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## FEER for the CFA Franc

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## **IMF Working Paper**

African Department and IMF Institute

### **FEER for the CFA Franc**

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#### **Abstract**

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The views expressed in this Working Paper are those of the author(s) and do not necessarily represent those of the IMF or IMF policy. Working Papers describe research in progress by the author(s) and are published to elicit comments and to further debate.

We apply the fundamentals equilibrium exchange rate (FEER) approach and the Johansen cointegration methodology to investigate the behavior of the real effective exchange rates of the two monetary unions of the CFA franc zone (CEMAC and WAEMU) vis-à-vis their long-run equilibrium paths. For both CEMAC and WAEMU, our results indicate that: (i) the fundamentals account for most of the fluctuation of the real effective exchange rates, with increases in the terms of trade, government consumption, and productivity improvements causing the exchange rate to appreciate, and increases in investment and openness leading to a depreciation; (ii) at end-2005 both the CEMAC and WAEMU real effective exchange rates were broadly in line with their long-run equilibrium values; and (iii) following a shock, reversion to equilibrium is twice as fast in WAEMU than in CEMAC.

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## I. INTRODUCTION

The debate in the literature on structural adjustment and macroeconomic stabilization has emphasized the crucial role played by the real exchange rate, given its importance for export promotion and for the generation of optimal paths of output and employment.<sup>2</sup> It is argued that successful developing countries owe much of their success to having maintained their exchange rate at an “appropriate” level. Further, it is believed that a distinguishing feature of East and Southeast Asia’s success with sustainable growth has been the consistent avoidance of overvaluation.<sup>3</sup>

The CFA Franc arrangement dates back to the mid-1940s and is among the longest standing fixed exchange rate regimes worldwide.<sup>4</sup> The CFA Franc zone includes France on one side and two monetary unions in Central and West Africa on the other, WAEMU (which includes Benin, Burkina Faso, Côte d’Ivoire, Guinea-Bissau, Mali, Niger, Senegal, and Togo) and CEMAC (which includes Cameroon, Central African Republic, Chad, Republic of the Congo, Equatorial Guinea, and Gabon).<sup>5</sup> Over the past two years the CFA franc appreciated—along with the euro to which it is pegged—by more than 25 percent in nominal terms vis-à-vis the U.S. dollar putting additional pressure on the region’s competitiveness. This has led to a renewed interest in the prospects of and the outlook for the CFA franc.

Assessing competitiveness and necessary exchange rate or other appropriate policy action requires quantitative analysis of the actual and equilibrium exchange rates. This paper analyzes the movements of the actual real exchange rates (REER) for the two monetary unions of the CFA franc zone vis-à-vis their long-run equilibrium values. We use the fundamentals equilibrium exchange rate (FEER) approach based on the Edwards (1989) model and the Johansen (1995) cointegration methodology. The fundamentals approach is particularly appropriate in assessing whether a movement of the REER represents a misalignment or whether the equilibrium real effective exchange rate (EREER) itself has shifted because of changes in the economic fundamentals. Our empirical findings are summarized as follows. First, we show that the proposed fundamentals account for most of the fluctuation of the real effective exchange rates: increases in the terms of trade, government consumption, and productivity improvements tend to cause the exchange rate to appreciate, while increases in investment and openness lead to a depreciation. Second, based on these fundamentals, we estimate that while both the WAEMU and CEMAC real exchange rates were slightly more appreciated than their estimated long-run equilibrium levels at end-2005, the estimated misalignments are not statistically significant. Finally, we identify a feedback effect for both CEMAC and WAEMU, which suggests that following a shock there is reversion to the time-varying long-run equilibrium, with the speed of reversion about two times faster in WAEMU than CEMAC.

The rest of the paper is organized as follows. Section II presents some background, a brief literature review, and develops the empirical formulation of the FEER. Section III presents the econometric

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<sup>2</sup> See Mussa (1974, 1978), Edwards and van Wijnbergen (1986), Obstfeld and Rogoff (1996). Also, Acemoglu, Johnson, Robinson, and Thaicharoen (2003), and Easterly and Levine (2003).

<sup>3</sup> See Dornbusch (1982), Harberger (1986), and Hinkle and Montiel (1999).

<sup>4</sup> Appendix A provides some background and key CFA Franc zone dates. Also, see Hadjimichael and Galy (1997) and Masson and Pattillo (2004) for details on the CFA Franc zone.

