

Olowofeso, Olorunsola E. et al.

**Research Report**

## Comparative analysis of nominal and real convergence in West African Monetary Zone (WAMZ): Time varying parameter approach

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## Comparative Analysis of Nominal and Real Convergence in West African Monetary Zone (WAMZ): Time Varying Parameter Approach<sup>1</sup>

WAMI OCCASSIONAL PAPER SERIES 33

By

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## Abstract

This study estimates the rate and distance to convergence of WAMZ Member States and provides a comparative analysis of nominal and real convergence to evaluate WAMZ's preparedness for monetary integration. We employ monthly data on the consumer price index and nominal exchange rate from January 2003 to December 2022 to assess nominal convergence, while annual real GDP growth rate data from 1980 to 2022 is used to evaluate real convergence among member states. The findings of the study reveal some evidence of convergence in exchange rates, especially for Guinea and Liberia. For inflation, there is no evidence of convergence; however, some countries are catching up. Regarding real convergence, there is no evidence of convergence towards the criteria, with only Ghana seeming to converge towards the reference country, Nigeria. The results showed little support for convergence, as evidenced by the estimated higher distance to convergence on average by member states. The study highlights that recent external macroeconomic shocks have hindered convergence efforts, necessitating policies to enhance resilience. It emphasizes the importance of prioritizing nominal convergence to achieve long-term economic stability and integration in the region

**Key Words:** Convergence; Inflation; Exchange rate; Growth; Time-varying parameters  
**JEL Classification :** E31, O47, F31.

### 1.0 Introduction

To promote economic growth, stability, and regional integration, the Member states of the West African Monetary Zone (WAMZ) have been collaborating to create a monetary union. The establishment of a single currency is a crucial component of this effort, which is anticipated to enable cross-border trade and investment, improve economic efficiency, as well as increase the region's competitiveness in global context. Member states of the West African Monetary Zone (WAMZ) are required to meet a series of convergence criteria agreed by the Authority of the Heads of State in the region to aid economic integration. The criteria include an inflation rate of 5 percent or below, a budget deficit of at most 3 percent of GDP, Central Bank financing below 10 percent of the previous year's tax revenue, three (3) months' worth of import coverage, debt below 70 percent of GDP, and an exchange rate variance below 10 percent. Meeting these requirements is essential for harmonizing domestic policies and fostering the integration process. Despite some level of advancements since 2003, macroeconomic convergence has remained a daunting task. The monetary union's official commencement, however, has been continuously deferred due to the issues with macroeconomic convergence. Currently, the conditions for the single currency appear stern for the countries. This has made the implementation of the single currency difficult, especially with the advent of global

economic turmoil such as COVID-19, oil price shocks and the Russia-Ukraine war. In the same vein, achieving nominal and real convergence among the WAMZ member states is a necessary condition for the integration process. By evaluating pertinent literature on the subject, this study seeks to provide a comparative analysis of nominal and real convergence within the WAMZ and estimate the time to convergence. The ex-ante convergence criteria focus on nominal convergence whereas the theory of Optimal Currency Area criteria focuses largely on the convergence of real economic variables of the countries in forming a currency union.

Article 55 of the revised ECOWAS treaty (2010) specifies the adoption of a common policy in all fields of socio-economic activity, particularly agriculture, industry, transport, communications, energy, and scientific research. It underscores the total elimination of all obstacles to the free movement of people, goods, capital, and services and the right of entry, residence, and establishment. The treaty stipulates the harmonization of monetary, financial, and fiscal policies, the setting up of a West African monetary union, the establishment of a single regional Central Bank, and the creation of a single West African currency. Thus, the treaty aligns largely with real convergence in the region.

Nominal convergence is the synchronization of selected macroeconomic variables across the participating countries, including inflation, interest rates, exchange rates, and fiscal balances (Debrun, Masson, & Pattillo, 2005). Prior to the creation of a monetary union, member states of the Economic Community of West African States (ECOWAS) were expected to meet convergence criteria (ECOWAS, 2010) to simplify policy coordination and reduce the possibility of financial crises and imbalances within the Union. These criteria are intended to ensure that member states maintain comparable macroeconomic performance levels (Masson & Pattillo, 2004). On the contrary, real convergence entails the alignment of structural and institutional factors that influence economic performance, including income levels, labor market circumstances, technical improvements, productivity, and technological advancements (Barro & Sala-i-Martin, 1991). To ensure that the advantages of monetary integration are fairly spread among member nations and that the single currency does not widen already existing economic gaps, real convergence is necessary (Frankel & Rose, 1998). The execution of structural changes and the harmonization of policies in sectors like education, infrastructure, and labor market laws are necessary to achieve real convergence (Eichengreen, 1992; Glick & Rose, 2002).

In evaluating the WAMZ preparedness for monetary integration and the potential issues that may occur during the process, a comparative examination of nominal and real convergence is essential. This is to enable us to determine whether it is nominal or real convergence that aids integration process better. The advancement of the member nations in achieving the convergence criteria has been the subject of several studies (Adam, Agyapong, & Gyamfi,

2010; Orji, Uche, & Ilori, 2014). There is, however, little research on the degree of regional real convergence and its implications for the monetary union's success (Saka et al., 2015).

According to Debrun *et al.* (2005) and Masson and Pattillo (2004), the pursuit of nominal and real convergence in the WAMZ is influenced by several variables, including the heterogeneity in the region's economic structures, the peculiar difficulties that each country faces, and the varied effects of external shocks on the regional economies. The region also exhibits diversity in levels of economic development and resource endowments. Regardless of initial conditions, countries are expected to balance their own economic aims with those of the region's monetary integration in order to achieve convergence (Bénassy-Quéré and Coulibaly, 2014).

In order to create a strong monetary union, the WAMZ is faced with the goal of achieving nominal, real, and structural convergence among its member countries. The synchronization of macroeconomic indices such as inflation, interest rates, and currency rates is referred to as nominal convergence (Masson and Pattillo, 2004). For the economic environment to remain stable, this kind of convergence is necessary while real convergence seeks to reduce variations in income levels, economic structures, and growth rates (De Grauwe and Schnabl, 2005), the former is the more desirable goal. This kind of convergence is essential for encouraging economic integration and making sure that member nations are developing fairly. The alignment of institutional frameworks and policy contexts is another focus of structural convergence (Tsangarides *et al.*, 2006). This component of convergence is essential to build a community that fosters efficient operation of a monetary union.

This paper carries out a comparative analysis of real and nominal convergence in the WAMZ. By doing so, it addresses critical policy-related questions relevant to the WAMZ, such as, after several years of monitoring and anticipation, what has been the rate of convergence of key indicators? In other words, does policy synchronization aimed at reducing disparities in inflation and exchange rates, promotes convergence among WAMZ member countries?

The value addition of this study lies in its comprehensive examination of both nominal and real convergence in the WAMZ, where the inclusion of real GDP growth rate is used to examine real convergence, unlike Adam *et al.* (2010), that examined only nominal convergence in the WAMZ. Also, the study will estimate distance to convergence by incorporating diverse theoretical perspectives and assessing the current state of economic convergence in the WAMZ. The study contributes to the ongoing debate on the importance and interplay between nominal and real convergence in achieving a successful monetary union, Cobham & Robson (1997), (Badarau *et al.* (2013).

Following this introduction, the rest of the paper is structured as follows. Section 2 discusses the level of performance of WAMZ member states regarding the six macroeconomic convergence criteria. Section 3 reviews the literature on nominal and real convergence, while

Section 4 describes the methodology and data. Section 5 presents and discusses the results, and Section 6 concludes the paper and proffer recommendations.

## 2.0 Nominal Macroeconomic Convergence in the West African Monetary Zone

Nominal macroeconomic convergence requirements are necessary to be met before joining any form of union. Effective currency unions are built on the foundation of agreed macroeconomic convergence requirements. The WAMZ single currency programme is hinged on countries satisfying the four primary convergence criteria and the two secondary convergence criteria. The primary criteria consist of an average inflation rate less than 5 percent, a fiscal deficit of less than 3 percent of GDP, central bank financing of the fiscal deficit of less than 10 percent of the previous year's tax revenue, and gross external reserves of not less than 3 months of imports cover. The secondary criteria were public debt-to-GDP ratio had to be lower than 70 percent, and the nominal exchange rate variation not surpassing 10 percent (Table 1).

**Table 1: Nominal Convergence Criteria**

<b>Primary Criteria</b>	
Inflation Rate (ave)	$\leq 5\%$
Fiscal Deficit /GDP (%) excl. Grants	$\leq 3\%$
Central Bank Fin of fiscal def as % of previous year's tax rev	$\leq 10\%$
Gross External Reserves (Months of Imports)	$\geq 3$
<b>Secondary Criteria</b>	
Exchange Rate Variation	$\pm 10$
Public Debt to GDP Ratio	$\leq 70\%$

**Source:** Author computation.

Although significant progress had been made over the years, the performance of the Member States on both the primary and secondary convergence criteria had produced mixed results over the years but has worsened as of the end of December 2022 due to external shocks. This turn of events reflects the impact of Russia-Ukraine war, which led to a double deficit position in most of the Member States. In addition, the problem regarding the increase in the cost of living led to inflationary pressure, which hampered output growth in the year 2022. An analysis of the individual countries' performances regarding macroeconomic convergence for example, in 2022, revealed that Gambia, Guinea and Liberia satisfied three primary convergence criteria each, while Nigeria met two primary criteria. On the other hand, Ghana and Sierra Leone met one primary criterion each in 2022. Gambia, Guinea and Liberia met all the primary convergence criteria except for the inflation rate criterion of 5 percent. Nigeria met the Fiscal Deficit as a percentage of GDP and gross external reserves in months of import cover criteria, while Ghana met the Fiscal Deficit as a percentage of GDP criterion and Sierra Leone met gross external reserves in months of import cover criterion. The only primary convergence criterion that was not met was the inflation rate criterion of 5 percent. According to the preliminary evaluations of the key convergence criteria, it appears that none of the member



nations have been able to satisfy the condition for an inflation rate of less than 5 percent. The Member States continued to find the inflation rate criterion of 5 percent and the budget deficit to be the most difficult criteria to meet on average; nevertheless, gross external reserves (in months of import cover) were the most attained criterion met on average during the review periods. (see Table 4A-4D).

Regarding secondary convergence, Nigeria satisfied both secondary requirements, while The Gambia only met the criterion for exchange rate, and Guinea and Liberia met the condition for the ratio of public debt to GDP. Again, for instance, in 2022, Ghana was not successful in meeting any of the secondary criteria (Table 5A-5B). Overall, not one of the Member States was able to meet the key convergence criteria during the period between the beginning of 2022 and the end of the year, as they had done during the same time in 2021.

