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Monetary Union in West Africa and Asymmetric Shocks: a Dynamic Structural Factor Model

by

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DISCUSSION
PAPER

Monetary Union in West Africa and Asymmetric Shocks : A Dynamic Structural Factor Model Approach*

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Abstract

We analyse the costs of a monetary union in West Africa by means of asymmetric aggregate demand and aggregate supply shocks. Previous studies have estimated the shocks with the VAR model. We discuss the limitations of this approach and apply a new technique based on the dynamic factor model. The results suggest the presence of economic costs for a monetary union in West Africa because aggregate supply shocks are poorly correlated or asymmetric across these countries. Aggregate demand shocks are more correlated between West African countries.

- Keywords: Asymmetric Shocks, Monetary Union, Factor Model.

  JEL Classification: C33, F42, E52, E58.

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1 Introduction

Following the introduction of the euro as the single currency of the European Monetary Union, there has been a renewed and a growing interest in monetary integration around the world[1]. One special case is the monetary union project in the Economic Community of West African States (ECOWAS) area. ECOWAS is a regional group of 15 countries[2] and it already includes a monetary union. This monetary union only involves the former French colony members of ECOWAS. It is known as the West African Economic and Monetary Union[3] (WAEMU). On April 2000, ECOWAS adopted a strategy of a two-track approach to the implementation of a monetary union in the whole area. As a first step, the non-WAEMU members[4] of ECOWAS agreed to form a second monetary union, the West African Monetary Zone (WAMZ). And later on, WAEMU and WAMZ will merge to form a wider monetary union in the ECOWAS area.

When countries decide to participate in a monetary union they abandon their national currency and fix their nominal exchange rates with respect to each other. From then on, the monetary policy is managed by a common central bank with area-wide objectives. As a consequence, the country members of the union lose the control of their national monetary policy. They can no longer change the price of their currency, nor can they determine the quantity of their money anymore; moreover, they can no longer change the short-term interest rate. Only factor (capital and labour) mobility and wage flexibility remain the main adjustment mechanisms[5] as alternatives to the exchange rate. Therefore, if wages are rigid and factor mobility is limited, countries will find it harder to adjust to asymmetric shocks. The loss of the ability to independently operate national monetary and exchange rate policies, in the presence of asymmetric shocks, is referred to as the costs of a monetary

[1] In 1947, the number of independent currencies in the world was 65 for 76 countries (Alesina et al., 2002). Today, there are 193 countries, which use 158 different currencies in international transactions. Consequently, the ratio of the number of currencies to the number of countries has decreased between 1947 and today. This ratio is expected to drop rapidly when one considers the proposed regional currency areas.

[2] ECOWAS members are Benin, Burkina Faso, Cape Verde, Cote d'Ivoire, Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, and Togo. Mauritania was a founding member but it left the group later.

[3] WAEMU includes Benin, Burkina Faso, Cote d'Ivoire, Guinea Bissau, Mali, Niger, Senegal, and Togo. WAEMU is also part of the CFA zone which has the CFA franc as the common currency. CFA franc is defined as the *franc de la Coopération Financière Africaine*. Figure B1 in Appendix B summarises the overlaping membership of WEAMU. Apart from Guinea Bissau, which is a Portuguese colony, WAEMU countries are French speakers.

[4] WAMZ members are Gambia, Ghana, Guinea, Nigeria and Sierra Leone. Liberia and Cape Verde are the two remaining ECOWAS countries that are not involved in the monetary project. Liberia has declined to participate in WAMZ project. Cape Verde has its currency, the Cape Verde Escudo, pegged to the Euro with the support of Portugal. WAMZ countries are English speaking.

[5] For empirical evidences see Atkeson and Bayoumi (1993), Eichengreen (1990), EC Commission (1990); Blanchard and Katz (1992), Bentivogli and Pagano (1999), and Decressin and Fatas (1995).

union in the Optimal Currency Area (OCA) literature. Mundell (1961), Mckinnon (1963) and Kenen (1969) are the pioneers of the theory of OCA. A currency area is optimal if the benefits that a country receives for joining the union outweigh the costs. The potential benefits of a monetary union are expected to include the creation of a larger regional market and the enhancement of economic competitiveness. A monetary union is also expected to increase intra-regional trade via lower transaction costs and the reduction of exchange rate uncertainties (see De Grauwe, 2003, Chapter 3).

In this paper, we analyze the correlation of aggregate demand and aggregate supply shocks across West African countries during the period 1966-2000. Unlike previous studies, the shocks are extracted from the generalized dynamic factor model proposed by Forni et al. (2000 and 2004) and Forni and Lippi (2001).

Previous studies[6] have mainly used the Vector Auto-Regressive (VAR) model to analyze asymmetric shocks in West Africa. Actually, these studies followed the standard technique applied to industrialized countries, pioneered by Bayoumi and Eichengreen (1992). For example, Fielding and Shields (2001) identify output and price shocks for CFA franc countries. They use a 4-variable (output growth, inflation, money growth and foreign inflation) VAR model and find a high degree of correlation between inflation shocks across countries. The correlation of output shocks is, however, not uniform. Some CFA franc countries (Benin, Burkina Faso, Senegal, Togo, Niger, Cameroon, Gabon, Central African Republic and Chad) exhibit a positive correlation contrary to the rest. Fielding and Shields (2003) extend this study to WAMZ. They use a 3-variable (output growth, real exchange rate and money growth) VAR model and the terms of trade as an exogenous variable. The results suggest less real exchange rate volatilities for CFA countries and negative output shocks correlation, although the latter result is not significant. In a related analysis, Hoffmaister et al. (1998) use a 5-variable (the world interest rate, the terms of trade, output, the real exchange rate, and prices) VAR model to analyse macroeconomic fluctuations in Sub-Saharan African countries. They find that external shocks are the main sources of macroeconomic fluctuations in

[6]There are other papers that apply different methods to analyze the similarity of shocks in West African countries. Masson and Pastillo (2001) find very low term of trade correlations across West African countries. They interpret this result as asymmetric shocks. Bayoumi and Ostry (1997) study output disturbances for Sub-Saharan African countries. They use an AR (2) model of real output per capita and find little real disturbance correlations across countries. Recently, Bénassy-Quéré and Coupet (2003) use the cluster analysis to test the Optimal Currency Area hypothesis for sub-Saharan Africa. Their conclusions suggest the rejection of this hypothesis. However, they identify the core of WAEMU based on several economic indicators. More interestingly, they show that WAEMU can be extended to other ECOWAS countries such as Ghana, Gambia, Sierra Leone, but not Nigeria. A similar result for Nigeria has been found by Debrun et al. (2002). They apply a multi-country model and show that the monetary union project in ECOWAS would not be in the interest of the other countries unless this process is accompanied by an effective discipline over Nigeria's fiscal policies. Furthermore, Ogunkola (2002) analyses real exchange rate shocks for ECOWAS members. He finds a lower volatility for intra-CFA countries than any others. Nigeria displays the highest volatility.

these countries and the results seem to be more pronounced for CFA countries.

The problem with these studies lies in the use of the VAR model. First of all, the VAR model assumes that the shocks and the impulse response function are fundamental,[7] i.e. they are innovations to the variables included in the system. This might not be the case for the small VAR aforementioned. The critique here is that economic agents might use a superior information set to the one used in the VAR model such that the few variables included in the VAR may not be sufficient to explain the whole dimension of the economy. Second, the number of parameters estimated with the VAR model grows with the square of the number of variables included in the system. For example in a 5-variable VAR model with 2 lags, the number of parameters is 50 (excluding the constant term). This fact may lower the number of degrees of freedom of the estimation. Third, the number of shocks is equal to the number of variables included in the VAR such that a large number of restrictions is needed to achieve identification.

The main motivation of this paper is to apply a new method based on the dynamic structural factor model to compute aggregate demand and aggregate supply shocks for West African countries. The dynamic factor model is a non-parametric tool to analyze a large time series data set in a cross-section dimension. It has been applied for predictions (Bernanke and Boivin, 2003; Stock and Watson, 2002a and 2002b; and Forni et al., 2002), for structural analysis (Giannone et al., 2002; Forni and Reichlin, 1998; and Forni et al. 2003) and for constructing economic indicators (Forni et al. 2001). In our specification, each variable of the economy is driven by two common shocks (aggregate demand and aggregate supply shocks) and an idiosyncratic shock. On the one hand, the common shocks affect all the variables in the economy. They have a strong correlation with these variables. On the other hand, idiosyncatic shocks are specific to each variable and they are poorly correlated with the rest of the variables. They can be interpreted as measurement errors or short-run disturbances (see Forni et al., 2000). To identify the structural shocks, we use the restriction, like in Blanchard and Quah (1989), that aggregate demand shocks have only a temporary effect on output.

