 (0.08)	-5.80 (0.00)	-6.39 (0.00)[c)]	-12.42 (0.00)	-1.06 (0.73)	-8.47 (0.00)	-1.11 (0.71)	-3.52 (0.01)
Kenya	-2.56 (0.10)	-5.31 (0.00)	0.38 (0.98)	-5.80 (0.00)	-5.63 (0.00)	-8.00 (0.00)	-0.17 (0.94)	-7.60 (0.00)	-1.42 (0.58)	-3.14 (0.02)
Rwanda	-2.28 (0.18)	-2.86 (0.05)	-1.31 (0.63)	-3.46 (0.01)	-4.84 (0.00)	-8.39 (0.00)	[d)]----	-----	-0.91 (0.78)	-3.21 (0.02)
Tanzania	-1.75 (0.41)	-6.15 (0.00)	-1.40 (0.58)	-6.22 (0.00)	-6.55 (0.00)	-8.36 (0.00)	-0.19 (0.94)	-6.66 (0.00)	0.07 (0.96)	-3.50 (0.01)
Uganda	-3.02 (0.03)	-3.63 (0.01)	-2.42 (0.14)	-3.79 (0.00)	-5.71 (0.00)	-11.36 (0.00)	0.68 (0.99)	-6.15 (0.00)	-0.10 (0.95)	-5.22 (0.00)

Note: [a)] This column indicates the first difference of the variable. [b)] The first entry is the ADF statistic, while the entry in parentheses is the associated p-value. The nominal exchange rate for Burundi and Uganda are stationary, I(0), in levels at the 5% significance level. [c)] The inflation variable is I(0) in levels for all the countries at the 1% significance level. [d)] Adequate monetary base data is not available for Rwanda.

Table 2. Test of cointegration for nominal exchange rate

Null hypothesis: r	Maximum eigenvalue test			Trace test		
	λ_{max} statistic	5% critical value	1% critical value	λ_{trace} statistic	5% critical value	1% critical value
0	22.52[*1]	20.97	25.52	34.41[*1]	29.68	35.65
1	7.98[*5a)]	14.07	18.63	11.89[*5]	15.41	20.04
2	3.91	3.76	6.65	3.91	3.76	6.65

Note: These results are based model 1 and 2 lags. [*5a)] The null hypothesis of no cointegration, $r = 0$, is rejected while the null hypothesis of zero or one, $r \leq 1$, cannot be rejected against the alternative of, $r = 2$, at the 5% level.

Table 3. Test of cointegration for real exchange rate

Null hypothesis: r	Maximum eigenvalue test			Trace test		
	λ_{max} statistic	5% critical value	1% critical value	λ_{trace} statistic	5% critical value	1% critical value
0	41.64	36.41	41.58	88.10	77.74	85.78
1	16.57[*1, 5a)]	30.33	35.68	46.45[*1, 5]	54.64	61.21
2	13.74	23.78	28.83	29.88	34.55	40.49
3	9.35	16.87	21.47	16.14	18.17	23.46
4	6.78	3.74	6.40	6.78	3.74	6.40

Note: These results are based on model 2 and 1 lag. [*1, 5a)] The null hypothesis of no cointegration, $r = 0$, is rejected while the null hypothesis of zero or one, $r \leq 1$, cannot be rejected against the alternative of, $r = 2$, at the 5% and 1% level.

Table 4. Test of cointegration for monetary base

Null hypothesis: r	Maximum eigenvalue test			Trace test		
	λ_{max} statistic	5% critical value	1% critical value	λ_{trace} statistic	5% critical value	1% critical value
0	40.50	31.46	36.65	102.50	62.99	70.05
1	40.12	25.54	30.34	62.00	42.44	48.45
2	11.76*1, 5a)	18.96	23.65	21.88*1, 5	25.32	30.45
3	10.12	12.52	16.26	10.12	12.25	16.26

Note: These results are based on model 2* and 4 lags. *1, 5a) The null hypothesis of $r \leq 2$ cannot be rejected against the alternative, $r = 3$, at the 5% and 1% level.

Table 5. Test of cointegration of nominal exchange rate under different restrictions

Submodel	Maximum eigenvalue test (λ_{max})		Trace test (λ_{trace})	
	1% level	5% level	1% level	5% level
Model 0. Trend (None)	0	1	0	1
Model 1*. Trend (rconstant)	0	1	1	1
•Model 1. Trend (constant)	0	1	0	1
Model 2*. Trend (rtrend)	0	0	0	0
Model 2. Trend (trend)	0	0	0	1

Note: •The LR tests suggest this is the best sub-model. The results shown here are based on two lags indicated by the AIC and HQIC tests as optimal. Tests of cointegration are carried out for only three countries (Kenya, Rwanda, and Tanzania). Burundi and Uganda are not included because the ADF tests indicate the variable is I(0) in levels.

Table 6. Test of cointegration of real exchange variable under different restrictions

Sub-model	Maximum eigenvalue test (λ_{max})		Trace test (λ_{trace})	
	1% level	5% level	1% level	5% level
Model 0. Trend (None)	1	1	2	2
Model 1*. Trend (rconstant)	1	1	1	2
Model 1. Trend (constant)	1	1	1	2
Model 2*. Trend (rtrend)	1	1	1	1
•Model 2. Trend (trend)	1	1	1	1

Note: •The LR tests suggest this is the best sub-model. The results shown here are based on one lag indicated by the AIC and HQIC tests as optimal.

Table 7. Test of cointegration of monetary base variable under different restrictions

Sub-model	Maximum eigenvalue test (λ_{max})		Trace test (λ_{trace})	
	1% level	5% level	1% level	5% level
Model 0. Trend (None)	2	2	2	2
Model 1*. Trend (rconstant)	2	2	2	2
Model 1. Trend (constant)	2	2	2	2
•Model 2*. Trend (rtrend)	2	2	2	2
Model 2. Trend (trend)	1	1	1	2

Note: •The LR tests suggest this is the best sub-model. The results shown here are based on four lags indicated by the AIC and HQIC as optimal. Cointegration test is carried out for only four countries. Rwanda is excluded for lack of data.

Table 8. Test of cointegration of real gdp under different restrictions

Sub-model	Maximum eigenvalue test (λ_{max})		Trace test (λ_{trace})	
	1% level	5% level	1% level	5% level
Model 0. Trend (None)	2	3	2	3
Model 1*. Trend (rconstant)	2	3	3	3
•Model 1. Trend (constant)	1	1	1	1
Model 2*. Trend (rtrend)	0	1	0	1
Model 2. Trend (trend)	1	1	1	1

Note: •The LR tests suggest this is the best sub-model. The results shown here are based on two lags.