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Economic Growth in the Cemac Countries: Fractional Integration, Mean Reversion and Gdp Convergence

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***Abstract**: This paper deals with the analysis of the GDP growth in the CEMAC countries, which are Chad, the Central African Republic, Congo, Gabon and Cameroon and Equatorial Guinea. We use time series techniques based on the concept of fractional integration and cointegration. The univariate analysis based on fractional integration aims to determine whether the series are I(1) or alternatively I(d) with d<1, which would imply mean reversion. We examine the nature of the shocks in the real GDP series in these countries along with the hypothesis of convergence in relation with the US. Starting with the univariate results, the results indicate strong evidence of persistence, with the orders of integration being around the I(1) case. Testing the hypothesis of convergence, by means of looking at the order of integration of the difference between the log real GDP (and real GDP per capita) or each country minus the one corresponding to the US, we obtain further evidence to support the unit roots, rejecting thus any possibility of long run relationships between these African countries and the US.*

***Keywords:** real GDP; real GDP per capita; long memory; persistence; fractional integration; long-range dependence; fractional cointegration.*

I. Introduction

The African continent is not homogeneous. The fifty-four countries do not have the same history regarding colonization and furthermore their natural, economic, social and political environments are very different. These countries are grouped into eight regional communities (not necessarily disjointed from each other) and there are three monetary unions: The Economic and Monetary Community of Central Africa (EMCCA or CEMAC in French), the West African Economic and Monetary Union (WAEMU), and the South African Common Monetary Area (CMA).

When it comes to EMCCA, some of the countries have set certain goals, with the ultimate objective of evolving into emerging economies. In this regard, five of the six CEMAC countries have already quantified their stated targets. Among these countries, Cameroon has formally expressed its ambitions and declared its intention to be emerging by 2035, Chad by 2030, Congo and Gabon by 2025, and Equatorial Guinea by 2020. Only the Central African Republic, faced with political instability and struggling to cope with the negative effects of the recent civil war, has not yet officially expressed an objective to become an emerging economy in the near future.

As expected, the member countries of the CEMAC want to follow a path that leads to becoming an emerging economy. To achieve this, they must achieve an acceptable level of economic growth, sustainable over time because only a sustainable rate of economic growth can lead them to the stage of becoming emerging economies in relation to the timeframe they have assigned. However, in order to achieve these levels of economic growth accompanied by appropriate social indicators and the well-being of their citizens, they require precise knowledge of their real GDP and real GDP per capita in order to implement relevant economic and social policies. This will enable their economies to emerge securely. Indeed, the CEMAC, which has abundant natural resources, seeks to transform these assets into wealth that will benefit its citizens. The identification of the GDP and GDP per capita as key variables is therefore crucial for choosing the type of economic and social policies to be applied in order to reach the stage of an emergent economy.

That is why this study examines the convergence hypothesis in a group of six countries that belong to the Economic and Monetary Community of Central Africa (CEMAC), these being Chad, Central African Republic, Congo, Gabon, Cameroon and Equatorial Guinea, using their real GDP and real GDP per capita data. We conduct a long memory and fractional integration modelling framework. Additionally, we also conduct a cointegration analysis of the real GDP and real GDP per capita of each of the countries belonging to the communities. We examine the nature of the shocks in the real GDP series in these countries along with the hypothesis of convergence in the long run.

There are several contributions in this work. Firstly, the use of long memory and fractional integration techniques, which have not been very much employed in the analysis of GDP data. Secondly, the focus on the CEMAC countries, which have not been so far investigated with these techniques, and finally the hypothesis of real convergence by using fractional integration and cointegration methods is another important contribution of this work.

The main motivation for this work is to analyze the economic advancement of several countries in the CEMAC which have shared the same monetary policy, almost comparable in term institutions and currency, yet which have performed and developed in different ways during the last decades, and we test the real convergence hypothesis in Cameroon, Chad, Congo, Gabon, Equatorial Guinea and Central African Republic, with respect to the Unites States.

II. Contextual setting

The EMCCA which stands for Economic and Monetary Community of Central Africa (more commonly referred to as CEMAC from its name in French, Communauté Économique et Monétaire de l'Afrique Centrale) is an organization of six Central African states. Currently CEMAC is composed of five former French colonies in Central Africa: Chad, the Central African Republic, Congo, Gabon and Cameroon and Equatorial Guinea, a former Spanish colony. Those countries are also members of the *Economic Community of Central African States* (ECCAS) that was created in 1983 and which comprises 11 member countries: Angola, Burundi, Cameroon, Congo, Gabon, Equatorial Guinea, Central Africa, the Democratic Republic of Congo, Rwanda, Sao Tome and Principe and Chad. In July 2004, members approved the creation of a free trade area (FTA) to be in place by January 1, 2008).

CEMAC was established to promote intra-community trade and industrial cooperation, the institution of a true common market, and a strong solidarity between the people of this community. In general terms, it was set up to promote the comprehensive process of sub-regional integration through the forming of a monetary union, with the Central African CFA franc as a common currency as part of the policy of 'Coopération financière en Afrique centrale' (Financial Cooperation in Central Africa).