The factor model is superior to the VAR model on a number of points. First, the factor model distinguishes measurement errors and other idiosyncratic disturbances in the data. Macroeconomic data are computed with errors. These errors can be very large in developing

[7] The fundamentalness critic is discussed in Lippi and Reichlin (1993 and 1994). A VAR representation is fundamental if the shocks belong to the linear space spanned by the present and past of the variables included in the system. In this case the roots of the determinant of the MA representaion are outside the unit circle. When the roots of the determinant of the impulse response function lie inside the unit circle, the VAR is no longer fundamental. In this case, the shocks belong to the linear space spanned by the past and future of the variables in the system. Therefore, the estimation of shocks and the impulse response function are biased since the future of the variables are not included in the system.

countries where data are subject to substantial revisions and are released with a long delay. Therefore, our consideration of measurement errors can improve the efficiency of the results. In this respect, the factor model is also superior to other techniques applied in previous studies. Second, the factor model allows us to analyze a large information set and exploits the covariance structure of the panel to extract a limited information set. This reduces the number of restrictions needed to identify the shocks. We use 54 variables for each country to compute only two structural shocks. This would not be possible with a VAR model and any other techniques applied in previous studies. Third, Forni et al. (2003) show that the factor model is superior to the VAR model because the fundamentalness assumption is less restrictive within the factor model framework.

The rest of the paper is organized as follows. In the next section, we present the correlation of output growth and inflation across countries. Section 3 is devoted to the methodology. We present the dynamic structural factor model and the estimation procedure. Section 4 gives empirical results. In section 5 we discuss the implications of the results. The last section provides a conclusion.

2 Correlation of Output Growth and Inflation

Different preferences about inflation and output growth of countries may make the introduction of a common currency costly. On the one hand, a fast-growing country will have to follow deflationary policies,[8] which constrain growth, if it forms a monetary union with a low-growing country. On the other hand, a high inflation country will increasingly lose its competitiveness[9] if it forms a monetary union with a lower inflation country. These points motivate our comparative analysis of inflation and output growth across West African countries.

To begin with, we plot the historical performance[10] of output growth and inflation of WAEMU and WAMZ in Figure 1. Table 1 reports the mean and the standard deviation of output growth and inflation. The data are annual and span the period from 1966 to 2000. Real GDP is our measure of output and GDP deflator is our proxy for the price level. We compute aggregate inflation and output growth of WAEMU and WAMZ as the weighted sum of inflation and output growth of countries in each group. The weights are one period lag shares of real GDP as suggested by Beyer et al. (2001). Lack of data forces us to exclude

[8] A fast-growing country will need fast-growing imports, and owing exports to grow at the same rate as imports, this country has to make its exports cheaper; otherwise there will be a large current account deficit. If this country were not in a monetary union, it could just depreciate its currency to increase exports.

[9] This follows from the standard PPP theorem.

[10] Additional indicators are provided in Tables B_1, B_2 and B_3 in Appendix B.

some countries. Our aggregate WAEMU involves Benin, Burkina Faso, Cote d'Ivoire, Niger, Senegal and Togo. The WAMZ countries considered are Nigeria, Gambia and Ghana. In the paper, we will sometimes refer to WAEMU countries as CFA countries or French speaking countries and to the WAMZ ones as English speaking countries.

[Figure 1 and Table 1 about here]

One fact from Figure 1 and Table 1 is that inflation is much lower in CFA countries. Moreover, English speaking countries have on average the highest volatility of both output growth and inflation. The relatively low levels of inflation in WAEMU have been explained by the peg of the CFA franc to the French franc before 1999 and now to the Euro (see Bleaney and Fielding, 2002). Regarding output growth, there is not a clear difference between the two groups. There are some periods when English speaking countries did better than French speaking ones and vice-versa.

Next, we analyze the correlation of output growth and inflation across countries. Figures 2 and 3 display the correlations of output growth and inflation with the aggregate WAEMU and WAMZ, respectively. Tables 2 and 3 report the correlation matrices of output growth and inflation.

[Figures 2 and 3 and Tables 2 and 3 about here]

WAEMU countries have a strong and positive inflation correlation with their aggregate. This is also true for output growth except for Benin and Togo, which have a negative and a low output growth correlation, respectively. Ghana and Nigeria, two WAMZ countries, are a bit closer to French speaking countries. They have a weak positive correlation of inflation and output growth with WAEMU, respectively. Gambia has negative output growth and inflation correlations.

According to the correlation with WAMZ, the member countries also exhibit a positive correlation except for Gambia. However, the correlations here are less pronounced compared to the WAEMU ones. Besides, French speaking countries have little or negative output growth and inflation correlation with WAMZ. These results are also confirmed by the correlation matrices in Tables 2 and 3. Nigeria is approximately at the place where Cote d'Ivoire was when we computed the correlation with WAEMU (see Figures 2 and 3). This may suggest that Cote d'Ivoire and Nigeria can be considered as the core of WAEMU and WAMZ, respectively. The result is not surprising given the high weights[11] of Cote d'Ivoire and Nigeria in the computation of aggregate output growth and inflation of WAEMU and WAMZ, respectively.

[11] Cote d'Ivoire and Nigeria are the largest economies of WAEMU and WAMZ, respectively (see Tables B1 and B2 in Appendix B).

The main conclusion of this section is that WAMZ countries have a relative high level of inflation. This implies a loss of competitiveness for these countries if they form a monetary union with WAEMU members. They can reduce these costs by lowering their inflation. This will, however, create another problem. A lower inflation implies less seigniorage forcing WAMZ countries to increase taxation or let the budget deficit increase. The question is whether the correlations of aggregate demand and supply shocks are similar to what we have observed here. The next sections provide the analysis of shocks where we focus on results relative to Cote d'Ivoire and Nigeria.

3 Methodology

In this section, we present the dynamic structural factor model. Thereafter, we describe the estimation procedure. We conclude with a short description of the data set.

3.1 The Dynamic Structural Factor Model

We assume that the process x_{it} is the sum of two unobservable components as follows:

$$x_{it} = \chi_{it} + \xi_{it}, \tag{1}$$

where, x_{it}, $i = 1, \ldots, n$, $(n \in \mathbb{N})$, $t = 0, \ldots, T$, $(T \in \mathbb{Z})$, is a stationary process with zero mean. n represents the number of variables included in the panel and T is the number of observations. χ_{it} is called the common component and ξ_{it} is the idiosyncratic component. Next, we assume that the economy is driven by two common shocks such that the common component can be expressed as:

$$\chi_{it} = b(L)u_t = b_{i1}(L)u_{1t} + b_{i2}(L)u_{2t}, \tag{2}$$

where, the filters $b_{ij}(L)$ are one-sided polynomial of order s in the lag operator L. $u_t = (u_{1t}, u_{2t})'$ represents a 2-dimentional vector of the common shocks. We call u_{1t} and u_{2t} aggregate supply shocks and aggregate demand shocks, respectively. The vector of shocks, u_t, is orthonormal white noise. ξ_{it} is a zero-mean stationary process and orthogonal to u_{jt-k} for any i, j, t, and k.

Equation (1) can be restated in matrix notation as:

$$\mathbf{x}_{nt} = \boldsymbol{\chi}_{nt} + \boldsymbol{\xi}_{nt} = B_n(L)u_t + \boldsymbol{\xi}_{nt}, \tag{3}$$

where, $\mathbf{x}_{nt} = (x_{1t} \ldots x_{nt})'$; $\boldsymbol{\chi}_{nt} = (\chi_{1t} \cdots \chi_{nt})'$ and $\boldsymbol{\xi}_{nt} = (\xi_{1t} \cdots \xi_{nt})'$. $B_n(L) = B_0^n + B_1^n L + \ldots + B_s^n L^s$ is a $n \times 2$ matrix, which has the $b_{ij}(L)$ as entries.

Equation (3) is the generalized dynamic factor model proposed by Forni et al. (2000) and Forni and Lippi (2001) where the 2 entries of u_t represent the dynamic factors. This model reconciles the two strands of literature on factor models. On the one hand, Forni et al. (2000 and 2001) generalize the dynamic factor model introduced by Sagent and Sims (1977) and Geweke (1977) by allowing for non-orthogonal idiosyncratic terms (see assumption 1). On the other hand, the model is a generalization of the factor model of Chamberlain (1983) and Chamberlain and Rothschild (1983) which assumes non-orthogonal idiosyncratic components but it is static.

Denote by $\mathbf{\Sigma}_n^{\mathbf{x}}(\theta)$, $\theta \in [-\pi\ \pi]$, the spectral[12] density matrix of $\mathbf{x}_{nt}$ and $\mu_i^{\mathbf{X}}(\theta)$, $i = 1, 2, \ldots, n$, its eigenvalues in decreasing order of magnitude. The $\mu_i^{\mathbf{X}}(\theta)$ are called dynamic eigenvalues[13]. Similarly, $\mu_i^{\chi}(\theta)$ and $\mu_i^{\xi}(\theta)$ represent the dynamic eigenvalues of the spectral density matrices of the common component, $\mathbf{\Sigma}_n^{\chi}(\theta)$, and the idiosyncratic component, $\mathbf{\Sigma}_n^{\xi}(\theta)$, respectively.

