

The Convergence of Macroeconomic Variables within the East Africa Community

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study seeks to establish whether the East African Countries are realizing convergence in their macroeconomic policies as efforts are geared towards the establishment of an economic union and subsequently a monetary union in a bid to foster economic growth in the region. Five EACs were included in the analysis using panel data for the period 2008-2018. The methodology employed in the analysis involved; sigma convergence, beta convergence using fixed-effect model, and finally stochastic convergence was tested. The findings show that there is no evidence of macroeconomic convergence and the less developed countries are neither catching up with the relatively developed countries. The macroeconomic variables are also not showing a tendency to be moving the same direction as time goes by. Therefore, for the EACs to realize a common union, either economic or monetary, they need to formulate policies that will ensure that the member states adhere to the desired macroeconomic policies that would lead the region to convergence.

Keywords: *Macroeconomic variables; macroeconomic policies; monetary union.*

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1. INTRODUCTION

Interest in the integration of countries in the same region has grown tremendously over the decades in the aftermath of independence in Africa and even globally and different unions have been established. The ideas were started by the drive to have more influence at the global stage and generally the relatively small size of individual economies which prohibit countries from enjoying the benefits of economies of scale both in production and in the sale of the goods abroad. In Africa, the CFA franc zones which were previously colonized by the French and the Common Monetary Area (CMA) of Southern Africa are the only two monetary unions that are there in Africa. Other regions are also emphatically trying to establish their own. The following regional blocks are in the pipe-line: East African Community (EAC), South African Development Community (SADC), Common Market for Eastern and South Africa (COMESA), and the Economic Community of West African States (ECOWAS). All these regions have the ultimate objective of a common currency for the Africa continent [1].

When countries establish a monetary union successfully, they will realize a reduction in the exchange rates amongst themselves, they will realize economies of scale because of the regional pool of resources, there will be price harmony in the region and generally, the traders will not be subjected to exchange rates risks [2]. The members in a monetary union must be however ready to lose their sovereign right to alter their monetary policies at will, they will not also be able to effect changes that will lead to change in exchange rates. More so, these nations are likely to be faced with asymmetric shocks and a uniform monetary policy may not be a panacea to all. That is, these countries will not have control over monetary policy instruments and exchange rate policies that are traditionally used when dealing with country-specific macroeconomic shocks.

An agreement to form a Tripartite Commission for East African Co-operation was signed in the year 1993. This led to the desire to further the unionization agenda leading to the establishment of the East African Community (EAC) in 1999. Subsequently, the region agreed to form a Customs Union in the year 2004 followed by a Common Market Protocol (CMP) in the year 2009. Thereafter, the region agreed that they should be able to form a Monetary Union by the

end of the year 2012. During the 11th Ordinary summit, it was agreed that the push to a common market is put on high gear.

For the long-term objective of a sustainable MU to be realized, the EACs have to achieve macroeconomic convergence. For the union members to be deemed to have achieved MU, they must exhibit monetary policy convergence, and this is exhibited by similarities in inflation and interest rates as part of macroeconomic variables. An empirical study conducted by Rose [3] found that countries that are members of currency unions realize enhanced trade, which is two to three times faster than countries that are not in a union. She alluded that MU leads to similar demand patterns and the prices will be oscillating in the same direction for the member countries.

When countries join a MU they tend to become more alike and comparison amongst them becomes easy. When analyzing countries for suitability to form a monetary union, and these characteristics are found to be endogenous, then, these nations need not meet the optimum currency area criteria for the union to be adopted. This was evident with the establishment of the European Monetary Union (EMU), the subsequent gains were dismal, only 15% [4,5]. The same analysis was conducted by Carmignani [6] and Tapsoba [7] to establish the effect of endogeneity on trade for the existing African MUs. They found that it increases the way Business cycles are synchronized but the overall gain was dismal.

Even though the drawbacks of endogeneity may not be quantified, the finding of insignificant impact is a warning that countries should not be so engrossed with the idea of forming a MU. Within the EAC, empirical findings show that trade benefits are only 15%, the inter-EACs trade is quite low given that these nations mostly depend on primary products. Therefore, to reduce any negative effects from a loss of control on monetary policy instruments by member countries, convergence before a monetary union is critical for the EAC.

Our literature review did not find evidence of research conducted to test the impact of convergence of macroeconomic variables thresholds set out at the launching of EAMU in 2010. It is however anticipated that the set of convergence criteria including those of annual GDP growth rate, inflation rate, national savings

plus foreign reserves that formed the basis of EAC targeted macroeconomic variable that require convergence would play crucial role in economic growth in the region. The criteria are as follows (Table 1).

The behavior of the targeted macroeconomic variables for the EAC economies is presented in

Fig. 1, and Fig. 2. Fig. 1 shows smaller dispersion in the behavior of GDP growth rate within the economies of EAC.

The inflation rate for the five economies within EAC follows a similar pattern for the period 2008-2018 as depicted by Fig. 2.

Table 1. EAC macroeconomic convergence criteria

Criteria	Stage I 2007-2010	Stage II 2011-2014	Stage III 2015
Primary Criteria			
Budget deficit/GDP (excluding grants)	<6%	<5%	Introduction and circulation of a single East African currency
Budget deficit/GDP (including grants)	<3%	<2%	
External reserves (months of imports of goods and non-factor services)	>4	>6	
Annual inflation rate	<5%	<5%	
Secondary Criteria			
Exchange rates	Stable	X	
Interest Rates	Stable	X	
Real GDP growth rate	>7%	>7%	