The treaty that detailed the legal and institutional arrangements of CEMAC set up the bodies of the Central African Economic Union (Union Economique de l'Afrique Central – UEAC) with an Executive Secretariat based in Bangui, the Central African Republic and the Monetary Union of Central Africa (Union Monétaire de l'Afrique Centrale), which set out the responsibilities of the Central Bank, The Bank of Central African States (Banque des Etatsd'Afrique Centrale-BEAC) and the Central African Banking Commission (Commission Bancaire de l'Afrique Centrale-COBAC). BEAC is a single central bank for the region and there is a single currency (CFA franc) and defined criteria for macroeconomic convergence. BEAC regulates the sector through its regional Banking Commission, COBAC, which shares liability with the national Ministries of Finance of all of the six countries for licensing new banks and regulating microfinance institutions. There is also a budgetary agreement between the French Treasury (Ministry of Finance) and BEAC with fixed convertibility of the CFA franc and control with veto powers held by the French Treasury.

The countries of Central Africa very soon realized the value of economic cooperation and regional integration as factors that could contribute to accelerating their growth and development. Indeed, before independence, the Central African Republic, the Congo, Gabon and Chad constituted an integrated economic entity under the name of French Equatorial Africa (AEF from its name in French, Afrique Equatoriale Francaise). On June 29, 1959, these countries created the Equatorial Customs Union (UDE from its name in French, Union Douanière Equatoriale). Having become autonomous and then independent in 1960, they opted for the consolidation of the ties woven under the colonial regime and for the strengthening of their customs union. (Source: UDEAC-CEMAC - Février 1999).

In 1962, Cameroon joined the UDE, and on December 8, 1964 the Chairmen of the five countries signed the treaty establishing Customs and Economic Union of Central Africa (UDEAC from its name in French, Union Douanière et Economique de l'Afrique Centrale) in Brazzaville (Republic of Congo) confirming thus a process of regrouping begun during the colonial period. This treaty came into force on January 1st, 1966. The republic of Equatorial Guinea accedes to UDEAC in January 1985. The union operated continuously until February 1998. The Economic and Monetary Community of Central Africa (or CEMAC from its name is French, Communauté Économique et Monétaire de l'Afrique Centrale) created in March 16, 1994 by a treaty at N'Djamena, Chad took over from UDEAC to deepen and reinvigorate the process initiated between the six States and those who would become members of the Community. (Source : UDEAC-CEMAC - Février 1999)

The region has an economic space of 3 million km^2 and represents a market of about 44.1 million people, an average population growth rate of 2.8 percent, a real GDP growth rate (real GDP) of 4.6% and a growth rate GDP per capita of 1.8%. Cameroon is the largest economy in the region with about half of the region's financial assets (which generate 28.6% of regional GDP). Crude oil and agriculture have been the mainstay of most of the economies in the region. The mining industry is expanding with new exploration and mining activities in Cameroon. The region is blessed with minerals such as diamond, gold, gas, manganese, uranium, aluminum-crude and derivatives, oil products and bauxite. The countries in the region are about 50 percent urbanized. Gabon has the highest level of urbanization at 86 percent, with a third of the country's population living in the capital Libreville. The main objectives of the CEMAC are to promote a harmonious development of member states within the framework of the establishment of a true common market, to achieve convergence of macro-economic policies and indicators and to create greater economic competitiveness through open markets.

This study examines the time series behavior of two variables (real GDP and real GDP per capita) in the six countries that belong to the CEMAC, being this the only available data that we could work with. We use fractional integration techniques because they are useful to test the convergence hypothesis in each of CEMAC countries since they are more general than the standard methods that use integer degrees of differentiation. Additional, (fractionally) cointegration techniques are also employed.

The outline of the study is as follows: Section 3 briefly describes the literature review, focusing on the convergence process and fractional integration techniques on macro data in Africa. Section 4 is devoted to the methodology; Section 5 presents the data; Section 6 analyzes the data and the main empirical results, while Section 7 deals with the conclusions and discussion and implications for policy.

III. Literature Review

The study of the convergence process of African countries has generated relatively few empirical studies. Savvides (1995), analyzing the determinants of growth in Africa, was one of the precursors. In particular, its fixed-effects panel estimates from 28 countries African countries over the period 1960-1987 corroborated the conditional convergence hypothesis. However, this transversal approach was subject to numerous criticisms. For instance, Quah (1993) showed that the transversal approach tends to accept the hypothesis of convergence even when the distribution of income between countries does not change all the time. Thus, Bernard and Durlauf (1996) explained that the transversal approach tends to favor the rejection of the hypothesis of no convergence when countries are characterized by different stationary conditions. McCoskey (2002) used a larger sample of 42 Sub-Saharan countries on which he conducted unit root tests and cointegration in a panel over the period 1960-1989. These results show a lack of convergence between sub-Saharan African countries, not only across similar countries but also across those belonging to the same regional community such as the CDAU. The results in Joubert et al (2013) also lead to the lack of convergence between 46 countries in sub-Saharan Africa over the period 1985-2005 using the methodology proposed in Evans and Karras (1996) from the generalized method of moments. On the other hand, they found convergence clubs set up by ECOWAS, UEMOA, CEMAC and CDAU. With the evolution of unit root tests towards taking into account trend breaks, and based on the criticisms of Perron (1989), Cuñado and Perez de Gracia (2006) worked on the convergence of the per capita incomes of 43 African countries related to the average of the per capita income of these countries, and also with respect to that in the United States over the period 1950-1999. Their results suggested that most African countries experienced events that introduced trend breaks in their relative per capita income and these essentially took place between the end of the 1970s and the early 1980s. Then, taking into account the breakdown in the trend they showed in their analysis a process of catching up with per capita income in the United States for Cape Verde, Egypt, Mauritius, Seychelles and Tunisia. The results of most of the studies on the convergence of African countries are mitigated. Also, there is no unanimity on the convergence clubs. While McCoskey (2002) does not highlight any convergence club, Joubert et al (2013) argue that convergence clubs exist for ECOWAS, UEMOA, CEMAC and the CDAU.

