Investigating the Sources of Asymmetric Growth and Inflation Shocks in the WAEMU Region

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Investigating the Sources of Asymmetric Growth and Inflation Shocks in the WAEMU Region

By

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Abstract

Empirical research has already established the existence of asymmetric shocks between the countries of the West African Economic and Monetary Union (WAEMU). The current study re-examines this issue by attempting to answer the following question: Are the asymmetries within the WAEMU region related to country specific shocks or do they stem from heterogeneous responses to common shocks?

To answer this question, the study relied on the estimation of a bivariate structural VAR model for each WAEMU member country using annual data from 1997 to 2019. The results reveal weak correlations between growth shocks in WAEMU countries, while price shocks appear relatively more correlated. This situation can be explained by the existence of persistent national factors that largely determine fluctuations in real gross domestic product (GDP) and the harmonized consumer price index within the Union.

Counterfactual analyses were conducted to ascertain what the symmetry of shocks would be if they had only a specific or common component. They show that the persistence and extent of country-specific factors contribute significantly to the differences in growth and inflation rates within the WAEMU region. Moreover, shocks common to the member countries of the Union explain most of the fluctuations in the real GDP and consumer price cycle within the Union. The observed national asymmetries would not be associated with heterogeneous responses to common shocks among the Union's member countries. Rather, they are due to the persistence and significance of specific national factors. Regressions carried out on panel data from the Union countries support the persistence over time of specific factors linked to growth and inflation.

Key words: monetary union, optimal monetary zone, asymmetric shocks, WAEMU.

JEL classification: E32, C33, F2, F44.

1. Introduction

Participation in a monetary union involves major economic stakes to the extent that monetary policy is a tool for economic adjustment and its management can promote or hinder a country's development efforts. The importance of these issues is underscored by the theory of optimal currency area (OCA). According to this theory, exchange rate flexibility can be an effective policy instrument, capable of accommodating temporary macroeconomic asymmetries between countries. However, a country joining a monetary union loses control over the exchange rate, which is an important tool that enables national authorities to implement systematic policies to compensate for asymmetric shocks or asymmetric transmission of common shocks (Eickmeier and Breitung, 2006).

In a monetary union context characterized by deferment of monetary policy to a supranational authority, poorly functioning adjustment mechanisms such as wage flexibility and labour mobility may increase membership costs (De Grauwe, 2000). In this respect, the optimality of renouncing national monetary sovereignty is directly related to the level of similarity of the structural characteristics of the union's member countries and their degree of integration.

According to Zdzienicka et al (2013), a shock that affects all members of a monetary union in a similar way can, in principle, be addressed by a common monetary policy or by a coordinated fiscal policy response. However, common monetary policy interventions cannot be an appropriate response to an asymmetric shock. For this type of shock, a fiscal policy response (national or via fiscal transfers) remains the primary available instrument.

Synchronization of business cycles of the member countries of a monetary union is, therefore, crucial if they are to derive greater benefit from their union membership. Indeed, a high degree of synchronization of business cycles between member states is supposed to allow a smooth functioning of a monetary union. According to Rogoff (1985) or Clarida et al (1999), a common monetary policy will respond more effectively to common shocks and its implementation will be easier when the economic cycles of member countries are less volatile and more synchronized. Similarly, Gayer (2007) argues that economic policy coordination would be easier and conducting a common monetary policy would be relatively easier when national business cycles are highly synchronized. To the contrary, a low degree of synchronization may increase the risk of asymmetric shocks and asymmetric transmission of common monetary policy measures across countries of the union (Altavilla, 2004).

These theoretical and empirical literature findings raise questions about the extent to which recent macroeconomic developments in the WAEMU region, particularly

those related to the convergence efforts initiated since 1999, have impacted on the degree of shock symmetry between countries.

Monetary policy in the WAEMU region operates within an institutional framework governed by the monetary cooperation agreements with France. These agreements are governed by four fundamental principles. These are: the guarantee of unlimited convertibility for the CFA franc issued by the Central Bank of West African States (BCEAO[1]); the fixed parity with the Euro; free transferability within the CFA zone; and the centralization of foreign exchange reserves. In return for the unlimited convertibility guaranteed by the French Ministry of Finance, BCEAO deposits 50% of its foreign exchange reserves in the "operations account", a special account held by the French Ministry of Finance. These agreements provide the exchange rate regime with elements of both a monetary union regime and a fixed exchange rate regime. Indeed, the exchange rate of the local currency, the CFA franc, is strictly fixed in relation to the French franc, and then to the euro from January 1999, following the adoption of the euro by France. In addition, monetary issuance is limited by the amount of foreign exchange reserves.

Overall, countries in the Union have been able to take advantage of their macroeconomic stability, improved national political institutions, investment efforts and favourable commodity prices to record strong and sustained growth performances in recent years (over 6% since 2012). In addition, the link to the Euro has permitted a low level of inflation (less than 3% per year on average). Moreover, the fiscal discipline imposed through the convergence criteria has made it possible, in a context of improving terms of trade, to maintain budget deficit ratios below 3%.

However, the WAEMU region does not meet all the criteria necessary for an optimal currency zone. According to BCEAO (2012), the economic cycles of WAEMU countries are not synchronized, due to several structural factors. The structure of their economies subjects them to specific internal and external shocks. Indeed, all these economies are highly concentrated in the production and, above all, the export of a limited range of primary goods with little processing. Such an economic structure makes the countries of the Union vulnerable to external shocks and to climatic conditions to the extent that agricultural production depends on rainfall.[3] These shocks are reportedly frequent and, to a large extent, asymmetric (Basdevant et al, 2015). In addition, the sub-region has also experienced recurrent socio-political turbulence that has had a significant impact on economic activity (IMF, 2013b)[4].

On the other hand, there are clear signs of heterogeneity within the Union and economic integration in the region has been limited (IMF, 2013a). More specifically, the economic structures in place are still characterized by disparities. Indeed, the Sahelian economies of the Union (Burkina, Mali and Niger)—highly susceptible to climatic hazards—are different from the coastal economies whose performance depends greatly on external trade (Benin and Togo). Côte d'Ivoire and Senegal form a third group of economies that are relatively more industrialized and strongly dominated by the tertiary sector and primarily by activities in the service sector.

These structural characteristics have warranted the establishment of convergence policies within the Union. Efforts undertaken by the Union States within the framework

of the Convergence, Stability, Growth and Solidarity Pact (CSGP) constitute potential levers to bring the economic cycles of the different countries of the Union into a common state of play. This multilateral surveillance mechanism, which has been in place since 1999, includes key criteria relating to the ratio of the basic budget balance to nominal GDP (≤3%), the average annual inflation rate (≤3%), the ratio of outstanding domestic and external debt to nominal gross domestic product (GDP) (<70%) and the non-accumulation of payment arrears. This could contribute to a synchronization of economic cycles. Indeed, according to Frankel and Rose (1998), business cycle synchronization can be endogenous and increase over time with the level of economic integration within a monetary union. In particular, the efforts made since 1999 within the framework of the Convergence, Stability, Growth and Solidarity Pact (CSGP) could have favoured a better synchronization of the economic cycles among WAEMU countries.

This study focuses on the recent asymmetry of shocks between WAEMU member countries. This emphasis is due to the macroeconomic reforms carried out during this period, which could bring the national economic cycles within the Union into convergence. Furthermore, the paper attempts to answer a question which was not addressed by previous studies. Indeed, studies dealing with shock asymmetry in the WAEMU region have been limited to calculating the correlation between shocks affecting the different member countries of the Union. However, these empirical results give little indication as to the sources of the asymmetry of shocks within the Union.

Thus, the objective of this was twofold. First, it sought to reassess the asymmetry of shocks in the WAEMU region, based on annual data taken from 1997 to 2019. Second, it looks at the sources of the asymmetry by assessing the relative contributions of common and country-specific shocks to economic growth and inflation fluctuations.

In summary, this study differs from the previous ones in two main aspects. First, it uses a methodological approach borrowed from Giannone and Reichlin (2006) and Stavrev (2007, 2008) to explore the sources of shock asymmetries between WAEMU member countries. These are two bivariate structural vector autoregressive (SVAR) model for each member country of the Union, one for growth and another for inflation. These models are estimated using data from 1997 to 2019. Second, the study helps answer the following question: is the asymmetry of shocks within the WAEMU region driven by shocks specific to member countries or by varied responses to common shocks? Thirdly, the impact of convergence policy reforms and the persistence of country-specific factors in the Union are addressed. The rest of the paper is presented as follows. Section 2 is devoted to the empirical literature review. The stylized facts are set out in Section 3. Section 4 is concerned with the methodological approach and estimation results. An analysis of the persistence of country-specific factors is conducted in Section 5. The last section provides the conclusion.

2. Empirical literature review

The transition to the Euro and the expansion of the European Union to include the Central and Eastern European Countries (CEECs) have generated a rich and varied literature on the asymmetry of macroeconomic shocks in Europe. An important research question has been whether economic and monetary integration efforts in the Union have led to a high degree of similarity in European business cycles in recent years. Overall, the literature on the Euro zone suggests that there has been a greater degree of synchronization of cycles after the launch of the Euro (Benalal et al, 2006; Bower and Guillemineau, 2006; Giannone and Reichlin, 2006; Giannone et al, 2009).

The issue of cycle convergence has also prompted empirical investigations in sub-Saharan African countries in general and the WAEMU region in particular. However, the literature on this region of the world is relatively less developed. The main empirical results available are presented here. N'Goma (2000) identifies supply and demand shocks (real and nominal) and examines their influence on macroeconomic variables in 11 countries of the CFA zone. In general, the results show that supply and demand shocks have symmetric effects on macroeconomic variables in all the countries studied. However, only monetary shocks are significantly attached to the common component. N'Goma (2000) concludes that the countries of the CFA monetary zone are more similar in terms of their currencies than in terms of their productive structures. Fielding and Shields (2001) note a positive and significant correlation between national inflation shocks. By focusing on inflation shocks alone, a hasty conclusion could establish a probably low cost of participating in the currency zone. Indeed, an inverse conclusion could be drawn when supply shocks are taken into account. These do not appear to be similar across all countries. Houssa (2008) agrees, noting the existence of asymmetric supply shocks; such a situation may make it difficult to establish a common currency for the West African Monetary Zone (WAMZ[5]) and WAEMU countries. However, like Fielding and Shields (2001), Houssa (2008) finds that demand shocks are more similar in WAEMU countries. Such a result could be attributed to the sharing of a common currency. All existing studies suggest the existence of strong national divergences in macroeconomic structures. However, the homogeneity of the partner economies within the WAEMU region is undoubtedly a necessary condition for the proper functioning of the monetary zone.

Qureshi and Tsangarides (2008) analysed the relevance of the proposed formation of currency unions in West Africa using a set of convergence indicators and the theory of optimal currency zones. To do so, they explore the synchronization of output and terms of trade shocks, exchange rate variability, inflation, regional trade intensity

of individual countries, fiscal balance and debt service requirements. Their analysis over the periods 1990–2004 and 1995–2004 reveals considerable differences in the economic characteristics of the member countries, particularly the WAMZ countries. Within WAMZ, there is a significant lack of homogeneity between Nigeria and Ghana, which appear as independent singletons. The WAMZ countries do not form a cluster with the WAEMU countries. These findings cast doubts on the feasibility of a monetary union including all WAMZ countries and, more importantly, on the prospects for wider monetary integration within the Economic Community of West African States (ECOWAS). Furthermore, when the countries of West and Central Africa are considered together, a great heterogeneity is noted within the CFA franc zone. However, some interesting similarities are found between Central African and WAMZ countries. These countries tend to form a group.

Gammadigbé (2012) explores the extent to which business cycles are synchronized in the WAEMU using annual real GDP data from 1970 to 2010. The study concludes that real business cycles in the Union are weakly synchronized. In particular, the real business cycles of Côte d'Ivoire, Mali and Niger are most in line with that of the WAEMU region as a whole. A significant but weak correlation is observed between the cycles of Burkina, Senegal and Togo and that of the Union. Only Benin's business cycle is inconsistent with that of the WAEMU region. The study concludes that the use of a common monetary policy in response to asymmetric shocks would be costly.

In contrast, based on data from 1980–2004, the study by Diagne and Niang (2008) reveals the existence of a fairly significant economic co-movement between most of the countries in the zone despite weakness in their trade relations. These co-movements would be strongly "dictated" by the "leading" countries, namely Côte d'Ivoire and Cameroon, whose common components are strongly correlated with those of the CFA zone as a whole. However, some countries such as Democratic Republic of Congo, Gabon and Guinea-Bissau seem to have economic cycles that are less influenced by the CFA zone as a whole. The analysis conducted at the level of the two sub-zones confirms that the business cycle of Côte d'Ivoire and Cameroon has a strong influence on that of the WAEMU and the CEMAC zones respectively. The CEMAC zone seems to have a configuration less similar to that of the group of countries in this monetary area. For example, Chad seems to be much less influenced by the CEMAC business cycle than by that of the CFA zone as a whole. This is not the case for the Democratic Republic of Congo , whose economic fluctuations remain closely linked to those of the CEMAC sub-zone.

This finding is similar to that of Sarr and Ndiaye (2011). Their sigma-convergence tests of fiscal policies in the WAEMU zone over the period 1980 to 2005 suggest the existence of a convergence pattern of fiscal policies and shocks. The analysis is completed by estimating a structural vector autoregressive and time-varying parameter models to highlight the degree of symmetry and dynamic convergence of fiscal shocks.

It appears that most fiscal variables converged during the period 1995-2005 corresponding to the implementation of the convergence criteria, despite contrasting developments. Moreover, policy heterogeneity would exist in relation to national fiscal policy asymmetries.

Similar results are obtained by Bamba (2004). The process of fiscal policy convergence is well highlighted; however, the degree and dynamics of this process vary according to the fiscal variables. The institutional framework put in place by the WAEMU Treaty to promote convergence of the zone's economies is insufficient. The divergence of economic structures calls for increased recourse to fiscal policy to stabilize shocks. The study of the (a)symmetry and convergence of the various shocks within the zone underscores the presence of two sources of heterogeneity in the zone: structural heterogeneity, reflected in the asymmetric transmission of the various shocks (budgetary shocks, supply shocks, demand shocks) at the national level; and political heterogeneity, reflected in asymmetries in the conduct of national budgetary policies.