<sup>5</sup> Each monetary union has a separate note-issuing central bank, La Banque Centrale des États de l’Afrique de l’Ouest (BCEAO) and La Banque des États de l’Afrique Centrale, (BEAC), respectively. The Comorian franc is also pegged to the euro. WAEMU, CEMAC, Comoros, and France form the Franc zone.

methodology and the data used for the analysis. Section IV presents the empirical results including the time-series properties of the data, the long run and short run behavior, misalignment, and speed of adjustment. Section V concludes.

## **II. BACKGROUND**

### **A. Brief Literature Review**

A number of different approaches exist in the literature for calculating the equilibrium real exchange rate.<sup>6</sup> These include traditional uncovered interest parity (UIP) and purchasing power parity (PPP) theories as well as more recent approaches such as the fundamental equilibrium exchange rate (FEER) approach, the underlying internal-external balance approach (UIEB), and the behavioral equilibrium exchange rate (BEER) approach.

The UIP and PPP arbitrage conditions are common starting points when analyzing movements in the exchange rate. The UIP condition is more informative in explaining the rate of change (or the adjustment path back to equilibrium) and not the level of the exchange rate. UIP by itself has not been successful at predicting exchange rate movements, partially because UIP estimation does not account for possible shifts in the equilibrium exchange rate. Along the same lines, the PPP theory predicts that price levels are equalized when measured in the same currency, which suggests that the real equilibrium exchange rate should be constant and equal to unity. However, empirical work on testing PPP (such as Rogoff (1996), and MacDonald (2000)) is not very supportive of the theory, which suggests that alternative approaches are needed. In order to explain the persistence in real exchange rates, it is possible to combine the UIP and PPP and estimate a cointegrating relationship between relative prices, nominal interest rate differentials and the nominal exchange rate (see, for example, Johansen and Juselius (1992)). This approach is known as the capital enhanced equilibrium exchange rate (CHEER) approach, which has produced higher speed of convergence estimates than other simple PPP models.

Another popular approach used to estimate equilibrium exchange rates is the underlying internal-external balance (UIEB) approach (also known as the macroeconomic balance approach). This approach defines the equilibrium real exchange rate as that rate which satisfies both internal and external balance. For the underlying balance to hold, planned output must equal aggregate demand (the sum of domestic demand and net trade), with the real exchange rate playing the role of relative price which must move to equilibrate demand and supply. The most popular variants of the UIEB approach is the FEER approach of Edwards (1989), Williamson (1994), and Wren-Lewis (1992), the desired equilibrium exchange rate (DEER), and the natural real exchange rate (NATREX) approach of Stein (1994).<sup>7</sup>

Finally, a method with a shorter time horizon is the behavioral equilibrium exchange rate (BEER) approach associated with Clark and MacDonald (1999). BEERs aim to use a modeling technique which captures movements in real exchange rates over time, not just movements in the medium or

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<sup>6</sup> Driver and Westaway (2004) provide a complete taxonomy of the different empirical approaches on equilibrium exchange rates estimation used in the literature. See also MacDonald and Stein (1999).

<sup>7</sup> In the DEER the theoretical assumptions are as in FEER but the external balance is based on optimal policy. The NATREX is a longer time horizon than the FEER and DEER and adds the assumption of portfolio balance (so domestic real interest rate is equal to the world rate).

long-run equilibrium level. Partly reflecting this, the emphasis in the BEER approach is largely empirical with variables used to represent long-run fundamentals, in the same way that they would influence FEERs.

Pertinent methodological issues central to estimating equilibrium exchange rates and the associated misalignment include the definition and measurement of the REER, the theoretical and empirical determinants of the EREER, and empirical estimation of the equilibrium REER. As emphasized in Driver and Westaway (2004) there is no one single definition of equilibrium exchange rate. The choice between the various approaches depends on the question of interest, and in particular the time horizon in question.

### **FEER Model Specification**

The fundamentals equilibrium real exchange rate (FEER) approach is a well recognized approach for calculating equilibrium real exchange rates.<sup>8</sup> We follow Edwards (1989) in defining the equilibrium exchange rate which results in the simultaneous attainment of internal and external equilibrium in the economy.<sup>9</sup> Internal equilibrium is achieved when the market for non-tradable goods clears in the present and expected to clear in the future as price and wage flexibility ensure that the condition of internal balance (demand equal to supply) is satisfied. External equilibrium is achieved with the current account balance being at a “sustainable” level as given by a sustainable level of capital flows. Since only real factors (the fundamentals) can influence the EREER, the model can be used to describe nominal misalignments by separating the factors that can affect the long-run equilibrium real exchange rate with permanent changes, and the short-run misalignments of the nominal exchange rate stemming from policy variables.