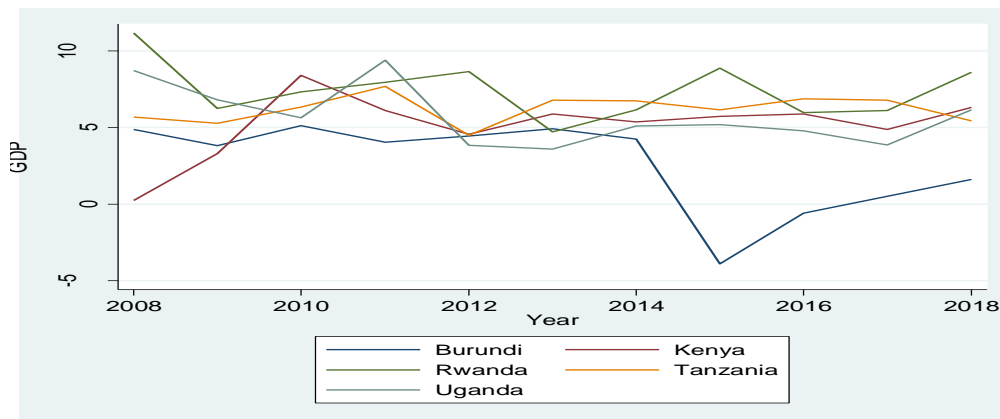


Fig. 1. GDP growth rate for Burundi, Rwanda, Uganda, Kenya, and Tanzania

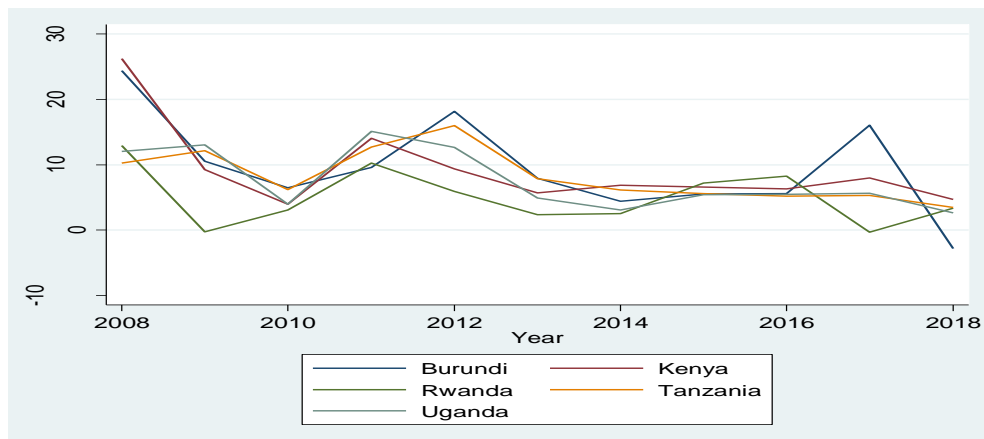


Fig. 2. Inflation rate for Burundi, Rwanda, Uganda, Kenya, and Tanzania

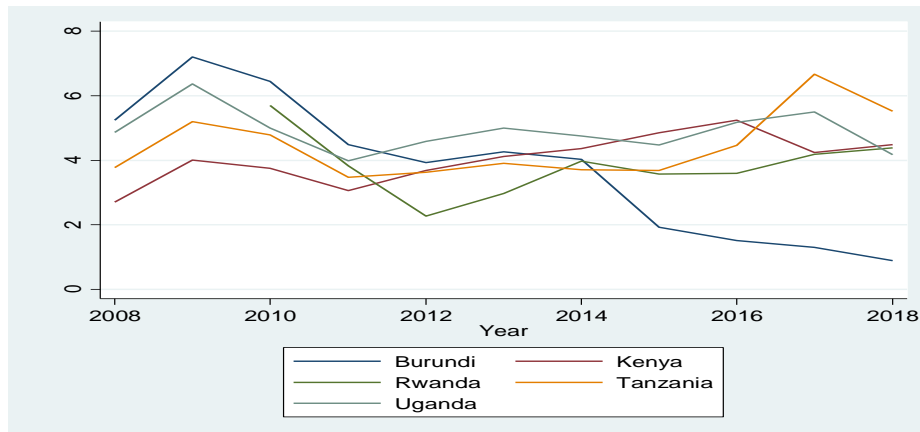


Fig. 3. External reserve for Burundi, Rwanda, Uganda, Kenya, and Tanzania

The panel data generally exhibits a stationary trend for each of the macroeconomic variables of interest.

The EAC treaty was signed in 1999, a custom union treaty in 2004, a common market protocol (CMP) in 2009, and an objective to form MU by 2012 were also agreed upon. Taking a glance at the EAC, none of these agreements seem to have been achieved. In the recent past, there have been trade sanctions between Uganda and Rwanda, and Kenya and Tanzania, which is against the spirit of the common trade area and free movement of labor and the desire to share a common currency ultimately. It is therefore important to investigate key macroeconomic variables within the EAC and understand their behavior to come up with suggestions and policies that may help these nations realize their dream.

Several studies have been conducted to investigate the aspect of nations converging concerning GDP only [8,9,10], but this study seeks to analyze key macroeconomic variables and establish whether there is a tendency to converge as envisioned by the EAC treaties. The member countries are lagging and there seems to be no cooperation amongst them to realize the benefits of a common trade area and subsequently a monetary union. The member countries appear to be pursuing their interests and, in some instances, there are tendencies to protect local companies and traders against regional competition.

A review of empirical research on economic convergence, most studies focus on GDP convergence and no particular study has focused on the convergence of macroeconomic variables

[8,9,10]. The study seeks to establish how specific macroeconomic factors affect the desire to realize a common union. This analysis provides empirical evidence on the importance of focusing on macroeconomic variables convergence so that we can realize economic convergence in the end. These tests were achieved by using various convergence methodologies to ascertain the trends in the EA region.

This paper used panel data to examine whether GDP growth, inflation, external reserves, and domestic savings converge among members of EAC. Given the recent interest in monetary integration, the extent of convergence between these variables will not only inform policy regarding the direction of the EAC but will also inform macroeconomic policy in EAC in general.

In determining the convergence of macroeconomic policies; the economic fundamentals of the countries within the EAC, their macro-economic history, and the behavior of these variables over time must be studied and their relationship established.