Dedehouanou (2009) identifies and evaluates the degree of asymmetry of shocks using a triple distribution (supply shocks, real demand shocks and monetary shocks). His results indicate that the degree of asymmetry of the three types of shocks is remarkable in most cases. Structural shocks are more specific to member countries, with the common regional component of each type of shock hardly exceeding 50%. Based on these results, the study assesses the usefulness of potential non-market adjustment mechanisms. Public finances in WAEMU countries could play a role in cyclical stabilization. However, the budget deficit and debt burden constraints of WAEMU countries would limit their fiscal autonomy and the capacity of public finances to play this role.

Zdzienicka et al (2013) show that shocks have been frequent in the WAEMU region and often asymmetric. Some of them are political in nature, as illustrated by the crises experienced in recent years in Côte d'Ivoire, Guinea Bissau and Mali. Exogenous shocks of various kinds: climatic (droughts and floods), with a heavy toll on the population and agriculture, but also economic (e.g., terms of trade fluctuations), with a significant impact on key sectors and the cost of living. In general, economic cycles within the WAEMU region appear to be poorly synchronized. Indeed, over the period 1980–2012, business cycle synchronization in the region averaged 0.2, ranging from about 0.2 for Togo (the least synchronized economy) to about 0.5 for Mali and 0.6 for Burkina Faso (the most synchronized economies). The correlation between business cycles would tend to be higher in landlocked countries (Burkina Faso, Mali and Niger), more dependent on intra-WAEMU trade, and lower in countries with higher extra-regional trade links (Benin, Senegal and Togo). The economic cycles of many WAEMU countries have become more synchronized with those of the Euro area, especially in the recent period (except for Côte d'Ivoire and Togo).

Basdevant et al (2015) also argue that WAEMU countries are prone to frequent and asymmetric shocks. These countries appear to be poorly diversified and vulnerable to external shocks. Shock smoothing mechanisms at the regional level are limited.

At the national level, the capacity of member countries to cope with shocks is also constrained by limited fiscal space and the need to preserve external stability. In addition, disparities exist between the economic structures of these countries. Economic integration in the region has been limited. In this context, national economic cycles within the Union have not been well aligned. Such asymmetry would diminish over time. Indeed, Sarr and Wade (2015) show that the degree of asymmetry of these shocks diminishes over time. Moreover, supply and monetary shocks are divergent, while demand shocks are convergent. Moreover, fiscal shocks appear to be divergent despite the CSGP concluded between the Union's member countries.

At the South African Development Community (SADC) level, Kabundi and Loots (2007) present strong and significant evidence of co-movement or synchronization of the South African business cycle with those of Swaziland, Botswana, Zimbabwe, DRC, Mauritius, Lesotho and Angola. Moderate but still significant synchronization is also evident with Mozambique, Mauritius and Namibia. However, no significant difference in co-movement exists between the business cycle of South Africa and those of Malawi and Zambia respectively.

Zehirun et al (2015) study the probability of success of a proposed monetary union in SADC. The results, using data from 1995 to 2012, confirm the success of a monetary union in the region, with the exception of Angola and Mauritius. These two countries may exhibit asymmetry in response to external shocks, disqualifying them from an Optimal Currency Area (OCA) at the SADC level. Similar results were reported by Zehirun et al (2014). They found that 10 of the 15 SADC member countries potentially met the OCA criteria, based on the symmetry of their business cycles for the period 1970–2010. However, the evidence based on bilateral co-movements in the business cycles of SADC countries raises doubts. Indeed, Mauritius, Mozambique, DRC, Seychelles, Tanzania, Zambia and Zimbabwe have a relatively high intensity of co-movements in their business cycles compared to the rest of the SADC members. This is not the case for the other member countries. The authors therefore conclude that macroeconomic convergence is not a sufficient condition for all member states to enter the monetary union. A common monetary policy will not be optimal for all countries in the region, especially in the short term.

Drummond et al (2015) explore the susceptibility of countries in the East African Community (EAC)— Burundi, Kenya, Rwanda, Tanzania and Uganda — to asymmetric shocks. The paper finds that despite some similarities in the structures of the EAC economies, the EAC is even more susceptible to asymmetric shocks. Cluster analysis suggests that, from the point of view of an optimal currency area, the differences between the EAC economies remain significant.

In summary, the literature review concludes that existing empirical analyses demonstrate the existence of shock asymmetries within African economic groupings. A summary of this work is presented in Annex A. However, the existing empirical literature does not investigate the sources of the asymmetries found. This study complements the literature by determining the explanatory factors of shock asymmetry in the case of the WAEMU zone.

3. Stylized facts of the WAEMU economies

WAEMU countries all depend on the production and export of primary goods with minimal processing. Beyond these common characteristics, disparities remain between the member economies of the Union. Indeed, data in Table 1 suggest an important role of the primary sector in GDP in all countries except Senegal (14.53%). The relative contribution of the secondary sector to national production in some countries, notably Guinea Bissau (13.46%), Benin (17.24%) and Togo (17.18%), is far below the sub-regional average (see Table 1). Côte d'Ivoire and Senegal are the economies of the Union with a relatively more advanced level of industrial development, despite the relatively high contribution of the secondary sector in Burkina Faso (22.41%).

Table 1. Contribution of economic sectors to GDP (Average from 1997 to 2019) in %

	Benin	Burkina Faso	Côte d'Ivoire	Guinea Bissau	Mali	Niger		Togo	WAEMU
Primary Sector	27.03	25.25	19.68	36.84	31.00	34.35	14.53	24.80	22.53
Secondary Sector	17.24	22.41	20.76	13.46	21.48	19.68	23.96	17.18	20.85
Tertiary Sector	55.73	52.34	59.57	49.70	47.52	45.96	61.51	58.01	56.62

Source: Author's calculation based on BCEAO statistical publications

Disparities in national production structures are explained by differences in levels of industrial development and differences in natural resource endowments. Such disparities are also present in trade patterns. Thus, these differences could determine growth and inflation performance (see, e.g., Campa and Gonzalez, 2006). Indeed, several aspects of the trade in WAEMU show differences that could justify their differential exposure to external shocks. The heterogeneity of national trade structures is apparent in the geographical orientation of trade (see Table 2), the composition of exported products (see Table 3) and the participation of countries in intra-regional trade. Under these conditions, the evolution of the prices of the products exported by the member countries of the Union could affect them in a non-symmetrical way.

Table 2. Geographical distribution of trade in the WAEMU zone (relative share in percentage)

Benin	Burkina Faso	Côte d'Ivoire	Guinea Bissau	Mali	Niger	Senegal	Togo
Africa (77.0%)	Europe (63.3%)	Europe (42.3%)	Asia (96.1%)	Europe (33.7%)	Europe (28.4%)	Africa (49.7%)	Africa (68.6%)
WAEMU (8.7%)	Asia (19.5%)	Africa (23.5%)	Africa (2.7%)	Africa (47.6%)	Africa (49.8%)	WAEMU (33.3%)	WAEMU (51.2%)
Asia (20.1%)	Africa (11.2%)	WAEMU (13.5%)	WAEMU (1.8%)	WAEMU (14.1%)	WAEMU (21.6%)	Europe (22.1%)	Europe (9.8%)
Europe (2.1%)	WAEMU (3.7%)	Asia (19.9%)	Europe (0.7%)	Asia (17.9%)	Asia (16.8%)	Asia (18.7%)	Asia (18.2%)
America (0.7%)		America (12.8%)			America (4.9%)		America (1.8%)
							Oceania (1.6%)

Source : Data drawn from the reports on the 2018 balance of payments of WAEMU countries.

Table 3. Structure of export composition (relative share in percentage)

Benin	Burkina Faso	Côte d'Ivoire	Guinea Bissau	Mali	Niger	Senegal	**Togo**
Cotton (56,9%)	Gold (68.0%)	Cocoa beans (27.5%)	Cashew nuts (67.4%)	Gold (69,7%)	Uranium (17.5%)	Oil products (16.9%)	Industrial products (45.7%)
Cashew nuts (14.4%)	Cotton (11,4%)	Oil products (14.5%)	Timber (31,7%)	Cotton (13,6%)	Agro-pastoral products (35.7%)	Fishery products (17.6%)	Mining products (19.5%)
Iron and steel (3.4%)	Cashew nuts (5.3%)	Processed cocoa (11.1%)		Live animals (5.4%)	Refined oil (19.4%)	Chemical products (12.4%)	Agricultural products (19.8%)
Oil products (2.7%)	Zinc (4.3%)	Cashew nuts (8.9%)		Fertilizers (1.7%)	Gold (3,8%)	Cement (4,9%)	Oil products (9.0%)
Timber (0.7%)	Sesame nuts (3.2%)	Gold (6,8%)		Others (9,6%)	Others (23,6%)	Groundnut products (3.5%)	Others (6,0%)
Others (21,8%)		Rubber (6.4%)				others (37,0%)	

Source: Data drawn from the reports on the 2018 balance of payments of WAEMU countries.

Furthermore, these disparities appear to be coupled with a divergence in macroeconomic performance. This divergence can be illustrated by descriptive analysis and measurement of the correlation between key economic indicators of the member countries.

Despite decades of experience with exchange rate regimes, neither any symmetry in national structures nor homogeneity in their macroeconomic performance seem to exist.

The heterogeneity of performance is explored by means of graphical analysis and computation of correlations between key economic indicators.

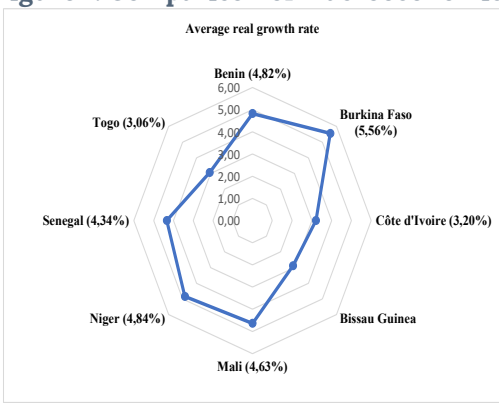
Graphical analysis of macroeconomic performance gaps

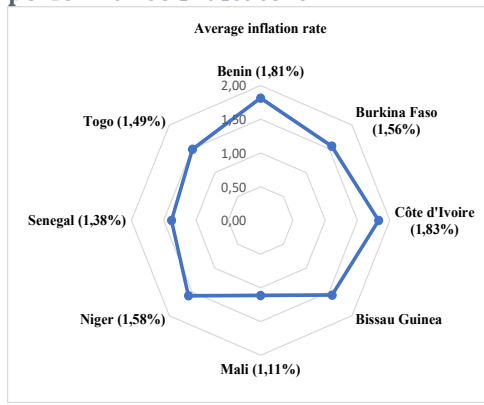
Disparities in national performance are examined by looking at five indicators. These are: the real GDP growth rate; the annual inflation rate; the basic fiscal balance/GDP ratio; the real effective exchange rate; and the external debt/GDP ratio. Polygons are constructed from individual average annual data from the eight WAEMU member countries. Problems of scale could make it difficult to compare growth rates and ratios if they were represented on the same graph. This problem is avoided by constructing the polygons by indicator. The national values of the indicators considered are obtained from the averages over the period 1997–2019.

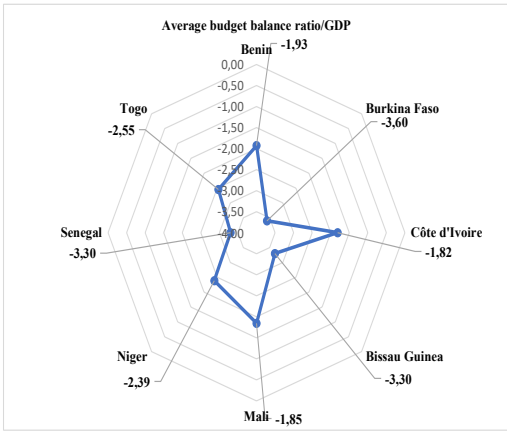
The octagons tracing the distribution of average performance appear uneven. They reflect a divergence in national performance among the countries of the Union. In terms of real GDP growth, Burkina Faso clearly stands out from the rest of the Union with an average growth rate of 5.56%, compared with 2.98% for Guinea Bissau, 3.06% for Togo and 3.20% for Côte d'Ivoire. The relatively low average real growth rates in Guinea Bissau, Togo and Côte d'Ivoire can be explained by the socio-political unrest they experienced during the study period. Similarly, the polygon showing real effective exchange rates is very inconsistent, reflecting differences in the international competitiveness of the Union's economies and their exposure to various trade shocks. The same disparities are observed when the polygons representing the primary balance/GDP and external debt/GDP are considered (see Figure 1). Only the national inflation rates show relatively less variation. Their average national values are in the range of 1.11% and 1.83%, respectively in Mali and Côte d'Ivoire.

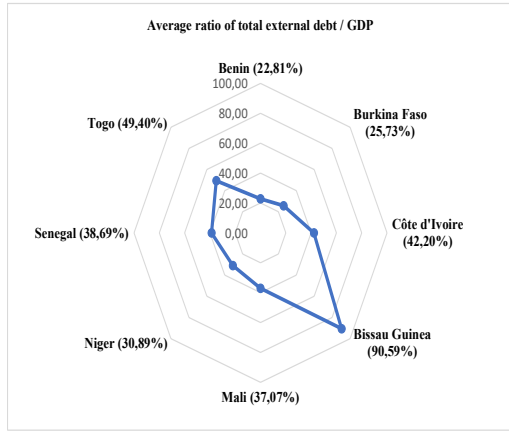
In summary, this graphical analysis (Figure 1) reveals the existence of gaps between national macroeconomic performances. In addition to this, national disparities are investigated, based on an analysis of the degree of business cycle and price synchronization.

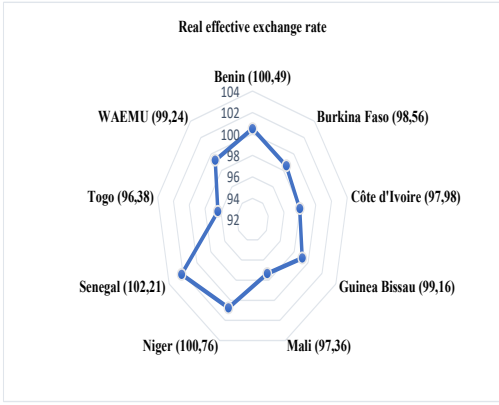
Figure 1. Comparison of macroeconomic performance indicators[6]











Note: Author's calculations from statistical publications of the Central Bank (BCEAO).