Edwards (1989) uses a two-period inter-temporal optimization in a dynamic model with perfect foresight of a three-good (exportables, importables and nontradables) small open economy. The economy produces an exportable and non-tradable goods and consumes the importable and non-tradable goods. Nationals hold both domestic and foreign assets, and initially there is no international capital mobility. The government consumes importables and non-tradables and uses non-distortionary taxes and domestic money creation to finance expenditures. It is assumed that neither the private sector nor the government can borrow from abroad and that the private sector has inherited a stock of foreign money. Later, capital mobility is allowed in the model, with the government not subject to capital controls and with capital flows in and out of the country. There is a dual exchange rate system (capturing the fact that in most developing countries there is a parallel market for financial transactions), characterized by a fixed nominal exchange rate for commercial transactions and a freely floating nominal exchange rate for financial transactions. There is a tariff on imports which is handed to the public. The price of exportables is fixed in terms of the foreign currency. These assumptions give rise to equations that describe portfolio decisions, the demand and supply of non-tradables, the government sector, and the external sector. When these four conditions hold simultaneously, the equilibrium real exchange rate associated is attained at the steady state, ensuring simultaneous internal and external balance. The instantaneous equilibrium in the nontraded goods market for given levels of some exogenous and policy fundamentals, is as follows:

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<sup>8</sup> For example, see Williamson (1994), Faruquee, Isard, and Masson (1999), MacDonald and Stein (1999), and Wren-Lewis (2003).

<sup>9</sup> The model is discussed in detail in Williamson (1994) so we only sketch the proof here. See also Montiel and Hinkle (1999). Cerra and Saxena (2002) and Mathisen (2003) are applications of Edwards’ methodology.

$e = e(\text{Terms of trade, Government spending, Trade controls, Technological progress, Investment})$

The model predictions suggest the following expected signs for the fundamentals:

- *Terms-of-trade of goods.* The terms-of-trade affect the REER through the wealth effect. A positive terms-of-trade shock induces an increase in the domestic demand, hence an increase in the relative price of non-tradable goods, which leads to a REER appreciation. Alternatively, viewed from an internal-external balance angle, an increase in the terms-of-trade leads to an increase in real wages of the export sector and a trade surplus. In order to restore external balance the REER must appreciate. Hence, the expected sign is positive.
- *Government consumption as a share of GDP.* This is a proxy for government demand for nontradables. Changes in the composition of government spending affect the long-run equilibrium in different ways, depending on whether the spending is directed toward traded or non-traded goods.<sup>10</sup> If government spending is primarily directed towards nontradable (tradable) goods, an increase in government consumption will result in an appreciation (depreciation) of the REER. The expected sign is ambiguous in the absence of a breakdown of government spending in tradable and nontradable goods.
- *Degree of trade controls/restrictions.* As trade controls or barriers are reduced, the total amount of trade is expected to increase. The demand for imports leads to external and internal imbalances which require a depreciation to correct. Therefore, the expected sign is negative. We proxy the reduction in trade controls and restrictions with openness.<sup>11</sup>
- *Productivity.* This captures the Balassa-Samuelson effect. An increase in the productivity of tradables versus nontradables of one country relative to a foreign country raises its relative wages. This increases the relative price of nontradables to tradables and, hence, causes a REER appreciation. The expected sign is positive
- *Investment.* Edwards suggests that inclusion of investment in the theoretical model results in supply-side effects that are dependent on the relative factor intensities across sectors, and as a result, the expected sign may a priori be ambiguous. However, given developing country evidence that investment may have a high import content, a rise in the investment share of GDP could shift spending towards traded goods and thus depreciate the REER, suggesting an expected negative sign.

The REER fluctuates around a time-varying equilibrium defined by its relationship with the long-run fundamentals. Since only real factors (the fundamentals) can influence the EREER, the model can be used to describe nominal misalignments by separating the factors that can affect the long-run equilibrium real exchange rate with permanent changes ( i.e., with permanent changes in the

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<sup>10</sup> See, for example, Montiel (1999) for a discussion on this. It is noted, however, that most empirical studies using this framework tend to find a positive relationship between the REER and government consumption.

<sup>11</sup> Openness as a measure of trade restrictions is used by Montiel. Edwards uses two alternative measures (import tariffs as ratio of tariff revenues and the spread between the parallel and official rates) which he acknowledges to have important limitations.



fundamentals bringing about changes in the long-run EREER), and the short-run misalignments of the nominal exchange rate stemming from policy variables.<sup>12</sup>

Measuring the degree of misalignment requires constructing an unobserved variable, the EREER, which requires a decomposition of the fundamentals into their “permanent” and “transitory” components. Edwards (1989) uses two methods to derive the permanent component of the fundamentals: a Beveridge-Nelson decomposition, and a moving average of each of the fundamental series together with the equilibrium equation. Other potential methods for finding the permanent component of the fundamentals include the approaches of Hodrick-Prescott (1997), Quah (1992), Casa (1992), and Gonzalo and Granger (1995). The Gonzalo-Granger method is more theoretically appealing, as by construction (and unlike the Quah and Casa methods), the decomposition is derived so that the transitory component does not Granger cause the permanent component in the long-run, which implies that a temporary shock does not have a permanent effect on the series.