2. LITERATURE REVIEW

The basic paradigm of macroeconomic convergence originated from the Solow-Swan neoclassical exogenous growth model, which assumes that diminishing marginal returns to capital, of an economy that has lower capital to labor ratio exhibits a high marginal product of capital, and therefore grows much quicker than an economy with higher capital to labor ratio since the differences of the countries decrease with time as income per person and economic growth converges towards similar equilibrium in

the future. This implies that in cases where countries have the same choices and level of technology, over time, they will have the same stable income levels and growth rate as long as they can both access and utilize the same technology. This scenario is called absolute or unconditional beta convergence, because there is no endogenous control of the differences such as technology between the countries.

On the contrary, exogenous growth theory, is where technology taken as a factor within the model, is subjected to rigorous decision making at any given firm, thereby leading to a situation where each country achieves a different level of income towards the level of convergence. This scenario is called conditional beta convergence and applies to a situation where the differences in the steady states across countries are controlled for factors such as capital accumulation, human capital, social capability, infrastructure, and institutional environment [11].

In addition, the optimum currency areas (OCA) theory was formulated by Mundell [12] and further supported by McKinnon [13] and thereafter by Kenen [14]. The idea was to establish the conditions under which a country is likely to benefit by joining a currency union. The theory argues that for a country to be a member of a currency union it has to ensure that it has to weigh a balance of the loss of economic stability (sovereignty to adjust their monetary policies) against the gains of monetary efficiency. These gains are brought about by competitive gains because of the decline of the general price level, the increase in aggregate demand, and enhanced exports because of being a member to a single currency.

However, if the integration process is not conducted with care, poorly integrated members are likely to experience asymmetric macroeconomic shocks. An asymmetric shock happens when some member countries in the union are hit by a shock while others are not. If some of the member countries were affected by positive or negative demand shock, this would lead to disequilibrium because of price variation in the affected countries. When the union central bank tries to help the affected countries by increasing their money supply to help them regain economic strength, this would only lead to inflation. The intention of the unitary central bank to resuscitate the ailing nation can salvage an economy from economic turmoil but at the cost of increased inflation. Therefore, if there were

asymmetric shocks, the unitary central bank's monetary policies to salvage some countries in the union would only be at the expense of the others.

In Africa, some studies have been done in the ECOWAS, SADC, and EAC regions pursuing the benefits of economic and monetary unions. Olalekan [15] investigated whether the primary and secondary criteria established by the ECOWAS, under the West African Zone (WAMZ) were leading towards macroeconomic convergence. The study used the Keynesian framework as the analytical model, whose basic assumption captures both the demand and supply side of the economy, and incorporates the variables such as interest rate, exchange rate, inflation, fiscal deficit, investment, and labor in explaining the economic growth rate. In the WAMZ scenario, the study also added financial reforms and trade openness due to the pursuit of liberalization policies by member states. The data was obtained from the World Bank World Development Indicators, as well as the Ministry of Finance and the Bureau of Statistics in Nigeria. For diagnostic tests, the researcher performed Normality Test (J-Qtest); Serial Correlation (LM test); Heteroscedasticity (ARCH), and Stability (Cusum square) tests. Using panel cointegration, the results showed that there is a significant between all the variables and GDP growth rate, except for fiscal deficit in Nigeria [15].

Another study in ECOWAS by Saka, Onafowokan and Adebayo [16] investigated the process of establishing a monetary union, with a special interest in the convergence criteria, using data drawn from the 2000 to 2008 period. They adopted a neoclassical growth model in explaining the conditional convergence among the member states. The panel estimation sought to establish the effects of all explanatory variables on the income growth rate. The findings showed that the central bank debt financing harmed the income growth rate with a unit increase in deficit financing inducing a 0.03% decrease in income rate. The fiscal deficit also harmed the income growth rate with a unit increase in fiscal deficit leading to a 0.11% decrease in income growth. The effect of external reserves on the income growth rate was negative but not significant. Therefore, all the explanatory variables had indirect and negative effects on the income growth rate in the ECOWAS region [16].

Kumo [17] investigated the convergence in real per capita GDP and macroeconomic activity in the SADC region, using data drawn from the 1999 to 2009 period. Using standard deviations, the tests showed that there was no sigma convergence, by employing both real GDP per capita and purchasing power parity (PPP). Results implied that the disparities in real income increased over the study period, as some countries grew richer and others poorer. For beta convergence, the study, employing a sample of 11SADC states, using Generalized Least Squares found out that there was no conditional beta convergence [17]. Another study, in the same region, examined the suitability of the SADC macroeconomic convergence criteria. The descriptive analysis indicated positive progress in 2009 and 2010 in meeting inflation targets, but inferential statistics indicated that member states would not be able to meet the targets [18].

Further, Mainza [19] carried out a study to assess in SADC the convergence of real per capita GDP in the face of structural differences across member countries (conditional beta convergence) and the possibility of reducing income dispersions (sigma convergence). The theoretical framework adopted was the growth model based on the original Solow model. The data was obtained from the World Bank, IMF, and 15 member countries Central Bank and Bureau of Statistics institutes. The variables of interest in the study were mean years of schooling for the population aged between 25 and 64 years and gross capital formation. Based on the panel estimation, there was conditional beta convergence among SADC countries, since the coefficient of log per capita GDP (β), 0.905, which satisfied the conditional β -convergence requirement of $0 < \beta < 1$. Further, short and long run, the accumulation of human capital was also significantly and positively related to the growth in GDP in the SADC zone, indicating movement in the right direction [11].