Analysis of the degree of synchronization of business cycles and prices within the WAEMU

In Mundell's pioneering analysis, the synchronization of economic cycles appears to be a crucial criterion for the establishment of an optimal currency zone (OMZ). Indeed, according to this theory of OMZ, the optimality of a monetary union depends strongly on the degree of synchronization of business cycles. The examination of the degree of synchronization between the business and price cycles within the WAEMU is therefore important. It is conducted using the Darvas et al (2005) approach. It consists of an analysis of the bilateral correlation between real activity in country i and country j over the study period, using real GDP and the unemployment rate as proxies for real economic activity. In the absence of a series on the unemployment rate in the WAEMU member countries, this study uses real GDP as an indicator of real economic activity. The analysis of business cycle synchronization is supported by price cycle analysis. To this end, the Harmonized Consumer Price Index (HCPI) is used.

Darvas et al (2005) examine the indicators in their log form. Cycle fluctuations are captured by considering: (1) the first-order difference of the business indicators; and (2) the difference between the values of these indicators and their respective Hodrick-Prescott filters. To do so, the study uses annual real GDP and HICP data for the period 1997–2019.

From a theoretical point of view, synchronization of business cycles of two countries would result in a positive and significant correlation. Calculations based on the first-order difference in real GDP show that fluctuations in real GDP are weakly correlated between the Union countries. Of a total of 28 correlations, 15 are positive, of which only two emerge as significant. For those country pairs with a positive correlation, the business cycles are relatively congruent. However, in 46.42% of cases, the correlations are negative between the cycles of WAEMU member countries. This is the case, for example, in Benin, on the one hand, and in Burkina, Guinea Bissau, Mali and Togo, on the other.) For this group of countries, fluctuations in activity are not synchronized, that is, they are in opposite phases.

Measuring business cycle synchronicity on the basis of the difference between real GDP and its associated Hodrick-Prescott filter leads, with a few exceptions, to similar results. Indeed, the two-way correlations appear positive in 78.57% of cases. These correlations are positive and significant at a 5% risk of error threshold in 14.29% of cases. This proportion increases to 25.00% when the risk of error threshold is 10%.

In contrast, fluctuations in the Harmonized Consumer Price Index (HCPI) for WAEMU member countries appear to be relatively more synchronous compared to those of real GDP. Indeed, the bilateral correlations are all positive. Moreover, these correlations are significant when price fluctuations are determined by the difference between the HCPIs and the Hodrick-Prescott filter associated with them (see Tables 4.c and 4.d). Therefore, prices seem to evolve much more closely in the WAEMU countries. Such a result can be attributed to the sharing of a common currency and the similarity of the price shocks that affect these countries.

Table 4.a. Correlation matrix of real GDP fluctuations (first order difference)

Country	Benin	Burkina Faso	Côte d'Ivoire	Guinea Bissau	Mali	Niger	Senegal	Togo
Benin	1.00							
	-							
Burkina Faso	-0.02	1.00						
	0.9457	-						
Côte d'Ivoire	0.21	0.01	1.00					
	0.3305	***0.9612***	-					
Guinea Bissau	-0.37	-0.03	-0.15	1.00				
	0.0807	***0.8784***	***0.4811***	-				
Mali	-0.09	0.42	-0.07	-0.02	1.00			
	0.6991	***0.0479***	***0.7572***	***0.9297***	-			
Niger	-0.03	0.61	0.37	-0.39	0.26	1.00		
	0.8752	***0.002***	***0.0811***	***0.0664***	***0.2281***	-		
Senegal	0.2	0.44	0.39	-0.08	0.34	0.17	1.00	
	0.3591	***0.0373***	***0.0644***	***0.7002***	***0.1095***	***0.4293***	-	
Togo	-0.19	0.04	0.33	0.281293	-0.02	0.15	-0.09	1.00
	0.3965	***0.8513***	***0.1239***	***0.1935***	***0.9233***	***0.4941***	***0.685***	-
WAEMU	0.2	0.19	0.94	-0.15	0.08	0.49	0.45	0.31
	0.3485	***0.3826***	***0.0000***	***0.4832***	***0.7063***	***0.0171***	***0.0297***	***0.1471***

Note: Author's calculation based on statistical publications of the Central Bank (BCEAO).

Values in bold and italics are the probabilities associated with the correlation coefficients.

Table4.b.CorrelationmatrixofrealGDPfluctuations(differencewithHodrick-Prescottfilter)

Country	Benin	Burkina Faso	Côte d'Ivoire	Guinea Bissau	Mali	Niger	Senegal	Togo
Benin	1.00							
	-							
Burkina Faso	-0.12	1.00						
	0.5986	-						
Côte d'Ivoire	0.57	0.15	1.00					
	0.0045	***0.4934***	-					
Guinea Bissau	-0.3	0.11	-0.26	1.00				
	0.159	***0.604***	***0.2351***	-				
Mali	-0.13	0.18	0.16	0.21	1.00			
	0.5608	***0.4205***	***0.455***	***0.325***	-			
Niger	0.04	0.61	0.36	-0.33	0.07	1.00		
	0.855	***0.0018***	***0.0959***	***0.1237***	***0.7407***	-		
Senegal	0.27	0.39	0.57	0.05	0.48	0.07	1.00	
	0.2104	***0.0652***	***0.0044***	***0.8372***	***0.0201***	***0.7587***	-	
Togo	0.02	0.18	0.09	0.13	0.04	0.39	-0.2	1.00
	0.9287	***0.4036***	***0.6705***	***0.5448***	***0.8465***	***0.0642***	***0.3659***	-
WAEMU	0.52	0.42	0.94	-0.18	0.29	0.5	0.68	0.18
	0.0117	***0.0442***	***0.0000***	***0.4151***	***0.1790***	***0.0159***	***0.0003***	***0.4123***

Note: Author's calculation based on statistical publications of the Central Bank (BCEAO)

Values in bold and italics are the probabilities associated with the correlation coefficients.

Table 4.c. Correlation matrix of price changes (first order difference)

Country	Benin	Burkina Faso	Côte d'Ivoire	Guinea Bissau	Mali	Niger	Senegal	Togo
Benin	1.00							

Burkina Faso	0.86	1.00						
	0.0000	-----						
Côte d'Ivoire	0.87	0.76	1.00					
	0.0000	***0.0000***	-----					
Guinea Bissau	0.34	0.41	0.35	1.00				
	0.1089	***0.0541***	***0.0982***	-----				
Mali	0.9	0.86	0.83	0.28	1.00			
	0.0000	***0.0000***	***0.0000***	***0.2025***	-----			
Niger	0.65	0.85	0.62	0.52	0.65	1.00		
	0.0008	***0.0000***	***0.0017***	***0.0103***	***0.0007***	-----		
Senegal	0.52	0.52	0.55	0.82	0.48	0.54	1.00	
	0.0107	***0.0109***	***0.0069***	***0.0000***	***0.0192***	***0.0079***	-----	
Togo	0.84	0.76	0.85	0.31	0.91	0.65	0.42	1.00
	0.0000	***0.0000***	***0.0000***	***0.1526***	***0.0000***	***0.0007***	***0.0433***	-----
WAEMU	0.93	0.86	0.96	0.44	0.92	0.71	0.63	0.91
	0.0000	***0.0000***	***0.0000***	***0.0367***	***0.0000***	***0.0001***	***0.0013***	***0.0000***

Note: Author's calculation based on statistical publications of the Central Bank (BCEAO)

Values in bold and italics are the probabilities associated with the correlation coefficients.

Table 4.d. Correlation matrix of price changes (difference with Hodrick-Prescott filter)

Country	Benin	Burkina Faso	Côte d'Ivoire	Guinea Bissau	Mali	Niger	Senegal	Togo
Benin	1.00							
	-							
Burkina Faso	0.81	1.00						
	0.0000	-						
Côte d'Ivoire	0.85	0.72	1.00					
	0.0000	***0.0001***	-					
Guinea Bissau	0.63	0.63	0.55	1.00				
	0.001	***0.0009***	***0.0051***	-				
Mali	0.89	0.85	0.86	0.52	1.00			
	0.0000	***0.0000***	***0.0000***	***0.0091***	-			
Niger	0.69	0.87	0.61	0.68	0.72	1.00		
	0.0002	***0.0000***	***0.0015***	***0.0003***	***0.0001***	-		
Senegal	0.62	0.65	0.55	0.87	0.58	0.64	1.00	
	0.0012	***0.0006***	***0.0051***	***0.0000***	***0.0027***	***0.0007***	-	
Togo	0.82	0.78	0.86	0.55	0.92	0.73	0.55	1.00
	0.0000	***0.0000***	***0.0000***	***0.0056***	***0.0000***	***0.0001***	***0.0058***	-
WAEMU	0.91	0.87	0.95	0.68	0.93	0.76	0.7	0.92
	0.0000	***0.0000***	***0.0000***	***0.0003***	***0.0000***	***0.0000***	***0.0001***	***0.0000***

Note: Author's calculation based on statistical publications of the Central Bank (BCEAO)
Values in bold and italics are the probabilities associated with the correlation coefficients.

Generally speaking, there seems to be a relatively stronger positive correlation between fluctuations in the HCPI for WAEMU countries than in real GDP. Thus, the results are generally mixed and sometimes not very favourable to a real convergence of the economies of the Union. However, the positive correlations between inflation rates allows us to hypothesize that prices within the WAEMU economies are affected by common shocks. Conversely, the low or even negative bilateral correlation coefficients between fluctuations in real GDP suggest that production variations are largely determined by specific shocks.

4. Study methodology and results

Study methodology

Studies on the symmetry of shocks between WAEMU countries have mainly relied on two approaches. The first consists of a simple calculation of correlations between key economic indicators such as the growth rate or inflation. The second approach is based on the calculation of correlations between structural shocks extracted from a structural VAR model, with long-term restrictions of Blanchard and Quah (1989), as developed by Clarida and Jordi (1994). A variant of this second methodology developed by Boone (1997) applies the Kalman filter to evaluate the dynamics of shocks over time. This methodological innovation is used by Sarr and Wade (2015) to explore the convergence dynamics of macroeconomic shocks in the WAEMU region. Although relevant, these methodologies remain silent on the sources of asymmetries between WAEMU countries. Indeed, they provide little information on the specific origin of shocks versus heterogeneous responses to shocks common to the countries of the Union.

The approach used in this study fills in this gap. It allows us to explore the sources of asymmetry in macroeconomic shocks between WAEMU countries. The asymmetries can be due either to idiosyncratic shocks (specific to the countries) or to heterogeneous responses to common shocks. The existence of idiosyncratic shocks would reflect heterogeneous structural characteristics between the economies of a monetary union and their inadequate integration. Thus, the degree of synchronization of economic cycles would depend on the similarity of economic structure, trade and financial openness, as well as on the presence and type of idiosyncratic shocks and the effectiveness of adjustment mechanisms in dealing with such shocks (De Grauwe, 2005).

From this point of view, the methodology used consists of assessing the relative importance of asymmetric shocks, that is, determining the relative contribution of the specific component of shocks and that of the varied responses to common shocks in explaining the asymmetries observed. This methodology is borrowed from Giannone and Reichlin (2006) and Stavrev (2007, 2008). They estimate the relative importance of common and specific shocks by using two bivariate VARs for each Euro zone country, one for inflation and another for growth.

VAR modelling requires that a prior analysis be performed on the data to study the joint dynamics of the series. In the case of stationary series, structural vector auto regression models (SVAR) can be implemented. In the presence of integrated series

of order one (1) but co-integrated, vector error correction models (VECM) will be specified. To ensure the most appropriate type of model, prior analyses have been carried out on the data. These include unit root tests of data series.

Data and unit root tests

As mentioned above, two key economic indicators are considered for the econometric analysis. These are real growth and inflation. The growth rate (g) of real GDP is defined as follows:

$$g_{i,t} = \text{Log}\left(\frac{PIBR_{i,t}}{PIBR_{i,t-1}}\right) \quad (1)$$

with GDPR denoting real GDP.
Inflation rate (π) is calculated as follows:

$$\pi_{i,t} = \text{Log}\left(\frac{IHPC_{i,t}}{IHPC_{i,t-1}}\right) \quad (2)$$

Where HCPI is the Harmonized Consumer Price Index.

Data are taken from the BCEAO statistical database on a quarterly basis and cover the period 1997–2019. The augmented Dickey-Fuller tests allow us to conclude that the hypothesis regarding the presence of a unit root is not applicable. The robustness of the tests is verified by performing Phillips-Perron unit root tests (see Table 5). T series of the two variables considered are stationary at the country and Union level. This characteristic of the data enables the VAR models to be introduced.

Table 5. Results of the Augmented Dickey-Fuller and Phillips-Perron tests

	Benin	Burkina Faso	Côte d'Ivoire	Guinea Bissau	Mali	Niger	Senegal	Togo	
Real Growth Rate									
Augmented Dickey-Fuller test	-4.49	-4.55	-6.75	-7.25	-6.47	-7.64	-4.39	-5.96	-3.71
	0.0020	***0.0020***	***0.0100***	***0.0000***	***0.0000***	***0.0000***	***0.0024***	***0.0100***	***0.0422***
Phillips-Perron test	-2.98	-6.31	-1.63	-7.32	-6.44	-7.78	-4.40	-5.85	-3.71
	0.0518	***0.0000***	***0.0966***	***0.0000***	***0.0000***	***0.0000***	***0.0023***	***0.0093***	***0.0422***
Inflation Rates									

Augmented Dickey-Fuller test	-7.26	-4.16	-3.84	-4.24	-3.52	-5.14	-4.53	-3.49	-6.94
	0.0000	***0.0186***	***0.0384***	***0.0159***	***0.0177***	***0.0005***	***0.0020***	***0.0194***	***0.0000***
Phillips-Perron test	-7.86	-8.15	-9.84	-4.43	-7.71	-6.65	-4.13	-6.29	-6.95
	0.0000	***0.0000***	***0.0000***	***0.0103***	***0.0000***	***0.0000***	***0.0045***	***0.0000***	0.0000

Note: Values in bold and italics are the probabilities associated with the statistics.

Model specification

The approach used involves the analysis of common versus country-specific shocks by considering a bivariate VAR of reduced form specified as follows:

$$C(L)Y_t = u_t C(L)Y_t = u_t \tag{3}$$

$$C = \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix}$$

Where ut is a vector of white noise, with mean zero and variance Σ ; $\begin{bmatrix} y_t^i \\ \bar{y}_t \end{bmatrix}$; and y_t^i is an indicator considered at the level of a given Union country i and $\bar{y}_t$ is the average value of this indicator at Union level. This indicator can either be real growth or inflation. This makes it possible to have two SVAR models per country: one for real growth and the other for inflation.