Identification of the common and idiosyncratic components requires two additional assumptions:

Assumption 1: The first dynamic eigenvalue of the spectral density matrix of the idiosyncratic component is uniformly bounded[14], i.e., there exists a real Λ such that $\mu_1^{\xi}(\theta) \preceq \Lambda$, $\forall$ $\theta \in [-\pi\ \pi]$. This implies that variations caused by idiosyncratic components are small and tend to zero as i tends to infinity.

Assumption 2: The first two largest dynamic eigenvalues of the spectral density matrix of the common component diverge almost everywhere (a.e.) in $[-\pi\ \pi]$, i.e., $\mu_j^{\chi}(\theta) \longrightarrow \infty$ as $n \longrightarrow \infty$, a.e. in $[-\pi\ \pi]$, $j = 1, 2$. This means that each of the two dynamic factors is infinitely present in the cross-section units. Note that this assumption only concerns the first two largest dynamic eigenvalues of the common components because we implicitly assume two common shocks. We will show later that the assumption of two common shocks is supported by our data.

Under these requirements, Forni et al. (2000) show that the first two largest eigenvalues of $\mathbf{\Sigma}_n^{\mathbf{x}}(\theta)$ diverge a.e. in $[-\pi\ \pi]$ whereas the third one is uniformly bounded. This guarantees the identification of the common and idiosyncratic components (see Forni and Lippi, 2001).

[12] The spectral density function of a variable is the decomposition of the variance of this variable into orthogonal components in the frequency domain.

[13] The term dynamic eigenvalue is used to make a difference with the eigenvalue of the variance covariance of $\mathbf{x}_{nt}$. See Brillinger (1975).

[14] Assumption 1 ensures that the variance of a linear combination of idiosyncratic components vanishes as n goes to infinity. This requirement is satisfied in cases where the idiosyncratic components are orthogonal or weakly correlated (see Forni and Lippi, 2001).

To identify the structural shocks, we use the transformation $v_t = Ru_t$, with $RR' = I_2$, where I_2 is a 2×2 identity matrix. The problem consists of choosing the appropriate rotation matrix R that corresponds to our identification assumption. We will come back to this point later.

The static form representation of Equation (3) is:

$$\mathbf{x}_{nt} = A_n F_t + \boldsymbol{\xi}_{nt}, \tag{4}$$

where, $A_n = (a_1' \ldots a_n')' = (B_0^n \; B_1^n \; \ldots B_s^n)$ and $F_t = (u_{1t} \; u_{2t} \; u_{1t-1} \; u_{2t-1} \ldots u_{1t-s} \; u_{2t-s})'$. The $r = 2(s+1)$ entries of F_t are called static factors. From the expression of F_t, it follows by definition that:

$$F_t = CF_{t-1} + e_t, \tag{5}$$

where, $C = \begin{pmatrix} 0 & 0 \\ (2 \times 2s) & (2 \times 2) \\ I & 0 \\ (2s \times 2s) & (2s \times 2) \end{pmatrix}$; $e_t = \begin{pmatrix} u_t \\ 0 \\ (2s \times 1) \end{pmatrix}$ and F_{t-1} is orthogonal to e_t.

The vector F_t is only identified up to a pre-multiplication by a unitary matrix. So we cannot estimate it directly. We rather estimate[15] the common static factors space. This is the vector G_t whose entries span the linear space as the entries of F_t. Suppose that $G_t = EF_t$, where E is a non-singular matrix. Given the definition of G_t and Equation (5) , it follows the VAR(1) representation:

$$G_t = DG_{t-1} + \epsilon_t, \tag{6}$$

where, $D = ECE^{-1}$ and $\epsilon_t = Ee_t$. The residual from the VAR(1) in Equation (6) can be expressed as:

$$\epsilon_t = E_2 u_t = E_2 R' R u_t = PMRu_t, \tag{7}$$

where E_2 is the matrix formed by the first two columns of E. M represents the diagonal matrix having on the diagonal the square roots of the first two largest eigenvalues of the covariance matrix of the residual, ϵ_t. P is the matrix whose columns are the eigenvectors corresponding to these eigenvalues. Replacing the residual ϵ_t by its expression in Equation (7) and inverting the VAR (1) gives:

[15] We deal with the estimation issue in the next subsection.

$$G_t = (I_r - DL)^{-1} PMRu_t, \tag{8}$$

where L is the lag operator and I_r is a $r-$dimensional identity matrix. Substituting Equation (6) in Equation (4) and replacing EF_t by G_t gives:

$$\mathbf{x}_{nt} = Q_n G_t + \boldsymbol{\xi}_{nt} = Q_n(I_r + DL + D^2L^2 + \ldots + D^sL^s)PMRu_t + \boldsymbol{\xi}_{nt}, \tag{9}$$

with $Q_n = A_n E$ and R is a rotation matrix which is chosen according to our identification restriction. Note that this sum is finite because $\boldsymbol{\chi}_{nt}$ is orthogonal to u_{t-k} for $k \succ s$. From Equation (9), we identify the impulse response function (IRF) as follows:

$$IRF = Q_n(I + DL + D^2L^2 + \ldots + D^sL^s)PMR. \tag{10}$$

3.2 Estimation

In this section we explain the different steps to estimate the unknown parameters in Equation (10). These parameters are contained in the matrices Q_n, D, P, M, and R.

Following Stock and Watson (2002a and 2002b), we estimate the static factors space, G_t, by the first r principal components of $\mathbf{x}_{nt}$:

$$G_t = V'\mathbf{x}_{nt}, \tag{11}$$

where V is a $n \times r$ matrix whose columns are the eigenvectors corresponding to the first r largest eigenvalues of the variance-covariance matrix of $\mathbf{x}_{nt}$. The number of static factors, r, is determined by the information criteria proposed by Bai and Ng (2002). We find the values for r ranging between 3 and 6. We choose 5 static factors[16] to allow comparison of the results between countries.

Based on Equation (9) and on Stock and Watson (2002a and 2002b), we estimate Q_n by OLS as:

$$Q_n = \sum_{t=1}^{T} \mathbf{x}_{nt} G_t' \left(\sum_{t=1}^{T} G_t G_t' \right)^{-1} = V. \tag{12}$$

Having determined G_t, we estimate the VAR(1) in Equation (6) by OLS. This gives the value for D:

[16] The results do not change fundamentally when we use different numbers of static factors.

$$D = \sum_{t=2}^{T} G_t G'_{t-1} \left(\sum_{t=2}^{T} G_{t-1} G'_{t-1} \right)^{-1}. \tag{13}$$

Next, we compute the variance-covariance matrix of the residual ϵ_t in Equation (6) by:

$$\Gamma = \frac{1}{T-1} \sum_{t=2}^{T} G_t G'_t - D \left(\frac{1}{T-1} \sum_{t=2}^{T} G_{t-1} G'_{t-1} \right)^{-1} D'. \tag{14}$$

After that, we run the first 2 principal components on this matrix to estimate P and M. M is the diagonal matrix having on the diagonal the square roots of the first 2 largest eigenvalues of the covariance matrix of ϵ_t, and P is the matrix whose columns are the eigenvectors corresponding to these eigenvalues.

Based on Equation (7), we estimate u_t by:

$$u_t = R' M^{-1} P' \epsilon_t, \tag{15}$$

where $\epsilon_t = V'\mathbf{x}_{nt} - DV'\mathbf{x}_{nt-1}$ (see Equation (6)).

Finally, the rotation matrix is represented by:

$$R = \begin{pmatrix} \sin(a) & \cos(a) \\ -\cos(a) & \sin(a) \end{pmatrix}, \tag{16}$$

where $a \in [0, \pi)$. The parameter a is fixed such that the long-run effect of the demand shock on output is zero. More specifically, the parameter a minimizes the distance between zero and the accumulated impulse response function (see Equation (10)) of output to aggregate demand shocks.

Using this framework, we compute aggregate demand and aggregate supply shocks for each ECOWAS country. After that, we take the correlation of these shocks across countries. We test the significance of the correlation coefficients by the statistic:

$$z = \frac{\sqrt{n-3}}{2} \ln \left(\frac{1+r}{1-r} \right), \tag{17}$$

where r is the correlation coefficient and n is the number of years for which we have computed each shock. After considering the lag structure of the model we end up with 33 observations. Under the null hypothesis that r is equal to zero, the statistic z has a normal asymptotic distribution.

3.3 Data

The data used in the paper are at the annual basis. They span the period from 1966 to 2000. We use 54 series of different nature, including real, nominal and financial variables (see Appendix A for data description).

The data come from the International Monetary Fund (International Financial Statistics), the World Bank (the World Development Indicators) and the Penn World Table 6.1 (Heston et al. 2002).