Extensive research has been done in the EAC over the past two decades. Mkenda [19] conducted a study on the validity of a monetary union, which involved three East African countries (Kenya, Uganda, and Tanzania). The study involved analyzing whether they meet the optimum currency area (OCA) criteria using a Generalized Purchasing Power Parity (GPPP) model, which was suggested by Enders and Hurn [20]. The model seeks to explain the determinants of real exchange rates and the fundamentals of an economy like income and

terms of trade, which should trend together for a region to be considered OCA. The idea is that the real exchange rates of the countries in OCA should be co-integrated. The study concluded that the EACs are an OCA. The analysis in the study suggested that there is co-integration in the real exchange rates from 1981 to 1998. This means that they are affected by similar stochastic trends. However, this may be disputed given that the market price and nominal exchange rates are controlled by respective governments, and may not trend freely as expected [21].

Buigut & Valev [22] first analyzed symmetry and asymmetry of macro-economic shocks for the EAC (Uganda, Kenya, Tanzania, Burundi, and Rwanda) applying the bivariate SVAR approach. The methodology that was applied followed the one that was used by Bayoumi and Eichengreen [23]. The data that was used ranged from 1970 to 2001 which comprised of real GDP and real GDP deflator. Their analysis showed that EAC was dominated by asymmetric shocks, positive and significantly correlated supply shocks were evident only in Kenya and Burundi. They concluded that it was not possible to form a monetary union and they recommended the need to integrate more.

In 2006, Mburu [24] analyzed whether political atmosphere and economic conditions would favor the formation of MU in the East African region. The method of analysis that was used involved synchronization of the business cycle and shocks criterion. The study concluded that the adoption of OCA would not be appropriate given the prevailing conditions. He found that there was no evidence of macroeconomic convergence among the EACs, the reasons that he gave were; intra-regional trade and that the degree of factor mobility is low, and the countries in the EA region do not have political and institutional structures that would support a monetary union.

Debrun et al. [25] came up with a comprehensive cost-benefit analysis to analyze monetary integration that was costumed to data available in Africa. They used their developed model on the existing monetary unions and the proposed unions that included the EAC. They found that EAMU would be of minimal benefit to the member countries save for Tanzania. The reason is that each nation has an effective central bank that is independent and targets a lower level of inflation of its interest. They also established that

the level of asymmetry in trade shocks is lower in EAC than in the other blocs. On average, there is a higher correlation within the EACs from 1990 to 2007 than that of WAEMU and CMA in the existing African Monetary Unions. The findings also show that these correlations have a downward trend from 2006 to 2008; these show the countries develop different export patterns due to a decline in the commodity prices.

In a different study, it was established that overall observations indicated that EAC countries were converging towards a common trend. In a test of the convergence of per capita GDP, the results were mixed. Preliminary results showed that EAC countries were converging towards zero in terms of GDP per capita for the period, 1980-2007. However, overall, the mean convergence of real GDP fluctuated between -0.60 and 0.80 showing that the means are not approaching zero [26]. Hence there is no clear indication of convergence.

In 2012, Mafusire and Brixiova [27] assessed the preparedness of EAC for a monetary union where they applied a structural vector autoregressive model with a keen interest in macroeconomic shocks in the region. The findings were that the level of asymmetry in macroeconomic shocks affecting the region was very low and they recommended that the EACs should not rush into a MU but rather focus on economic convergence. Sheikh [28] conducted a similar study, where he analyzed the suitability concerning the EA region with reference to the optimum currency variable. The study employed a four variable structural auto-regression (SVAR) model to analyze four types of shocks, which included domestic demand and supply shock, monetary supply shock, and global supply shock. He then analyzed the symmetry and asymmetry of these shocks, simple correlation analysis, followed by impulse response analysis, then variance decomposition analysis, and lastly one-way Anova analysis.

Sheikh [28] proceeded to apply a second method, which involved business cycle synchronization analysis of HP (Hodrick-Prescott) and the Bandpass (BP) filters. He first established the cycles, trends, and then applied them to cross-country correlation analysis and analysis of variance to check whether the EAC are affected uniformly by business cycles or not. His findings were not significant for the formation of a MU at the moment but indicated a promising future for the same. These are supported by the

fact that the shocks become more symmetrical with time and the business cycles have become more synchronized in the region for the last ten years. The correlation analysis shock showed that domestic demand shock and external demand shock are concentrated in the EA region. The output for business cycle analysis showed that EACs are similar in cycle components but have a difference in permanent components in the growth trends.

The study recommended that East African countries should develop a well-designed institutional framework that may lead to the creation of a regional central bank that would be more independent than the existing national central banks. Different nations employ different fiscal measures to curb budgetary deficits, having a common central bank within a MU would better resist the need to borrow from outside than a national central bank.

Dridi and Nguyen [29] examined inflation convergence in five East African Nations and in particular, the study focused on Rwanda, Uganda, Tanzania, Burundi, and Kenya. The paper studied convergence in inflation using Global Vector Autoregressive (GVAR). The global VAR model was used in this study on the merit that it explores the various channels and interlinkages. The finding from the study showed that price rise disparities among the East African Community nations are not of importance value which implied a price change convergence. The convergence is attributed to a correspondence in the type of disturbances affecting EAC nations and the type of foreign variables which are drivers of price fluctuations.

Generally, the prevailing studies give differing findings on the readiness of the EACs to adopt a monetary union. Most of the studies assert that the EACs are not ready for a currency union. Therefore, it is on these bases that we seek to find out the latest formation and status of the region with regard to macroeconomic convergence.