- $u_t = \begin{bmatrix} u_t^i \\ \bar{u}_t \end{bmatrix}$; $\bar{u}_t$ being a common average shock to Union member countries while u_t^i is a specific shock.

The infinite mobile average form of the process is written as follows:

$$Y_t = D(L)\, u_t \tag{4}$$

A well-chosen orthogonalization matrix S can be written as:

$$u_t = S\, \varepsilon_t \text{ et } E(\varepsilon_t \varepsilon_t') = I$$

with e_t being the vector of structural shocks associated to innovations contained in the vector u_t. The vector of structural shocks $\boldsymbol{\varepsilon_t}$ is written as:

$$\varepsilon_t = \begin{bmatrix} \varepsilon_t^i \\ \bar{\varepsilon}_t \end{bmatrix} \tag{5}$$

The infinite variable average form of the structural VAR is then written as:

$$Y_t = \Phi(L)\,\varepsilon_t \tag{6}$$

with $\Phi(L) = D(L)S$ (6)'

$$Y_t = \Phi_0\varepsilon_t + \Phi_1\varepsilon_{t-1} + \Phi_2\varepsilon_{t-2} + \cdots = \sum_{k=0}^{\infty} L^k\Phi_i\varepsilon_{t-k} \tag{6}''$$

In this term, the Φ_i are matrixes (2 × 2) transmitting the effects of shocks to variables of the SVAR system.

Cholesky orthogonalization requires imposing sufficient restrictions in order to identify the orthogonal (structural) components of the error terms. Let's consider matrices A and B of dimension (2 × 2) such that:

$$Au_t = B\varepsilon_t \tag{7}$$

We recall that structural innovations are assumed to be orthogonal, that is, their covariance matrix is an identity matrix. Indeed, $E^{(\varepsilon_t\varepsilon_t')} = I$. Thus, the following restrictions can be imposed on A and B:

$$A\Sigma A' = BB'A\Sigma A' = BB' \tag{8}$$

with $\Sigma = E[u_t u_t']\Sigma = E[u_t u_t']$

The innovations in the reduced model can be obtained as linear combinations of structural innovations. For $A = I$, for example:

$$u_t^i = b_{11}\varepsilon_t^i + b_{12}\bar{\varepsilon}_t \tag{9.a}$$

$$\bar{u}_{i,t} = b_{21}\varepsilon_t^i + b_{22}\bar{\varepsilon}_t \tag{9.b}$$

This expression can be rewritten with a matrix containing units on the diagonal by defining a new set of structural shocks as follows:

$$\zeta_t^i = b_{11}\varepsilon_t^i\zeta_t^i = b_{11}\varepsilon_t^i \tag{10.a}$$

$$\bar{\zeta}_t = b_{22}\bar{\varepsilon}_t\bar{\zeta}_t = b_{22}\bar{\varepsilon}_t \tag{10.b}$$

Therefore,

$$u_t^i = \zeta_t^i + (b_{12}/b_{22})\bar{\zeta}_t u_t^i = \zeta_t^i + (b_{12}/b_{22})\bar{\zeta}_t \tag{11.a}$$

$$\bar{u}_{i,t} = (b_{21}/b_{11})\varsigma_t^i + \bar{\varsigma}_t \bar{u}_{i,t} = (b_{21}/b_{11})\varsigma_t^i + \bar{\varsigma}_t \quad (11.b)$$

B thus becomes : $B = \begin{pmatrix} 1 & \frac{b_{12}}{b_{22}} \\ \frac{b_{21}}{b_{11}} & 1 \end{pmatrix}$, $\varsigma_t = \begin{bmatrix} \varsigma_t^i \\ \bar{\varsigma}_t \end{bmatrix} \sim \left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} b_{11}^2 & 0 \\ 0 & b_{22}^2 \end{bmatrix} \right)$

with b_{11}^2 et b_{22}^2 being the respective variances of the structural shocks of the newly defined series. The structural shocks are identified using the Cholesky decomposition and assuming that shocks specific to member countries do not have contemporary effects on other member countries but affect them with time lags. The imposition of a Cholesky decomposition assumes that shocks are propagated in a given order. The order used in this case is $y_t^i, \bar{y}_t$.

Thus, the error structure is a lower triangular matrix with 1's on the diagonal such that:

$$\begin{bmatrix} u_t^i \\ \bar{u}_t \end{bmatrix} = \begin{bmatrix} 1 & \frac{b_{12}}{b_{22}} \\ 0 & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_t^i \\ \bar{\varepsilon}_t \end{bmatrix} \quad (12)$$

A shock at the domestic level of a given country i in the Union does not directly affect the other member countries but affects them indirectly through its delayed effect in the VAR. Estimation of the $\frac{b_{12}}{b_{22}}$ coefficient allows us to identify structural shocks from the residuals of the reduced model. The impulse response functions of the above VARs are estimated and used to calculate the impact of common and country-specific shocks on growth and inflation. The impact of shocks is obtained as follows:

$$\begin{bmatrix} y_t^i \\ \bar{y}_t \end{bmatrix} \approx \sum_{j=1}^{\infty} \begin{bmatrix} \emptyset_{11}(j) & \emptyset_{12}(j) \\ \emptyset_{21}(j) & \emptyset_{22}(j) \end{bmatrix} \begin{bmatrix} \varepsilon_{t-j}^i \\ \bar{\varepsilon}_{t-j} \end{bmatrix} \quad (13)$$

where $\phi_{11}(j)$ is the impulse response function to the indicator in each WAEMU country to country-specific shocks, $\phi_{12}(j)$ is the response function to the impulse indicator in each country to common shocks, $\phi_{21}(j)$ is the response function of the impulse indicator at the WAEMU zone level to specific shocks, and $\phi_{22}(j)$ is the response function to the impulse indicator at the WAEMU level to common shocks. The contribution of specific shocks to indicator distribution is calculated using the above shock decomposition.

Sources of asymmetries are identified by analysing the cumulative effects of country-specific shocks on:

- Growth rate gap and inflation rate gap, that is:

$$\frac{\partial \sum_{s=1}^{h}\left[\Delta y_{t+s}^{i} - \Delta \bar{y}_{i,t+s}\right]}{\partial \varepsilon_{t}^{i}}, h = 1, 5, 10$$

- Growth rate and inflation rate, that is:

$$\frac{\partial \sum_{s=1}^{h}\left[\Delta y_{t+s}^{i}\right]}{\partial \varepsilon_{t}^{i}}, h = 1, 5, 10$$

An examination of the symmetry of shocks between countries is often based on the calculation of correlations between shocks. This analysis is further complemented in this study through the calculation of counterfactual correlations in order to identify the nature and intensity of the co-variation between the structural shocks affecting the selected indicators at the national level and in the rest of the Union's member countries. The counterfactual analysis approach used is inspired by the one proposed in Kilian and Lutkepohl (2017). It consists of three steps. First, the actual innovations related to growth and inflation are extracted from the SVAR model. This allows for the calculation of the actual correlations.

Secondly, the counterfactual innovations of the Y indicator are constructed on the basis of the decomposition of innovations into specific shocks and common shocks following equations 9.a and 9.b. Two scenarios have been identified. The first consists of assuming that the innovations of the Y indicator at the level of a given country are only due to specific shocks. The second scenario assumes that the innovations of the Y indicator at the level of a given country are only due to common shocks. On the basis of these scenarios, counterfactual innovations are calculated to determine the relative contributions of structural shocks (specific and common) to the symmetry between shocks affecting the Y indicator at the level of a country and at the average level of the other Union member countries. The respective counterfactual innovations are calculated using the same estimated parameters of the SVAR models. Indeed, given the variation of the indicator Y under the counterfactual scenarios, it is necessary to infer from these models how much the innovations associated with the indicator vary in each period, subject to the past data, in order to obtain its counterfactual values.

Thirdly, the original set of country-level Y-indicator innovations is replaced and then new correlation coefficients between shocks are simulated under the new set, leaving the average structural shocks to the other Union members unchanged.

Thus, under the counterfactual scenario of only specific shocks, the correlation coefficient is equal to:

$$\text{Corr}\left(u_{t}^{i} ; \bar{u}_{t}\right) = \text{Corr}\left(\varepsilon_{t}^{i} ; b_{21}\varepsilon_{t}^{i} + b_{22}\bar{\varepsilon}_{t}\right) \quad (14)$$

Under the counterfactual scenario of only common shocks, the equation can be expressed as follows:

$$\text{Corr}\,(u_t^i\,;\,\bar{u}_t) = \text{Corr}\,(\bar{\varepsilon}_t\,;\,b_{21}\varepsilon_t^i + b_{22}\bar{\varepsilon}_t) \qquad (15)$$

The same specification is used for all country models. The only difference is the number of delays included. In general, the SVAR models are estimated by considering a delay duration determined according to the Akaike or Schwarz criteria. The lag that minimizes these criteria is then chosen. When the indications of the information criteria do not match, the shortest delay is chosen for the sake of parsimony. This choice is common in the literature on VAR models. The results are summarized in Table 6.

It is common practice in VAR modelling to perform causality tests. This tradition is followed by performing Granger causality tests. The results are presented in Tables 9.a and 9.b. It appears that growth in the Union does not significantly cause domestic growth in any of the WAEMU countries. However, domestic growth in Burkina Faso, Guinea Bissau, Mali or Togo significantly causes growth in the Union. There is no evidence of bidirectional causality.

Table 6. Number of lags included in the SVAR models

Country	Number of lags	
	Growth model	Inflation model
Benin	1	2
Burkina Faso	1	1
Côte d'Ivoire	1	2
Guinea Bissau	1	1
Mali	1	2
Niger	1	1
Senegal	1	1
Togo	1	2

Note: Author's estimates.

Table 7.a. Results of Granger causality tests (of growth rates)

Country	Null Hypothesis		Null Hypothesis	
	Growth within the Union does not cause domestic growth		Domestic growth does not cause growth within the Union.	
	F-Statistic	Probability	F-Statistic	Probability
Benin	0.16	0.8576	2.06	0.1586
Burkina Faso	0.80	0.3822	4.11	0.0561
Côte d'Ivoire	0.02	0.8988	2.01	0.1714
Guinea Bissau	0.15	0.8639	4.18	0.0334
Mali	0.66	0.4254	4.44	0.0478
Niger	0.00	0.9680	1.24	0.2784
Senegal	0.13	0.7177	1.41	0.2490
Togo	0.30	0.7479	4.76	0.0239

Note: Author's estimates.

Table 7.b. Results from Granger causality tests (of inflation rates)

	Null hypothesis		Null hypothesis	
Country	**Union's inflation does not cause domestic inflation**		**Domestic inflation does not cause inflation in the Union.**	
	F-Statistic	**Probability**	**F-Statistic**	**Probability**
Benin	0.23	0.6361	0.18	0.6791
Burkina Faso	8.94	0.0025	12.18	0.0006
Côte d'Ivoire	2.68	0.0939	1.65	0.2377
Guinea Bissau	0.03	0.8735	3.42	0.0802
Mali	3.50	0.0768	4.44	0.1089
Niger	4.63	0.0259	5.93	0.0119
Senegal	3.46	0.0564	8.61	0.0029
Togo	0.29	0.7538	0.88	0.4326

Note: Author's estimates.

With regard to inflation, data from Burkina Faso, Niger and Senegal support the hypothesis of a bidirectional causality. In the cases of Côte d'Ivoire, Guinea Bissau and Mali, the relationship is unidirectional and significant at a 10% risk of error level. Benin and Togo stand out due to lack of significant causality between domestic and Union inflation, regardless of the direction of the relationship.

In addition to the causality tests, the stationarity of the VAR models is verified on the basis of the inverse roots of the polynomial characteristic. Due to the number of countries, these results are not published but are available on request. They show that the SVARs are stationary. The impulse response functions of the structural VARs are shown in Annex B.

Empirical results analysis

According to results obtained by decomposing the variance of growth forecast errors, the contribution of specific shocks to fluctuations in real GDP is very significant, regardless of the period considered (see Table 8.a). This contribution is on average 100.00% at the one-year period, 98.08% at the five-quarter period and 97.97% at the 10-quarter period. This predominance of the effects of country-specific shocks would explain the heterogeneity of national real GDP growth rates. Indeed, results in Table 8.a show that the gap between growth in a given member country i and that of the Union is very strongly determined up to a 10-quarter period by specific shocks, especially for countries such as Senegal (86.76%), Mali (86.44%), Benin (85.78%) and Burkina Faso (85.42%). For Guinea Bissau, Niger and Togo, the role of national specificities remains relatively less strong but still significant. As for Côte d'Ivoire, the contribution of specific shocks to the growth gap is relatively weaker in relation to sharp determination of real growth in the Union based on the evolution of economic activity in that country.[7]

Thus, a substantial and persistent proportion of heterogeneity in real GDP growth rates among the countries of the Union is due to factors specific to WAEMU member countries. These factors may be temporary and linked to the existence of a process of "catching up" between the more developed economies of the Union (such as Côte d'Ivoire and Senegal) and the less developed ones or to exposure to asymmetric shocks. They may also be related to lasting or permanent differences in national economic structures, to national budgetary policies or to member countries' responses to Union-wide policies. Moreover, even if all countries share the same profile of high dependence on production and export of low-processed primary goods, they are still characterized by significant differences (see the stylized facts presented in Section 3). The importance of specific growth shocks in determining output fluctuations may well be related to their differentiated exposure to the uncertainties affecting commodity prices and production conditions. The model used in this study does not allow shedding light on the contribution of each of these factors in explaining results.

In general, our results are similar to those obtained for the Euro zone by Giannone and Reichlin (2006). Indeed, they conclude that country-specific shocks would largely explain the growth gap. However, their role would be limited in output fluctuations, particularly with regard to the medium-term period, except for Greece, Finland and Ireland. Similarly, Stavrev (2008) finds that 70% of growth differentials between euro zone countries are explained by specific shocks, with the exception of Austria (45%) and Greece (40%).