### III. METHODOLOGY AND DATA

#### A. Econometric Methodology

The Johansen (1988, 1991, and 1995) maximum likelihood procedure is first used to test for the existence of a long-run cointegrating relationship between the exchange rate and its fundamentals. Next, the equilibrium levels of the fundamentals are computed, namely, by extracting the permanent component from the series. Then, the vector of long-run parameters (estimated from the long-run relationship between the real exchanger rate and the fundamentals) and the extracted permanent component of the fundamentals are combined to calculate the equilibrium real effective exchange rate.

#### Cointegration

We begin by specifying a vector of variables  $Y_t$  assumed to be in vector autoregressive (VAR) form:

$$Y_t = \pi_0 + \sum_{i=1}^p \pi_i Y_{t-i} + \Psi D_t + \varepsilon_t, \quad (1)$$

where  $Y_t$  is a  $(6 \times 1)$  vector:

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<sup>12</sup> In addition to the long-run relationship, Edwards considers “inconsistent” macroeconomic policies (such as excess supply of domestic credit and a measure of fiscal policy) that may result in short-run misalignments, given that they generate higher domestic price levels, which, in a fixed exchange rate lead to an appreciation of the REER. However, these conditions (high domestic inflation with a nominal exchange rate fixed to a low inflation country) are not met, as inflation has remained in the low levels and nominal exchange rate adjustment outpaced adjustment through the price level. Consequently, we don’t include these variables in the short-run specification of our analysis.

$$Y_t = \begin{bmatrix} \text{Real effective exchange rate}_t \\ \text{Terms of trade of goods}_t \\ \text{Government consumption}_t \\ \text{Investment}_t \\ \text{Technological progress}_t \\ \text{Openness}_t \end{bmatrix},$$

where  $\pi_0$  is a  $(6 \times 1)$  vector of deterministic variables;  $\pi_i$  are  $(6 \times 6)$  matrices of coefficients on lags of  $Y_t$ ;  $D_t$  is a vector of dummy-type variables;  $p$  is the lag length; and  $\varepsilon_t$  is a  $(6 \times 1)$  vector of independent and identically distributed errors assumed to be normal with zero mean and covariance matrix  $\Omega$ . As such, the VAR comprises a system of six equations, where the right-hand side of each equation comprises a common set of lagged and deterministic regressors.

The VAR specification in (1) provides the basis for cointegration analysis. Adding and subtracting various lags of  $Y_t$  yields an expression for the VAR in first differences:

$$\Delta Y_t = \pi_0 + \pi Y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + \Psi D_t + e_t, \quad (2)$$

where  $\Delta$  denotes the difference operator,  $\Gamma_i = -(\pi_{i+1} + \dots + \pi_p)$  is a  $(6 \times 6)$  coefficient matrix, and

$$\pi \equiv \left( \sum_{i=1}^p \pi_i \right) - I.$$

The VAR model in differences is actually a multivariate form of the Augmented Dickey-Fuller (ADF) unit root test, with the rank of  $\pi$  determining the number of cointegrating vectors:

(i) If  $\text{rank}(\pi) = 6$  or  $\text{rank}(\pi) = 0$ , then no cointegration exists among the elements in a long-run relationship, and in these cases, it is appropriate to estimate the model in levels (for  $\text{rank}(\pi) = n$ ), and first differences (for  $\text{rank}(\pi) = 0$ ).

(ii) If  $0 < \text{rank}(\pi) \equiv r < 6$ , then there are  $r$  cointegrating vectors/relationships. In this case, matrix  $\pi$  can be expressed as the outer product of two full column rank  $(6 \times r)$  matrices  $\alpha$  and  $\beta$  where  $\pi = \alpha\beta'$ .