It appears to be a challenge for each member state to concurrently fulfil all the criteria for macroeconomic convergence, and it also seems to be a struggle for member countries to meet all these criteria individually. Since 2001, not a single country has satisfied all the requirements continuously. The Gambia fulfilled all the requirements seven times, that was only from 2006 to 2012; Nigeria was the second country that performed best. From 2006 to 2007, as well as from 2013 to 2015, Nigeria achieved the target five times but not continuously. It was from 2006 to 2007 and from 2013 to 2015. In addition, Liberia met the criteria once that was in 2010. Sierra Leone performed in the year 2013. (see Table 2). Given this trend, attaining the primary criteria on a sustained basis by member states continues to be a big challenge. This could partly be attributed to the differences in economic fundamentals of member states and their level of vulnerabilities to external shock.

**Table 2: Number of Primary Criteria met by Countries (2001-2022)**

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Gambia	2	1	1	3	3	4	4	4	4	4	4
Ghana	1	0	2	1	3	2	2	0	2	3	3
Guinea	3	2	0	0	2	1	2	1	1	0	3
Liberia	n.a	n.a	n.a	n.a	n.a	n.a	1	2	4	4	3
Nigeria	3	3	2	3	3	4	4	3	3	2	3
Sierra Leone	2	2	0	2	2	2	3	3	1	1	1
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Gambia	4	2	2	1	1	3	2	3	3	2	3
Ghana	3	2	1	2	1	2	2	2	3	3	1
Guinea	3	3	3	1	3	3	2	3	3	3	3
Liberia	3	3	3	3	2	1	1	1	1	3	3
Nigeria	3	4	4	4	3	3	2	2	3	2	2
Sierra Leone	2	4	3	2	1	1	1	3	1	1	1

**Source:** Author computation.

Regarding the secondary criteria (Table 3), throughout the period under consideration that is from 2010 to 2022, Guinea achieved a score of nine (9) times between the years 2012 and 2015,

and between the years 2017 and 2021. Nigeria was able to fulfil all the requirements seven (7) times, including in 2010, 2014, and every year except 2020, from 2017 through 2022. Next is Sierra Leone, which fulfilled the requirement five (5) times between the years 2010 and 2013 and again in 2017. Also, Ghana satisfied the secondary requirements five (5) times in 2010 and 2011 and between 2016 and 2018. Liberia four (4) times between 2010 and 2012, as well as in 2014. In addition, Gambia fulfilled the requirements of the secondary criteria on two (2) separate occasions in 2010 and 2011.

**Table 3: Number of Secondary criteria met by Countries (2010-2022)**

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
<b>Gambia</b>	2	2	1	0	1	0	0	1	1	1	1	1	1
<b>Ghana</b>	2	2	1	1	1	1	2	2	2	1	1	0	0
<b>Guinea</b>	0	0	2	2	2	2	1	2	2	2	2	2	1
<b>Liberia</b>	2	2	2	1	2	1	1	1	1	1	1	1	1
<b>Nigeria</b>	2	1	1	1	2	1	1	2	2	2	1	2	2
<b>Sierra Leone</b>	2	2	2	2	1	1	1	2	1	1	1	0	0

**Source:** Author computation.

Overall, Nigeria was successful in meeting the primary criteria for five (5) years and the secondary criteria for seven (7) years. Additionally, The Gambia fulfilled the primary for a period of seven (7) years but just the secondary for a period of two (2) years. whilst Guinea fulfilled the requirement for the secondary criteria on average for a total of nine times.

During the reviewed period, Nigeria performed better in meeting the primary criteria than other member states. Besides the inflation rate target, which The Gambia was the best performing member state, Nigeria was the best performing member state for the remaining primary criteria.

During the review period, from 2001-2022, Nigeria met the fiscal deficit target for twenty-one (21) years, the central bank financing of fiscal deficit target for seventeen (17) years and the gross external reserve in months of import cover target for twenty-two (22) years. (see Table 4A-4D).

Nigeria performance regarding the primary and secondary criteria helped to justify why we selected Nigeria as the reference country.

**Table 4: Number of each Primary Criteria met by Countries (2001-2022)****Table 4A: Inflation rate (ave.)**

	2001-2005	2006-2010	2011-2015	2016-2020	2021-2022
Gambia	3	5	5	3	0
Ghana	0	1	2	1	0
Guinea	2	1	2	3	0
Liberia	NA	4	4	0	0
Nigeria	0	2	3	0	0
Sierra Leone	2	1	3	0	0

Source: Author computation.

**Table 4B: Fiscal Deficit incl. grants (% of GDP)**

	2001-2005	2006-2010	2011-2015	2016-2020	2021-2022
Gambia	0	5	2	4	2
Ghana	1	0	1	5	2
Guinea	1	3	3	5	2
Liberia	NA	2	4	5	2
Nigeria	5	4	5	3	2
Sierra Leone	0	2	1	2	1

Source: Author computation.

**Table 4C: Central Bank financing of fiscal deficit as % of previous year's tax revenue**

	2001-2005	2006-2010	2011-2015	2016-2020	2021-2022
Gambia	2	5	3	4	1
Ghana	3	4	3	3	1
Guinea	1	1	4	4	2
Liberia	NA	4	5	1	2
Nigeria	4	5	5	3	0
Sierra Leone	4	2	4	1	0

**Table 4D: Gross External Reverses (Months of Imports)**

	2001-2005	2006-2010	2011-2015	2016-2020	2021-2022
Gambia	5	5	4	3	2
Ghana	3	4	5	5	1
Guinea	2	0	4	2	2
Liberia	NA	2	1	0	2
Nigeria	5	5	5	5	2
Sierra Leone	2	5	4	5	2

Source: Author computation.

**Table 5: Number of each Secondary Criteria met by Countries (2010-2022)****Table 5A: Exchange Rate Variation +/- 10%**

	2010-2015	2016-2021	2022
Gambia	3	5	1
Ghana	2	4	0
Guinea	4	5	0
Liberia	5	0	0
Nigeria	2	4	1
Sierra Leone	4	2	0

Source: Author computation.

**Table 5B: Public Debt to GDP ratio < 70%**

	<b>2010-2015</b>	<b>2016-2021</b>	<b>2022</b>
Gambia	3	0	0
Ghana	6	4	0
Guinea	4	6	1
Liberia	6	6	1
Nigeria	6	6	1
Sierra Leone	6	4	0

Source: Author computation.

### **3.0 Literature Review**

#### **3.1 Theoretical Framework**

In economic growth literature, there is a debate about the approach to adopt in the process of the convergence of economies. A strand of the literature argues that real convergence should allow the catching up of nominal variables, with the proponents providing the arguments for the optimal monetary area (OCA) theory. In this regard, real convergence is assessed in terms of similarity over time of real economic variables such as production, income, employment, productivity, etc. On the other hand, the second strand argues that nominal convergence would lead to economic convergence. They focus on a gradual harmonization over time of nominal variables, indicative of macroeconomic stability, in particular inflation rates, debt, exchange rates, etc.

Increasingly, the world economy is characterized by both globalization and the creation of regional groups. A monetary union implies the abandonment of monetary policy to a supranational body which is the common central bank. According to Mundell (1961), the Optimal Currency Area (OCA) theory defines the criteria that candidate countries must meet in order to mitigate the costs of abandoning monetary autonomy. An OCA represents an economic space where the factors of production are mobile and where the regions are affected in a symmetric way by common shocks. Nations have an interest in forming a monetary zone if and only if the mobility of factors within the zone they constitute is higher than with the outside. Extensions have made it possible to add other criteria such as the degree of openness, the nature of the specialization of economies, financial and fiscal integration, the homogeneity of preferences. These additional criteria contribute to reducing the risk of fluctuating exchange rates and a strong imbalance in the balance of payments that could be caused by the opening of economies. The difficulty in fulfilling all these criteria highlights the idiosyncrasies of countries intending to form an Optimal Currency Area. To reduce the negative externalities of economic and political integration, thus, there is a consensus on the need to make economies converge.

Different views on the notion of convergence that have emerged over the years include:

- convergence in terms of economic growth rate and that in terms of income levels;
- beta-convergence and sigma-convergence;
- unconditional (or absolute) convergence and conditional convergence; and
- global convergence and local convergence (or convergence club).

The neoclassical theory of growth assumes that countries possess the same levels of technological progress, and therefore the poorest grow faster and eventually reach the growth rate of the wealthiest. In contrast, proponents of convergence in terms of income level stipulate that countries have the same production functions, in addition to the assumption of increasing returns to capital. Moreover, convergence is called  $\beta$ -convergence, when there is a negative correlation between the initial income level and the subsequent growth rate of the group. Thus, the coefficient ( $\beta$ ) of the regression of the equation of growth rates on initial incomes must be negative. As for  $\delta$ -convergence, we refer to the dispersion measured in terms of the standard deviation of the incomes or growth rates of a distribution. Convergence is said to be conditional or relative when the convergence of economies over time considers differences in structural characteristics, including technology, population growth, savings rate, preferences, etc. However, the absolute or unconditional convergence of countries does not consider their structures, they are assumed to be identical.

### **3.2 Empirical Literature**

It is generally acknowledged that the structural characteristics of the countries forming Monetary Union may not meet the criteria of an optimum currency area (OCA) at its nascent stage. Despite the importance of nominal variables convergence, the potential member economies may vary significantly in terms of GDP growth, labour productivity and unemployment rates.

Regarding the importance and relationship between nominal and real convergence in the context of monetary unions, experts have varied opinions. Nominal convergence, according to some experts, should take prominence since it serves as the foundation for a stable monetary union by ensuring price stability and minimizing macroeconomic imbalances (Mundell, 1961; McKinnon, 1963). According to this point of view, it is essential to concentrate on lining up macroeconomic indices like inflation, interest rates, and exchange rates in order to provide a solid foundation for the union.

However, other studies (Frankel and Rose, 1998; Acemoglu *et. al.*, 2005) emphasize the significance of real convergence, which promotes long-term economic growth and reduces income disparities, ultimately contributing to the durability and resilience of the monetary union. Real convergence proponents contend that overcoming disparities in income levels, economic structures, and growth rates across member nations is essential for the union's long-

term success. The ongoing argument over the relative importance of nominal and real convergence serves as an example of how complex the convergence process is and emphasizes the need for a multifaceted approach (Tavlas, 1993; De Grauwe, 2009). In order to successfully address the difficulties and complexity involved in the creation and maintenance of a successful monetary union, a well-balanced approach that considers both nominal and real components of convergence is probably more effective.

Key macroeconomic variables in WAMZ member states will be impacted positively by achieving nominal, real, and structural convergence. Less inflation and more price stability are possible outcomes of successful nominal convergence (Alesina and Barro, 2002). Income disparities can be decreased, and GDP growth rates can be enhanced as a result of real convergence (Barro and Sala-i-Martin, 1995). According to Eichengreen and Bayoumi (1999), structural convergence can encourage sustainable public debt levels and strengthen fiscal restraint. It is essential for policymakers to comprehend these consequences in order to develop successful strategies for achieving convergence in the WAMZ. Concerns among policymakers about the region's progress towards nominal and real convergence have increased in recent times due to emerging trends in the economic indicators in the WAMZ, such as escalating inflation, elevated policy rates, rising debt levels, depleting external reserves, and depreciating value of national currencies (African Development Bank, 2021). These worries show the critical need for fresh initiatives to address macroeconomic imbalances and promote convergence within the WAMZ (IMF, 2021).