Table 8.a. Percentage of growth forecast error due to country specific shocks

Country	$\frac{\partial \sum_{s=1}^{h}\left[\Delta y_{t+s}^{i} - \Delta \bar{y}_{t+s}\right]}{\partial \varepsilon_{t}^{i}}$			$\frac{\partial \sum_{s=1}^{h}\left[\Delta y_{t+s}^{i}\right]}{\partial \varepsilon_{t}^{i}}$		
	h = 1	*h = 5*	*h = 10*	*h = 1*	*h = 5*	*h = 10*
Benin	98.50	85.83	85.78	100.00	93.78	93.76
Burkina Faso	82.48	85.40	85.42	100.00	99.82	99.82
Côte d'Ivoire	12.88	10.05	10.02	100.00	99.84	99.84
Guinea Bissau	81.07	81.18	81.18	100.00	99.95	99.95
Mali	99.59	86.47	86.44	100.00	98.84	98.84
Niger	76.99	82.46	82.51	100.00	93.89	93.08
Senegal	83.38	86.75	86.76	100.00	99.46	99.46
Togo	86.13	64.82	64.70	100.00	99.07	99.06

Note: Author's estimates.

Table 8.b. Percentage of inflation forecast error due to country specific shocks

Country	$\frac{\partial \sum_{s=1}^{h}[\Delta y_{t+s}^{i} - \Delta \bar{y}_{t+s}]}{\partial \varepsilon_{t}^{i}}$			$\frac{\partial \sum_{s=1}^{h}[\Delta y_{t+s}^{i}]}{\partial \varepsilon_{t}^{i}}$		
	h = 1	*h = 5*	*h = 10*	*h = 1*	*h = 5*	*h = 10*
Benin	18.04	15.52	15.52	100.00	73.60	73.22
Burkina Faso	46.93	21.48	21.48	100.00	64.87	64.87
Côte d'Ivoire	21.72	23.13	23.14	100.00	84.80	84.63
Guinea Bissau	47.70	42.08	42.08	100.00	95.30	95.30
Mali	38.24	19.68	19.21	100.00	79.54	79.01
Niger	21.59	22.42	22.42	100.00	90.35	90.35
Senegal	60.60	49.57	49.57	100.00	88.01	88.01
Togo	34.93	36.87	36.86	100.00	99.76	99.73

Note: Author's estimates.

With regard to inflation rates, results shown in Table 8.b reveal that their evolution is also dominated by specific factors. Indeed, it appears that the contribution of specific shocks to fluctuations in the harmonized index of consumer prices is 100%, 84.53% and 84.39% at the end of the first, fifth and tenth quarters, respectively. However, in contrast to real growth rates, country-specific shocks would contribute relatively less to the distribution of inflation rates across WAEMU countries (see Table 8.b). As a result, the spread of inflation rates between the countries of the Union would be much less due to national factors. It should be noted, however, that in the cases of Senegal, Guinea Bissau and Togo, the cumulative effects of specific shocks on the inflation gap are significant.

With respect to these three countries, the projection error variance would be explained by these shocks respectively at 49.57%, 42.08% and 36.86%, over a 10-quarter period. The hypothesis can be put forward that, generally speaking, inflation rate gaps between WAEMU member countries are much more determined by the common shocks affecting them. These could be common monetary policy shocks or shocks affecting import prices. Indeed, due to insufficient domestic supply and their level of development, WAEMU countries are highly dependent on imports of food, capital goods and petroleum products. This common characteristic exposes them to shocks affecting prices of imported goods. These results differ somewhat from those obtained by Stavrev (2008), who finds that at least 75% of inflation rate differentials are due to country-specific shocks.

It is standard practice when investigating the symmetry of shocks to calculate the correlation between structural shocks of the same nature. This tradition is followed in this study by calculating correlations between innovations in a given country i and average innovations in other Union member countries. Calculations are made for growth rates and for inflation rates. They are obtained from the following equation:

$$\text{Corr}\,(u_t^i\,;\,\bar{u}_t) = \text{Corr}\,(b_{11}\varepsilon_t^i + b_{12}\bar{\varepsilon}_t\,;\,b_{21}\varepsilon_t^i + b_{22}\bar{\varepsilon}_t) \qquad (16)$$

To do this, residuals from the equations y^i and from $\bar{y}$ are extracted from the

SVAR models estimated for each country. For the record, indicator Y is either real GDP growth or inflation. y^i represents indicator Y considered at the level of a country i, while $\bar{y}$ denotes its average value at the level of the eight Union member countries.

Results in Table 9 indicate four subgroups of countries when the correlations of shocks affecting growth in the WAEMU countries are examined. In the first subgroup, there is a positive correlation between shocks affecting growth in a given country and those in other countries. For these countries (Benin, 12.27%, and Mali, 6.39%), growth shocks are symmetric but the intensity of co-movements is low. In the second sub-group (Côte d'Ivoire), the intensity of co-movements is very high, 93.34. Niger, Burkina Faso, Senegal and Togo form a third subgroup, characterized by average positive correlation coefficients (47.97%, 41.86%, 40.77% and 37.24% respectively). Guinea Bissau stands out with a negative and significant correlation (i.e., -43.51%). These results imply that the growth cycle of each of the countries in the first three sub-groups identified is in line with the WAEMU average cycle. This is not the case for Guinea Bissau. Its situation would be linked to what distinguishes it mainly from the other countries of the Union during the study period, that is, the frequency of socio-political shocks.

With regard to inflation rates, results in Table 9 suggest that the correlation coefficients of shocks affecting them are relatively higher and all appear positive. This indicates a better symmetry between the shocks affecting prices. Here too, sub-groups of countries can be distinguished. The correlation coefficient is relatively lower in Senegal (62.77%), Guinea Bissau (72.32%) and Burkina Faso (72.85%), compared to that in other Union member countries. These results can be linked to the sharing of a common currency but also to the strong dependence of inflation within the WAEMU on its imported component (see Diallo and Doé, 1997; Diarisso and Doé, 1997; Nubukpo, 2002; Toe, 2010; Diaw and Sall, 2012). Countries import almost a similar set of goods. Thus, the external shocks affecting prices are more symmetrical.

Table 9. Actual correlations between shocks

Country	Actual correlations (in %)	
	Growth	Inflation
Benin	12.27	90.53
Burkina Faso	41.86	80.29
Côte d'Ivoire	93.34	88.48
Guinea Bissau	-43.51	72.32
Mali	6.39	78.59
Niger	52.01	88.55
Senegal	40.77	62.77
Togo	37.25	80.67

Note: Author's estimates.

Another question that the study attempts to answer is whether asymmetries in growth and inflation between WAEMU countries are explained by idiosyncratic shocks or by heterogeneous responses to common shocks. To answer this question, counterfactual correlations between the structural shocks of a given country i in the

Union and those of the other member countries were calculated. The analysis relates to a hypothetical investigation of what the correlations would have been if the shocks were only specific or only common. This would give a better appreciation of the symmetry of growth or inflation shocks between a given Union country and the rest of its members. Correlations would be relatively higher and more stable if the economic indicators considered were only affected by shocks common to the member countries. This would imply that the existence of asymmetries would be due to idiosyncratic shocks rather than heterogeneous responses to common shocks. Therefore, Union-wide shocks would propagate in a similar way across member countries.

Results of the counterfactual analysis indicate that, based on the hypothesis that only common shocks influence economic growth, the counterfactual correlations are generally higher than what is actually observed, with the exception of Guinea Bissau and Mali. The same observation can be made for inflation, except for Togo (see Tables 10.a and 10.b). These results imply that the occurrence of asymmetries in growth and inflation rates of WAEMU countries is due to significant specific factors. Nevertheless, common shocks would explain a high share of fluctuations in real GDP and the harmonized consumer price index. Under these circumstances, as Giannone and Reichlin (2006) point out in the context of the Euro zone, asymmetries would be explained by idiosyncratic shocks rather than by heterogeneous responses to common shocks. Thus, shocks at the level of the monetary union would propagate in a similar way to all member countries. This would also be the case for the WAEMU.

In summary, factors specific to the Union's member countries would exert persistent effects on the evolution of growth and inflation rates. However, common shocks would explain a non-negligible part of the fluctuations in output and price cycles. Thus, despite the existing heterogeneity within the WAEMU, member countries would respond in a similar way to common shocks affecting them. The asymmetries of shocks would therefore be explained by the persistence of national factors that are still important. However, a greater symmetry of shocks within a monetary union is crucial for the effectiveness of the common monetary policy and for the fact that the costs of renouncing national monetary policy are relatively less important than the benefits of belonging to the union.

Table 10.a. Counterfactual correlation between growth shocks

Country	Correlations (in %)		
	Actual	With common shocks only	With specific shocks only
Benin	12.27	32.00	18.90
Burkina Faso	41.86	53.97	-20.81
Côte d'Ivoire	93.34	99.75	77.85
Guinea Bissau	-43.51	-51.33	26.71
Mali	6.39	10.29	99.98
Niger	52.01	88.05	70.51
Senegal	40.77	88.90	43.84
Togo	37.25	24.40	-26.55

Note: Author's estimates.

Table 10.b. Counterfactual correlation between inflation shocks

Country	Correlations (in %)		
	Actual	With common shocks only	With specific shocks only
Benin	90.53	91.01	71.73
Burkina Faso	80.29	97.76	75.03
Côte d'Ivoire	88.48	95.26	89.56
Guinea Bissau	72.32	97.97	63.83
Mali	78.59	99.76	36.12
Niger	88.55	99.90	36.48
Senegal	62.77	91.33	62.21
Togo	80.67	82.02	95.01

Note: Author's estimates.

5. Analysis of the evolution of country-specific factors: Is there persistence?

One hypothesis of this work is that, as a result of the reforms adopted within the WAEMU region, the convergence of incomes and price levels could accelerate and have an impact on the patterns of growth and inflation of the member countries. This hypothesis is tested by estimating growth and inflation equations on panel data from WAEMU countries. The specification of the equations is derived from Stavrev (2008).

For the equation capturing the variations between growth rates, it is written as follows:

$$g_{i,t} - \bar{g}_t = \alpha_g + \rho_g\left(g_{i,t-1} - \bar{g}_{t-1}\right) + \gamma_g log\left(\frac{YH_{i,t-1}}{\overline{YH}_{t-1}}\right) + \zeta_{i,t}^{g} \quad (17)$$

Where $g_{i,t} - \bar{g}_t$ measures the deviation of a member country i's growth from the union average; and $\log\left(\frac{YH_{i,t-1}}{YH_{t-1}}\right)$ captures the percentage difference in real GDP per capita[8] of each member country compared to the Union-wide average.

For the equation capturing the dispersions between inflation rates, the equation is written as follows:

$$\pi_{i,t} - \bar{\pi}_t = \alpha_\pi + \rho_\pi\left(\pi_{i,t-1} - \bar{\pi}_{t-1}\right) + \gamma_\pi log\left(\frac{P_{i,t-1}}{\bar{P}_{t-1}}\right) + \zeta_{i,t}^{\pi} \quad (18)$$

Where $\pi_{i,t} - \bar{\pi}_t$ represents the deviation of inflation in member country i from the Union-wide average; $\log\left(\frac{P_{i,t-1}}{P_{t-1}}\right)$ is the deviation of the price level of a member country i from that of the Union-wide average; γ_g and γ_π capture the persistence of national disparities (a low absolute value of γ_g et γ_π corresponds to a slow adjustment or a low convergence speed); and $\zeta_{i,t}^{g}$ *et* $\zeta_{i,t}^{\pi}$ are distortions associated with each of the two equations.

In the study by Stavrev (2008), the dispersion equations for growth and inflation are estimated in isolation. By taking into account the mutual influences of the growth and inflation gaps, a simultaneity bias could exist. In this respect, the present study introduces the lagged values of the gaps in the above specifications. This makes it possible to write the equation as follows:

$$g_{i,t} - \bar{g}_t = \alpha_g + \rho_g\left(g_{i,t-1} - \bar{g}_{t-1}\right) + \upsilon_g\left(\pi_{i,t-1} - \bar{\pi}_{t-1}\right) + \gamma_g log\left(\frac{YH_{i,t-1}}{YH_{t-1}}\right) + \zeta_{i,t}^{g} \quad (17')$$

$$\pi_{i,t} - \bar{\pi}_t = \alpha_\pi + \rho_\pi\left(\pi_{i,t-1} - \bar{\pi}_{t-1}\right) + \upsilon_\pi\left(g_{i,t-1} - \bar{g}_{t-1}\right) + \gamma_\pi log\left(\frac{P_{i,t-1}}{P_{t-1}}\right) + \zeta_{i,t}^{\pi} \quad (18')$$

Where υ_g and υ_π measures the mutual effects of inflation and growth rate gaps.

Analysis of the properties of the panel variables

Before the estimations, the stationarity of the panel data was tested using the first generation unit root test methods of Levin et al (2002). Howe ver, this test assumes the homogeneity of the autoregressive root under the alternative hypothesis. This is its main limitation. The test of Im et al (2003) makes it possible to fill this gap. The results of these two tests allow us to conclude that the gaps in the real growth rate, real GDP per capita, inflation rate and HCPI are stationary, at a risk of error threshold of 5% (see Tables C11.a to C11.d).

The context of a monetary union gives meaning to the assumption of a cross-sectional dependence of the variables considered in a panel. This hypothesis could invalidate the results of the unit root tests of Levin et al (2002) and Im et al (2003). To this end, a cross-sectional dependence test developed by Pesaran (2004) is conducted. Under the zero hypothesis of cross-sectional independence, the probability associated with the Pesaran (2004) test statistic is close to zero, indicating that the data are correlated within the panel groups.

The empirical results show that the probabilities associated with the test statistic are above the 5% risk of error threshold. Thus, for this variable, the H0 hypothesis of cross-sectional independence is not supported. There is, therefore, strong cross-sectional independence for the other variables, suggesting the absence of common effects correlated with the observations from the countries in the panel (see Table C11.g).

It is then necessary to perform a second-generation unit root test taking into account the cross-sectional dependence of the observations to confirm or refute these results. For this purpose, tests of Pesaran (2007) are performed. They also assume parameter heterogeneity. Two test models are considered. The first one includes a constant, specific to each country and the second one includes a linear trend. The tests are performed for lags from 0 to 4. Under the zero hypothesis H0 of the test, each individual time series is assumed to contain a unit root while the alternative hypothesis postulates stationarity for part of the series. The results of the test (see Tables C11.e and C11.f) show that the H0 hypothesis is not supported at a 5% risk

level for all variables.

In summary, the results of the unit root tests of Levin et al (2002) and Im et al (2003) conducted on the variables are confirmed by the tests of Pesaran (2007). They are therefore stationary in level. In addition, Pesaran's (2007) tests also confirm the existence of heterogeneity in growth, inflation and HCPI gaps among WAEMU member countries.

Method and equation estimation results method

The simultaneous equations system (17' and 18') is estimated using annual panel data for the eight WAEMU member countries over the period 1997–2019.