If the condition in (ii) is met the VAR can be expressed as a vector error correction model (VECM):

$$\Delta Y_t = \pi_0 + \alpha\beta' Y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + \Psi D_t + \varepsilon_t. \quad (3)$$

The matrix  $\beta'$  contains the cointegrating vector(s) and the matrix  $\alpha$  has the weighting elements for the  $r$ th cointegrating relation in each equation of the VAR. The matrix rows of  $\beta' Y_{t-1}$  are normalized on the variable(s) of interest in the cointegrating relation(s) and interpreted as the deviation(s) from the “long-run” equilibrium condition(s). In this context, the columns of  $\alpha$  represent the speed of

adjustment to “long-run” equilibrium.<sup>13</sup> The estimated vector  $\beta$  can be used to provide a measure of the equilibrium real exchange rate and also quantify the misalignment gap between the prevailing real exchange rate and its equilibrium level. The estimated  $\alpha$  captures the speed at which the real exchange rates converge to the equilibrium level.

### Permanent and transitory decomposition

The presence of cointegration implies that the vector  $Y_t$  may be thought of as being driven by a smaller number of common trends or permanent components. The permanent component  $Y_t^P$  is taken to be the measure of equilibrium whereas  $Y_t^T$  measures transitory fluctuations. There are a number of alternative methods of extracting the permanent component of the series. All of these methods attempt to determine common trends driving the real exchange rate and other identified fundamentals, and identify real shocks that are considered to be permanent and nominal shocks that are considered to be transitory.<sup>14</sup>

We apply two different decomposition methods to the fundamentals’ time series, namely, (i) the Hodrick-Prescott (HP) (1997) filter and (ii) the Gonzalo-Granger (GG) (1995) decomposition.

The construction of the permanent component of the fundamentals series using the HP filter has become a popular choice among business cycle analysts. The HP filter is obtained by solving the minimization problem:

$$\min_{\{Y_t\}_{t=1}^T} \sum_{t=1}^T (Y_t - Y_t^T)^2 + \lambda \left[ (Y_{t+1}^T - Y_t^T) - (Y_t^T - Y_{t-1}^T) \right]^2, \quad (4)$$

where  $\lambda$  is an arbitrary constant that penalizes the variability in the smoother so that when  $\lambda = 0$  the smooth component is the data itself and no smoothing takes place. Conversely, as  $\lambda$  grows large, the smooth component is a linear trend.

As seen from (4), one of the virtues and downfalls of the HP filter is its flexibility: the filter depends on the choice of  $\lambda$  which makes the resulting cyclical component and its statistical properties highly sensitive to this choice. Further, it is not possible to calculate an approximately “optimal”  $\lambda$  for each series via estimation. While this method produces smooth permanent component series, it lacks sound theoretical basis. Therefore, we only use it for illustration purposes.<sup>15</sup>

The GG decomposition is more theoretically appealing. It is based on the assumption that shocks to the transitory component (i.e., misalignments) do not affect the permanent component (i.e., the equilibrium). The decomposition is derived so that first, the transitory component does not Granger-cause the permanent component in the long run and second, the permanent component is a linear

<sup>13</sup> If the coefficient is zero in a particular equation, that variable is considered to be weakly exogenous and the VAR can be conditioned on that variable.

<sup>14</sup> As discussed in Maravall (1993) and Quah (1992), a unique decomposition between permanent and transitory components does not exist.

<sup>15</sup> Moreover, as also discussed in Cerra and Saxena (2002), if simple smoothing processes were sufficient to arrive at the equilibrium values for the fundamental series, then, presumably, the same smoothing process could be employed to arrive at the equilibrium real exchange rate series, without the need for the VECM estimation.

combination of contemporaneous observed variables. The first restriction implies that changes in the transitory component will not have an effect on the long-run values of the variables; the second restriction makes the permanent component observable and assumes that the contemporaneous observations contain all the information necessary to extract the permanent component.<sup>16</sup> Drawing from Gonzalo and Granger (1995), a brief sketch of the GG procedure follows.

Continuing from the VECM in (3), define the orthogonal complements  $\alpha_{\perp}$  and  $\beta_{\perp}$  as the eigenvectors associated with the unit eigenvalues of the matrices  $I - \alpha(\alpha'\alpha)^{-1}\alpha'$  and  $I - \beta(\beta'\beta)^{-1}\beta'$ , respectively, where  $\alpha'_{\perp}\alpha = 0$  and  $\beta'_{\perp}\beta = 0$ . If the vector  $Y_t$  is of reduced rank, Gonzalo and Granger (1995) show that the elements of  $Y$  can be explained in terms of a smaller number of  $6 - r$  I(1) variables called common factors,  $f_t$ , plus some I(0) components, and the transitory part,  $Y_t^T$ :

$$Y_t = A_1 f_t + Y_t^T. \quad (5)$$

If the common factors are linear combinations of the variables  $Y_t$  so that  $f_t = B_1 Y_t$  and the permanent-transitory decomposition is given by (5), then the only linear combination of  $Y_t$  such that  $Y_t^T$  has no long-run impact on  $Y_t$  is  $f_t = \alpha_{\perp} Y_t$ . This identification of the common factors allows the decomposition of  $Y_t$  into a permanent and a transitory part, as follows:

$$Y_t = \underbrace{\beta_{\perp}(\alpha'_{\perp}\beta_{\perp})^{-1}\alpha_{\perp}Y_t}_{Y_t^P} + \underbrace{\alpha(\beta'\alpha)^{-1}\beta'Y_t}_{Y_t^T}. \quad (6)$$