3. METHODOLOGY

3.1 Theoretical Framework

The Solow model postulates that growth is a function of capital (K), labor (L), and the level of technology (A). The approach assumes a Cobb-Douglas production function at a given point in time:

$$Y(t) = K(t)^\alpha (A(t)L(t))^{1-\alpha} \quad 0 < \alpha < 1 \quad (1)$$

From the equation, Y is output, L is labor, and A is the level of technology. The following are taken as exogenous; savings, population growth, and technological progress. L and A are assumed to grow at the rate n and g defined at a given time t by:

$$L(t) = L(0)e^{nt} \quad (2)$$

$$A(t) = A(0)e^{gt} \quad (3)$$

The two equations imply that effective labor $A(t)L(t)$ grows at $n + g$, and that output is an increasing function of the stock of capital (K). The model assumes that output is not entirely consumed but rather a fraction of it (s) is saved and invested. Defining k as the stock of capital per effective worker, $k = \frac{K}{AL}$, and y the level of output per effective worker, $y = \frac{Y}{AL}$, the rate of change in capital per effective worker can be expressed as:

$$\begin{aligned} \dot{k}(t) &= sy(t) - (n + g + \delta)k(t) \\ &= sk(t)^\alpha - (n + g + \delta)k(t), \end{aligned} \quad (4)$$

The level of investment in the economy is given by sy_t and the rate of growth of population and depreciation is given by $(n + g + \delta)k(t)$. According to equation (4), if the level of investment is greater than the rate of depreciation and population growth, a nations capital stock will only increase to the level where k converges to the steady-state k^* , at this level investment is just enough to replace the depreciated old stock of capital. This level can be expressed as:

$$k^* = \left[\frac{s}{n + g + \delta} \right]^{1/(1-\alpha)} \quad (5)$$

The equation states that the steady-state level of capital per effective worker is related to the rate of saving positively and negatively to the rate of population growth. When an economy gets to this level, investments and depreciation are equal and no new capital is created because the economy has reached its maximum level of capital stock accumulation. Given that the effective labor $A(t)L(t)$ is taken as constant and output (Y) increases due to an increase in capital stock, then, the steady-state of capital determines the steady-state level of output.

Taking Equation (5) and substituting into Equation (1) and taking the log of both sides, the steady-state income per capita is given by:

$$\begin{aligned} \ln\left(\frac{Y(t)}{L(t)}\right) &= \ln(A(0)) + gt + \frac{\alpha}{1-\alpha} \ln(s) \\ &\quad - \frac{\alpha}{1-\alpha} \ln(n + g + \delta) \end{aligned} \quad (6)$$

The equation states that the steady-state level per capita is related t technological progress and investments positively and negatively to the rate of population and depreciation. The model predicts that economies will in the long run converge to the steady-state level of per capita income, which is directly affected by the long-run steady-state of capital.

3.2 Empirical Model

The empirical model is divided into stages; fast-testing for the presence of convergence, second-analyze the speed of convergence, and finally, conduct tests for stochastic convergence (unit-root tests and co-integration).

3.2.1 Macroeconomic variables convergence

3.2.1.1 Sigma convergence (σ)

Convergence is tested using sigma (σ) convergence. In the process, the country's macro-economic variables are converging overtime when their differentiation decreases over time. The macro-economic variables dispersion is measured by analyzing standard deviation or variation (coefficient of variation (CV) of the macroeconomic variables in the economies. The study checks for the decline of coefficient of variation for the macro-economic variables per capita over the period of study which is given by:

$$\begin{aligned} CV &= \frac{\text{Standard deviation}}{\text{mean}} \end{aligned} \quad (7)$$

The convergence hypothesis is tested by estimating the trend line of the co-efficient of variation over time for the EACs given by:

$$\begin{aligned} CV &= \alpha_0 + \alpha_1 t \\ &\quad + \varepsilon_t \end{aligned} \quad (8)$$

The dependent variable (CV) is the coefficient of variation for the macro-economic variables for

the EACs and the independent variable is the time over which the analysis is conducted: $t = 1, \dots, 10$ for the years between 2008 to 2018, and the error term is given by ε_t . The presence of convergence is confirmed when the coefficient α_1 is negative.

3.2.1.2 Beta convergence (β)

When less developed countries grow at a faster rate than developed countries, where, the initial income is negatively related to the growth rate, Beta convergence (β) is said to have occurred. This form of convergence can either be absolute (unconditional) or conditional. Variables are said to be conditionally convergent when determinants of convergence are controlled in the model (Mankiw et al., 1992). On the other hand, absolute convergence happens when the national outputs converge to a steady-state without controlling for the factors that affect the change in them. Countries can realize β convergence and fail to realize σ convergence because; β convergence is a necessary condition but not sufficient condition for the realization of σ convergence. This means that countries may realize β convergence and fail to realize σ convergence, this paper will analyze both absolute and conditional convergence.

To measure β convergence, the annual growth rates of the GDP are regressed on the GDP levels of the previous year. In the absolute case; the control variables are not added and for the conditional convergence, the control variables are added.

$$\begin{aligned} \log y_{it} - \log y_{it-1} &= \alpha_0 + \alpha_1 \log y_{it-1} \\ &+ \sum_{k=1}^n \phi_k x_{kt} + \varepsilon_{it} \end{aligned} \quad (9)$$

From the equation, $\log y_{it}$ is the natural logarithms of GDP per capita in a given country i at time t , α_0 is constant (autonomous change), x_{kt} is the vector of control variables, and ε_{it} is the error term. The analysis employed fixed effects using panel data. For the absolute convergence, the analysis was done without the control variables x_{kt} , and in the case of conditional convergence, the control variables are added. For β convergence to be evident the value of α_1 has to be negative ($\alpha_1 < 0$) indicating that higher initial income levels negatively affect the rate at which the GDP growth rates for the following years will grow.

3.2.1.3 The speed of convergence

Using Equation (9), the β coefficient is estimated to establish the speed of convergence.

$$\beta = -\frac{1}{T} \ln(1 + \alpha_1 T) \quad (10)$$

For the panel data $T = 1$. β Measure the distance from the steady-state for the economies that are converging in a given year.

3.3 Stochastic Convergence

This study went further to check for the presence of convergence by conducting a unit root test and subsequently co-integration test. The unit root test checks whether the variables are stationary while the co-integration test checks for there is the presence of a long-run relationship in the macroeconomic variables.