When it comes to long memory fractional integration, several papers have been conducted on macroeconomic issues in African countries. For instance, focusing on the exchange rates, some results show that except for South Africa none on the SADC (Southern African Development Community) real exchange rates are fractionally integrated (Mokoena et al., 2009). Fractional integration has also been used to analyse the stock market structure (Anouro and Gil-Alana, 2010), inflation (Gil-Alana and Barros, 2013) and global financial crisis (Gil-Alana et al., 2015). Nevertheless, investigating GDP on CEMAC there are no papers focusing on this approach.

On the other hand, cointegration techniques have been examined in various papers. For instance, Chowdbury and Mallik (2011) proved that there exists evidence of a long-run positive relationship between GDP growth rate and inflation for four South Asian countries (Bangladesh, India, Pakistan and Sri Lanka), obtaining significant feedback between inflation and economic growth. In another context, to determine which European Union countries would form a successful Economic and Monetary Union (EMU), based on long-run behavior of the nominal convergence criteria laid down in the Maastricht treaty, cointegration techniques were also used. The results in Haug et al. (1999) suggested that not all of the twelve original countries of the European Union could possibly form a successful EMU over time, unless several countries made significant adjustments. Focusing on Africa, Agboulaje and Olaleye (2013) propose an error correction model of GDP and inflation based on a long-run equilibrium relationship for the Nigerian economy. They conclude that nominal GDP is positively correlated with both GDP per capita and inflation rates. All these paper, however, focus on standard cointegration, in the sense that consider the individual series to be I(1) and the cointegrating errors I(0), not allowing for fractional degrees of differentiation.

IV. Methodology

As earlier mentioned we use techniques based on fractional integration and cointegration. A handy review of these methods and their applications in economics and finance can be found in Gil-Alana and Hualde (2009).

Given a zero-mean covariance stationary process $\{x_t$, t = 0, ±1, …} with autocovariance function $E[(x_t - Ex_t)(x_{t-j} - Ex_t)] = \gamma_j$, in the time domain, long memory is defined such that:

$$\lim_{T\to\infty} \sum_{j=-T}^{T} |\gamma_j| = \infty . \qquad (1)$$

Now, assuming that x_t has an absolutely continuous spectral distribution function, with a spectral density function given by:

$$f(\lambda) = \frac{1}{2\pi}\sum_{j=-\infty}^{\infty} \gamma_j \cos\lambda_j , \quad -\pi < \varepsilon \le \pi , \qquad (2)$$

according to the frequency domain definition of long memory the spectral density function is unbounded at some frequency λ in the interval $[0, \pi]$, i.e.,

$$f(\lambda) \to \infty , \; as \; \lambda \to \lambda^*, \qquad \lambda^* \in [0,\pi], \qquad (3)$$

(see McLeod and Hipel, 1978). Most of the empirical literature has focused on the case when the singularity or pole in the spectrum occurs at the zero frequency ($\lambda = 0$), i.e.,

$$f(\lambda) \to \infty, \quad as \quad \lambda \to 0^+ . \qquad (4)$$

A very convenient model satisfying the above long memory property is the one based on the concept of fractional integration. We say that a process $\{x_t$, t = 0, ±1, …} is integrated of order d, and denoted as I(d) if it can be represented as:

$$(1 - B)^d x_t = u_t , \quad t = 0, \pm 1, ..., \qquad (5)$$

where B is the backshift operator ($Bx_t = x_{t-1}$), d can be any integer or fractional value and u_t is supposed to be I(0) defined for our purposes as a covariance stationary process where the infinite sum of the autocovariances is finite. Examples of I(0) processes are the white noise case and stationary AutoRegressive Moving Average (ARMA) processes.[1] Thus, this is a quite general specification since it includes the classical ARMA and ARIMA models as particular cases of interest if d = 0 and 1 respectively. The polynomial $(1 - B)^d$ in equation (5) can be expressed in terms of its Binomial expansion, such that, for all real d,

$$(1 - B)^d = \sum_{j=0}^{\infty} \binom{d}{j} (-1)^j B^j = 1 - dB + \frac{d(d-1)}{2} B^2 - \cdots,$$

and thus,

$$(1 - B)^d x_t = x_t - dx_{t-1} + \frac{d(d-1)}{2} x_{t-2} - \cdots,$$

implying that equation (5) can be expressed as

$$x_t = dx_{t-1} - \frac{d(d-1)}{2} x_{t-2} + \cdots + u_t .$$

The above process can also admit an infinite moving average (MA) representation such that $x_t = \sum_{k=0}^{\infty} a_k u_k$, where $a_k = \frac{\Gamma(k+d)}{\Gamma(k+1)\Gamma(d)}$ and $\Gamma(x)$ represent the Gamma function. Moreover, the differencing parameter d is quite relevant from different perspectives. Thus, if d = 0, x_t is short memory or I(0), while d > 0 implies long memory behavior, so-named because of the strong degree of association between the observations. From a statistical viewpoint, 0.5 is another relevant value: if d < 0.5, x_t is covariance stationary, while d ≥ 0.5 implies nonstationarity (in the sense that the variance of the partial sums increases in magnitude with d); finally, from an economic viewpoint d = 1 is also relevant: d < 1 indicates mean reversion, with shocks disappearing in the long run, while d ≥1 shows lack of mean reversion with shocks persisting forever. In view of all the above, the parameter d is crucial to determine the degree of persistence in the data, and higher the value of d is, the higher the degree of persistence is, or alternatively, the lower the value of d is, the faster is the convergence process of a series to its original level after a shock.