We transform the original series to reach stationarity as required by our model. In most cases, the series are $I(1)$ such that we apply the first difference. The series are taken in deviation from the mean value and divided by their standard deviation. This allows comparison between series as they are now expressed in the same unit[17].

4 Supply and Demand Shocks across West African Countries

First, we check whether the assumption of two shocks is plausible in ECOWAS countries. To this end, we compute the percentage of the variance explained by two dynamic principal components. Technical details are given in Appendix C. Table 4 reports the results.

We observe that two dynamic principal components capture on average more than 60% of the variance of the panel in each country (see column 2 in Table 4). These values are significant for standardized data. They imply a high co-movement between the series and the two shocks.

Now, we look at the shocks. Figure 4 displays the underlying aggregate demand and supply shocks for selected countries.

[Figure 4 about here]

During the period studied, Cote d'Ivoire and Nigeria experienced on average similar demand and supply shocks. Cote d'Ivoire had a severe demand shock in 1994 following the devaluation of CFA franc. Nigeria faced big demand shocks in the late 1980s and in the 1990s.

Cote d'Ivoire went through a recession at the end of the 1970s and in the beginning of the 1980s. This corresponds to the financial crisis in the French speaking countries in Africa. The crisis has led to the bankruptcy of the financial system. Benin was among the most affected countries. In 1989 all the commercial banks that were operating in the Beninese economy collapsed. The negative supply shock in Cote d'Ivoire in 1993 may be related to the

[17] Each series has now zero mean and one standard deviation.

loss of competitiveness in WAEMU countries. The positive supply shock of 1995 corresponds to the supply response to the devaluation of CFA franc.

Let us look at the size of the shocks. This is measured by their standard deviation. Table 5 summarizes the results. The larger the asymmetric shocks, the more difficult it will be for countries to maintain a fixed exchange rate. This is particularly true for supply shocks since demand shocks can be adjusted with domestic policies. The results show comparable size across West African countries. The sizes of the shocks reported here are much bigger than the ones found by Bayoumi and Eichengreen (1992) for industrialized countries. This is not the case when we compare the results with the work by Fidrmuc and Korhonen (2003). The findings of that research were that many European countries had bigger demand shocks than West African countries. These are, for example, the UK, Belgium, Finland, Germany, Denmark, Spain, Sweden and Bulgaria. On the contrary, West African countries experienced relatively larger supply shocks.

Tables 6 and 7 report the correlation matrices of aggregate demand and supply shocks across countries. As mentioned in section 3, we focus on results relative to Cote d'Ivoire and Nigeria, the two largest economies of WAEMU and WAMZ, respectively. Figures 5 and 6 display the correlation of demand and supply shocks with Cote d'Ivoire and Nigeria, respectively. For comparison, we plot in the same graphs the results for European countries found by Fidrmuc and Korhonen (2003). The correlations for European countries are evaluated with Germany.

[Figures 5 and 6 and Tables 6 and 7 about here]

CFA countries, except for Togo and Niger, have positive demand shocks correlation with Cote d'Ivoire (see Figure 5). The result is, however, only significant for Senegal at the 5% significance level (see Table 6). The magnitudes of their demand shocks correlation are smaller than those of their inflation correlation found earlier in Table 3. Demand shocks correlation between WAEMU countries are comparable with those among European countries. Nigeria is the only WAMZ member having positive demand shocks correlating with Cote d'Ivoire. However, the correlation is weak and the result is not significant.

Supply shocks present a similar picture for WAEMU countries. However, two differences subsist. First, the correlations are much bigger here for Benin and Burkina Faso. Second, Cote d'Ivoire has more asymmetric supply shocks with Niger and Togo. Moreover, supply shocks are more similar between European countries than among WAEMU members. The correlation of supply and demand shocks reported here for WAEMU countries are much smaller than output and inflation shocks correlations found by Fielding and Shields (2001). The difference between the results may be due to measurement errors and the use of a limited information set in Fielding and Shields (2001).

We now turn to results relative to Nigeria. The data display a similar pattern for demand shocks between WAMZ countries compared to WAEMU members. Ghana has positive and significant demand shocks correlating with Nigeria, contrary to Gambia (see Figure 6). Except for Niger and Senegal, WAEMU countries have demand shocks similar to Nigeria. According to supply shocks, Nigeria displays asymmetric shocks with the rest of WAMZ members (Gambia and Ghana). Except for Niger, Nigeria has asymmetric supply shocks with WAEMU countries as well. However, the correlation is small for Niger and the result is not significant.

Let us summarize our findings. First, demand shocks are as similar between CFA countries as between WAMZ members. The results are comparable to the ones between European countries. This conclusion extends to correlations between WAMZ and WAEMU countries, so to all ECOWAS members. Second, supply shocks are poorly correlated between CFA countries and more asymmetric between WAMZ members. Asymmetric supply shocks are observed between WAEMU countries and the WAMZ ones as well. Supply shocks are less similar between West African countries than European countries. The results for supply shocks may reflect the different specialization in commodity goods in West African countries (see Table B3). Hence, if wages are rigid and factor mobility is limited in West Africa, a monetary union in the ECOWAS area will be costly. Our results also suggest that WAEMU can be extended to Ghana. A similar result has been found by Bénassy-Quéré and Coupet (2003).

To check the robustness of our analysis, we look at the sign predictions of output and price in the aggregate demand and supply framework. A positive demand shock is supposed to increase the price level while a positive supply shock is expected to reduce it. Figure 7 reports the impulse response functions of output and price for selected countries.

[Figure 7 about here]

The sign predictions are satisfied in all cases. However, there are some irregularities for Nigeria and Burkina Faso.

For comparison, output reaches its pick at roughly 10 years after a positive supply shock in Nigeria while it is about 20 years for Cote d'Ivoire and Burkina Faso. The long-run response is much bigger for Cote d'Ivoire. In addition, there is some persistence in the impulse response functions for WAEMU countries.

Finally, we look at the adjustment speed between Cote d'Ivoire and Nigeria. We measure the adjustment speed as the ratio of the value of the accumulated impulse response function after some period to its long-run response value. A high value would indicate a large amount of adjustment. For comparison, we look at the output response to a positive supply shock.

Only about 53% of the long-run level of the accumulated response is reached after 3 years for Cote d'Ivoire. This indicator is about 83% for Nigeria. Bayoumi and Eichengreen (1992) report 94% and 72%, respectively, for the US economy and European countries. After 10 years, the difference in the adjustment process between the two countries is still significant. Nigeria completes 100% against 85% for Cote d'Ivoire. These results clearly show a lower adjustment speed of output following a supply shock for Cote d'Ivoire compared to Nigeria. Fidrmuc and Korhonen (2003) find a similar result for France and Germany. After 4 quarters, the adjustment speed of the output to a positive supply shock is about 87% for Germany against 92% for France. The difference in the speed of adjustment between Nigeria and Cote d'Ivoire may reflect the difference in the exchange rate regimes between the two countries.

5 Discussion

The analysis of the feasibility of a monetary union in West Africa is only complete once we also look at the benefits side. In a monetary union, countries have a fixed bilateral exchange rate. A fixed exchange rate reduces transactions and conversion costs. It also reduces bilateral exchange rate fluctuations. Therefore, the greater the amount of inter-regional trade, the higher the benefits of a monetary union. Masson and Pattillo (2001) estimate internal trade at 10% and 4.7% between 1997 and 1998 for WAEMU and WAMZ, respectively. Hugon (1999) provides an estimate of 12% for WAEMU in 1998. These values are far from the estimation of 46% for EMU in the same year. Then, the benefits for forming a monetary union in West Africa could be lower than in EMU.

We do not have to worry much about this result for different reasons. First of all, the gravity model predicts that their intra-trade should be lower because of their small level of income per capita. This is why Foroutan and Pritchett (1993) show that intra-African trade is comparable to the trade between low -and middle- income developing countries. Secondly, the trade statistics that are usually published do not take into account informal trade, thereby introducing a bias in the analysis. For example, Lares (1998) estimates informal trade between Benin and Nigeria. The study shows that the official statistics should be multiplied by 12 and 13 for imports and exports, respectively.

ECOWAS has introduced a trade liberalization project to increase intra-regional trade. The objectives of this project are: to establish a custom union; to eliminate custom duties and taxes of equivalent effects; to remove non-tariff barriers; and to establish common custom external tariffs. In any case, Alesina et al., (2002), among others, find that a monetary union has a positive effect on trade[18]. In addition, Frankel and Rose (1998) show that integration

[18] Fielding and Shield (2003 and 2004) and Anyanwu (2003) provide evidences on African countries.

leads to more trade, which will result in high business cycle correlations.