3.3.1 Unit root testing

Unit root test is used to check whether time series are random or stationary. For this, a stochastic process model is used which is specified as:

$$\begin{aligned} y_{it} &= \alpha + \phi y_{it-1} + \varepsilon_t \end{aligned} \quad (11)$$

The null hypothesis is $H_0: \phi = 1$. When a time series has $\phi=1$, the model is random. When the null hypothesis is accepted, it means that the model is random and when it is rejected it means that the time series is converging to a stable state. Therefore; we check whether the model $\phi = 1$ (unit root) or not.

3.3.2 Analysis of co-integration

After checking for the presence of a unit root and confirming that the time series variables are random, we can also check whether the random variables have a common trend in the future (they converge in the future) or they are co-integrated. The idea is to then check whether time series variables are converging (co-integrating) in the long run.

$$\begin{aligned} x_{i,t} &= \beta_0 + \beta_1 x_{-i1,t} + \beta_2 x_{-i2,t} + \dots + \beta_3 x_{-ik,t} \\ &+ \varepsilon_t \end{aligned} \quad (12)$$

Where; $-i, t (t = 1 \dots k)$ represent time series i at time t . In estimating the above model only time series that are integrated of order 1

were included in the analysis. The analysis employed various tests to determine the order of integration when conducting the unit root test. Co-integration is confirmed when by establishing $p - 1$ co-integrating vectors, in the time series data, p is the total number of time series variables that are included in the model. When less than $p - 1$ co-integrating vectors are established, the variables will be deemed to have partially converged, implying that not all the series in the analysis are converging. If the finding is that there is no co-integrating vector, the analysis concluded that there is no convergence. Several tests were employed to affirm our findings.

4. RESULTS AND DISCUSSION

4.1 Descriptive Statistics

The descriptive statistics for the variables considered in this chapter as defined in Table 1 are shown in Table 2. The economies of Burundi, Kenya, Tanzania, Uganda, and Rwanda all had relatively low inflation between 2008 and 2018. For these economies, Burundi had an average inflation rate of 9.6%, Kenya had 9.18%, 8.2% for

Tanzania, and 7.6% for Uganda while Rwanda had an average inflation rate of 6.5%. The summary statistics have demonstrated that the inflation rate in these economies does not diverge much from each other. The summary statistics further show that Rwanda's economic performance is strongest among the east Africa economies. For example, the GDP growth rate for Rwanda averaged 7.8%, followed by Tanzania at 6.2% while Burundi recorded the worst economic performance of 2.6% within the EAC.

4.2 Results of the Model on Macroeconomic Convergence

In this section, Sigma convergence is analyzed for each macro variable to establish if there is convergence in the long run. The procedure involves estimating the variation coefficient and subsequently analyzing its movement over time. Thereafter, Beta convergence is estimated to examine the speed with which these macroeconomic variables converge to the steady-state given their status at the base year, and the vector of control variables of interest.

Table 1. Descriptive statistics

Country	Variable	Obs	Mean	Std. Dev.	Min	Max
Burundi	Inflation	11	9.626581	7.492575	-2.8147	24.40695
	GDP	11	2.641155	2.904747	-3.9	5.124163
	Savings	11	-8.2588	4.18912	-15.6861	-2.06624
	Reserves	11	3.748576	2.117701	0.892541	7.206232
Kenya	Inflation	11	9.182374	6.290076	3.961389	26.23982
	GDP	11	5.148362	2.057241	0.232283	8.405699
	Savings	10	-0.61104	2.506591	-5.40782	2.528295
	Reserves	11	4.048494	0.737186	2.703131	5.245344
Rwanda	Inflation	11	5.031606	4.273718	-0.30953	12.94115
	GDP	11	7.436421	1.82477	4.71983	11.16126
	Savings	9	2.856904	2.640225	-1.01538	5.865374
	Reserves	9	3.831132	0.949216	2.274631	5.696362
Tanzania	Inflation	11	8.262844	3.945212	3.494458	16.00109
	GDP	11	6.203345	0.904821	4.500154	7.672155
	Savings	10	16.32131	2.35689	13.05759	20.30634
	Reserves	11	4.436743	1.011983	3.475476	6.667255
Uganda	Inflation	11	7.631511	4.587878	2.623975	15.12515
	GDP	11	5.732222	1.919882	3.586906	9.391668
	Savings	11	5.824079	4.022489	-0.51152	14.37416
	Reserves	11	4.898788	0.654176	3.9869	6.372568

Source: Author's own computation from Stata

4.2.1 Macro-economic variables convergence (Sigma convergence)

The coefficient of variation (σ_t) on macro-economic variables for all EACs is estimated, a simple plot is generated to be able to get a visual impression as to whether the macro-economic variables could be having a common trend in the future. From the Fig. 4, the y-axis is the σ_t , which is plotted against the time coefficient as provided by Equation 8.

In theory, given a set of countries, the variance (dispersion) δ^2 should be declining over time for convergence to be realized. It demonstrates that the variation in the economic activities of the countries is declining over time. This is called sigma (σ) convergence among countries. The analysis in Fig. 4 illustrates a very weak and erratic form of sigma convergence among the EACs macro-economic variables. The variance of the GDP, reserves, and inflation are almost constant throughout the period, they exhibit a slight decline from 2008 to 2010 (convergence tendency) then, they become constant to 2018. Inflation is inclining from 2008 to 2009 (divergence) but thereafter it assumes an erratic pattern which on average seems to be that of

divergence than convergence. Savings seems to be the most erratic macro variable among the EACs. It indicates convergence and divergence periodically, from 2017 to 2018 there seems to be a sharp tendency to converge. However, given the previous trends, this is less likely to be sustainable. The movement in Fig. 4 generally demonstrates a very weak form of convergence among the EACs.

To evaluate sigma (σ) convergence for the EACs macro-economic variables, a simple regression is conducted for each of the macro variables in line with Equation 8. For this analysis, T=11 years and $\log \sigma_t$ (coefficient of variation) are generated from the data for all the years. The log for sigma σ_t is taken to solve the problem of heteroscedasticity, which we know is inherent in time series data. The regression analysis results in Table 3 below show the absence of convergence given that the coefficients for the time (year) variable is positive for GDP and inflation, and negative for savings and reserves. According to theory, for convergence to happen, the value of α should be less than zero ($\alpha_1 < 0$). The dependent variable in the model is the coefficient of variation.