Estimating the above equations system would pose two major problems related to the endogeneity of the regressors and the correlation structure between the residuals of the equations. These two problems are addressed by using a full information method. This is the case of the Seemingly Unrelated Regression Equations (SURE) method. Indeed, the problem of endogeneity of the regressors does not arise in a system of simultaneous regressions. In addition, the SURE method makes it possible to take into account the correlations between the residuals of the equations. Thus, it allows researchers to obtain the maximum accuracy compared to other approaches such as the triple least squares method. The equations are estimated by assuming the existence of entity and time fixed effects. However, the null test for time fixed effects is positive.[9]

This leads us to focus on the fixed effects linked to the countries forming the panel. The relevance of this specification is also tested by conducting a Hausman (1978)specification test. Indeed, it is used to differentiate between fixed and random effects models. The results show that the probability associated with the Hausman test (performed on the difference of the coefficients of the random and fixed effects models) is 0.06%. The chi-square statistic (3) is positive at 17.50. Thus, the random effects model would be appropriate. However, the variance matrix of the difference of coefficients from the estimation of the two types of models (VB - Vb) is not positive (see Tables 12 to 14). Consequently, the estimated model does not meet the asymptotic assumptions of the Hausman test. The Hausman test should, therefore, be interpreted with caution.

In this respect, the fixed effects model is then considered by testing the nil status of the country fixed effects. The Wald test, conducted for this purpose, indicates a probability associated with the Chi-square (14) statistic of 0.03%, which means that the zero hypothesis that all coefficients associated with the fixed effects are simultaneously zero is rejected. This implies that the country fixed effects have a significant effect on real growth and inflation, at the 5% risk of error threshold (see Table 15). Thus, country specificities appear important in the fluctuations of growth and inflation within the WAEMU.

Regression results are summarized in Table 16. This table also displays the regressions over the sub-period 2010–2019 to examine the evolution of convergence

over the last decade. It is found that the differences between the real GDP growth rate and inflation rate of a countrv i relative to the respective Union averages exhibit low inertia. Indeed, the value of ρ_g and that of ρ_π are -0.09 and -0.02 respectively over the period 1997–2019. Value of ρ_g increases at the end of the period, that is, 0.17 between 2010 and 2019, whereas an inverse evolution is noted in the case of the value of ρ_π. The value of ρ_π is -0.11 over the 2010–2019 period. However, the value of the inertia force is not significant in any case.

In addition, coefficient values γ_g and γ_π are significant respectively -0.04 and -0.32 over the period 1997–2019 and -0.22 and -0.56 over the period 2010–2019. These values are still lower than those found by Starev (2008) using data for the Euro zone. These differences would be linked to differences in the efforts to implement structural projects, economic and social policies favourable to the integration of the economies of the two monetary unions. The absolute values of the coefficients γ_g and γ_π have increased in the WAEMU over the period 2010–2019. This reflects an acceleration in the convergence of growth rates and inflation rates within the Union over recent years. However, the adjustment of the general level of consumer prices is faster than the production adjustment.

These results support the hypothesis that reforms undertaken within the WAEMU region have affected the pace of convergence of the economies, particularly with regard to growth and inflation. However, it remains that dispersions characterizing these two indicators are persistent over time. Thus, while convergence within the Union could be attributed to policy reforms, the persistence of disparities would be linked to the heterogeneity of economic structures and to different levels of structural reforms undertaken in the member countries. Our results do not allow us to test this hypothesis. However, in our opinion, it is plausible. These structural factors would explain the importance of specific shocks and even heterogeneous responses to common shocks. Future investigations could examine the impact of differences in economic structures on the dispersion of national growth and inflation rates in the WAEMU region.

Table 16. Evolution of growth and inflation dispersions

Period	1997–2019				2010–2019			
	Growth	Prob.	Inflation	Prob.	Growth	Prob.	Inflation	Prob.
α	0.01	0.5660	0.00	0.9990	-0.05	0.0170	0.00	0.7010
ρ	-0.09	0.1960	-0.02	0.8160	0.17	0.1350	-0.11	0.2230
υ	0.60	0.0000	0.15	0.0000	-0.60	0.0170	-0.06	0.1180
γ	-0.04	0.0240	-0.32	0.0000	-0.22	0.007	-0.56	0.0000
(1- ρ)/γ	-27.25	-	-3.19	-	-3.77	-	-1.98	-
Adjusted R^2	0.12		0.25		0.17		0.37	
Chi^2	40.00	0.0000	79.58	0.0000	21.71	0.0167	54.10	0.0000

6. Conclusion

This study re-examines the issue of asymmetric shocks in monetary unions using data from the WAEMU member countries. It is generally accepted that in the presence of asymmetric shocks, costs associated with belonging to a monetary union may exceed the benefits that a country derives from it if compensation mechanisms do not work well.

In view of the reforms undertaken since January 1994, notably the adoption of a convergence and multilateral surveillance framework, it is appropriate to question the degree of asymmetry between the member countries of the Union and to identify the sources of the dispersion of national economic performances. In this respect, this study explores the asymmetry of shocks among WAEMU countries over the recent period and attempts to answer a question not addressed by previous studies. Indeed, this work on the asymmetry of shocks in the WAEMU region has been limited to the calculation of the correlation between shocks affecting the different member countries of the Union. This work provides little indication of the sources of the asymmetry of shocks within the Union. Thus, while revisiting the asymmetry of shocks in the Union on the basis of annual data from 1997 to 2019, our study identifies the sources of the asymmetry by assessing the relative contributions of common and country-specific shocks to fluctuations in economic growth and inflation.

The econometric analysis was based on a bivariate structural VAR specification for each member country. The results reveal weak correlations between the growth shocks of WAEMU countries, while those affecting prices appear relatively more correlated. This situation can be explained by the existence of persistent national factors. Counterfactual analyses were also conducted under the hypothesis of the presence of common shocks or specific shocks acting alone. These analyses make it possible to affirm that idiosyncratic shocks contribute significantly to the dispersions of growth rates and inflation rates within the Union. Common shocks would explain most of the fluctuations in real GDP and consumer price cycles. Thus, the observed national asymmetries would not be linked to heterogeneous responses to common shocks but rather to the persistence and importance of specific national factors.

The persistence of specific factors is tested by estimating panel data equations of growth and inflation dispersions. The results suggest that reforms undertaken within the WAEMU region have led to greater convergence in growth and inflation rates. However, dispersion of the two indicators is persistent over time. While policy reforms have favoured convergence between the Union's member economies, structural factors are still decisive and explain the persistence of dispersions observed.

Greater symmetry of shocks is important to improve the effectiveness of a common monetary policy and to reduce opportunity costs associated with national monetary policy. From this point of view, it is important that economic policy actions be taken to reduce the asymmetries observed within the WAEMU region. This perspective requires reducing the importance of national factors that still largely determine the economies of the Union. The stylized facts presented in this study reveal that the countries in the Union do not have the same economic structures and depend on the production and export of a reduced number of goods, which differ from one Union member country to another. Thus, national economic cycles are not determined in the same way by the evolution of international commodity prices. The prospect of greater symmetry of shocks within the zone could consist of actions aimed at reducing the role of national factors, particularly socio-political shocks, in three main directions: diversification of economies; strengthening intra-zone trade in order to bring national economic cycles into the same phase; and consolidating the efforts undertaken in the context of the CSGP.

Notes

1 West African Economic and Monetary Union (Benin, Burkina Faso, Côte d'Ivoire, Guinea Bissau, Mali, Niger, Senegal and Togo).

2 BCEAO is the Central Bank of the eight WAEMU member countries.

3 See Sections 2 and 3 for comments on climate and economic shocks.

4 An illustration of the occurrence of socio-political shocks is provided in Section 1 of the Annex.

5 Member countries are: The Gambia, Ghana, Guinea, Liberia, Nigeria and Sierra Leone.

6 The average real growth rate and average inflation rate for the period are obtained from the geometrical averages of the respective annual growth rates of real GDP and the harmonized consumer price index. The average ratios for the period are obtained from the average ratios of the overall budget balances, including grants to GDP, and external debt to GDP. The average real effective exchange rates for the period are geometrical averages of the annual real effective exchange rates.

7 Over the study period, the real GDP of Côte d'Ivoire represents 43.25% of the Union's total GDP.

8 This is GDP per capita, expressed in terms of international dollars, using purchasing power parity factors. The data are considered in constant 2007 international dollars. They are taken from the World Bank's online database.

9 To keep the paper short, the test results are not shown. They are available on request.

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Annexes
Annex A: Summary table of the literature review results

Author (s)	Countries Studied	Main Findings
Benalal et al (2006); Bower and Guillemineau (2006); Giannone and Reichlin (2006); Giannone et al (2009)	Euro zone countries.	There is greater synchronization of national economic cycles.
Kabundi and Loots (2007)	SADC countries	Strong and significant evidence of co-movement or synchronization of South Africa's economic cycle with those of Swaziland, Botswana, Zimbabwe, DRC, Mauritius, Lesotho and Angola.
Zehirun et al (2014)	SADC countries	Ten of the 15 SADC member countries potentially meet the OCA criteria, based on the symmetry of their business cycles over the period 1970-2010. However, evidence based on bilateral co-movements in the business cycles of SADC member countries refutes this claim. Macroeconomic convergence is not sufficient among all member states for entry into the monetary union.
Zehirun et al (2015)	SADC countries	There are indications that there is good evidence for the success of a monetary union in the region with the exception of Angola and Mauritius. These two countries may exhibit asymmetry in response to external shocks.
Drummond et al (2015)	Burundi, Kenya, Rwanda, Tanzania and Uganda	The differences between EAC countries remain significant. Despite some similarities in their economic structures, these countries are still more susceptible to asymmetric shocks.
N'Goma (2000)	WAEMU countries	Supply and demand shocks have symmetric effects on macroeconomic variables across the countries studied. However, only monetary shocks are significantly attached to the common component.
Fielding and Shields (2001)	CFA Franc zone countries.	There is a positive and significant correlation between national inflation shocks. In contrast, supply shocks do not appear to be similar across countries.

Author (s)	Countries Studied	Main Findings
Bamba (2004)	WAEMU countries	Emphasis on the presence of structural heterogeneity and political heterogeneity.
Houssa (2008)	ECOWAS countries	Existence of asymmetric supply shocks. But demand shocks are more similar in WAEMU countries.
Qureshi and Tsangarides (2008)	ECOWAS and Franc Zone countries	Within the WAMZ, there is a significant lack of homogeneity. The WAMZ countries do not form a cluster with the WAEMU countries. Moreover, a great heterogeneity is noted within the CFA zone.
Diagne and Niang (2008)	CFA Franc zone countries.	Existence of a fairly significant economic co-movement between most of the countries in the zone despite poor trade relations. These co-movements are strongly "dictated" by the "leading" countries, namely Côte d'Ivoire and Cameroon. However, some countries seem to experience economic cycles that are less influenced by the CFA zone as a whole.
Dedehouanou (2009)	WAEMU countries	The degree of asymmetry in real and monetary supply and demand shocks is remarkable. Potential non-market adjustment mechanisms via public finance in WAEMU countries would be useful.
Sarr and Ndiaye (2011)	WAEMU countries	Existence of a convergence of budgetary policies and shocks. It also appears that most budgetary variables converged during the period 1995-2005.
Gammadigbé (2012)	WAEMU countries	The real cycles in the Union would be weakly synchronized. The real cycles of Côte d'Ivoire, Mali and Niger are the most in sync with that of the WAEMU. Benin's business cycle is out of phase with that of the WAEMU.
Zdzienicka et al (2013)	WAEMU countries	Frequent asymmetric shocks of a political, climatic and economic nature. Economic cycles within the WAEMU appear to be poorly synchronized
Basdevant et al (2015)	WAEMU countries	Existence of frequent and asymmetric shocks. At the national level, the capacity of member countries to cope with shocks is also constrained by limited budgetary space and the need to preserve external stability. In addition, disparities exist between the economic structures of these countries.
Sarr and Ndiaye (2011)	WAEMU countries	Existence of a convergence of budgetary policies and shocks. It also appears that most budgetary variables converged during the period 1995-2005.
Sarr and Wade (2015)	WAEMU countries	The degree of asymmetry of these shocks diminishes over time. Supply and monetary shocks are divergent, while demand shocks are convergent. Moreover, budgetary shocks appear divergent.

Author (s)	Countries Studied	Main Findings
Kabundi and Loots (2007)	WAEMU countries, SADC countries	Strong and significant evidence of co-movement or synchronization of South Africa's economic cycle with those of Swaziland, Botswana, Zimbabwe, Democratic Republic of Congo, Mauritius, Lesotho and Angola.

Section 1: Political shocks in WAEMU countries

Countries in the West African Economic and Monetary Union (WAEMU) have frequently been affected by negative political shocks. Over the 2000s and the 2010s, for example, Côte d'Ivoire, Guinea Bissau, Mali and Togo were affected by political crises. However, other Union member countries, which enjoyed relative stability over these two decades, also experienced periods of unrest that were detrimental to peace and social security. This section reviews some major socio-political events in the eight WAEMU countries.

Benin stands out for its democratic stability in a sub-region where its neighbours experience a very lively political life. However, things were not rosy during the three decades following the country's independence. The country's history is marked by five military coups between October 1963 and October 1972. Mathieu Kérékou's authoritarian one-party revolutionary regime ensured relative political stability from 1972 to 1990. With the collapse of the Soviet bloc, external and internal pressures forced the military regime to open up to economic and political liberalism. The political changeover in February 1991 brought President Nicéphore Soglo to power and put an end to military rule. Since then, the country has been cited as a model for democracy. Unfortunately, this is not the case for its neighbouring countries.

Burkina Faso's political history has been turbulent. The country has experienced several popular uprisings (in 1966, 2011 and 2014) and five coups d'état (1974, 1980, 1982, 1983 and 1987). In the recent past, the country has experienced political instability that has adversely affected its economy. The socio-political crisis in Côte d'Ivoire has spilled over to its neighbour Burkina Faso. The Ivorian land conflict in September 2000 led to the mass evacuation of Burkinabè. In addition, following the election of President Laurent Gbagbo in Côte d'Ivoire in 2001, riots broke out and thousands of Burkinabè were forced to return to their country of origin. More recently, in 2011, violent demonstrations by schoolchildren and traders and mutinies in the army plunged the country into turmoil. The country's social and political stability has been undermined. The situation worsened in October 2014 with the popular uprising that toppled the regime of President Blaise Compaoré. Since January 2016, his successor has had to deal with terrorist attacks that have caused numerous casualties and hampered economic activity.