In the empirical section we test alternative values for d in the set-up given by:

$$y_t = \beta_0 + \beta_1 t + x_t , \qquad (6)$$

and (5), where y_t is the observed time series, and β_0 and β_1 are coefficients corresponding to an intercept and a time trend respectively. We use Whittle estimates of d in the frequency domain (Dahlhaus, 1989) along with a testing procedure proposed by Robinson (1994) that tests the null hypothesis:

[1]If u_t in (5) is ARMA, x_t is said to be Fractionally Integrated ARMA (FIARMA or ARFIMA) process.

$$H_o : d = d_o, \quad (7)$$

in the model given by (5) and (6) for any real value d_o. This method has several advantages compared with other approaches, the most important one is that it is valid for any real value d_o, thus including values in the stationary region ($d_o < 0.5$) but also in the nonstationary one ($d_o \geq 0.5$); also, its limit distribution is standard normal, and this limit behavior holds independently of the inclusion or not of deterministic terms such as those given in (6). Finally, this method is the most efficient one in the Pitman sense against local departures from the null.[2]

V. Data

The data sources used in this framework are mainly obtained from the World Development Indicators (WDI 2017). The panel constituted may be considered an annually cylinder Panel data covering the period from 1960 to 2015, for virtually all countries of the world. From these data sources, we have built times series comprising six countries, namely all CEMAC member states. The variables were further disintegrated into obtaining the real GDP (constant LCU) and real GDP per capita (constant LCU) for six CEMAC countries. CEMAC countries include: Cameroon, Chad, Central African Republic, Congo and Gabon and Equatorial Guinea. This study uses the log of real GDP and log of real GDP per capita because the log function is concave and non-decreasing. It further transforms observational values to linearity. In addition, due to the fact that we want to study the convergence of CEMAC countries with respect to the United States, this country respective real GDP and real GDP per capita variables were also extracted. Similar to that of the six CEMAC countries, the logs of these latter country (USA) were obtained. The choice of this period is justified by the availability of data and the relative stability of the latter. Some people might argue that the sample size is too small to conduct a long memory analysis; nevertheless, several Monte Carlo experiments conducted in Robinson (1994) showed that his method performs well in finite samples, and various empirical applications based on this approach were conducted with even fewer observations.[3]

[Insert Figures 1 - 2 about here]

Figure 1 displays the time series plots for the six African countries, while Figure 2 refers to the real GDP and real GDP per capita in the US. Starting with Figure 1 we can distinguish two different patterns across the countries. On the one hand we have one country displaying a relatively constant increase across the sample: Gabon. On the other hand, the remaining countries (Cameroon, Chad, Congo, Equatorial Guinea and Central African Republic) are characterized by an oscillating pattern with a substantial decrease during a certain period, and a posterior increase during the final years in the sample. In Figure 2 we observe that the real GDP and real GDP per capita in the US are both increasing over time.

[Insert Table 1 about here]

Table 1 presents some descriptive statistics. On average, the production of goods and services during the period from 1960 to 2015 is the highest in Cameroon (29.17827) over the rest of the CEMAC countries: Gabon (28.54989), Republic of Congo (27.09226), Republic of Chad (28.02501), Central African Republic (27.04327) and Equatorial Guinea (27.2419). It should be noted that during this period (1960-2015), Central African Republic is the country with the lowest production of goods and services, unlike Cameroon, which, on the other hand, has a strong production output. Moreover, the real GDP of United States exceed that of Cameroon at 0.53871 despite the position of Cameroon in the sub-region. On the other hand, the average real per capita income in Gabon is highest not only among the CEMAC countries but also higher than that of United States. These statistics confirm that a country can have strong growth with wide inequalities at the population level.

VI. Data Analysis

We start this section by estimating d in the model given by the equations (5) and (6). Tables 2 and 3 displays respectively for real GDP and real GDP per capita, the estimates of d along with the 95% confidence bands for the non-rejection values of d using Robinson's (1994) approach. We present the results for the three cases of no deterministic terms (i.e., $\beta_0 = \beta_1 = 0$ in (5)), an intercept ($\beta_0 = 0$ and β_1 estimated) and an intercept with a linear time trend (both β_0 and β_1 estimated). In the lower part of the tables we display the estimated coefficients once we have selected the appropriate model for the deterministic terms.

Starting with the GDP data (in Table 2) we observe that the time trend is only required in the case of Equatorial Guinea, while an intercept is sufficient for the description of the deterministic terms in the rest of the

[2] For more details, see Robinson (1994) or, more specifically, Gil-Alana and Robinson (1997) which focusses on the model given by (5) and (6).

[3] When using the critical values computed in Gil-Alana (2000) for finite samples, the results were almost identical to those reported here based on the asymptotic values.

cases, including the US. Focusing on the estimated values of d, we observe that the lowest value corresponds to Equatorial Guinea (0.34) while the highest one in the CEMAC refers to Central African Republic (1.26). However, the confidence intervals are so wide that the unit root null hypothesis (i.e., d = 1) cannot be rejected in any single case. For the US, the estimate of d is even higher, 1.62, and the unit root null is now rejected in favour of d > 1.