Recent literature has emphasized the importance of understanding the dynamics between real and nominal convergence in the context of monetary unions. For instance, Bénassy-Quéré and Coupet (2005) argue that achieving nominal convergence without considering real convergence could allow for asymmetric shocks and macroeconomic imbalances within the monetary union, potentially destabilizing the region. Their study underscores the necessity of addressing both types of convergence when designing macroeconomic policies for the WAMZ. Another study by Debrun *et. al.* (2005) highlights the importance of policy coordination and institutional frameworks for achieving and maintaining convergence within a monetary union. They contend that strong institutions and policy coordination mechanisms can help WAMZ countries manage potential challenges associated with the convergence process, ultimately contributing to the region's economic performance and integration. A more recent study by Adu *et. al.* (2021) investigates the role of trade and financial integration in promoting convergence within the WAMZ. Their findings suggest that deeper economic integration, particularly in the areas of trade and finance, can facilitate both real and nominal convergence, enhancing the region's overall economic stability and resilience.

Researchers have stressed the necessity for a coordinated strategy among WAMZ member nations to promote a stable and integrated monetary union (Asongu and Odhiambo, 2019).

This entails executing structural reforms intended to spur economic growth and development, enacting prudent fiscal and monetary policies, and harmonizing regulatory frameworks. The importance of strengthening regional cooperation and integration in areas like trade, infrastructure, and human capital development is also emphasized in recent literature in order to speed up the convergence process and foster resilience in the face of economic shocks. The WAMZ member countries can cooperate by pursuing these steps to achieve nominal and real convergence, ultimately assisting in the creation of a viable and long-lasting monetary union.

Eckhard and Achim (2003) examine the effects of the European Monetary Union (EMU) framework for monetary, fiscal and wage policies on overall growth and on convergence across the euro area. They discovered that the period before and after the euro introduction was characterized by a restrictive policy mix, which was not favourable neither to aggregate growth nor to real convergence.

Przemek (2003) discusses the processes of nominal and real convergence and their dependence on exchange rate regimes adopted in Central and Eastern European countries (CEECs) in the context of their future EMU accession. He conducted an empirical assessment of convergence of inflation to EU levels and economic growth of 7 CEE economies which had adopted different exchange rate regimes in the period 1993-2002 and found that fixed exchange rates seem to have been a better tool of fighting inflation as compared to floating exchange rates or intermediate regimes.

Sarah, Miguel, and Carolin (2008) assess the empirical importance of real convergence on the process of nominal convergence for the new EU Member States. Two of the main channels through which real convergence could affect relative prices with respect to the Euro area: productivity growth and increased trade openness are discussed. Growth in productivity could impact price levels positively through the Balassa-Samuelson effect, while increased openness results in a decline in mark-ups and costs; thereby impacting negatively on prices. Estimating a Structural VAR model, they found that generally, openness has a negative impact and productivity growth has a positive effect on price level convergence with respect to the Euro area.

Iancu (2009) presents analysis of the way the Central and Eastern Europe (CEE) countries handle the convergence criteria in accordance with the Maastricht Treaty after the institutional reform, in the pre and post Economic and Monetary Union (EMU). The nominal convergence criteria of the Maastricht Treaty adopted are price stability, sustainable fiscal status, exchange rate stability, and lower long-term interest rate. He clarifies that a shorter transition to the euro, the exchange rate equilibrium with the inflation rate reduction and the Balassa-Samuelson effect. The exchange rate and its deviation index reflect the real exchange rate equilibrium in the CEE countries, while the progress made by the CEE countries in nominal convergence leads to the transition to the Euro Area.

Enrico and Marcello (2010) assess nominal and real convergence within the EU countries, considering how both processes have been largely shaped by the advances in institutional integration. They investigate how institutional integration has affected real convergence, and an “ad hoc” integration index, which considers the progressive steps toward closer integration followed by EU countries. The empirical results show that in EMU countries, real convergence was well established in terms of productivity, labor market indicators, output correlations; only the pattern of convergence in economic structures was unclear.

The importance of real convergence in achieving nominal convergence in the WAMZ was investigated by Adedeji and Williams (2020). The study emphasizes the significance of both types of convergence when evaluating the member countries' readiness for the monetary union. They argue that convergence helps in lowering economic disparities and promotes growth across member nations. Thus, true convergence is essential for the union's long-term existence. Ofori-Abebrese (2006) examines real and nominal convergence in the WAMZ in another study and found that while nominal convergence had made some progress, real convergence had lagged. They argue that to achieve both real and nominal convergence within the Zone, policy coordination and deeper economic integration are required.

Current literature emphasizes the importance of understanding the interplay between real and nominal convergence in the context of the WAMZ. By exploring this relationship and drawing on the insights provided by recent research, this study aims to estimate the rate of convergence and distance to convergence, contribute to the development of more effective macroeconomic policies that promote higher rate of regional economic integration and ensure the long-term success of the proposed monetary union.

#### **4.0 Methodology and data description**

In this section, we present the methodology and the data used to assess the nominal and real convergence process. Our analysis relies on cointegration properties of the nominal and real convergence variables for the six member countries (The Gambia, Ghana, Guinea, Liberia, Nigeria and Sierra Leone) in the West African Monetary Zone (WAMZ), and a time varying parameters' model.

##### **4.1 Cointegration properties of the variables**

To examine convergence among the WAMZ member States, we follow Camarero *et al.* (2010) and Mikio *et al.* (2022) that consider convergence is concerned with relative long-run behaviour of a number of time series. According to Hall *et al.* (1992), economic convergence between two series will exist if they are cointegrated and the difference between them approximate to some constant. More formally, there is a long-run convergence in a variable  $x$  at time  $t$  between two countries  $i$  and  $j$ , if the long-term forecasts of the considered variable for both countries are:



$$\lim_{k \rightarrow 0} E(x_{i,t+k} - x_{j,t+k} | I_t) = 0$$

Where  $I_t$  represents the information available at time  $t$ . This is satisfied when the variables  $x_i$  and  $x_j$  are cointegrated and with a cointegration vector [1, - 1]. Therefore, our analysis begins by testing the cointegration behavior of our variables among the countries. In doing this and following Oxley and Greasley (1995) and Bernard and Durlauf (1996), we distinguish between two degrees of convergence: long-run convergence and catching-up. These levels of convergence are closely linked to the concepts of stochastic and deterministic cointegration, respectively.

The strategy we use to assess whether there is a long-run convergence or a catching-up is to test unit roots in the difference between two individual series. There is a catching-up between two countries in a variable when there is a narrowing of the gap, even though the countries have not yet converged. This concept implies the absence of a unit root in the difference between the two variables, but there exists a deterministic trend. Conversely, a long-run convergence is associated with the joint rejection of the unit root (stochastic trend) and a deterministic trend. To confirm the results, we perform a cointegration test with structural break, using the Gregory and Hansen (1996) residual-based test with regime shifts. This procedure tests the null hypothesis of no cointegration against an alternative of cointegration with a single regime shift in an unknown date.

#### **4.2 The time varying parameters' model**

Subsequently, a time-varying parameters model is used to assessing if the member States have begun the process of convergence. This complementary methodology helps derive the speeds of convergence between the different variables, as well as to test for a dynamic structural change in the implied variables.

The concept of convergence in the WAMZ being a gradual process, we test nominal and real convergence process, accounting for change over time of the long-run relationship in the variables of interest. This methodology adopts the model proposed by Hall *et. al.* (1992), that is time-varying parameter estimation. Let's consider a macroeconomic variable  $X$  for member countries in the WAMZ (inflation rate, exchange rate variation and real GDP growth rate).  $REF$  and  $CR$  being the reference country and the zone's criteria on the given variable respectively. Therefore:

- $X_{REF_t}$  and  $X_{WAMZ_t}$  defines the variable of interest (inflation, exchange rate or real GDP growth rate) for the reference country and the individual member country in the WAMZ respectively,
- $X_{CR_t}$  represents the criteria chosen for the variable of interest.

To assess whether a country convergence towards *REF* or *CR* and at which rate, we regress the equation<sup>2</sup>:

$$X_{REF_t} - X_{WAMZ_t} = \alpha_{WAMZ_t} + \beta_{WAMZ_t}(X_{REF_t} - X_{CR_t}) + \mu_{WAMZ_t} \quad (1)$$

where  $\mu_{WAMZ_t}$  is a white noise,  $\alpha_{WAMZ_t}$  and  $\beta_{WAMZ_t}$  provide information about the achievement of the temporal convergence of the country for the variable. Hence, a country (in WAMZ) converges towards *REF* if:

$$E \left[ \lim_{t \rightarrow \infty} (\beta_{WAMZ_t}) \right] = 0 \quad \text{and} \quad E \left[ \lim_{t \rightarrow \infty} (\alpha_{WAMZ_t}) \right] = 0$$

Conversely, if a member country converges towards *CR*, we will have:

$$E \left[ \lim_{t \rightarrow \infty} (\beta_{WAMZ_t}) \right] = 1 \quad \text{and} \quad E \left[ \lim_{t \rightarrow \infty} (\alpha_{WAMZ_t}) \right] = 0$$

It is worth noting that this model does not provide evidence for convergence that has already taken place, rather it informs if the process has started and at which rate. Further, this formulation characterizes a weak definition of convergence, compared to that of cointegration. Also, the estimation of the coefficients  $\beta_{WAMZ_t}$  indicates the speed of convergence in this three-variables setting. In the special case where  $\alpha_{it} = 0$ , different scenarios are possible:

- $E \left[ \lim_{t \rightarrow \infty} (\beta_{WAMZ_t}) \right] = 0 \Rightarrow X_{WAMZ_t} = X_{REF_t}$  : the country converges towards the reference
- $E \left[ \lim_{t \rightarrow \infty} (\beta_{WAMZ_t}) \right] = 1 \Rightarrow X_{WAMZ_t} = X_{CR_t}$  : the country converges towards the criteria

The setting of the model in equation (1) requires a choice of the reference country (*REF*) and the criteria (*CR*). Nigeria is chosen as the reference country among the WAMZ member States. The intuition is not only it is the largest economy in the region, but it performs<sup>3</sup> better on average in meeting the nominal convergence criteria (primary and secondary), according to Olowofeso *et. al.* (2021). To check the robustness of our estimation, a different country is chosen based on its performance in meeting individual nominal criteria. For the variables  $X_{CR_t}$ , the convergence criteria as stipulated in the ECOWAS Status of Macroeconomic Convergence for our variables of interest were used. But as the real GDP growth for which there is no explicit criterion, we use a pseudo-criterion that is the average of sub-Saharan Africa real GDP growth rate, computed from 2000 to 2022 published by the IMF World Economic Outlook.