The presence of asymmetric shocks between countries in a monetary union is not a problem in itself if labour is highly mobile across countries. When asymmetric shocks happen to countries in a monetary union it makes some countries richer and others poorer. If labour forces are mobile between countries, people in the poorer countries can emigrate to the richer countries. This process continues until countries go back to their initial situation (Mundell, 1961). Labour data are difficult to obtain for ECOWAS countries. The World Bank (2000) estimates the foreign residents at 26% in Cote d'Ivoire in 1998, 14% in Gambia and 8% in Guinea. These values are significant. ECOWAS has also introduced a common passport in 2000, which is supposed to increase labour mobility.

6 Conclusion

In this paper, we use the dynamic structural factor model to extract aggregate demand and aggregate supply shocks for West African countries. The correlations of the underlying shocks are evaluated across countries. The results show positive demand shocks correlation between French speaking countries, except for Togo and Niger. This is the same for English speaking countries, except for Gambia, which displays asymmetric demand shocks with Nigeria. Demand shocks are positively or less negatively correlated between all West African countries. Supply shocks are less correlated and more asymmetric between these countries, reflecting the different specialization in commodity goods in West African countries. Our results also suggest that only Ghana has macroeconomic shocks similar to CFA countries in West Africa. These results imply some costs for a monetary union in West Africa.

In the paper we have concentrated on correlations of shocks between countries. It may be interesting to compute the correlations of country specific shocks with the shocks faced by the aggregate of countries. This approach is more parsimonious since the common central bank will take an aggregate view in the decision making process. However, the aggregation of the shocks will not change the main conclusions of this paper.

The aim of this paper is not to give a definite answer to whether ECOWAS is an optimal currency area. We only analyze one dimension of this question, that is the costs of a monetary union in this area. We would have to deepen our work in the direction of a cost-benefit analysis to go further. We can apply the framework in Aksoy et al. (2002) to access the impact of asymmetric shocks on the welfare function when a common monetary policy is implemented in West Africa. This framework is useful since it will allow us to compute the net gain of a country when a common monetary policy is implemented in a situation when a national optimal monetary policy is decided. We would also like to assess the impact of different fiscal policies on the welfare function when a common monetary policy is implemented in West Africa.

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Figure 1: **Historical Output Growth and Inflation**

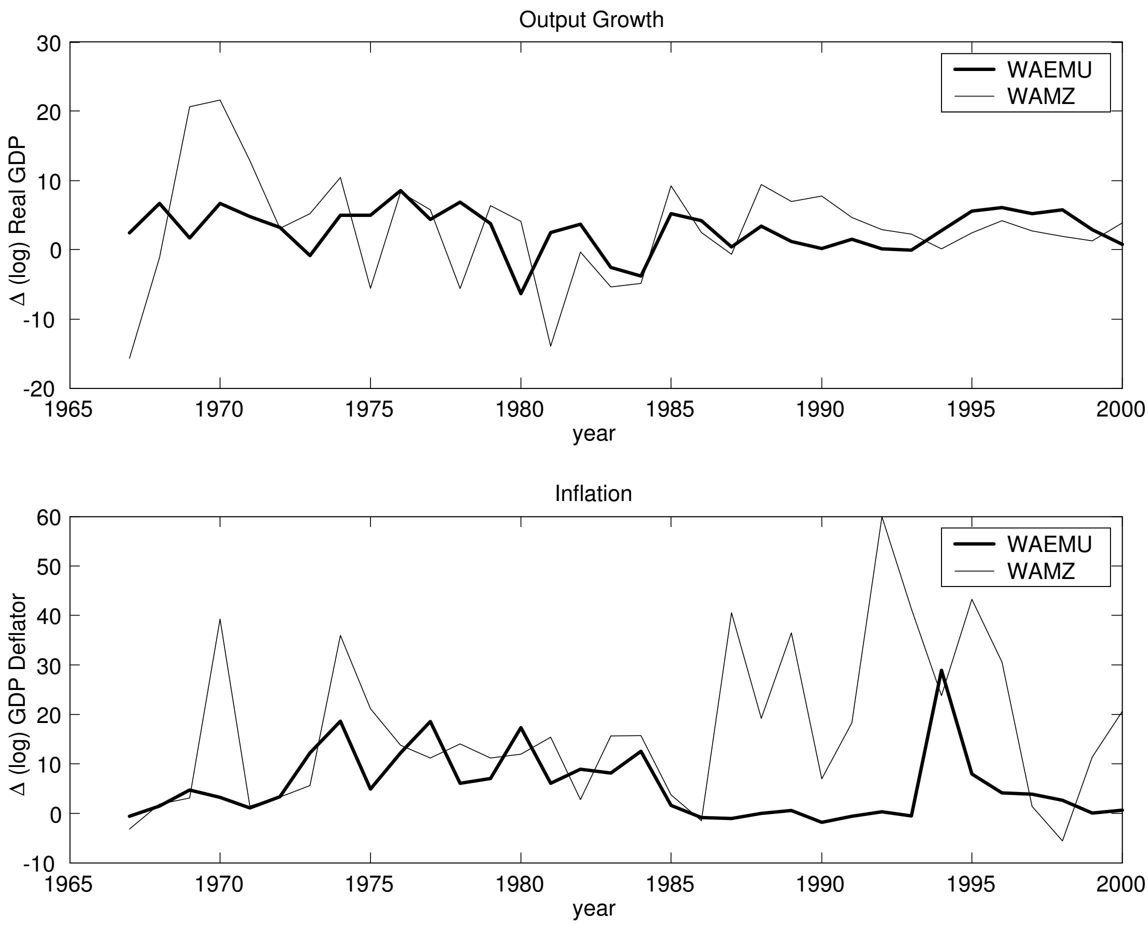
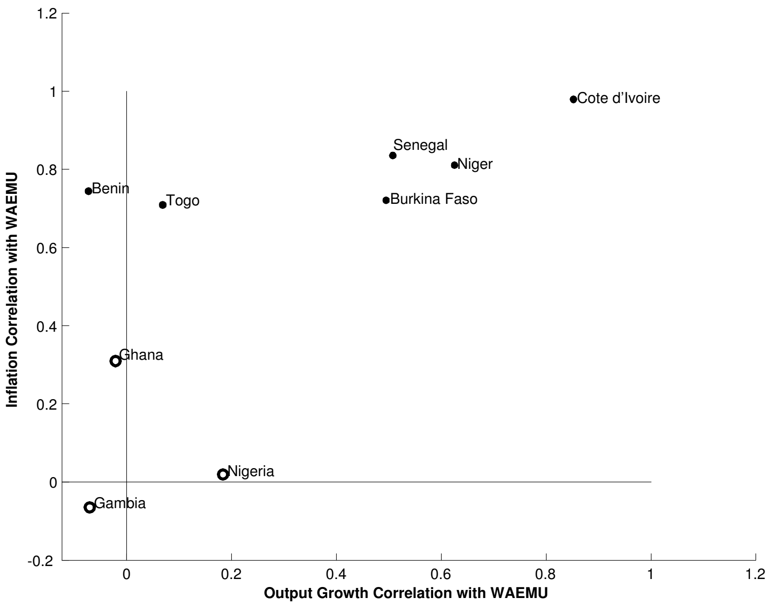
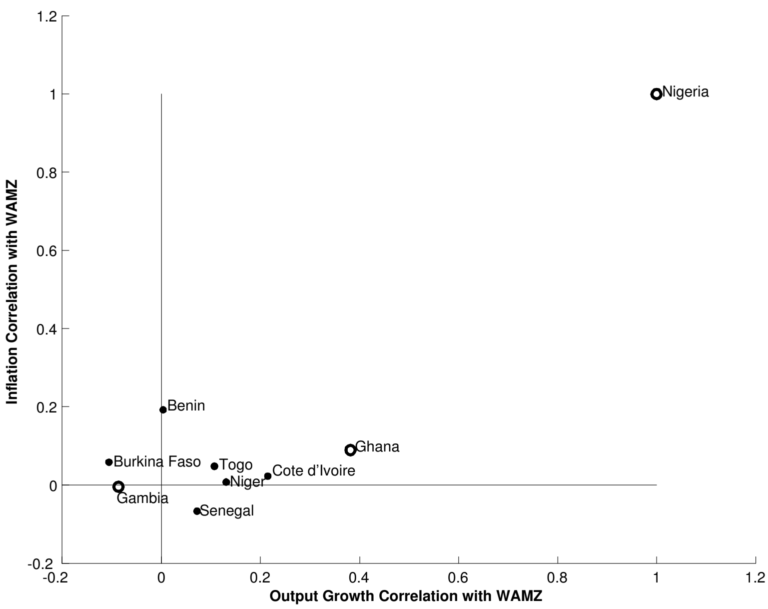


Figure 2: **Correlation of Output Growth and Inflation with the Aggregate WAEMU**



Note: • for WAEMU members; and ○ for WAMZ members.

Figure 3: **Correlation of Output Growth and Inflation with the Aggregate WAMZ**



Note: • for WAEMU members; and ○ for WAMZ members.