[Insert Tables 2 – 3 about here]

Table 3 focuses on the real GDP per capita series. Here, the time trend is required in a number of cases, in particular, for Central African Republic, Cameroon and Congo Republic, while only an intercept is required in the rest of the cases. For the CEMAC, the estimated values of d are slightly above 1 in all cases, ranging from 1.08 (Chad) to 1.27 (Equatorial Guinea), and the unit root null hypothesis, i.e., d = 1, cannot be rejected in the cases of Central African Republic, Chad, Gabon and Congo Republic, while this hypothesis is rejected in favour of higher degrees of integration in the cases of Cameroon and Equatorial Guinea. As with the real GDP data, the estimate of d for the US is very high, 1.61, and the unit root null is once more rejected in favour of higher degrees of differentiation.

Two conclusions can be drawn from the above results. Firstly, there is no evidence of mean reversion (i.e., d < 1) in any single case, so we strongly reject the hypothesis of transitory shocks in the series; secondly, the order of integration for the US case is much higher than that for the CEMAC countries, invalidating any analysis of cointegration in a vis-à-vis relationship of the series with respect to the US.[4] Thus, in what follows, we test the hypothesis of real convergence by investigating the order of integration in the differenced series log GDP_{cemac} – log GDP_{usa} to see if mean reversion holds (d < 1) and the hypothesis of real convergence is satisfied. In other words, we test now for cointegration but imposing the vector (0, -1) as the contegrating vector. Moreover, in doing so, we work with the observed data rather than with the estimated values.

Table 4 displays the results of convergence for both the real GDP and the real GDP per capita series. We see that the time trend is only found to be statistically significant in the case of the differences with respect to Equatorial Guinea in the case of the GDP data. In this case, the estimated value of d is equal to 0.38, which may suggest some degree of convergence. However, if we look at the confidence interval, we observe that it is extremely wide. In fact, the two standard hypotheses of I(0) and I(1) behaviour cannot be rejected here since the two values (0 and 1) are included in the interval. For the rest of the cases (with the real GDP data) the values are higher than 1, and the unit root null cannot be rejected for the differences of the US with respect to the Central African Republic, Chad, Gabon and Congo Republic, and this hypothesis is rejected in favour of an order of integration higher than 1 for Cameroon. Thus, no evidence of convergence is found in these data. If we focus now on the real GDP per capita data (Panel ii) in Table 4) the same results hold, and no evidence of convergence (d < 1) is found in any single case. Thus, according to these results we do not find evidence of real convergence between the CEMAC countries and the US, neither for real GDP nor for the real GDP per capita series. Within the CEMAC countries (which might share the same degree of integration) we also computed the FCVAR approach developed by Johansen and Nielsen (2010, 2012), and we do not find any evidence of fractional cointegration; using standard cointegration methods (Johansen, 1992, 1995, 1996) the results also reject the hypothesis of convergence. The results presented above indicate that within the CEMAC real GDP and real GDP per capita might be both I(1) though we do not find any evidence supporting any long run equilibrium relationship between the countries.

VII. Conclusions

In this article we have examined the statistical properties of the real GDP and real GDP per capita series in the CEMAC countries (Cameroon, Chad, Congo, Gabon, Equatorial Guinea and Central African Republic) as well as testing the convergence hypothesis of the GDP in these countries in relation to the US.

Starting with the series for the CEMAC countries, the results indicate strong evidence of persistence, with the orders of integration being around the I(1) case or with an order of integration slightly above 1. Thus, the first thing we observe is a lack of mean reverting behavior implying the permanency of the shocks. Thus, in the event of an exogenous shock affecting real GDP in these countries, if the shock is negative, strong policy measures should be adopted since the series will not return to their original level in the future. Similar evidence, or even stronger, is obtained with the US data, where the orders of integration are found to be significantly above 1 in the two series (real GDP and real GDP per capita). Testing the hypothesis of convergence, by means of looking at the order of integration of the difference between the log real GDP (and real GDP per capita) of each country minus the one corresponding to the US, we once more obtain evidence supporting the unit roots, rejecting thus any possibility of long run relationships between the African countries and the US. Using other

[4] Note that a necessary condition for cointegration in a bivariate case is that the parent series must display identical orders of integration.

approaches based on FCVAR or classical CVAR, the results reject the hypothesis of cointegration between the variables and the same evidence against cointegration is found when using only the CEMAC countries. Nevertheless, this might be a consequence of the wide confidence bands obtained due to the reduced number of observations used in the application, which is a clear limitation we face with Sub-Saharan African macro data.

The CEMAC countries do not converge with respect to the USA. This widely discussed economic literature may be otherwise known as the catch-up effect. The catch-up effect of the CEMAC countries towards the USA is said to be negative. The previously established notion that poorer countries such as the CEMAC countries will replicate production methods, technologies and institutions of developed countries over time is seen to be null. Our results show this from an empirical viewpoint. This work is limited by the small sample size of the annual time series data employed. In the future, one might consider applying artificially generated quarterly series to extend the dataset and exploit the information provided by the data more thoroughly. The analysis of the convergence with respect to other countries like China that has rapidly increased its ties with the continent in recent years will also be examined in future works.