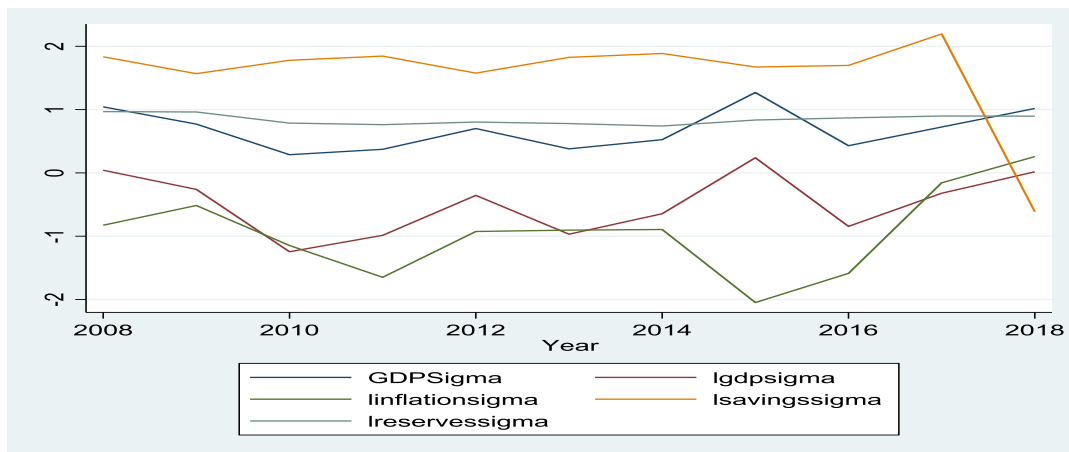


Fig. 4. The evolution of variation coefficient for all macro-economic variables

Table 2. Sigma Convergence regressions results

	GDP	Inflation	Savings	Reserves
Constant	-55.2680	-88.1890	184.6296	6.0462
Year (time)	0.0272	0.0433	-0.0909	-0.0026
p-value	0.5850	0.5240	0.2160	0.7510

Note: * signifies Significant at 1% level; ** signifies Significant at 5% level; *** signifies Significant at 10%

Source: Author's own computation from stata

According to the literature, the coefficient of the time variable must be strictly negative to indicate that the variance is declining over time. From the regression results above, GDP exhibits divergence although not significant. We take cognizance of the sign of the time coefficient in the regression even though all the tests are insignificant; this was also evident in Fig. 4 where the lines indicated no clear trend of either convergence or divergence. On the other hand, Savings and Reserves are negative but they are also not statistically significant, these are evident in Fig. 4, where they were declining at the initial stages but assume a constant trend thereafter. Generally, the control factors in the model (macro-economic variables) and the per capita GDP have all not shown any tendencies to converge over time.

4.2.2 Speed of convergence (beta convergence)

The speed of convergence is estimated following the discussion from Equations 11 in section three. Given that we are using panel data, β convergence is estimated using fixed-effects methods where the control variables (inflation, savings, and reserves) help to capture the influence of business cycles and other factors on the rate of economic growth. The regression result is presented as follows:

Given the macro variables for the period, four regression models are estimated where model 1 has all the control variables, and thereafter model 2 -4 is estimated by eliminating the list significant variables (10%*, 5%** and 1%*** where the list is 10%) in the previous analysis. Therefore, the last model does not include any control variable to test for absolute convergence using panel data. Since all the coefficients of $\log y_{it-1}$ were positive, following equation 9, for β convergence to be evident, the values of this coefficient have to be negative. Therefore, there is no evidence of β convergence for the macro-economic variables.

The panel data indicate that countries in EACs exhibit conditional divergence as shown in Table 4. That is, the annual GDP growth rate has a positive relationship with the GDP per capita of the year before it when the macro variables are controlled. The conditional divergence can be seen from model 1 where all the control variables

are included (inflation, savings, and reserves). The same was observed with the other models including model 4 where testing for the absolute convergence is done, only that the F statistics for models 3 and 4 renders the analysis not to be significant and therefore cannot be used for inference.

4.3 Stochastic Convergence

In this section, unit root and co-integration tests were conducted to establish the status and behavior of time series variables at the current state and in the long run.

4.3.1 Unit-root test for the series

In this section we assume that the EACs macro-economic variables are individually volatile (they are not stable), that is, they have a unit root. However, we are keen to establish whether they exhibit a stable relationship in the long run (co-integration). Therefore, the first stage is to establish whether they are stable before analyzing the long-run relationship. The test statistics here are to check whether all the panels contain a unit root or whether they are stationary. This test is done to all the macro-variables in this analysis and the results are presented in Table 5 below.

To achieve robustness, several tests are conducted. From Table 5 below; we can see that almost all the tests are significant indicating that most of the macro-economic variables in our analysis are stationary. However, the test by the Breitung unit demonstrates that the only GDP is stationary and the rest of the macro-economic variables are not stationary. Looking at reserves, the results of most of the tests show that the variable is stationary and confirms the presence of a unit root for this macro variable.

From the unit root test; we can only run co-integration tests for inflation, savings, and reserves, given that one test failed (Breitung unit) in showing that it is not stationary. The stationarity of the macro variables is also evident; where the lines were not trending but rather exhibited stationarity. This test will not apply to the GDP because it is stationary in the entire test. Time series data are said to be non-stationary when the mean and variance vary over time.