<sup>2</sup> For example, the model specification to assess whether the inflation of Ghana converge towards that of Nigeria (as the reference) or the convergence criteria (CR) is given by:

$$INF_{Nigeria_t} - INF_{Ghana_t} = \alpha_{Ghana_t} + \beta_{Ghana_t} (INF_{Nigeria_t} - INF_{CR_t}) + \mu_{Ghana_t}$$

<sup>3</sup> This performance is based on the number of total convergence criteria (both the primary and the secondary) met by Nigeria on average, over the period 2001-2022, compared to other WAMZ member countries.

Equation (1) can be represented in a state-space representation, with the distinction between the state-transition equation and the measurement equation. Given that the estimation is done country by country, the cross-section subscripts  $i$  may be deleted.

$$\xi_t = \phi_t \xi_{t-1} + v_t \quad (2) \quad \text{(State-transition equation)}$$

$$y_t = H_t \xi_t + \eta_t \quad (3) \quad \text{(Measurement equation)}$$

Where:  $y_t = (X_{REF_t} - X_{WAMZ_t})$ ,  $H_t = (X_{REF_t} - X_{CR_t})$ ,  $\xi_t = (\alpha_{WAMZ_t}, \beta_{WAMZ_t})$ . In equation (2),  $\phi_t$  is the transition matrix and  $v_t$  is a vector of stochastic disturbances which is independent of  $\xi_{t-1}$ . In equation (3),  $H_t$  is the measurement matrix and  $\eta_t$  is a vector of measurement errors, independent of  $\xi_t$ . The state regressors  $\alpha_t$  and  $\beta_t$  in equation (1) can be estimated using Kalman filter for each individual country in WAMZ. That is a recursive algorithm used for the estimation of time varying parameters. The object of Kalman filtering is to find an unbiased estimates of the sequence of the state vectors  $\xi_t$  via a recursive process of estimation<sup>4</sup>.

According to Lemoine M. and Pelgrin F. (2003), the use of a stochastic parameter model enables us to avoid many of the statistical problems that arise otherwise when using OLS. First, we avoid here the problems of unit root which arise prior to the estimation of ARMA models. In particular, the results of the Kalman filter remain valid in the presence of non-stationary series. Furthermore, this framework also allows us to relax the assumption of a Gaussian distribution for noise. Finally, the model coefficients can change and are not necessarily considered invariant during the estimation period.

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<sup>4</sup> See Box 1 for the summary of the estimation equations using the Kalman Filter.

### Box 1: A summary of the Kalman equations

Let's consider  $\mathcal{J}_t = \{y_1, y_2, \dots, y_t\}$  and  $\mathcal{J}_{t-1} = \{y_1, y_2, \dots, y_{t-1}\}$  to denote the information available at time  $t$  and  $t - 1$  respectively.

#### THE SYSTEM EQUATIONS

$$\xi_t = \phi_t \xi_{t-1} + v_t \quad \text{State transition}$$

$$y_t = H_t \xi_t + \eta_t \quad \text{Observation}$$

$$E(v_t) = 0, \quad \sigma(v_t) = \Psi_t \quad \text{System disturbance}$$

$$E(\eta_t) = 0, \quad \sigma(\eta_t) = \Omega_t \quad \text{System disturbance}$$

#### CONDITIONAL EXPECTATIONS

$$E(v_t) = 0, \quad \sigma(v_t) = \Psi_t \quad \text{System disturbance}$$

$$E(\eta_t) = 0, \quad \sigma(\eta_t) = \Omega_t \quad \text{Measurement error}$$

$$E(\xi_t | \mathcal{J}_{t-1}) = x_{t|t-1}, \quad \sigma(\xi_t | \mathcal{J}_{t-1}) = P_{t|t-1} \quad \text{State prediction}$$

$$E(\xi_t | \mathcal{J}_t) = x_t, \quad \sigma(\xi_t | \mathcal{J}_t) = P_t \quad \text{State estimate}$$

$$E(y_t | \mathcal{J}_{t-1}) = \hat{y}_{t|t-1}, \quad \sigma(y_t | \mathcal{J}_{t-1}) = F_t \quad \text{Observation prediction}$$

#### THE KALMAN FILTER

##### State prediction

$$x_{t|t-1} = \phi_t x_{t-1}, \quad \text{State prediction}$$

$$P_{t|t-1} = \phi_t P_{t-1} \phi_t' + \Psi_t, \quad \text{Prediction variance}$$

##### Observation prediction

$$\hat{y}_{t|t-1} = H_t x_{t|t-1}, \quad \text{Observation prediction}$$

$$F_t = H_t P_{t|t-1} H_t' + \Omega_t, \quad \text{Prediction variance}$$

##### Auxiliary variables

$$e_t = y_t - H_t x_{t|t-1}, \quad \text{Predictor error}$$

$$K_t = P_{t|t-1} H_t' F_t^{-1}, \quad \text{Kalman Gain}$$

##### State prediction updating

$$x_t = x_{t|t-1} + K_t e_t, \quad \text{State estimate}$$

$$P_t = P_{t|t-1} - K_t F_t^{-1} K_t', \quad \text{Estimate variance}$$

The object of Kalman filtering<sup>5</sup> is to find unbiased estimates of the sequence of the state vectors  $\xi_t$  via a recursive process of estimation. The process starts at time  $t = 1$ ; and it is assumed that prior information on the previous state vector  $\xi_0$  is available in the form of an unbiased estimate  $x_0$  which has been drawn from a distribution with a mean of  $\xi_0$  and a dispersion matrix of  $P_0$ . Generally, we set  $x_0 = E(\xi_0) = 0$ , which is the unconditional expectation; and it should be possible to infer the corresponding dispersion matrix  $P_0$  from the other parameters of the model. In each time period, new information on the system is provided by the vector  $y_t$ ; and estimates of  $\xi_t$  may be formed both before and after the receipt of this information. The estimate of the state at time  $t$  formed without a knowledge of  $y_t$  will be denoted by  $x_{t|t-1}$ ; whilst the estimate which incorporates the information of  $y_t$  will be denoted by  $x_t$ .

### 4.3 Data Source and Properties

This paper utilizes both monthly and annual data for the analysis. The monthly data are inflation as a measure of the annual change in the consumer price index (CPI) and the nominal exchange rate which span from January 2003- December 2022 for all the WAMZ member countries (Gambia, Ghana, Guinea, Liberia, Nigeria and Sierra Leone). The high frequency data on CPI and exchange rate were obtained from the International Monetary Fund (IMF) international Financial Statistics database (IFS 2023). The nominal exchange rate is the official period average exchange rate of the member countries and is measured by local currency unit (LCU) per the US dollar (\$). Data on real gross domestic product (RGDP) growth rate was on an annual basis from 1980 to 2022 for all member countries in the WAMZ. The RGDP growth rate data at constant prices is from World Bank, World Development Indicators (2023).

Tables 4 - 6 report descriptive statistics of inflation rate, exchange rate variation and RGDP growth rate of countries in the WAMZ. Table 4 shows that all, except Liberia's inflation rate are positively skewed. It is also clear that Liberia inflation rate has been more volatile over the period of study than the rest as seen in the standard deviation. Table 5 shows that except Gambia, Guinea, and Liberia, the changes in exchange rates of the other three WAMZ countries namely Ghana, Nigeria and Sierra Leone are negatively skewed. Contrary to the inflation rate, Liberia's changes in exchange rate compared to the rest of the countries in the Zone is more stable during the review period. Table 6 shows that the GDP of all countries apart from Sierra Leone in the WAMZ is positively skewed.

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<sup>5</sup> Further development on the estimation process of time-varying using Kalman Filter is provided in Durbin and Koopman (2012).

**Table 6: Inflation rate descriptive statistics**

	The Gambia	Ghana	Guinea	Liberia	Nigeria	Sierra Leone
Mean	6.2425	13.3887	14.8373	8.6330	12.5411	13.7857
Median	6.1277	11.7606	11.4575	9.1116	12.0626	13.3124
Maximum	18.0985	54.1440	42.6000	31.3189	28.2324	42.7100
Minimum	0.3537	5.7965	1.5000	45.3323	3.0085	1.2283
Std. Dev.	3.0647	6.3004	8.6453	13.8863	4.2889	5.9748
Skewness	1.3179	3.0220	1.3640	2.5617	0.5737	2.0119
Kurtosis	6.0380	16.8317	4.1270	11.0227	3.6509	9.4962
Jarque-Bera	153.6800	2164.5190	82.7638	860.8246	16.5320	554.7294
Probability	0.0000	0.0000	0.0000	0.0000	0.0003	0.0000
Observations	228	228	228	228	228	228

**Source:** Author computation, using EViews 13.0.

**Note:** Data on inflation is computed as the annual change in the consumer price index (CPI) for all WAMZ member States. International Financial Statistics (IFS) database, January 2003 to December 2022.

**Table 7: Exchange rate variation descriptive statistics**

	The Gambia	Ghana	Guinea	Liberia	Nigeria	Sierra Leone
Mean	-2.8060	-10.3858	-6.1334	-4.3515	-5.4670	-8.5841
Median	-3.6194	-7.1769	-3.6338	-3.7306	-1.1634	-8.4301
Maximum	46.2090	7.7735	53.4753	24.9527	8.7279	1.8611
Minimum	-26.1585	-54.8153	-46.4883	-26.7588	-36.3963	-39.7996
Std. Dev.	11.2892	10.3797	15.9469	10.5078	10.1733	7.6278
Skewness	1.3861	-1.3366	0.5773	0.3434	1.4420	1.0446
Kurtosis	6.5585	4.6871	5.4649	3.3608	4.5061	4.6380
Jarque-Bera	193.3096	94.9258	70.3819	5.7172	100.5621	66.9575
Probability	0.0000	0.0000	0.0000	0.0573	0.0000	0.0000
Observations	228	228	228	228	228	228

**Source:** Author computation, using EViews 13.0.

**Note:** Data on exchange rate variation is computed as the annual change in the nominal exchange rate of national currencies against the US dollar for all WAMZ member States. International Financial Statistics (IFS) database, January 2003 to December 2022.

**Table 8: Real GDP growth rate descriptive statistics**

	Gambia	Ghana	Guinea	Liberia	Nigeria	Sierra Leone
Mean	3.1711	4.5659	4.0396	1.7213	3.3551	1.7959
Median	3.6490	4.7740	4.0010	3.9710	3.2520	3.1870
Maximum	20.7590	13.9490	10.8210	99.9860	14.6040	26.4250
Minimum	-9.5230	-8.3030	-1.5380	-51.3310	-13.1300	-24.7870
Std. Dev.	5.1901	3.7990	2.1944	24.2379	5.3393	9.5416
Skewness	0.2283	-1.2726	0.7050	1.4427	-0.8497	-0.3670
Kurtosis	5.6998	6.5156	5.3647	9.4287	4.7732	4.5759
Jarque-Bera	13.4330	33.7503	13.5803	72.4108	10.8083	5.4151
Probability	0.0012	0.0000	0.0011	0.0000	0.0045	0.0667
Observations	43	43	43	35	43	43

**Source:** Author computation, using EViews 13.0.

**Note:** Data on real GDP growth at constant prices is obtained from the World Development Indicators (WDI), World Bank database, on an annual basis from 1980 to 2022.