Gonzalo and Granger (1995) show that innovations to the transitory components of all of the endogenous variables do not affect the long-run (equilibrium) forecast of  $Y_t$  captured by the permanent component. So, cyclical deviations of the fundamentals are removed in the construction of the equilibrium exchange rate. The transitory components defined this way will not have any effect on the long-run values of the variables captured by the permanent components.

Further, following results in Proietti (1997) and Johansen (2001) it is possible to calculate error bands around the permanent component of the series.<sup>17</sup> First, note that the moving average (MA) representation for  $\Delta Y_t$  in (3) follows from the Granger Representation Theorem (see Johansen (1995)) with a solution for the levels,  $Y_t$ , given by:

$$Y_t = C(1)\sum_{i=1}^t \varepsilon_i + C(1)\eta t + C^*(L)(\varepsilon_t + \eta) + A, \quad (7)$$

<sup>16</sup> Applications of the GG decomposition are also Alberolla et al. (1999), Cerra and Saxena (2002), and Mathisen (2003).

<sup>17</sup> This approach has been used by Osbat, Ruffer, and Chnatz (2003) and Engels, Konstantinou and Sondegaard (2005). Another methodology to construct asymptotic standard errors for the GG is discussed and applied in Alberola et al. (1999).

where  $C(1) = \beta_{\perp}(\alpha'_{\perp}\Gamma(1)\beta_{\perp})^{-1}\alpha_{\perp}$ ,  $C^*(L)$  is a polynomial in the lag operator,  $\pi_0$  are deterministic variables, and  $A$  is a function of the initial conditions such that  $\beta'A = 0$ . The matrix  $C(1)$  measures the long-run effect of shocks to the system, while  $\Gamma(1) = I - \sum_{i=1}^{p-1} \Gamma_i$  is a function of the short-run coefficients. Then, it can be shown that an equivalent decomposition to (6) into stationary and non-stationary parts is:

$$Y_t = \underbrace{C(1)\Gamma(1)Y_t}_{Y_t^p} + \underbrace{(I - C(1)\Gamma(1))Y_t}_{Y_t^T}. \quad (8)$$

Finally, using Johansen (2001) and the permanent-transitory decomposition in (8), error bands can be derived for the non-stationary component of the process. Let  $e_i$  denote the unit vector. The 95 percent confidence interval associated with the permanent component of the  $i$ -th variable is

$$e_i' C(1)\Gamma(1)Y_t \pm 1.96 \times \sqrt{\{(I - C(1)\Gamma(1))\beta(\beta'\beta)^{-1}Var(\beta'Y_t)(\beta'\beta)^{-1}\beta'(I - C(1)\Gamma(1))'\}_{ii}}. \quad (9)$$

## B. Variables and Data

As discussed in the previous sections, our VAR/VECM includes the following identified variables: the natural logarithm of the real effective exchange rate (LREER), the natural logarithm of terms-of-trade (LTTT), the natural logarithm of government consumption as a share of GDP (LCGR), the natural logarithm of real GDP per capita relative to trading partners (LPROD) to capture the Balassa-Samuelson effect, the natural logarithm of openness to GDP (LOPEN), and the natural logarithm of investment to GDP (LNIR). Dummy variables were used to capture the effect of the 1994 devaluation and the presence of outliers.<sup>18</sup>

The datasets for both the CEMAC and WAEMU regions consist of annual observations for the period 1970-2005.<sup>19</sup> The real effective exchange rate and the fundamentals employed in the empirical analysis are plotted for the CEMAC and WAEMU regions in Figures 1a and 1b in Appendix C, respectively. Some interesting patterns are worth highlighting. Economic performance under the arrangement was initially favorable, with growth in line with experiences in other African countries but markedly lower inflation. However, by the 1980s and early 1990s increasing domestic and external imbalances emerged: high current account deficits, low levels of international reserves and pressures on the exchange rate eventually forced a devaluation of the CFA franc in 1994 by 50 percent vis-à-vis the French franc. This sole devaluation is generally seen as a success, as it restored external competitiveness in the region and supported a resumption of growth. In contrast, measures to enhance the resilience of the exchange arrangement seem to have had less of an impact. Efforts initiated in 1994 to deepen regional integration in the context of two common markets failed to increase internal trade and factor mobility. Similarly, notwithstanding free capital markets in the region, financial markets remain shallow and segmented.<sup>20</sup>

<sup>18</sup> More details on this in the results section.