Table 3. Beta convergence regressions results

	Model 1	Model 2	Model 3	Model 4
Constant	-1.5145***	-1.4511***	-1.8436***	-1.9200***
Log y_{it-1}	1.0315***	1.0088***	0.9068***	0.8966***
Inflation	-0.0170	-0.0149	-0.0124	
Savings	0.0137	-0.1460**		
Reserves	-0.1478**			
F-statistics	2.0400*	2.6400**	1.9400	1.8100
R-square	within	0.5062	0.5025	0.4486
	between	0.3062	0.3863	0.3925
	overall	0.3434	0.3861	0.3822
B coefficient	-23%	-23%	-22%	-22%

Note: * signifies Significant at 1% level; ** signifies Significant at 5% level; *** signifies Significant at 10%

Source: Author's own computation from stata

Table 4. Unit root test for EACs macro-economic variables

Unit-root test	Statistic	GDP	Inflation rate	Savings	Reserves
Levin-Lin-Chu	Unadjusted t	-14.8505***	-7.9588***	-5.1087**	-7.0827***
	Adjusted t*	-12.9768***	-4.8355***	-1.7489**	-6.2854***
Harris-Tzavalis	rho	0.1896***	0.0040***	-6.27220***	0.5446**
Breitung unit	lambda	-1.6488**	-0.9583	-1.18770	-0.8415
Im-Pesaran-Shin	t-bar	-3.5472***	-3.5559***	-2.7052**	-1.9657
	t-tilde-bar	-2.2564***	-2.1724***	-1.8024**	-1.5939
	Z-t-tilde-bar	-2.9719***	-2.7139***	-1.5772**	-0.9367
Fisher-type	Inverse chi-squared(10) p	55.8437***	62.9649***	42.109***	16.2644*
	Inverse normal Z	-5.4130***	-5.3104***	-3.0459***	-1.2123
	Inverse logit t(29) L*	-6.8716***	-7.6646***	-4.6086***	-1.1817
	Modified inv. chi-squared Pm	10.2510***	11.8433***	7.1798***	1.4008*
Hadri LM	Z	2.7992***	2.6767***	2.8326***	6.5952***

Note: * signifies Significant at 1% level; ** signifies Significant at 5% level; *** signifies Significant at 10%

Source: Author's own computation from stata

Table 5. Co-integration test for macroeconomic variables

Co-integration test	Statistics	coefficient	P-value	Significance
Kao test	Modified Dickey-Fuller t	1.1150	0.1324	
	Dickey-Fuller t	-0.4146	0.3392	
	Augmented Dickey-Fuller t	0.3229	0.3734	
	Unadjusted modified Dickey-Fuller t	-4.6938	0.0000	***
	Unadjusted Dickey-Fuller t	-4.9844	0.0000	***
Pedroni test	Modified Phillips-Perron t	1.8759	0.0303	**
	Phillips-Perron t	-2.0276	0.0213	**
	Augmented Dickey-Fuller t	-5.1388	0.0000	***
Westerlund test	Variance ratio	-0.8339	0.2022	

Note: * signifies Significant at 1% level; ** signifies Significant at 5% level; *** signifies Significant at 10%

4.3.2 Co-integration tests

Co-integration tests assume that a combination of time series may not be stationary in the short run but may have a long-run equilibrium relationship. If variables are co-integrated we conclude that they are converging in the long run. The null hypothesis in this analysis is to check whether there is no co-integration and the alternative hypothesis is that all the panels are co-integrated. Several tests are conducted to ensure the robustness of the outcome. From the analysis, we can deduce that most tests are significant indicating that, the macroeconomic variables are co-integrated in the long run.

Since more tests are significant, there is sufficient evidence that these macroeconomic variables are converging over time. This is a pointer to the fact that the EACs' macro-economic variables are converging as time goes by.

5. CONCLUSION

There is no convergence amongst the EACs going by the findings of the study. The macro-economic variables of interest for the five EACs are not converging as time goes by. They rather demonstrate stationarity and in some instances erratic patterns. This is a pointer to the effect that the objective of the East African Community (EAC) of forming an economic union, which would later, translate to a monetary union is not being realized as intended.

The β convergence test shows that relatively poor countries in the EA region are not catching up with relatively developed nations in terms of economic development, the speed with which they are catching up with their peers is negative meaning their differences are increasing rather than decreasing. Therefore, poor countries are becoming poorer and those that are developing are increasingly being developed. This is a further pointer to the fact that the realization of an economic union and monetary union could be a pipe dream.

To further support the conclusion, the stochastic convergence tests confirm that the macro-economic variables are indeed stationary and they do not have a common trend in the future. This shows that the EACs are individually pursuing their development agendas and they are not pulling up their macro-economic policies that would lead to the realization of an economic union and subsequently a monetary union.

The findings above have important policy implications for the countries in the EA region. First, there is a need for coordination of the policies that govern the EA community to the extent that they are geared towards a uniform growth trajectory for all the members' states. The policies that affect trade and macro-economic factors should be coherent to the extent that economic actors operate in a certain environment as they conduct their business. The objective of having a stable macro-economic environment should be given more focus if these countries purpose to realize convergence.

To achieve convergence, the EACs may come up with robust monitoring and enforcement mechanisms that would deter member countries from deviating from the agreed guidelines. These guidelines could be a blueprint from which member countries must integrate their macroeconomics policies into their national planning and decision-making frameworks. The idea of macro-economic convergence is not only to establish free trade area but also to make it sustainable to achieve a deep integration. Due to different economic perspectives and governance structures amongst the EACs, the argument of convergence may not be desirable to all countries, therefore when policies are formulated they should take into account the conditional characteristics of the member countries. This is important because convergence objectives may not be a necessary and sufficient condition for economic prosperity for all nations.

For poorer countries to catch up with the relatively developed countries, the EA community should help the less developed members to realize; higher savings and investments, develop a highly skilled human resource capital, reduce the level of unemployment, improve the adequacy and standard of infrastructure, improve their production and manufacturing capacity, and finally, they should campaign for donor support from development agencies to realize convergence overtime for all member countries. This is in addition to the need for macro-economic convergence of the member countries.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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