Figure 4: **Aggregate Demand and Supply Shocks in Selected Countries**

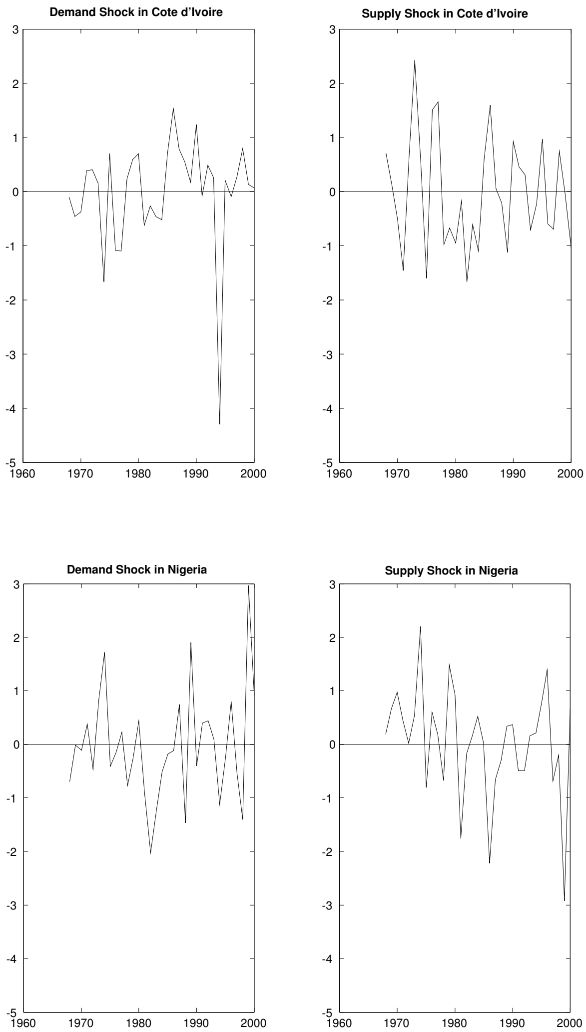
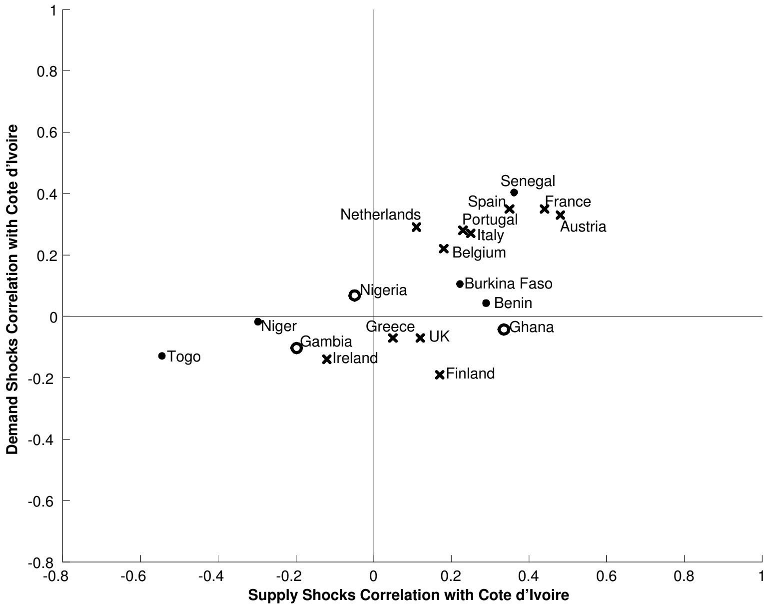
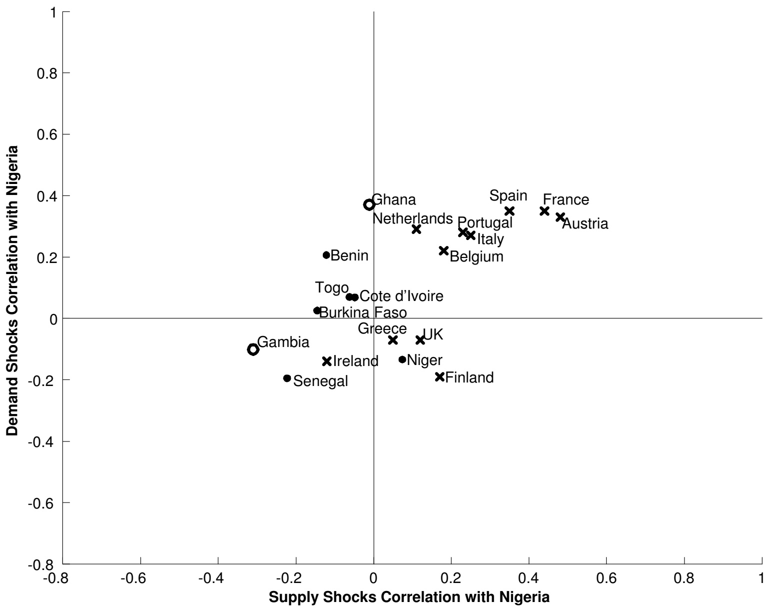


Figure 5: **Aggregate Demand and Supply Shocks Correlation with Cote d'Ivoire**



Note: • for WAEMU members; ∘ for WAMZ members; and × for EU members.

Figure 6: **Aggregate Demand and Supply Shocks Correlation with Nigeria**



Note: • for WAEMU members; ∘ for WAMZ members; and × for EU members.

Figure 7: **Impulse Response Function of Output and Prices in Selected Countries**

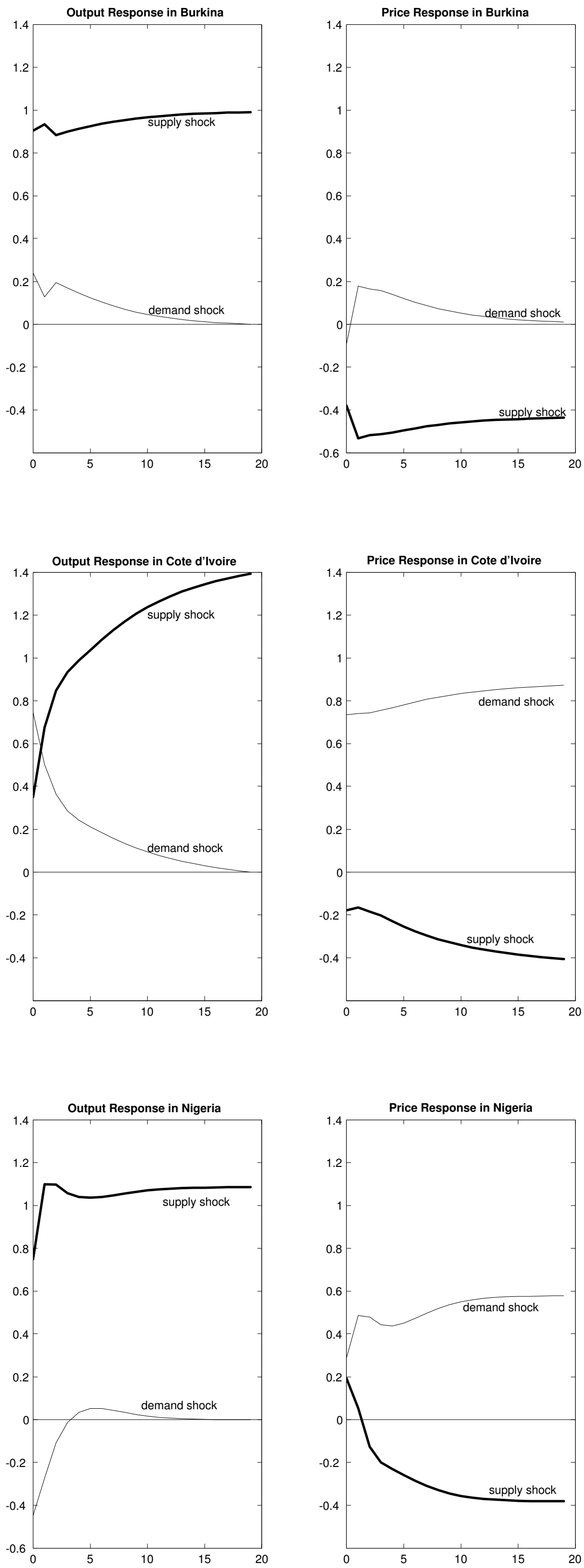


Table 1: **Inflation and Output Growth Developments**

	Output Growth		Inflation	
	Average	Std. Dev.	Average	Std. Dev.
WAEMU	02.83	03.22	05.66	07.05
Benin	03.20	03.30	05.70	06.60
Burkina F.	03.75	03.32	04.49	05.62
Cote I.	03.51	04.98	06.12	09.16
Niger	00.83	06.67	05.10	08.82
Senegal	02.56	04.66	05.41	05.36
Togo	02.58	06.07	05.63	09.42
WAMZ	03.15	07.69	16.80	15.83
Gambia	03.95	03.22	08.46	08.66
Ghana	02.51	04.73	26.28	16.64
Nigeria	03.18	07.98	16.88	16.29

Table 2: **Correlation Matrix of Output Growth**

	Benin	Burkina	Cote I.	Gambia	Ghana	Niger	Nigeria	Senegal	Togo	WAEMU
Benin	1									
Burkina	0.14	1								
Cote I.	0.25	0.21	1							
Gambia	-0.17	-0.20	0.08	1						
Ghana	-0.02	-0.06	0.03	-0.21	1					
Niger	0.00	0.47	0.27	-0.25	0.15	1				
Nigeria	-0.08	-0.11	0.22	-0.08	0.36	0.12	1			
Senegal	0.15	0.34	0.13	-0.06	-0.39	0.31	0.07	1		
Togo	-0.15	-0.12	0.14	-0.03	0.24	0.02	0.10	-0.22	1	
WAEMU	-0.07	0.49	0.85	-0.07	-0.02	0.62	0.18	0.50	0.06	1
WAMZ	0.00	-0.10	0.21	-0.09	0.38	0.13	0.99	0.07	0.10	0.18

Note: WAEMU members are Benin, Burkina Faso, Cote d'Ivoire, Niger, Senegal, and Togo. WAMZ members are Gambia, Ghana, and Nigeria.