<sup>19</sup> More details on the variable definitions and sources are presented in Appendix B.

<sup>20</sup> For evidence on the benefits of CFA membership see, for example, Stasavage (1997), Fouda and Stasavage (2000), Ebaldawi and Madj (1996) and Masson and Pattillo (2001, and 2004).

The 1994 devaluation was followed by a steady appreciation of the REER (see Tables 1a and 1b, and Figures 2a and 2b in Appendix C). First, for CEMAC, the real effective exchange rate ( $REER_C$ ) appreciated cumulatively by about 33 percent through December 2000 and by a further 16 percent from January 2001 to December 2005 (the latest appreciation essentially due to the strengthening of the euro to which the CFA franc is pegged). By December 2005  $REER_C$  was at 87 percent of its pre-devaluation level. For WAEMU, the real effective exchange rate ( $REER_W$ ) appreciated cumulatively by about 22 percent through December 2000, and by a further 12 percent from January 2001 to September 2005. By December 2004 the  $REER_W$  was at 76 percent of its pre-devaluation level.

We observe significant variations around the regional averages (see Figures 3a and 3b in Appendix C). In the WAEMU region, Benin has experienced the highest appreciation since the 1994 devaluation and Senegal the lowest, with their REERs appreciating by December 2005 and standing at between 56 percent (Senegal) and 91 percent (Benin) of their pre-devaluation levels. In the CEMAC region, there was somewhat a wider variance of REERs compared to WAEMU partly as a result of the new oil producers. Equatorial Guinea had the highest appreciation (115 percent of its pre-devaluation level) and Gabon the lowest appreciation (70 percent of its pre-devaluation level). For both regions, we observe a persistent decline in real GDP per capita with respect to trading partners starting in the mid 1970s until the end of the sample period; we also observe an increase of investment starting in the 1990s, and a quite volatile pattern of terms-of-trade, with an average increase in the 2000s as a result of favorable export commodity prices: oil for CEMAC and cotton, cocoa, and gold for WAEMU. Further, for the CEMAC region only, we observe a surge in foreign direct investment in 2000-2003 associated with oil-related construction in Chad and Equatorial Guinea, while in WAEMU, there was a slow down in that period. Next, for CEMAC, government consumption was constant until about 1990 with a slight decline since then. Finally, for WAEMU, there has been a continuous overall decline in the government consumption ratio since the mid 1980s.

There are also significant differences between the two regions. Within WAEMU some countries are semi-industrialized and more developed than others (such as Senegal and Cote d'Ivoire), and some are low-income landlocked close to the Sahara (Mali and Chad). WAEMU countries are net oil importers. The eight WAEMU countries had a total population of 76 million inhabitants in 2003 and a combined GDP of US \$ 37 billion. This is about the same population and GDP as Vietnam. The six CEMAC countries had a total population of 34 million inhabitants in 2003 and a combined GDP of US\$ 28 billion. This is about the same population as Tanzania, and the same GDP as Kazakhstan. With five of six CEMAC members now net oil exporters, economic developments and prospects are dominated by oil market developments. Except for Cameroon, each country has a dominant export commodity accounting for 80 percent or more of total primary exports.

## **IV. EMPIRICAL RESULTS**

### **A. Modeling the Data**

This section discusses the univariate and multivariate time series properties of the data. We start by testing for unit roots or the order of integration of the series. Then we formulate and estimate VAR models for WAEMU and CEMAC and test for cointegration.

#### **Integration Analysis**

Figures 1a and 1b in Appendix C show a somewhat trending behavior in the series and the autocorrelations were quite strong and persistent. Nelson and Plosser (1982) find that many

macroeconomic and aggregate level series are shown to be well modeled as stochastic trends, i.e. integrated of order one, or  $I(1)$ . Simple first differencing of the data will remove the non-stationarity problem, but with a loss of generality regarding the long run “equilibrium” relationships among the variables.