## 5.0 Empirical Results and Discussions

In this section, we present and discuss the results on assessing not only whether member states have converged using our nominal and real convergence variables of interest, but also how far the countries are in the process. To achieve this, we employ the cointegration properties for each variable and estimate a time-varying parameter model using the Kalman filter, which accounts for the dynamics of the convergence process. Additionally, our analysis evaluates the rate of convergence and distance to convergence for each of the countries based on our variables.

### 5.1 Unit root and cointegration tests

The concept of catching up implies the absence of a unit root in the series of differentials of our variables with their targets, represented here by the WAMZ convergence criteria. If the differential is non-stationary, then there is no convergence of the country variable considered towards the criterion. On the other hand, in case of stationarity, then there may be a long-term convergence relationship between the variable and the criterion. We performed the tests using:

- The difference between the real GDP growth rate and its target ( $\Delta GDP_{it} - \Delta GDP_{it}^{CR}$ ),
- The deviation of the inflation rate from its convergence criterion ( $INF - INF_{it}^{CR}$ ) and
- The deviation of the exchange rate variation and its criterion ( $\Delta EXCH - \Delta EXCH_{it}^{CR}$ ).

For country  $i$ ,  $\Delta GDP_{it}^{CR}$  is the targeted real GDP growth rate,  $INF_{it}^{CR}$  the inflation rate convergence criterion ( $\leq 10$  percent before January 2019 and  $\leq 5$  percent after) and  $\Delta EXCH_{it}^{CR}$  the exchange rate convergence criterion ( $\pm 10$  percent).

First, the Augmented Dickey Fuller (ADF) and Phillips-Perron (PP) unit root tests were carried out and the results obtained are presented in Tables 7. It is observed that at the 5 percent threshold, the differential of the inflation rate with respect to the convergence criterion is not stationary for any country in the zone. But at the 10 percent threshold, for the variable for Guinea, Liberia, and Nigeria, we reject the null hypothesis of the presence of a unit root. Regarding the exchange rate differential, the results indicate the absence of unit root at the 5 percent threshold for The Gambia, Guinea, Liberia, and Nigeria using the ADF and PP tests. The variable is non-stationary for Ghana and Sierra Leone. The results of the stationarity tests on the differentials of real GDP growth rates show the absence of unit roots for all countries.

**Table 9: Results of ADF and PP tests**

	$(INF - INF_{it}^{CR})$				$(\Delta EXCH - \Delta EXCH_{it}^{CR})$				$\Delta GDP_{it} - \Delta GDP_{it}^{CR}$			
	ADF Statistic	P-value	PP Statistic	P-value	ADF Statistic	P-value	PP Statistic	P-value	ADF Statistic	P-value	PP Statistic	P-value
The Gambia	-1.1512	0.6955	-1.9349	0.3159	-3.9438	0.0001**	-3.9937	0.0001**	-7.2873	0.0000**	-10.114	0.0000**
Ghana	3.1769	1.0000	2.8307	1.0000	-2.5143	0.321	-2.3122	0.4252	-3.5849	0.0433**	-3.2206	0.0943*
Guinea	-3.1903	0.0890*	-2.5061	0.3250	-2.6778	0.0075**	-2.5765	0.0100**	-4.5441	0.0040**	-4.4644	0.0049**
Liberia	-3.2798	0.0723*	-3.3852	0.0559*	-3.1327	0.0018**	-3.1207	0.0019**	-12.545	0.0000**	-3.2809	0.0866*
Nigeria	-2.5511	0.1049	-3.1386	0.0999*	-2.5731	0.2932	-3.0717	0.0022**	-2.5632	0.2982	-3.9789	0.0171**
Sierra Leone	0.7285	0.9997	-1.3963	0.8598	-1.9436	0.6282	-1.6453	0.7719	-3.6980	0.0335**	-3.5939	0.0425**

**Source:** Author computation, using EViews 13.0.

**Note:** Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests, with a null hypothesis of non-stationarity. \*\* and \* rejection of Null hypothesis at 5 percent and 10 percent significance respectively.

The results of the unit root tests for our variables of interest do not show to be integrated to the same degree. Also, to account for the catching-up over time in the convergence process, we carried out a set of cointegration tests, using the Gregory and Hansen Approach.

### 5.2 Gregory and Hansen Approach of Cointegration

The study uses Gregory and Hansen (1996) residual-based test approach of cointegration for the presence of structural break. This method, as an extension of the Engle and Granger (1987) cointegration, tests the null hypothesis of no cointegration against an alternative of cointegration with a single regime shift in an unknown date. To account for the time variation from the definition of the convergence as a process, the cointegration is considered to take time to manifest and the time of the long-run relationship may be unknown but can however be determined endogenously. This structural change may be reflected in the shifts in the intercepts (Model 1: with level shift – C) or in the trend (Model 2: with level shift and time trend – C/T) or in the slopes (Model 3: with level and regime shifts – C/S)<sup>6</sup>. Gregory and Hansen (1996) proposes three tests for the residuals of the series to determine if there is cointegration. One based on the augmented Dickey-Fuller test and two of them on Phillips (1987) test:

$$ADF^* = \inf ADF(\tau) ; Z_t^* = \inf Z_t(\tau) ; Z_\alpha^* = \inf Z_\alpha(\tau)$$

Where  $\tau$  denote the regime shift point.

<sup>6</sup> See Gregory and Hansen (1996) for more development.



**Table 10: Gregory-Hansen (1996) cointegration test**

Model	Procedure	Inflation		Exchange rate		GDP growth	
		t-stat	Break date	t-stat	Break date	t-stat	Break date
Level Shift (C)	$ADF^*$	-5.67**	2006M01	-4.60	2008M08	-7.90**	1984
	$Z_t^*$	-4.80	2005M12	-3.90	2014M06	-7.87**	1984
	$Z_\alpha^*$	-42.88	2005M12	-30.61	2014M06	-50.18	1984
Level Shift with Trend (C/T)	$ADF^*$	-5.93**	2006M01	-5.10	2017M09	-7.84**	1984
	$Z_t^*$	-4.96	2006M01	-4.21	2015M03	-7.81**	1984
	$Z_\alpha^*$	-45.36	2006M01	-35.22	2017M11	-49.81	1984
Regime Shift (C/S)	$ADF^*$	-6.12	2009M04	-7.34**	2016M08	-7.69**	2000
	$Z_t^*$	-6.71**	2008M02	-6.18**	2016M09	-7.77**	2000
	$Z_\alpha^*$	-76.74*	2008M02	-69.66**	2016M09	-47.81	2000

**Source:** Author computation.

**Note:** These are the test statistics for the procedures  $ADF^*$ ,  $Z_t^*$  and  $Z_\alpha^*$ , where \* and \*\* indicate significance at the 10 percent and 5 percent levels, respectively. In the columns “Break date” are the estimated  $\tau$ 's (the date in the sample where the smallest value of the test statistic is obtained).

As a result for inflation, the test which allow for a level shift (C and C/T) reject the null hypothesis of no cointegration for only the  $ADF^*$  tests at the 5% level, with a break point in January 2006, while the statistic test is significant with the regime shift for the  $Z_t^*$  and  $Z_\alpha^*$  tests. As for the exchange rate variation, all the three tests  $ADF^*$ ,  $Z_t^*$  and  $Z_\alpha^*$  are only significant at 5% for the most general alternative which allow both the intercept and the slop (regime) to shift. The real convergence variable, that is the GDP growth, reject the null hypothesis for all alternative specification (C, C/T and C/S) at 5% level for the statistics of the tests  $ADF^*$  and  $Z_t^*$ , but fails to reject the null of no cointegration for  $Z_\alpha^*$ . Therefore, and for all our variables of interest, we conclude that there seems to be evidence of long-run convergence, with break points of member countries in the WAMZ.

### 5.3 Time-varying parameter model

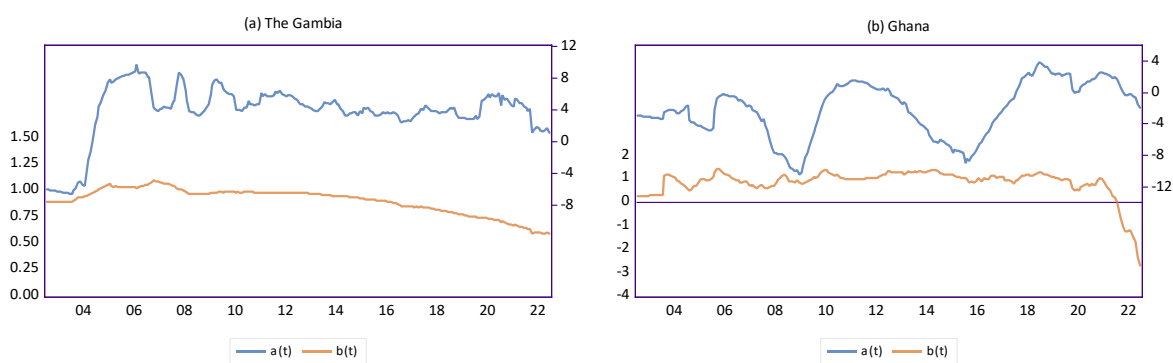
Cointegration is a necessary but not sufficient condition for the convergence of countries. To draw a conclusion on the state of nominal and real convergence, a time-varying parameter (TVP) model should be estimated using the Kalman filter for real GDP growth, inflation, and variation of exchange rates. The relevant estimates<sup>7</sup> of the varying parameters with Nigeria as reference country are displayed visually in Figures 1 to 3. We expect the coefficients  $\beta_2$  to converge toward 1 to meet the WAMZ convergence criterion. However, for a particular variable, if it tends towards 0, the country converges towards the reference which is Nigeria.