Côte d'Ivoire experienced its first military coup since the country gained independence on 24 December 1999. A political crisis with an ethnic dimension was

added to the economic crisis affecting the country. The presidential election held in October 2000 brought President Gbagbo to power but did not resolve the crisis. A failed coup attempt on 19 September 2002 turned into an armed rebellion, which resulted in the gradual occupation of the northern part of the country. The agreements reached on 4 March 2007 in Ouagadougou to bring peace and reunify the country made it possible to hold presidential elections in 2010. This should have marked the end of the crisis. Unfortunately, it led to protests and then to armed conflict. The country has since regained stability, but peace remains fragile.

Guinea Bissau experienced a short but violent civil war between forces loyal to President Joao Vieira and those of Ansoumane Mané, the Army Chief of Staff after a failed coup attempt against the government in June 1998. The rebellion finally overthrew the government in May 1999. The president elected in 2000, Kumba Yala, was also overthrown by a coup in September 2003. The country returned to democratic normalcy which led to legislative elections in 2004 and a presidential election in July 2005, marked by the return of Vieira as president. Vieira was assassinated in March 2009. President Malam Bacau Sanha succeeded him in July 2009. His term in office was marred by serious political incidents linked to drug trafficking. On 12 April 2012, an armed coup d'état deposed Prime Minister Carlos Gomes Junior in the context of a disputed presidential election. The country is gradually returning to constitutional legality with the election of President Jose Mario Vaz in 2014. However, instability persists, and prime ministers change often. The Conakry agreements led to a political compromise on 10 September 2016.

Mali experienced a democratic regime from 1992 to 2012. Since then, the country has experienced a difficult political and security situation. Indeed, the Tuareg rebellion, comprising the Mouvement National de Libération de l'Azawad and other rebels, launched an offensive in the north in January 2012. Three months later, a military coup overthrew President Amadou Touré. After an interim period, the presidential election of July 2013 brought Ibrahim Boubacar Keïta to the helm. The intervention by the French army freed the north of the country from jihadists, but the security situation in the country remains fragile.

In 1997–1998, Niger experienced an economic crisis caused by the fall in the price of uranium, the country's main export. This led to a political crisis which resulted in the dissolution of the government, strikes by civil servants and students and mutinies in the army. These movements led to the fall of President Ibrahim Maïnassara in April 1999. His successor, President Mamadou Tandja, was elected in November the same year. President Tandja's wish to run for a third term was met with internal and international criticism. A military coup led by Commander Salou Djibo that overthrew President Tandja took place on 18 February 2010. Presidential elections were held in January 2011 and ushered in a relatively stable era for the country.

Senegal is one of the most stable countries in Africa. It has experienced three peaceful political changeovers. But the country's government is facing a separatist rebellion led by the Movement of Democratic Forces of Casamance in the south of the country. The conflict began with the bloody repression of 26 December 1982 and

has had several episodes, including the clashes of July and August 1990 between the regular army and the separatists. The death of the movement's political leaders (Sidhi Badji in 2003 and Diamacoune Senghor in 2007) and the 30 December 2004 ceasefire helped restore peace, even if occasional clashes continued to occur between the army and the "rebels" in 2009, and also between rival groups. In addition to this conflict, the country has experienced jolts of pre- and post-electoral socio-political tensions, particularly the violence linked to the proposed constitutional reforms by President Wade in June 2011 and the Electoral Law introduced by President Macky Sall in April 2018.

For its part, Togo has not experienced any armed conflict but remains marked by a bloody coup d'état in January 1963. In addition, the country has experienced several episodes of crisis and violence linked to attempted coups d'état in September 1986 and March 1993, the political demands of the early 1990s with the massacre of January 1993, and the contestation of elections, particularly the presidential elections of 2005. More recently, from August 2017 to December 2018, the country has experienced politico-social unrest tied to demonstrations demanding constitutional reforms and the implementation of measures provided for in the Comprehensive Political Agreement signed in Ouagadougou in August 2006.

Section 2: Economic-related shocks

Union countries share a common characteristic of being exposed to shocks in terms of prices of the raw materials they each export. These shocks have consequences in terms of falling export revenues but also in terms of falling tax revenues. This makes their budget deficit performance dependent on commodity cycles. These shocks are frequent. As the Union's countries do not export the same goods, they do not necessarily experience the same economic shocks. However, common shocks such as those linked to the rise in oil prices affect them all but asymmetrically, i.e., with different magnitudes. Indeed, as a whole, the Union is a net importer of oil. Significant increases in oil prices lead to an increase in the oil costs, a deterioration in the trade balance and an increase in production costs. In addition, WAEMU countries are affected by economic shocks in the Union's economic partner countries. For example, member countries of the Union, including Benin, Niger and Togo". For example, member countries of the Union, including Benin, Niger and Togo. were affected by the devaluation of the naira in 2016 and the economic recession that followed.

Section 3: Climate-related shocks

WAEMU countries are exposed to the negative effects of climate change and natural disasters. In particular, the countries of the Sahel-Saharan strip (Burkina Faso, Mali, Niger and Senegal) are confronted with periods of intense drought with disastrous economic and human consequences. These droughts have had negative impacts on

agriculture and pastoral activity and have led to famines. For example, Boureima (2005) indicates that Niger experienced a serious famine in 2005, following a rainfall deficit in 2004, coupled with a locust invasion affecting production.

In 2008 Benin, Burkina Faso, Guinea-Bissau, Mali, Niger and Togo experienced heavy rains leading to flooding. These floods caused extensive damage to bridges, roads, railways and other critical infrastructure. In 2010 Benin and Togo also experienced significant disruptions to traditional cyclical systems due to heavy rains. These had serious consequences, including degradation of the road network, flooding of cultivated land, destruction of crops and disruption of economic activity. The floods have increased the number of cases of cholera and malaria. Niger and Senegal also suffered the devastating effects of rains in August 2012 that flooded towns and countryside and made roads impassable. These shocks have negatively impacted the production and financial capacities of the Union countries.

Section 4: Major economic reforms over the past two decades

A range of reforms have been adopted in the WAEMU region since the devaluation of the CFA franc in January 1994, when the Treaty establishing the Economic and Monetary Union was adopted. The Union's authorities have also adopted an additional Act on the Convergence, Growth and Solidarity Pact of WAEMU Member States. This Act complements the multilateral surveillance procedure provided for in Articles 70 to 75 of the WAEMU Treaty. In this regard, convergence criteria have been defined, mainly with regard to the basic budget balance, the average annual inflation rate, the debt ratio and the non-accumulation of domestic and external payment arrears. On analysis, it appears that the Union's member countries have made some effort to comply with these criteria. An assessment of the multi-annual convergence, stability, growth and solidarity programmes for the period 2009–2013 revealed that the conditions for convergence have not been met.

In 1996 the Member States of the Union also initiated a common commercial policy, supported by sectoral economic policies, aimed at developing a capacity and supply of competitive goods and services. This common trade policy is part of the Union's regional integration scheme and harmonization of economic policies with a view to improving the business environment within the Union. This policy progressively achieves the conditions for the free movement of goods, persons and their establishment as well as the attainment of the other conditions and factors necessary to ensure economic competitiveness. In addition, the Union's trade policy with the outside world has been revised, opening up gradually and qualitatively to the outside world with the Common External Tariff (CET). Thus, it has been harmonized to favour imports of capital goods and inputs and all goods necessary for the development of the zone's production potential.

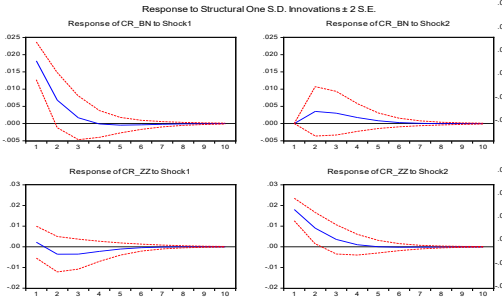
Furthermore, the Conference of Heads of State and Government of the Union initiated the Regional Economic Programme (REP), implemented since 2006, whose

objective is to "provide the Union with a solid structural foundation capable of stimulating stronger growth dynamics in the regional economy through structuring and integrating projects". This initiative complements the efforts of individual Union Member States to further synergize their national potential. The projects included in the REP include the construction of road infrastructure connecting countries as well as hydraulic, energy and agricultural projects, and the establishment of industrial units.

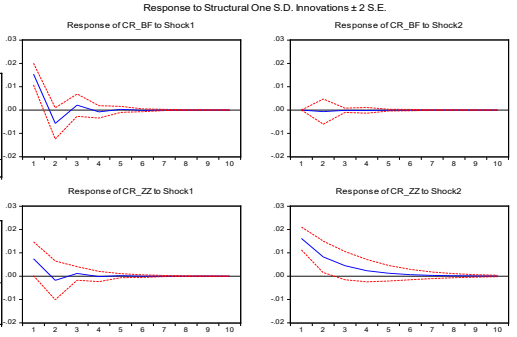
Intra-community trade has been dynamic over the last two decades. Indeed, intra-community exports have increased from 942.7 billion CFA francs in 2000 to 2,737.9 billion CFA francs in 2017. This dynamism could be linked to the adoption and implementation of trade policy reforms, as well as the improvement of transport infrastructure within the Union's member countries.

Annex A.1: Impulse response functions (growth models)

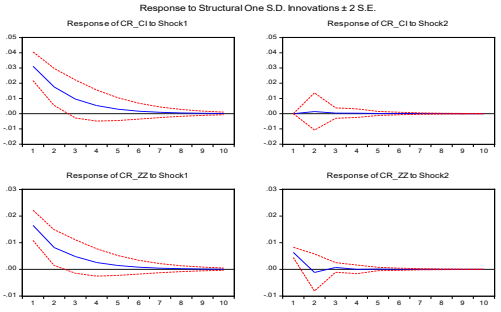
Benin



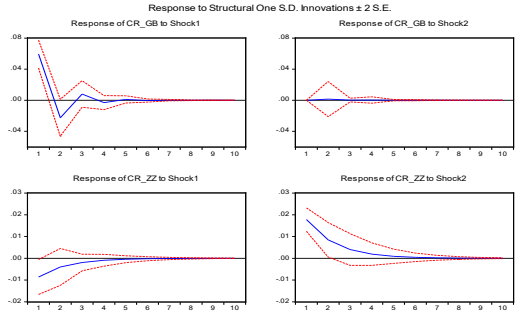
Burkina Faso



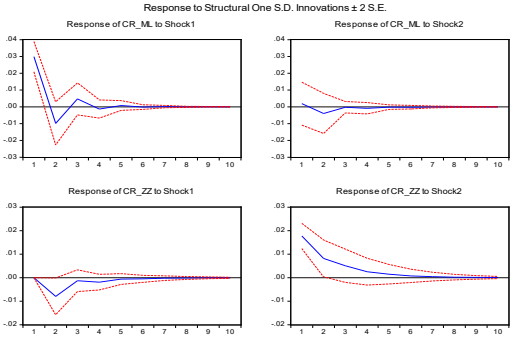
Côte d'Ivoire



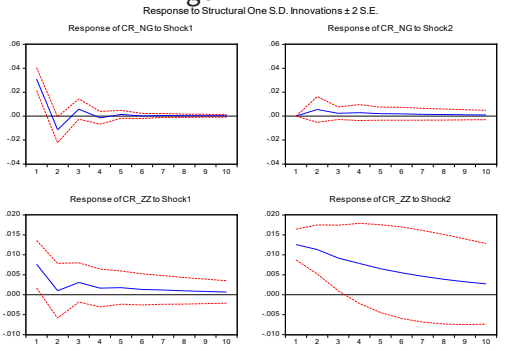
Guinea Bissau



Mali

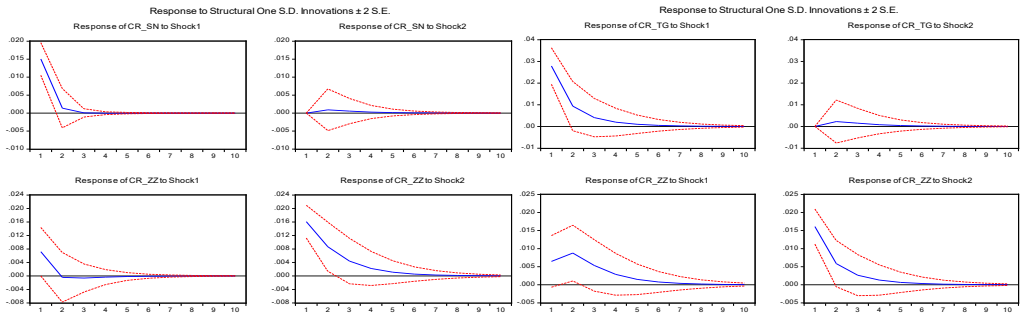


Niger



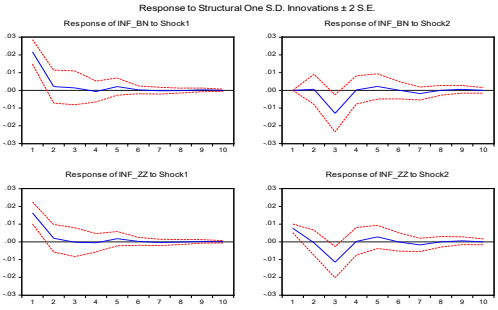
Senegal

Togo

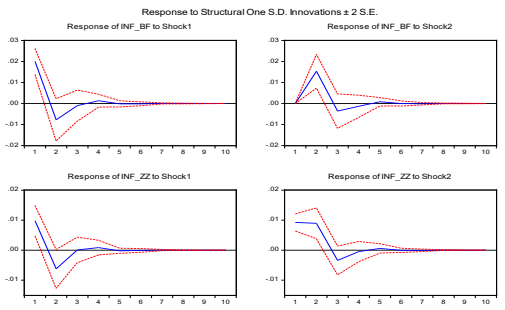

Response to Structural One S.D. Innovations ± 2 S.E.
Response of CR_SN to Shock1
Response of CR_SN to Shock2
Response to Structural One S.D. Innovations ± 2 S.E.
Response of CR_TG to Shock1
Response of CR_TG to Shock2
Response of CR_ZZ to Shock1
Response of CR_ZZ to Shock2
Response of CR_ZZ to Shock1
Response of CR_ZZ to Shock2

Annex A.2: Impulse response functions (Inflation models)