Table 3: **Correlation Matrix of Inflation**

	Benin	Burkina	Cote I.	Gambia	Ghana	Niger	Nigeria	Senegal	Togo	WAEMU
Benin	1									
Burkina	0.66	1								
Cote I	0.68	0.63	1							
Gambia	-0.22	-0.04	-0.7	1						
Ghana	0.20	0.49	0.25	0.05	1					
Niger	0.58	0.57	0.74	-0.29	0.28	1				
Nigeria	0.18	0.04	0.01	0.00	0.07	0.00	1			
Senegal	0.66	0.61	0.76	0.20	0.30	0.57	-0.07	1		
Togo	0.47	0.40	0.70	0.13	0.16	0.42	0.04	0.63	1	
WAEMU	0.74	0.72	0.97	-0.06	0.30	0.81	0.02	0.83	0.70	1
WAMZ	0.19	0.05	0.02	0.00	0.08	0.00	0.99	-0.06	0.04	0.02

Note: WAEMU members are Benin, Burkina Faso, Cote d'Ivoire, Niger, Senegal, and Togo. WAMZ members are Gambia, Ghana, and Nigeria.

Table 4: **Percentage of Variance Explained by the DPCs**

Number of DPCs	1	2	3	4	5
Benin	42.18	61.96	75.20	84.03	89.50
Burkina Faso	42.62	62.80	75.86	83.88	89.51
Cote d'Ivoire	44.01	64.14	77.45	85.30	90.46
Gambia	40.45	63.12	75.66	84.16	89.47
Ghana	43.63	62.90	76.24	84.32	89.61
Niger	39.67	59.56	74.14	82.93	88.71
Nigeria	45.05	65.12	77.77	85.62	90.72
Senegal	45.00	67.03	77.94	85.97	91.07
Togo	39.53	62.63	76.12	85.08	90.39

Note: DPC=Dynamic Principal Component. The values in the table are averaged over 101 frequencies.

Table 5: **Standard Deviation of Demand and Supply Shocks**

	Supply Shocks	Demand Shocks
WEAMU Countries		
Benin	1.0155	1.0152
Burkina Faso	1.0154	1.0155
Cote d'Ivoire	1.0150	1.0153
Niger	1.0155	1.0143
Senegal	1.0151	1.0155
Togo	1.0155	1.0153
WAMZ Countries		
Gambia	1.0155	1.0155
Ghana	1.0154	1.0152
Nigeria	1.0145	1.0149

Table 6: **Correlation Matrix of Demand Shocks**

	Benin	Burkina	Cote I.	Gambia	Ghana	Niger	Nigeria	Senegal	Togo
Benin	1								
Burkina	-0.24	1							
	(-1.39)								
Cote I	0.04	0.11	1						
	(0.23)	(0.58)							
Gambia	-0.18	0.30*	-0.10	1					
	(-1.05)	(1.70)	(-0.56)						
Ghana	0.01	0.15	-0.04	0.05	1				
	(0.10)	(0.86)	(-0.23)	(0.28)					
Niger	0.08	0.01	-0.01	-0.07	-0.04	1			
	(0.49)	(0.07)	(-0.09)	(-0.38)	(-0.20)				
Nigeria	0.20	0.02	0.06	-0.10	0.37**	-0.13	1		
	(1.14)	(0.13)	(0.37)	(-0.55)	(2.13)	(-0.73)			
Senegal	0.07	-0.19	0.40**	0.02	-0.30*	0.03	-0.19	1	
	(0.43)	(-1.08)	(2.34)	(0.10)	(-1.70)	(0.18)	(-1.08)		
Togo	-0.07	-0.01	-0.13	0.09	0.34**	0.24	0.06	-0.04	1
	(-0.43)	(-0.10)	(-0.70)	(0.51)	(1.97)	(1.37)	(0.38)	(-0.22)	

Note: The number in brackets are Z-statistics. We apply a two-sided test. The critical values are 2.58; 1.96 and 1.64 respectively for 1%, 5% and 10% significance levels. ***=significant at 1%; **=significant at 5%; *=significant at 10%. WAEMU members are Benin, Burkina Faso, Cote d'Ivoire, Niger, Senegal, and Togo. WAMZ members are Gambia, Ghana, and Nigeria.

Table 7: **Correlation Matrix of Supply Shocks**

	Benin	Burkina	Cote I.	Gambia	Ghana	Niger	Nigeria	Senegal	Togo
Benin	1								
Burkina	0.86***	1							
	(7.11)								
Cote I	0.28	0.22	1						
	(1.63)	(1.23)							
Gambia	-0.30	-0.25	-0.19	1					
	(-1.74)	(-1.45)	(-1.10)						
Ghana	0.12	0.15	0.33*	-0.15	1				
	(0.70)	(0.85)	(1.91)	(-0.88)					
Niger	-0.88***	-0.84***	-0.29*	0.38**	-0.02	1			
	(-7.63)	(-6.86)	(-1.68)	(2.22)	(-0.10)				
Nigeria	-0.12	-0.14	-0.04	-0.30*	-0.01	0.07	1		
	(-0.67)	(-0.80)	(-0.26)	(-1.75)	(-0.06)	(0.41)			
Senegal	0.78***	0.79***	0.36***	-0.26	0.05	-0.79***	-0.22	1	
	(5.85)	(5.92)	(2.70)	(-1.50)	(0.28)	(-6.00)	(-1.24)		
Togo	-0.37**	-0.30*	-0.54***	0.26	-0.29*	0.39**	-0.06	-0.55	1
	(-2.18)	(-1.72)	(-3.34)	(1.50)	(-1.66)	(2.30)	(-0.34)	(-3.42)	

Note: The number in brackets are Z-statistics. We apply a two-sided test. The critical values are 2.58; 1.96 and 1.64 respectively for 1%, 5% and 10% significance levels. ***=significant at 1%; **=significant at 5%; *=significant at 10%. WAEMU members are Benin, Burkina Faso, Cote d'Ivoire, Niger, Senegal, and Togo. WAMZ members are Gambia, Ghana, and Nigeria.

Appendix A: Data Description

N°	Variables	Source	Transformation
1	GDP (constant US$)	World Bank	DLOG
2	GDP deflator (base year varies by country)	World Bank	DLOG
3	GDP per capita (constant US$)	World Bank	DLOG
4	Consumer price index (1995 = 100)	World Bank	DLOG
5	Official exchange rate (LCU per US$, period average)	World Bank	DLOG
6	Crop production index (1989-91 = 100)	World Bank	DLOG
7	Exports as a capacity to import (constant US$)	World Bank	DLOG
8	Final consumption expenditure (constant US$)	World Bank	DLOG
9	Food production index (1989-91 = 100)	World Bank	DLOG
10	Labour force, total	World Bank	DLOG
11	Money (current US$)	World Bank	DLOG
12	Official development assistance and official aid (current US$)	World Bank	DLOG
13	Quasi money (current US$)	World Bank	DLOG
14	Foreign Assets (US $)	IMF	DLOG
15	Central Government Deposits (US$)	IMF	DLOG
16	Claims on Central Government (US$)	IMF	DLOG
17	Claims on Private Sector (US$)	IMF	DLOG
18	Demand Deposits (US$)	IMF	DLOG
19	Foreign liabilities (US$)	IMF	DLOG
20	Gross domestic income (constant US$)	World Bankk	DLOG
21	Gross value added at factor cost (constant US$)	World Bank	DLOG
22	Household final consumption expenditure (constant US$)	World Bank	DLOG
23	Price level of gdp	Penn World Table	DLOG
24	price level of consumption	Penn World Table	DLOG
25	Price level of cunsumption	Penn World Table	DLOG
26	Price level of investment	Penn World Table	DLOG
27	Age dependency ratio (dependents to working-age population)	World Bank	D
28	Agricultural machinery, tractors per 100 hectares of arable land	World Bank	D
29	Agriculture, value added (% of GDP)	World Bank	D