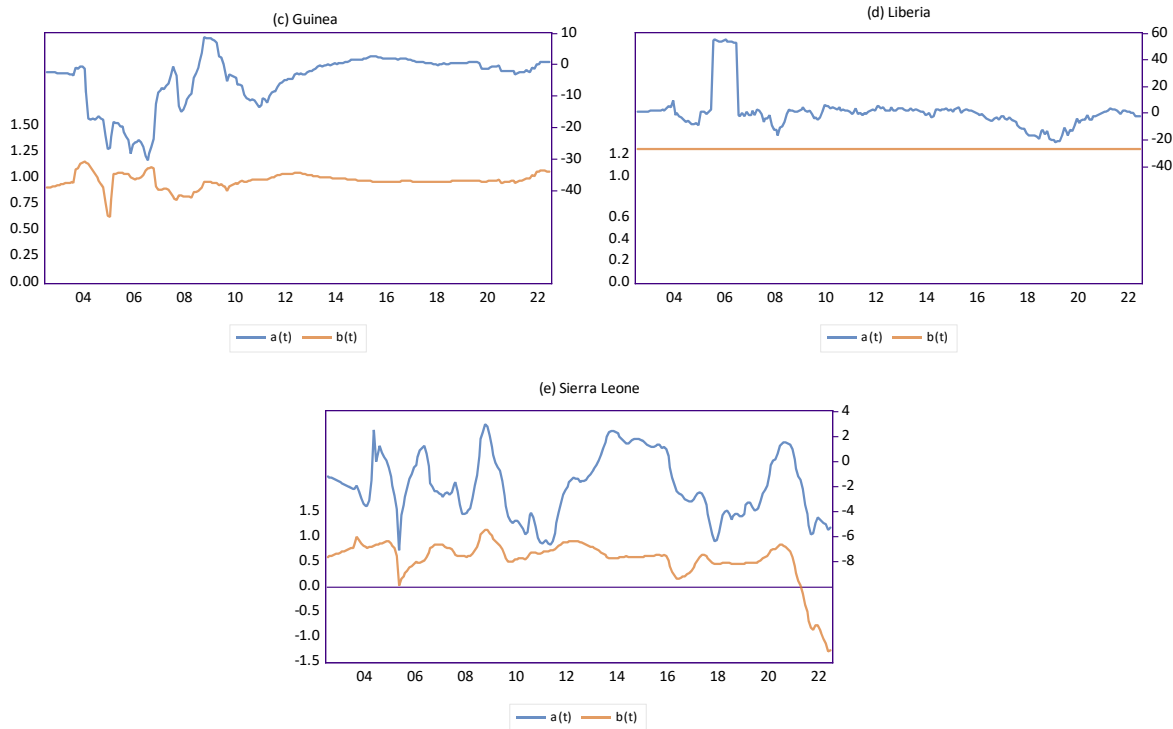
<sup>7</sup> See below in tables 9, 10 and 11 for the estimates of parameters for the three models.

### 5.3.1 The slope of the inflation rate equation

From the results presented in the top left of Figure 1, the trajectory of The Gambia's inflation rate indicates convergence around the WAMZ convergence criterion until May 2014 before slowly decreasing towards the Nigerian rate which it did not reach until the end of 2022. The country ultimately did not converge either towards the criterion or towards the reference. For Ghana, relative to Nigeria, the inflation rate fluctuated around the convergence criterion until April 2020. Due to the adverse impact of the Pandemic, the difference with the convergence criterion widened and increased until the country came closer to the rate of Nigeria at the end of 2021. It remains visible on the graph, Figure 1 (b), that the inflation rate of Ghana has diverged from that of the reference and much more from the WAMZ convergence criterion until the end of 2022, due to the effect of the COVID-19 pandemic. By omitting the first decade from January 2003 to March 2010 where the slope varied considerably, the trajectory of the regression coefficients for Guinea indicates some level of catching-up with the area criterion, with a relative stability of the inflation rate differential over the period. The trajectory of inflation catching up is recorded in Liberia over the study period (Figure 1 (d)). Indeed, the differential with the convergence criterion has remained stable, indicating that monetary policy transmission mechanism seems to be weak. This could be explained by the high dollarization of the economy, which would have dampened the efforts of the monetary authorities. For its part, the inflation rate gap in Sierra Leone fluctuated between the convergence criterion and the rate in Nigeria until December 2020. The effects of the COVID-19 pandemic caused the coefficient to suddenly decrease to reach that of Nigeria in October 2021. The results on Figure 1 (e) show that the inflation rate has moved away from that of the reference and even more from the WAMZ convergence criterion until the end of 2022.

**Figure 1: Inflation rate time-varying parameters**





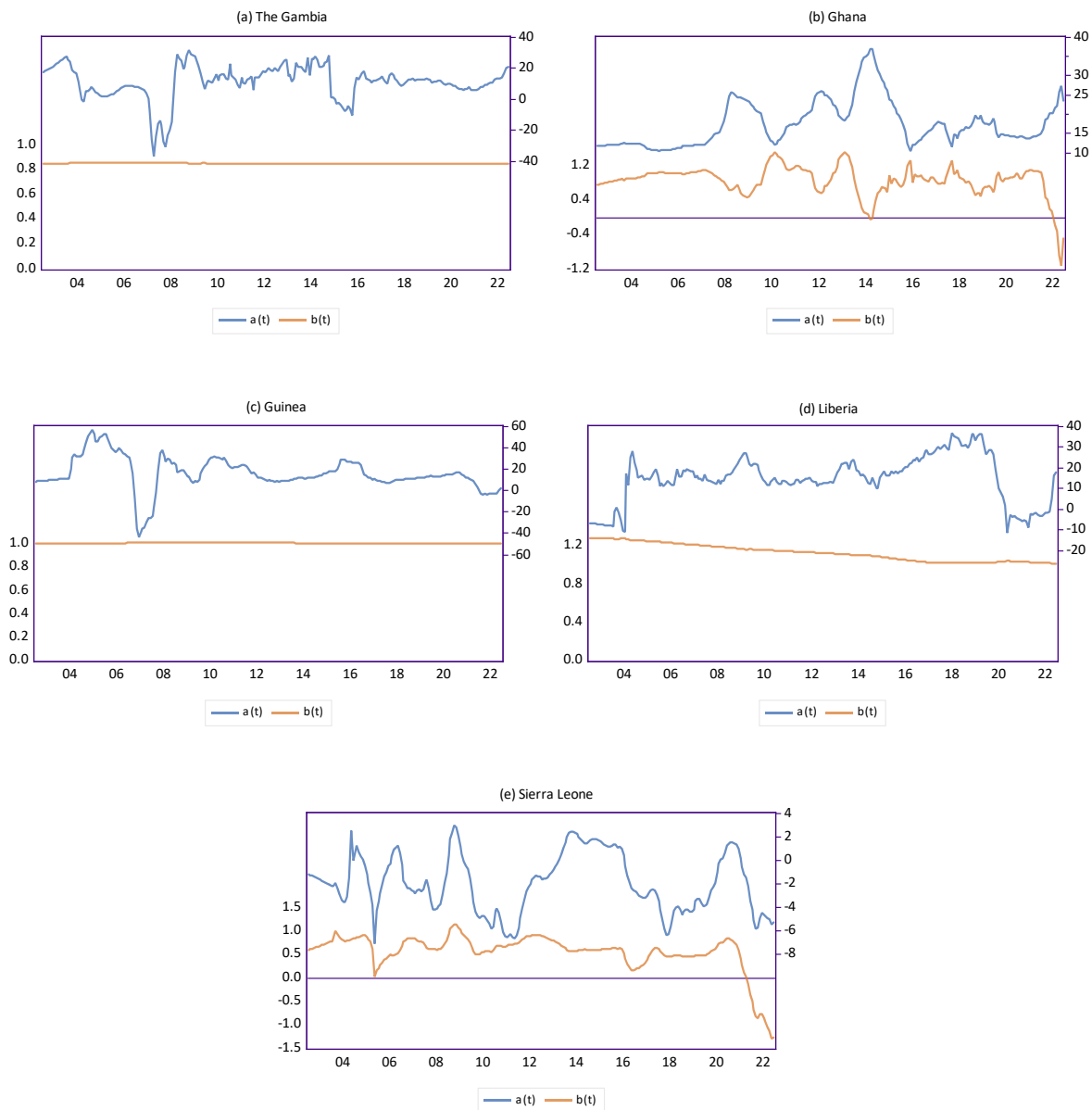
Note: The left axis represents the beta, and the right axis represents the alpha.

### 5.3.2 The slope of the variation of exchange rate equation

Regarding the exchange rate differential in The Gambia, Figure 2 shows a stability of the coefficients over the entire period of the study, but without reaching the criterion. By comparing these results with the analysis of the previous cointegration, we realize that the trend of the variation of the country's exchange rate remains stable over the entire period. This implies that the exchange rate policy of the monetary authorities fails to reduce the gap to converge towards the criterion. From the results for Ghana presented in the top right of Figure 2, the trajectory of the coefficients of the regression of the exchange rate differentials indicates a strong fluctuation around the convergence criterion until March 2022. Then, the slope of the variable decreases sharply to reach that of Nigeria in July 2022 before receding until the end of the year, in connection with the effects of COVID-19. In Guinea, exchange rate variation data indicate relative convergence towards the WAMZ criterion. From 2003 to 2022, the trend of the variable remains stable. We can confirm this trend with the results of the cointegration tests carried out above, which showed that the country's exchange rate differential has a long-term relationship with the zone's convergence criterion. The case of Liberia in Figure 2 shows a process of gradual catching up with the convergence criterion over the period. This is illustrated by the decrease in the slope, indicating the reduction of the gap between the volatility of the exchange rate in relation to the convergence criterion. The data shows that the country variable ends up converging in March 2022. This can be explained by the pegging of the Liberian dollar to the US dollar, and on the other hand by the reforms of the monetary authorities. Analysis of the graph for Sierra Leone indicates that the coefficient of the country's

regression converged towards the area criterion, which it reached in 2014. But from there it gradually diverged until end of 2022, illustrating that the trajectory does not have the same long-term trend as the criterion, as shown by the analysis of the previous cointegration. Indeed, the country was severely affected by the Ebola virus pandemic, and the effects of the fall in the price of mining products at the international level.