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Figure 1: Time series plots for the CEMAC countries

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<tr><th>Real GDP (current US$)</th><th>Real GDP per capita (current US$)</th></tr>
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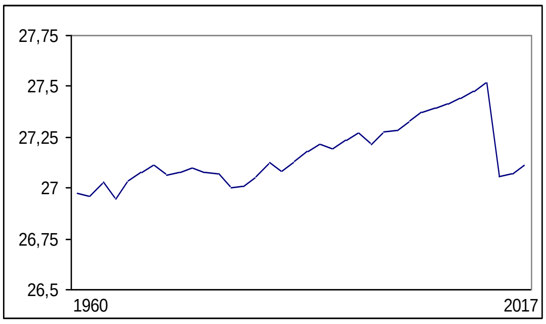

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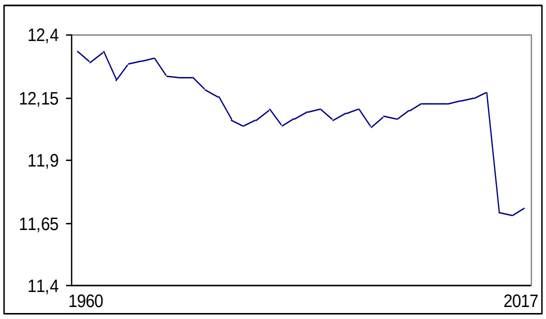

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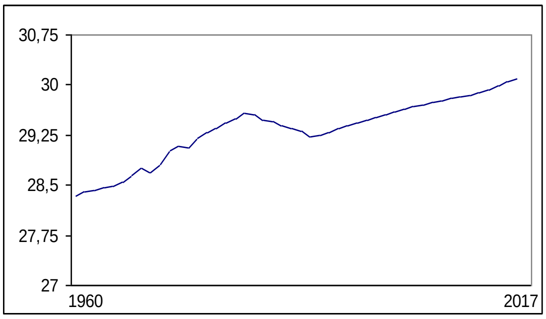

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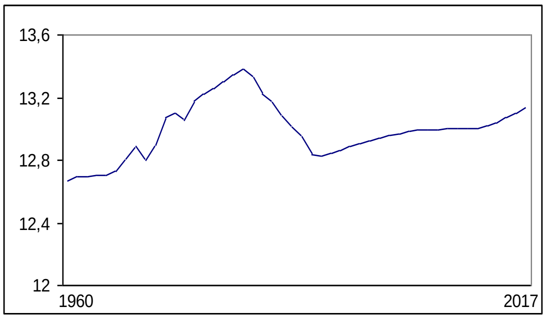

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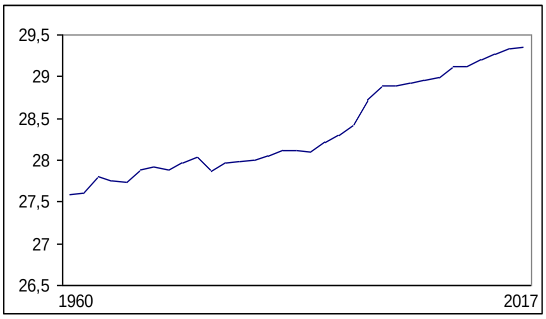

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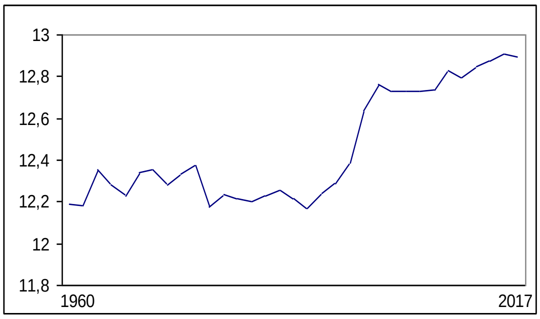

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<tr><td>Gabon</td><td>Gabon</td></tr>
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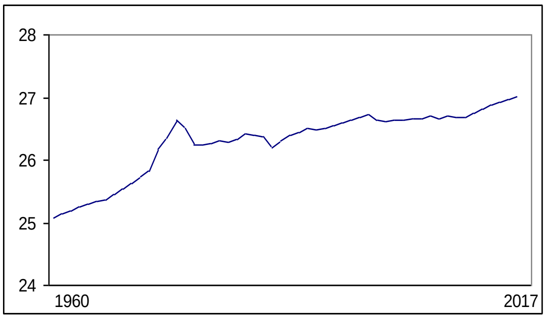
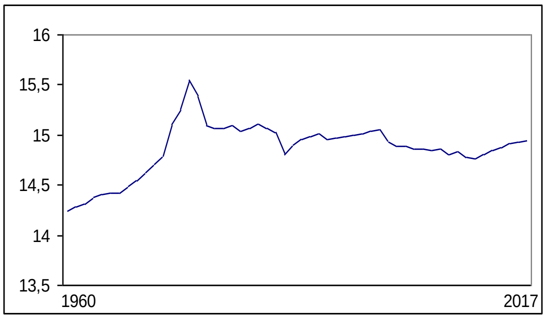
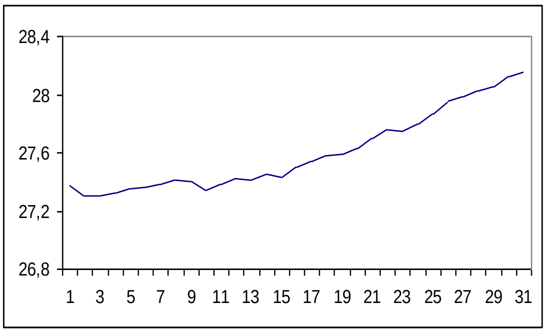
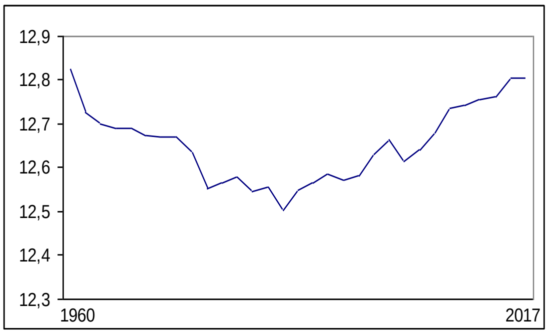