	Variables	Origine	Transformation
30	Livestock production index (1989-91 = 100)	World Bank	DLOG
31	General gov. final cons. expenditure (constant US$)	World Bank	DLOG
32	Net taxes on products (constant US$)	World Bank	DLOG
33	Terms of Trade Index	World Bank	DLOG
34	Land use, area under cereal production (hectares)	World Bank	DLOG
35	Cereal yield (kg per hectare)	World Bank	DLOG
36	Time and Savings and foreign currency Deposits (US$)	IMF	DLOG
37	Gross capital formation (constant US$)	World Bank	DLOG
38	Aid per capita (current US$)	World Bank	D
39	Comsumption share in real gdp per capita	Penn World Table	D
40	Government comsumption share in real gdp per capita	Penn World Table	D
41	Investment share in real gdp per capita	Penn World Table	D
42	Rural population (% of total population)	World Bank	D
43	Services, etc., value added (% of GDP)	World Bank	D
44	Liquid liabilities (M3) as % of GDP	World Bank	D
45	Money and quasi money (M2) as % of GIR	World Bank	D
46	Population density (people per sq km)	World Bank	DLOG
47	Imports of goods and services (% of GDP)	World Bank	D
48	Industry, value added (% of GDP)	World Bank	D
49	Labour force, female (% of total labour force)	World Bank	D
50	Gross national expenditure (% of GDP)	World Bank	D
51	Aid (% of gross capital formation)	World Bank	D
52	Bank liquid reserves to bank assets ratio	World Bank	D
53	Domestic credit to private sector (% of GDP)	World Bank	D
54	Exports of goods and services (% of GDP)	World Bank	D

Note: DLOG=first difference of log variables. D=first difference of variables in level.

Appendix B

Figure B1: The Membership of the ECOWAS and the CFA Zone

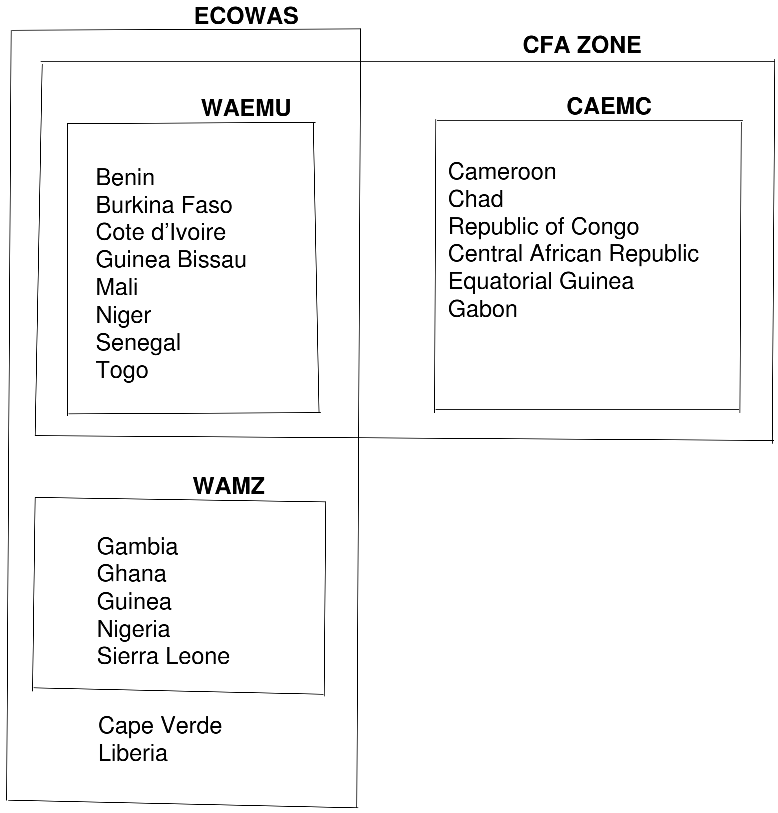


Table B1: **Selected Indicators for the WAEMU in 2001**

	Benin	Burkina Faso	Cote d'Ivoire	Niger	Senegal	Togo	WAEMU
Population[1]	6.62	12.2	16.7	11.64	9.9	4.77	75.09
Land area[2]	110.6	273.6	318.0	1,266.2	192.5	54.4	3,464.2
Intraregional trade							
Export in %	6.6	7.4	15.2	3.4	11.7	33.0	12.7
Import in %	5.5	31.8	1.1	22.1	3.8	8.7	8.9
Share in %							
GDP[3] in 2000	8.31	12.66	44.85	9.23	22.19	2.71	100.0
Net domestic assets	4.1	8.4	48.8	3.4	21.2	5.9	100.0
Net foreign assets	30.4	9.4	25.1	2.0	12.5	4.2	100.0
Fiscal balance[4]	-4.2	-12.6	0.4	-7.4	-3.9	-2.5	-5.0

Source: IMF (2003). 1=in million. The data come from the United Nations Populated Fund; 2= in 1000 sq.km; 3=the share of the 2 remaining countries of the WAEMU is less than 1%. 4=in % of the GDP and it is measured with exclusion of grants.

Table B2: **Selected Indicators for the WAMZ in 2001**

	Gambia	Nigeria	Ghana	WAMZ
Population (millions)	1.37	120	20.175	158
Land area (1000 of sq km)	10	910.77	227.54	
Intraregional Trade in 2002				
Export in %	0.81	5.06	3.89	4.00
Import in %	0.37	19.89	0.68	4.62
Share in %				
GDP[1] in 2000	9.9	89.9	0.09	100.0
Fiscal balance[2] as % of GDP	-11.1	-4.7	-7.4	-

Source: IMF (2003). 1=in the total of the 3 countries here. 2=excluded grants

Table B3: **Main Commodity Goods Exported and Exchange Rate Regimes**

	Commodities	Currency and Exch. rate Regime
	WAEMU Countries	
Benin	cocoa, coffee, cotton, groundnuts, oil palm, acajou	CFA peg[a] to euro
Burkina Faso	cotton, groundnuts.	CFA peg to euro
Cote d'Ivoire	cocoa, coffee, cotton, oil palm, rubber.	CFA peg to euro
Niger	uranium, cotton, groundnuts, groundnut oil, tobacco.	CFA peg to euro
Senegal	cotton, groundnuts, groundnut oil, phosphate, sisal, sugar.	CFA peg to euro
Togo	phosphate,cocoa, coffee, cotton, groundnuts.	CFA peg to euro
	WAMZ Countries	
Gambia	groundnuts, groundnut oil, oil palm.	Dalassi, independent float
Ghana	bauxite, cocoa, coffee, gold, manganese, oil-palm.	Cedi, independent float
Nigeria	oil, oil palm, rubber, cocoa.	Naira, managed float[b]

Source:Masson and Pattillo(2001) and IMF. a=CFA was pegged to the French franc before 1999. b=with no pre-anounced path for the exchange rate.

Appendix C: Dynamic Eigenvalues

In this part, we explain the estimation of the variance of the dynamic principal components.

Let us denote by $\mathbf{x}_{nt} = (x_{1t} \dots x_{nt})'$ the panel of series used in the paper. $\mathbf{x}_{nt}$ is $n \times T$, where n is the number of series and T is the number of observations.

First of all, we estimate a smooth spectral density matrix of $\mathbf{x}_{nt}$ by:

$$\mathbf{\Sigma}_n^{\mathbf{x}}(\theta) = \frac{1}{2\pi} \sum_{k=-m}^{m} w_k \Gamma_{nk} e^{-i\theta k}, \tag{18}$$

where $m = \text{round}(\sqrt{T})$. $\Gamma_{nk} = \frac{1}{T-k} \sum_{t=k+1}^{T} \mathbf{x}_{nt}\mathbf{x}_{n,t-k}$ is the k-lag covariance matrix $\mathbf{x}_{nt}$, $k = 0, \dots, m$. $w_k = 1 - \frac{|k|}{(m+1)}$ are the weights corresponding to the Bartlett lag window. We compute the spectra at 101 equally spaced frequencies $\theta_j = \frac{2\pi j}{100}$, where $j = -50, \dots, 50$ and $\theta_j \in [-\pi \ \pi]$.

Second, we compute the n eigenvalues and eigenvectors of $\mathbf{\Sigma}_n^{\mathbf{x}}(\theta)$ at each frequency θ_j. The principal components derived from these eigenvectors represent the dynamic principal components. The corresponding eigenvalues denote the variances of these dynamic principal components at each frequency.

After that we order the eigenvalues in decreasing order of magnitudes. Thereafter, we compute the percentage of the variance explained by each dynamic factor at each frequency. Finally, we take the average over the 101 frequencies of these percentages.