**Figure 2: Exchange rate variation time-varying parameters**



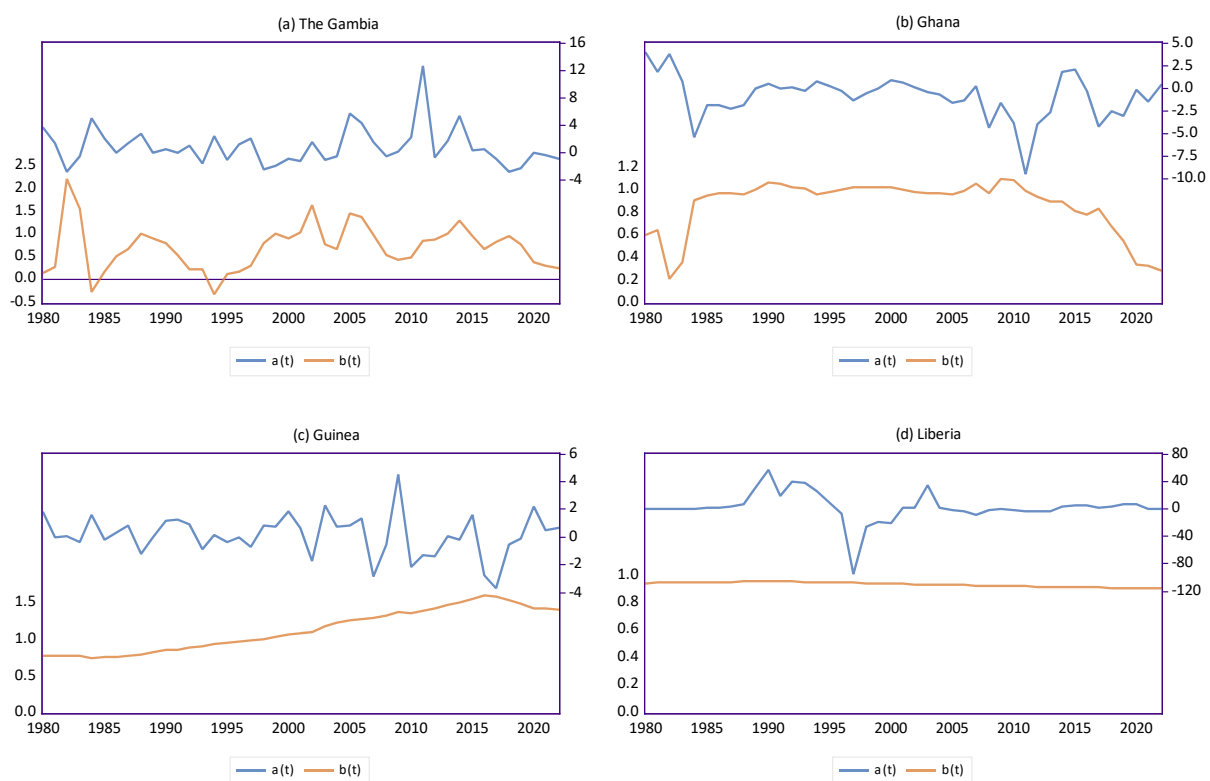
*Note: The left axis represents the beta, and the right axis represents the alpha.*

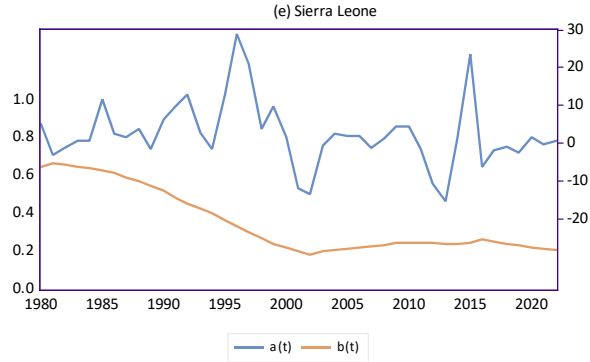
### 5.3.3 The slope of the real GDP growth rate equation

In Figure 3, we assess real convergence by visualizing the evolution of the regression coefficients of the differential in GDP growth rates of the member countries of the zone. For The Gambia, the trajectory of the regression coefficient remained unstable throughout the study

period. However, we highlight a relative convergence towards the growth rate of Nigeria from 2018. Concerning Ghana, the graph shows a convergence towards the optimal growth rate chosen as criterion until 2010. Then, the slope of the country's GDP growth rate is gradually decreasing and converging towards that of Nigeria. The situation of Guinea depicted in Figure 3 indicates a real convergence towards the criterion used until 1997, then a divergence of its growth rate over the rest of the period. In Liberia, the slope of the coefficient remained relatively stable throughout the study period. However, by slowly moving away from its trajectory, the country's GDP growth rate has not yet started its process of convergence towards the criterion. The results of the estimation for Sierra Leone indicate a convergence towards Nigeria until 2002. Then, the slope stops decreasing to stabilize around 0.2 but remains significantly different from 0. We deduce that the country had started its convergence towards the reference country but has not reached it. In sum, for all WAMZ member countries, the results find no evidence of long-run convergence or catching-up with the chosen criterion. However, the growth rates in The Gambia and Ghana were found to be catching-up with that of Nigeria, the reference country.

**Figure 3: real GDP growth rate time-varying parameters**





Note: The left axis represents the beta, and the right axis represents the alpha.

**Table 11: Estimates of the state space models for Inflation rate**

Countries	Coeff. Final State		Root MSE	Prob.
The Gambia	$\hat{a}$	0.9989	1.8815	0.5955
	$\hat{b}$	0.5816	0.1599	0.0003
Ghana	$\hat{a}$	-1.8318	2.8130	0.5149
	$\hat{b}$	-2.7073	0.2980	0.0000
Guinea	$\hat{a}$	0.8374	5.4573	0.8780
	$\hat{b}$	1.0427	0.4719	0.0272
Liberia	$\hat{a}$	-1.9077	6.0237	0.7515
	$\hat{b}$	1.2543	0.2576	0.0000
Sierra Leone	$\hat{a}$	-5.0549	3.3818	0.1350
	$\hat{b}$	-1.2649	0.3494	0.0003

Source: Author computation.

**Table 12: Estimates of the state space models for Exchange rate variation**

Countries	Coeff. Final State		Root MSE	Prob.
The Gambia	$\hat{a}$	19.8634	4.7749	0.0000
	$\hat{b}$	0.8414	0.0948	0.0000
Ghana	$\hat{a}$	23.5156	5.3775	0.0000
	$\hat{b}$	-0.4953	0.3204	0.1221
Guinea	$\hat{a}$	1.7165	4.2545	0.6866
	$\hat{b}$	0.9974	0.0867	0.0000
Liberia	$\hat{a}$	17.3328	4.0098	0.0000
	$\hat{b}$	1.0018	0.1360	0.0000
Sierra Leone	$\hat{a}$	52.2286	1.3844	0.0000
	$\hat{b}$	1.1088	0.0278	0.0000

Source: Author computation.

**Table 13: Estimates of the state space models for Real GDP growth rate**

Countries	Coeff. Final State		Root MSE	Prob.
The Gambia	$\hat{a}$	-0.1866	3.5728	0.9583
	$\hat{b}$	0.1575	1.0622	0.8821
Ghana	$\hat{a}$	0.2016	2.4204	0.9336
	$\hat{b}$	0.2679	0.5352	0.6167
Guinea	$\hat{a}$	0.0296	1.6151	0.9854
	$\hat{b}$	1.4045	0.2370	0.0000
Liberia	$\hat{a}$	-0.2415	20.8044	0.9907
	$\hat{b}$	0.8977	0.8095	0.2674
Sierra Leone	$\hat{a}$	0.3301	8.0935	0.9675
	$\hat{b}$	0.1981	0.4803	0.6799

Source: Author computation.

#### 5.4 Convergence rate and distance to convergence

For each country, it is possible to determine the speed at which each macroeconomic variable can take to catch up with the convergence criterion, all other things being equal. This notion refers to the concept of absolute beta convergence, due to Barro and Sala-i-Martin (1991). The rate of convergence indicates the speed at which, for a variable considered, an economy manages to close its gap with respect to the steady state. We estimate the average convergence rate  $\tau$  since the WAMZ implementation, as the arithmetic mean of the estimators of the dynamic coefficients of our equation (2):

$$\tau = \frac{\sum_{t=1}^T \beta_t}{T}$$

Where the  $\beta_t$  represent the dynamic estimates from the time-varying model. In addition, the half-life ( $\varphi$ ) can be defined as the time required for a country to manage to close half of its gap with respect to the convergence criterion of the variable. It is obtained as follows:

$$e^{-\tau\varphi} = \frac{1}{2}$$

From there, we derive the half-life  $\varphi$  as being:

$$\varphi = \frac{\ln 2}{\tau}$$

The convergence distance, estimated as  $d = 2\varphi$ , measures the time required for a country to converge with the criterion of the variable.

For WAMZ member countries, the rate of convergence and the distance to convergence of inflation rates, exchange rate variations and GDP growth rates are respectively displayed in Tables 9, 10 and 11. The results indicate slow rate of catching-up for all our nominal and real

variables, and hence high convergence distances, *ceteris paribus*. Thus, for the inflation rate, it will take an average of 45.64 years to close the gap with the convergence criterion of the monetary zone. The convergence rate of Liberia being the highest (1.2%), and that of Sierra Leone the lowest (0.54%), it will take 34.06 years and 63.83 years to converge to the criterion, *ceteris paribus*. The convergence distances of The Gambia, Ghana and Guinea are 43.34 years, 45.96 years, and 41.03 years respectively. Regarding the variation of the exchange rate, the average convergence distance of the area is 41.47 years, still with Liberia having the highest convergence rate (1.12%). To converge to the criterion, it would take 45.28 years, 44.98 years, 40.01 years, 36.89 years, and 40.18 years respectively for Gambia, Ghana, Guinea, Liberia, and Sierra Leone. The results for the real variable show an average of 643.08 years to reach the criterion retained. Guinea's GDP growth rate has the smallest convergence distance (441.20 years), while Sierra Leone has the largest distance to the chosen criterion (1,103.98 years). The Gambia, Ghana, and Liberia have convergence distances of 626.75 years, 537.25 years, and 506.42 years respectively.

**Table 14: Rate of convergence and distance to convergence of inflation rate**

Countries	Convergence rate (%)		Distance to convergence	
	<i>per month</i>	<i>per year</i>	<i>in months</i>	<i>in years</i>
The Gambia	0.90	10.75	520.11	43.34
Ghana	0.83	9.94	551.54	45.96
Guinea	0.97	11.59	492.36	41.03
Liberia	1.26	15.08	408.71	34.06
Sierra Leone	0.54	6.53	765.92	63.83

Source: Author computation.

**Table 15: Rate of convergence and distance to convergence of exchange rate variation**

Countries	Convergence rate (%)		Distance to convergence	
	<i>per month</i>	<i>per year</i>	<i>in months</i>	<i>in years</i>
The Gambia	0.84	10.14	543.37	45.28
Ghana	0.85	10.23	539.73	44.98
Guinea	1.00	11.99	480.16	40.01
Liberia	1.12	13.45	442.65	36.89
Sierra Leone	0.99	11.93	482.11	40.18

Source: Author computation.

**Table 16: Rate of convergence and distance to convergence of GDP growth rate**

Countries	Convergence rate (%)		Distance to convergence	
	<i>per month</i>	<i>per year</i>	<i>in months</i>	<i>in years</i>
The Gambia	-	0.70	-	626.75
Ghana	-	0.86	-	537.25
Guinea	-	1.13	-	441.20
Liberia	-	0.93	-	506.42
Sierra Leone	-	0.35	-	1,103.80

Source: Author computation.