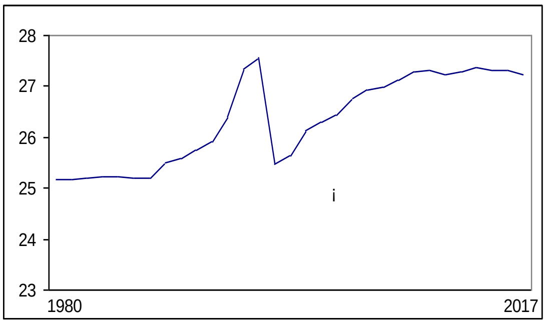


Congo Republic	Congo Republic





Equatorial Guinea	Equatorial Guinea



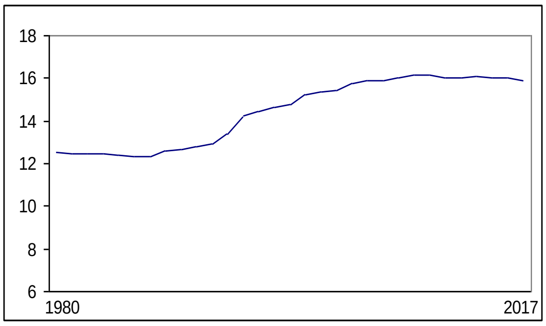
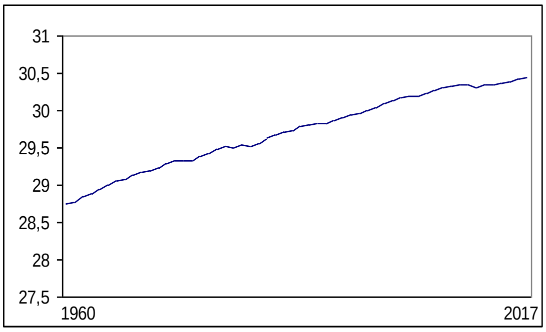


Figure 2: Time series plots for the US

Real GDP (current US$)	Real GDP per capita (current US$)



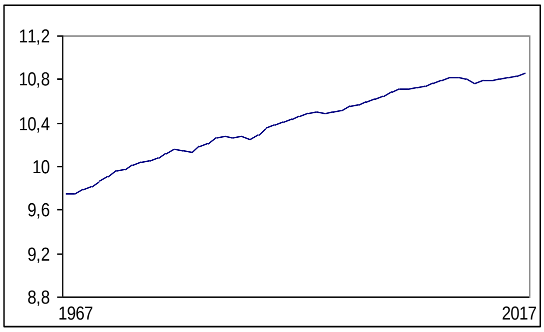


Table 1: Descriptive statistics for the log of real GDP

i) Log of real GDP					
Series	Mean	Std. Dev.	Minimum	Maximum	Normality(Prob>chi2)
CENTRAL AF. REP.	27.04327	.221257	26.65493	27.51378	0.7768
CAMEROON	29.17827	.5679108	28.22266	30.09877	0.0031
CHAD	28.02501	.6037707	27.37274	29.34851	0.0212
GABON	28.54989	.5775898	27.17004	29.30885	0.0223
EQU. GUINEA	27.2419	1.939635	24.92577	29.66278	0.0000
CONGO REPUBLIC	27.09226	.6784027	25.86315	28.15098	0.0106
U.S.A.	29.71698	.5034382	28.75532	30.44027	0.0075
i) Log of real GDP per capita					
Series	Mean	Std. Dev.	Minimum	Maximum	Normality(Prob>chi2)
CENTRAL AF. REP.	12.22065	.1926151	11.68182	12.47026	0.0216
CAMEROON	12.95297	.1910808	12.63262	13.38246	0.2921
CHAD	12.43174	.2318796	12.03917	12.90604	0.1346
GABON	14.8406	.2975274	14.0493	15.5429	0.0636
EQU. GUINEA	14.16992	1.589091	12.31469	16.1609	0.0000
CONGO REPUBLIC	12.49204	.2565367	12.03415	12.86597	0.0107
U.S.A.	10.39946	.3342764	9.743136	10.85201	0.0151