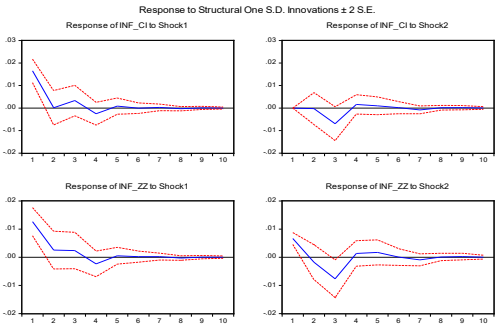
Benin



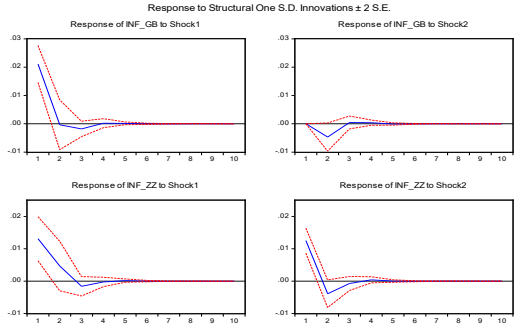
Burkina Faso



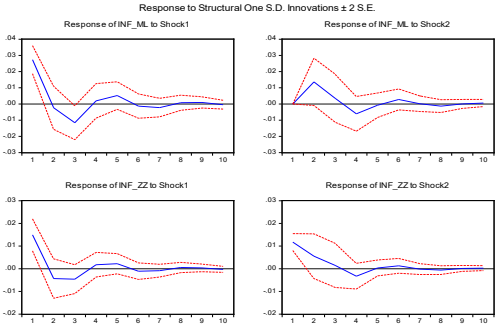
Côte d'Ivoire



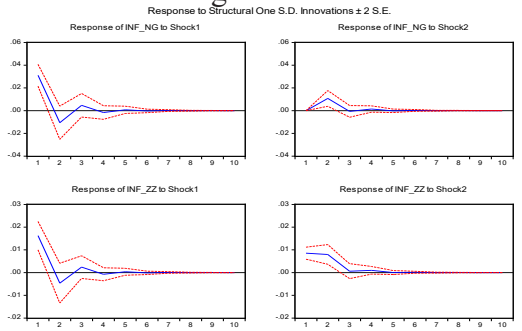
Guinea Bissau



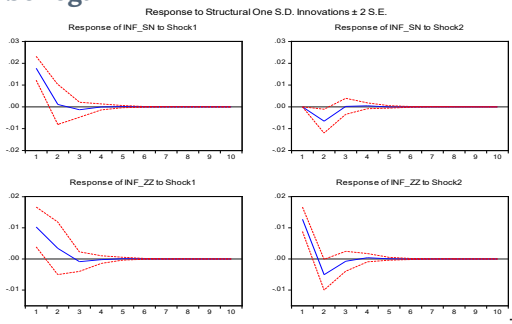
Mali



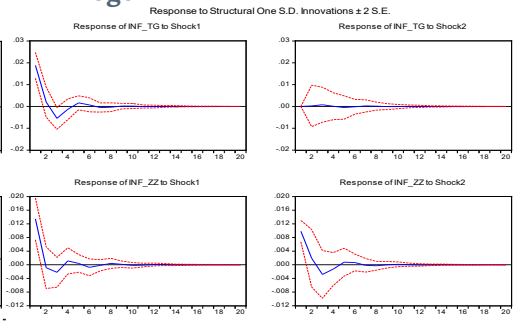
Niger



Senegal



Togo



Annex C: Unit root test results on panel data

Table C11.a: Levin, Lin and Chu (2002) unit root test (with constancy)

	Growth Gap		Inflation Gap		HCPI Gap		Real GDP per capita Gap	
Lag	Adjusted t*	Probability	Adjusted t*	Probability	Adjusted t*	Probability	Adjusted t*	Probability
0	-8.20	0.0000	-15.90	0.0000	-4.29	0.0000	-6.72	0.0000
1	-5.74	0.0000	-6.57	0.0000	-2.78	0.0027	-0.98	0.1633
2	-0.72	0.2347	2.05	0.9797	-4.06	0.0000	-0.77	0.2218
3	0.14	0.5571	8.13	1.0000	-1.28	0.1004	-0.94	0.1742
4	1.65	0.9509	13.21	1.0000	-1.02	0.1530	0.79	0.7840

Table C11.b: Levin, Lin and Chu (2002)unit root test (with pattern and constancy)

	Growth Gap		Inflation Gap		HCPI Gap		Real GDP per capita Gap	
Lag	Adjusted t*	Probability	Adjusted t*	Probability	Adjusted t*	Probability	Adjusted t*	Probability
0	-8,87	0.0000	-14,69	0.0000	-4.56	0.0000	-5.42	0.0000
1	-6,70	0.0000	-5,45	0.0000	-2.53	0.0057	-5.42	0.0000
2	-0,04	0,4832	3,22	0,9994	-1.55	0.0607	-0.18	0.5728
3	1,34	0,9097	11,58	1.0000	0.55	0.7099	-1.04	0.1484
4	5,86	1,0000	17,94	1.0000	1.36	0.9135	1.89	0.9708

Table C11.c: Im, Pesaran and Shin (2002) unit root test (with constancy)

	Growth Gap		Inflation Gap		HCPI Gap		Real GDP per capita Gap	
Lag	W[t-bar]	Probability	W[t-bar]	Probability	W[t-bar]	Probability	W[t-bar]	Probability
0	-9.52	0.0000	-15.85	0.0000	-3.35	0.0000	-6.84	0.0000
1	-7.13	0.0000	-10.06	0.0000	-1.73	0.0420	-1.75	0.0400
2	-7.13	0.0010	-6.80	0.0000	-1.58	0.0570	-1.85	0.0320
3	-2.24	0.0120	-3.96	0.0000	-0.36	0.3600	-1.55	0.0610
4	-0.93	0.1750	-2.15	0.0160	-0.60	0.2730	-0.56	0.2880

Table C11.d: Im, Pesaran and Shin (2002) unit root test (with trends)

	Growth Gap		Inflation Gap		HCPI Gap		Real GDP per capita Gap	
Lag	W[t-bar]	Probability	W[t-bar]	Probability	W[t-bar]	Probability	W[t-bar]	Probability
0	-9.75	0.0000	-14.72	0.0000	-4.03	0.0000	-4.48	0.0000
1	-6.26	0.0000	-8.73	0.0000	-2.24	0.0130	0.69	0.7560
2	-3.04	0.0010	-6.18	0.0000	-0.57	0.2840	0.74	0.7720
3	-2.49	0.0060	-2.68	0.0040	0.46	0.6790	0.15	0.5590
4	-0.54	0.2930	-0.88	0.1900	0.67	0.7490	1.28	0.9000

Table C11.e: Pesaran (2007) unit root test (with constancy)

	Growth Gap		Inflation Gap		HCPI Gap		Real GDP per capita Gap	
Lag	Z[t-bar]	Probability	Z[t-bar]	Probability	Z[t-bar]	Probability	Z[t-bar]	Probability
0	-5.76	0.0000	-11.19	0.0000	-0.78	0.2170	-3.28	0.0010
1	-4.52	0.0000	-6.79	0.0000	0.12	0.5490	0.70	0.7570
2	-2.18	0.0150	-3.94	0.0000	2.53	0.9940	0.65	0.7410
3	0.53	0.7010	-1.66	0.0480	2.66	0.9960	0.76	0.7780
4	1.71	0.9560	-0.20	0.4210	1.87	0.9690	1.55	0.9390

Table C11.f: Pesaran (2007) unit root test (with constancy and trends)

	Growth Gap		Inflation Gap		HCPI Gap		Real GDP per capita Gap	
Lag	Z[t-bar]	Probability	Z[t-bar]	Probability	Z[t-bar]	Probability	Z[t-bar]	Probability
0	-5.76	0.0000	-11.19	0.0000	-0.78	0.2170	-3.28	0.0010
1	-7.32	0.0000	-10.30	0.0000	-2.14	0.0160	-0.38	0.3540
2	-3.31	0.0000	-5.32	0.0000	-1.94	0.0260	2.79	0.9970
3	-2.16	0.0150	-2.81	0.0020	0.58	0.7180	3.15	0.9990
4	1.26	0.8960	0.99	0.8380	4.27	1.0000	3.95	1.0000

Table C11.g: Pesaran (2004) cross-sectional dependency test

	Growth Gap	Inflation Gap	HCPI Gap	Real GDP per capita Gap
Test CD	-0.20	-1.27	-0.79	-1.41
Probability	0.84	0.20	0.43	0.14
ρ average	-0.01	-0.05	-0.03	-0.11
ρ absolute average	0.31	0.32	0.55	0.59

Table C12. Random effects model results

```
. sureg (growth growth_1 inflation rgdp_per_capita_1) (inflation inflation_1 growth hcpi_1), corr

Seemingly unrelated regression
------------------------------------------------------------------------------
Equation              Obs    Parms        RMSE    "R-sq"       chi2         P
------------------------------------------------------------------------------
growth                183        3    .0370275    0.0266      22.76    0.0000
inflation             183        3    .0169793    0.1544      52.50    0.0000
------------------------------------------------------------------------------

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
growth       |
    growth_1 |   -.037163   .0719801    -0.52   0.606    -.1782414    .1039155
   inflation |   .6381904   .1464492     4.36   0.000     .3511552    .9252256
rgdp_per_c~1 |  -.0103721   .0061223    -1.69   0.090    -.0223715    .0016273
       _cons |   .0005678   .0027586     0.21   0.837    -.0048389    .0059745
-------------+----------------------------------------------------------------
inflation    |
  inflation_1 |  -.0823273   .0683414    -1.20   0.228    -.2162739    .0516193
      growth |   .1471928   .0331842     4.44   0.000     .0821529    .2122328
      hcpi_1 |  -.1790708   .0358561    -4.99   0.000    -.2493474   -.1087942
       _cons |   .0002804   .0012573     0.22   0.824    -.0021838    .0027446
------------------------------------------------------------------------------

Correlation matrix of residuals:

             growth  inflation
   growth     1.0000
inflation    -0.1634     1.0000

Breusch-Pagan test of independence: chi2(1) =     4.888, Pr = 0.0270
```

Table C13. Fixed effects model results

```
. sureg (growth growth_1 inflation rgdp_per_capita_1 i.country) (inflation inflation_1 growth hcpi_1 i.country), corr

Seemingly unrelated regression
------------------------------------------------------------------------------
Equation              Obs    Parms        RMSE    "R-sq"       chi2         P
------------------------------------------------------------------------------
growth                183       10    .0352723    0.1167      40.00    0.0000
inflation             183       10    .0159584    0.2530      79.58    0.0000
------------------------------------------------------------------------------

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
growth       |
    growth_1 |   -.091471   .0708165    -1.29   0.196    -.2302687    .0473267
   inflation |   .5994399   .1409294     4.25   0.000     .3232233    .8756565
rgdp_per_c~1 |  -.0369127   .0163317    -2.26   0.024    -.0689222   -.0049032
             |
     country |
           2 |   .0121309   .0145916     0.83   0.406    -.0164681      .04073
           3 |  -.0001499   .0159036    -0.01   0.992    -.0313203    .0310206
           4 |  -.0221627   .0113861    -1.95   0.052    -.0444791    .0001538
           5 |   .0036471   .0116805     0.31   0.755    -.0192463    .0265404
           6 |  -.0297053   .0141496    -2.10   0.036    -.0574381   -.0019725
           7 |   .0093752   .0142446     0.66   0.510    -.0185438    .0372941
           8 |  -.0281208   .0105839    -2.66   0.008    -.0488647   -.0073768
             |
       _cons |    .005281   .0091899     0.57   0.566    -.0127308    .0232928
-------------+----------------------------------------------------------------
inflation    |
  inflation_1 |  -.0155432   .0668915    -0.23   0.816    -.1466482    .1155617
      growth |   .1515688   .0322955     4.69   0.000     .0882708    .2148667
      hcpi_1 |  -.3249898   .0483938    -6.72   0.000      -.41984   -.2301397
             |
     country |
           2 |  -.0071226   .0050481    -1.41   0.158    -.0170167    .0027714
           3 |  -.0011134   .0049245    -0.23   0.821    -.0107653    .0085385
           4 |   .0105819   .0048597     2.18   0.029      .001057    .0201067
           5 |  -.0073665   .0047841    -1.54   0.124    -.0167432    .0020101
           6 |   .0055502   .0047364     1.17   0.241    -.003733    .0148334
           7 |   .0133615   .0051065     2.62   0.009      .003353      .02337
           8 |  -.0050831   .0049577    -1.03   0.305    -.0147999    .0046338
             |
       _cons |   6.28e-06    .003441     0.00   0.999    -.006738    .0067505
------------------------------------------------------------------------------

Correlation matrix of residuals:

             growth  inflation
   growth     1.0000
inflation    -0.1563     1.0000

Breusch-Pagan test of independence: chi2(1) =     4.468, Pr = 0.0345
```

Table C14. Hausman test results

```
. hausman RE_model FE_model

                 ---- Coefficients ----
                 (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
                 RE_model     FE_model       Difference          S.E.
-------------+----------------------------------------------------------------
    growth_1 |   -.037163     -.091471        .0543081        .0128906
   inflation |   .6381904     .5994399        .0387505        .0398281
rgdp_per_c~1 |  -.0103721    -.0369127        .0265406               .
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from sureg
            B = inconsistent under Ha, efficient under Ho; obtained from sureg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(3) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =       17.50
                Prob>chi2 =      0.0006
                (V_b-V_B is not positive definite)
```

Table C15. Fixed effects nullity test results

```
. testparm i.country

 ( 1)  [growth]2.country = 0
 ( 2)  [inflation]2.country = 0
 ( 3)  [growth]3.country = 0
 ( 4)  [inflation]3.country = 0
 ( 5)  [growth]4.country = 0
 ( 6)  [inflation]4.country = 0
 ( 7)  [growth]5.country = 0
 ( 8)  [inflation]5.country = 0
 ( 9)  [growth]6.country = 0
 (10)  [inflation]6.country = 0
 (11)  [growth]7.country = 0
 (12)  [inflation]7.country = 0
 (13)  [growth]8.country = 0
 (14)  [inflation]8.country = 0

           chi2( 14) =   39.89
         Prob > chi2 =    0.0003
```

Mission

To strengthen local capacity for conducting independent, rigorous inquiry into the problems facing the management of economies in sub-Saharan Africa.

The mission rests on two basic premises: that development is more likely to occur where there is sustained sound management of the economy, and that such management is more likely to happen where there is an active, well-informed group of locally based professional economists to conduct policy-relevant research.

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