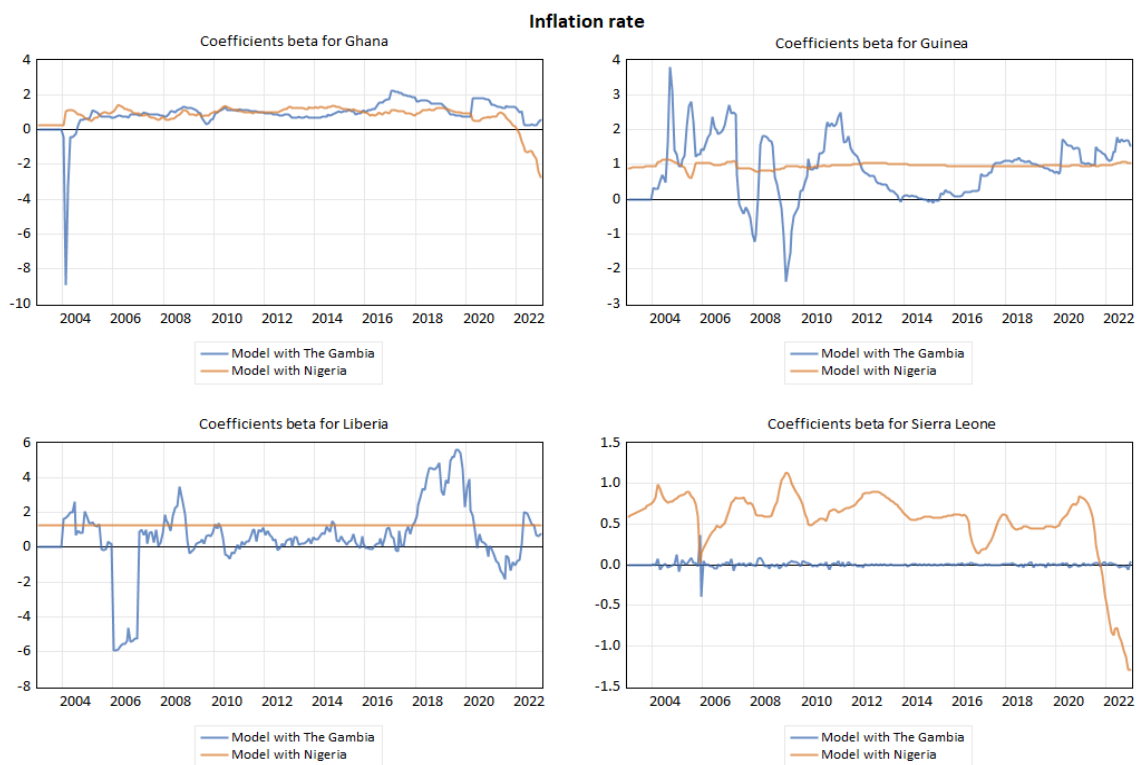


## 5.5 Robustness analysis

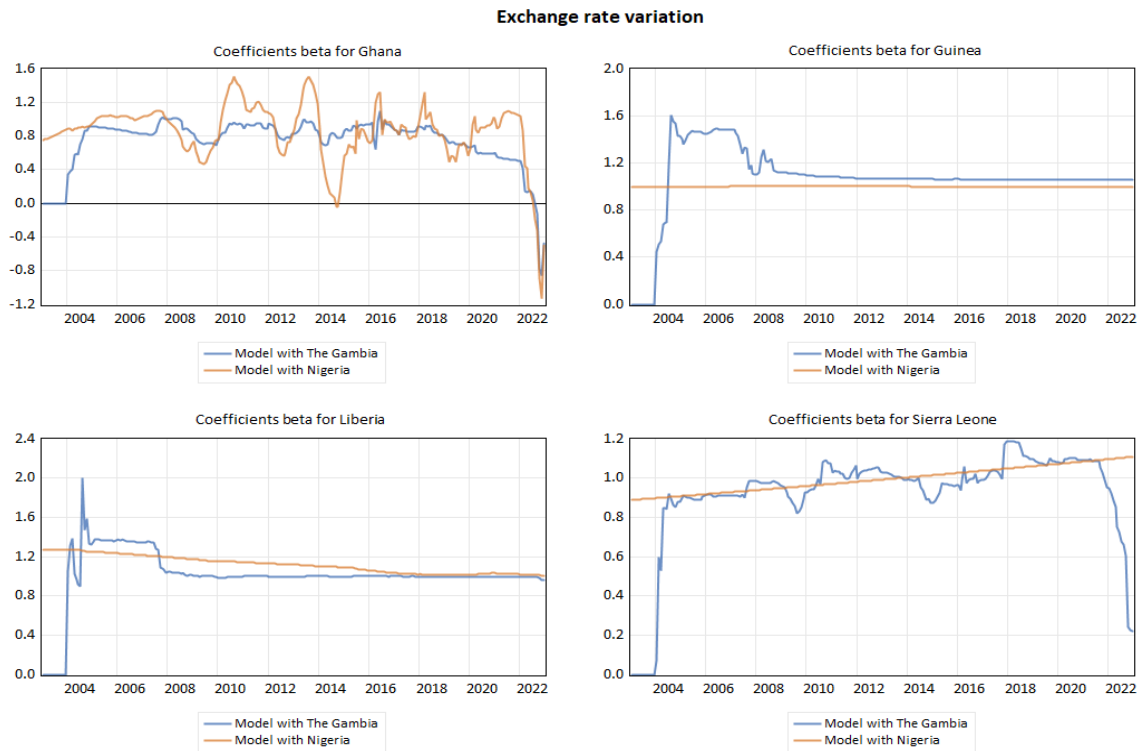
To check robustness of our result, we use alternative specifications of the models, with another country being used as reference. Specifically, instead of Nigeria we use The Gambia as the reference country in our time-varying parameters' model for the inflation and exchange rate models, and Ghana is chosen for the real convergence variable. The choice of two countries is based on their performance in meeting both the inflation and exchange rate variation criteria, and the quasi-criteria (for the real GDP growth). In the period 2001 – 2022, The Gambia has the lowest average inflation rate, and it has met more times the criteria of exchange rate variation, compared to all other member States, whilst Ghana experienced the relative highest average real GDP growth rate.

The results for each nominal and real convergence variable, which consist of graphs of the time-path for the member countries, are displayed in Figures 4 to 6, comparing both reference countries' models. We can see that the long-run relationships, represented by the coefficient betas in the models, have similar patterns, overall. The exceptions in the case of inflation for Liberia and Sierra Leone is because their coefficients are not statistically significant in the model using The Gambia as reference. As a result, we can conclude that our findings are globally robust to alternative specifications.

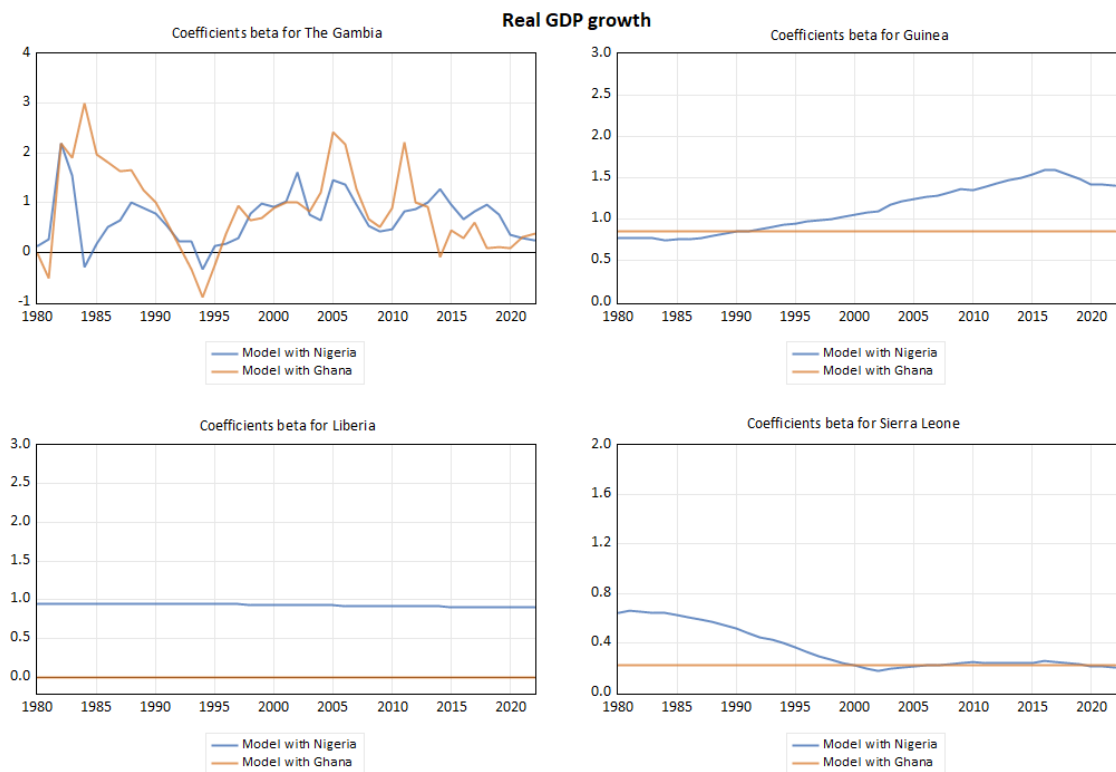
**Figure 4: Time-varying parameters beta for inflation in both specifications**



**Figure 5: Time-varying parameters beta for exchange rate variation in both specifications**



**Figure 6: Time-varying parameters beta for GDP growth rate in both specifications**



## **6.0 Conclusion and recommendations**

This study undertakes a comparative analysis of nominal and real convergence in the WAMZ using Nigeria as the reference country. Our robustness checks showed no significant differences in the findings when The Gambia and Ghana were used as reference countries. Regarding nominal convergence, specifically inflation and exchange rates, mixed results were observed. For inflation, The Gambia, Ghana, and Guinea initially converged towards the criteria until 2014, after which they diverged by the end of 2022. Guinea was the only country to consistently converge in exchange rates, while Sierra Leone converged until 2014 before diverging. Ghana and Liberia showed some catching up towards the criteria. The divergence post-2014 was linked to the 2014/2015 commodity price slump affecting export receipts of member countries. In terms of real growth rate, all countries diverged from the criteria, except Ghana, which converged towards Nigeria. The study notes that Nigeria's significantly larger GDP relative to other WAMZ countries likely influences convergence trends. The results indicate that episodes of divergence reveal periods of macroeconomic shocks, such as the 2014/2015 Ebola outbreak and commodity price slump. Additionally, the progress achieved up to 2019 was rolled back due to the adverse impact of the COVID-19 pandemic. This development reflects the vulnerability of WAMZ countries to external macroeconomic shocks, as seen in the individual countries' higher distances in terms of years to convergence. Consequently, policy actions aimed at reducing the susceptibility of member states to these shocks should be embraced, especially those that will enhance resilience. This includes, but is not limited to, reducing dependency on primary products, enhancing domestic productive capacity, and diversifying the export sector. In view of the observed slow convergence in real terms among WAMZ member states and relative improvement in nominal convergence, it is proposed that the region concentrate on nominal convergence. This is because nominal convergence, as stipulated by its primary and secondary convergence criteria, is already the agreed benchmark and can be easily measured and monitored in the short run.

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