Table 2: Estimates of d and 95% confidence bands for (log) real GDP

	No regressors	An intercept	A linear time trend
CENTRAL AFRICAN R.	0.88 (0.66, 1.20)	**1.26 (0.89, 1.57)**	1.26 (0.98, 1.56)
CAMEROON	0.93 (0.75, 1.19)	**1.19 (1.04, 1.43)**	1.18 (1.03, 1.42)
CHAD	0.88 (0.64, 1.22)	**1.09 (0.84, 1.57)**	1.09 (0.82, 1.57)
GABON	0.94 (0.77, 1.18)	**1.15 (0.97, 1.41)**	1.15 (0.96, 1.40)
CONGO REPUBLIC	0.88 (0.63, 1.23)	**1.10 (0.82, 1.54)**	1.09 (0.85, 1.52)
EQUATORIAL GUINEA	0.87 (0.61, 1.22)	0.46 (0.17, 1.16)	**0.34 (0.18, 1.16)**
USA	0.94 (0.77, 1.18)	**1.63 (1.39, 2.02)**	1.62 (1.39, 2.01)
	d	Intercept	Time trend
CENTRAL AFRICAN R.	1.26 (0.89, 1.57)	23.383 (232.26)	---
CAMEROON	1.19 (1.04, 1.43)	26.327 (448.01)	---
CHAD	1.09 (0.84, 1.57)	23.944 (227.61)	---

GABON	1.15 (0.97, 1.41)	12.011 (118.81)	---
CONGO REPUBLIC	1.10 (0.82, 1.54)	23.894 (287.20)	---
EQUATORIAL GUINEA	0.34 (0.18, 1.16)	21.745 (80.03)	0.032 (2-23)
USA	1.62 (1.39, 2.01)	26.138 (1061.34)	---

The values in bold in the upper panel refers to the significant cases in relation with the deterministic terms. The values in parenthesis are the 95% confidence bands of the non-rejection values of d. In the lower panel, the values in parenthesis in the third and four columns are the corresponding t-values.

Table 3: Estimates of d and 95% confidence bands for (log) real GDP per capita

	No regressors	An intercept	A linear time trend
CENTRAL AFRICAN R.	0.85 (0.62, 1.17)	1.28 (0.91, 1.59)	**1.27 (0.99, 1.56)**
CAMEROON	0.94 (0.77, 1.20)	1.23 (1.07, 1.37)	**1.20 (1.05, 1.45)**
CHAD	0.88 (0.65, 1.20)	**1.08 (0.80, 1.55)**	1.08 (0.81, 1.55)
GABON	0.95 (0.79, 1.18)	**1.16 (0.99, 1.41)**	1.16 (0.98, 1.41)
CONGO REPUBLIC	0.88 (0.64, 1.22)	1.10 (0.80, 1.56)	**1.09 (0.84, 1.52)**
EQUATORIAL GUINEA	0.81 (0.42, 1.19)	**1.27 (1.03, 1.69)**	1.27 (1.02, 1.69)
USA	0.95 (0.79, 1.19)	**1.61 (1.38, 2.00)**	1.61 (1.38, 2.00)
	d	Intercept	Time trend
CENTRAL AFRICAN R.	1.27 (0.99, 1.56)	8.800 (85.37)	-0.074 (-1,81)
CAMEROON	1.20 (1.05, 1.45)	10.685 (170.98)	-0.044 (-2.54)
CHAD	1.08 (0.80, 1.55)	8.560 (81.74)	---
GABON	1.16 (0.99, 1.41)	12.011 (119.04)	---
CONGO REPUBLIC	1.09 (0.84, 1.52)	9.383 (110.75)	-0.043 (-2.16)
EQUATORIAL GUINEA	1.27 (1.03, 1.69)	8.849 (46.73)	**---**
USA	1.61 (1.38, 2.00)	7.134 (288.89)	**---**

The values in bold in the upper panel refers to the significant cases in relation with the deterministic terms. The values in parenthesis are the 95% confidence bands of the non-rejection values of d. In the lower panel, the values in parenthesis in the third and four columns are the corresponding t-values.

Table 4: Estimates of d and 95% confidence bands for the differenced series w.r.t. USA

i) REAL GDP			
	No regressors	An intercept	A linear time trend
C. AF. REP. – USA	1.03 (0.82, 1.33)	**1.23 (0.80, 1.55)**	1.23 (0.92, 1.55)
CAMEROON –USA	1.19 (1.01, 1.47)	**1.21 (1.03, 1.50)**	1.21 (1.03, 1.50)
CHAD – USA	1.00 (0.73, 1.42)	**1.14 (0.88, 1.61)**	1.14 (0.86, 1.62)

GABON – USA	0.93 (0.74, 1.20)	**1.07 (0.83, 1.53)**	1.07 (0.83, 1.53)
CONGO REP. - USA	0.91 (0.61, 1.34)	**1.14 (0.86, 1.60)**	1.14 (0.87, 1.58)
GUINEA EQ. - USA	0.82 (0.56, 1.26)	0.46 (0.18, 1.15)	**0.38 (-0.14, 1.14)**
ii) REAL GDP PER CAPITA			
C. AF. REP. – USA	0.75 (0.52, 1.09)	**1.25 (0.84, 1.57)**	1.24 (0.93, 1.56)
CAMEROON –USA	0.97 (0.81, 1.23)	**1.21 (1.04, 1.50)**	1.21 (1.03, 1.50)
CHAD – USA	0.84 (0.64, 1.12)	**1.11 (0.84, 1.60)**	1.11 (0.84, 1.60)
GABON – USA	0.95 (0.79, 1.18)	**1.09 (0.87, 1.43)**	1.09 (0.85, 1.43)
CONGO REP. - USA	0.87 (0.61, 1.19)	**1.13 (0.80, 1.60)**	1.13 (0.85, 1.58)
GUINEA EQ. - USA	0.62 (0.41, 1.14)	**1.23 (1.01, 1.65)**	1.24 (0.98, 1.66)

The values in bold in the panel refers to the significant cases in relation with the deterministic terms.
The values in parenthesis are the 95% confidence bands of the non-rejection values of d.