We perform the standard augmented Dickey-Fuller (ADF) tests in both levels and first differences of the variables of interest. Table C2 contains the results for the CEMAC sample (top part) and the WAEMU sample (bottom part). The appropriate lag-length for the dependent variable in each test, chosen using the Schwarz Information Criterion, is provided in the second column. The t-ADF statistics are reported in the third column, and the one percent and five percent critical values are reported in the forth and fifth column, respectively. We cannot reject the null hypothesis of a unit root for all variables in levels. However, we strongly reject the null of a unit root in first differences. Hence, we conclude that all our variables are  $I(1)$  in levels or, equivalently, stationary in first differences.<sup>21</sup>

## Formulating the VAR

Our analysis of the exchange rate and its fundamentals suggests that the processes are non-stationary. This has implications with respect to the appropriate statistical methodology. While focusing on first differences eliminates the problem of spurious regressions, it also results in a potential loss of information on the long-run level interaction of the variables (e.g., Davidson et al. (1978)). We examine the hypothesis of whether there exist economically meaningful linear combinations of the  $I(1)$  series: the real effective exchange rate, terms-of-trade, government consumption, investment, technological progress, and openness that are stationary or  $I(0)$ . The Johansen maximum likelihood cointegration procedure discussed above is used for the analysis.

The procedure begins with the VAR specification. For both CEMAC and WEAMU, the VARs include the real effective exchange rate (LREER) and five fundamentals: terms-of-trade (LTTT), government consumption to GDP ratio (LNCGR), investment to GDP ratio (LNIR), technological progress (LPROD), and openness (LOPEN).<sup>22</sup> Predictions of the FEER model also suggest that capital controls may play an important role as a determinant of real effective exchange rates, as a liberalization of capital inflows increases present consumption (through the wealth effect), increases the demand for nontradables and hence leads to an appreciation of the REER in the short-run. However, the long-run effect of capital controls reduction is ambiguous. On one hand, the positive wealth effect increases consumption in all periods which increases demand for nontradables and results to an appreciation of the REER; on the other hand, by the intertemporal substitution effect future consumption is lower than present consumption, which decreases the (future) demand for nontradables and results to a depreciation of the REER.<sup>23</sup> In addition, choosing a variable that best represents sustainable or long-run capital flows has been a controversial issue in the literature. Despite these concerns, we investigate the impact using foreign direct investment (BFDIR) as a proxy for capital inflows/controls by initially including BFDIR in the list of fundamentals. Our empirical findings confirm the theoretical priors on the impact of BFDIR—namely that there is no net long-run

<sup>21</sup> The ADF test results in Table C2 are based on a specification with a constant term included (see notes for Table C2). We experimented with specifications that include both a constant and a deterministic time trend. The results are virtually unchanged from those reported in Table C2.

<sup>22</sup> Recall that all the variables are in natural logarithm.

<sup>23</sup> See also the discussion in Cerra and Saxena (2002).

effect of capital controls on the REER—suggesting that perhaps the two opposing effects are offsetting.<sup>24</sup> Hence, we proceed with the five identified fundamentals.

The VARs also include a constant term and dummy variables. For the CEMAC region, the VAR includes five impulse dummies for 1994, 1976, 1978, 1985, and 2001, while for WAEMU, the VAR includes three impulse dummies for 1994, 1974 & 1979, and 2003.<sup>25</sup> The use of these dummy variables can be justified on both economic and statistical grounds. Economically, for WAEMU, the impulse dummies for 1994, 1974 & 1979, and 2003 respectively capture the devaluation, the first and second oil price shocks, and the Côte d'Ivoire crisis. For CEMAC, the impulse dummy for 1994 captures the devaluation; the dummy for 1976 and 1978 capture large changes in real GDP growth of Gabon (40 percent and -28 percent in 1976 and 1978 respectively); the dummy variable for 1985 primarily captures a favorable terms-of-trade effect in Cameroon right before the collapse of oil prices in 1986;<sup>26</sup> and the dummy variable for 2001 captures the effect of the surge in foreign direct investment relating to oil construction/investment and somewhat a terms-of-trade increase. Statistically, an examination of the residuals of the VARs fitted without the impulse dummies reveals outliers in excess of three standard deviations and further induces misspecification in the residuals. The inclusion of the dummy variables results in a substantial improvement in the fit of the model, much better residual diagnostics, and statistically stable/constant VARs, as shown below.<sup>27</sup>

### **Lag-length, Residual Diagnostics, and Testing for Cointegration**

Before conducting the cointegration tests, the appropriate lag-length of the VAR must be determined and a constant model found. The lag length is not known a priori, so some testing of lag order must be done to ensure that the estimated residuals of the VAR are white noise. Initially, we start with a VAR that includes 3 lags on each variable, denoted VAR(3), then we estimate a VAR with 2 lags, VAR(2), and test whether the simplification from VAR(3) to VAR(2) is statistically valid. The process is repeated sequentially down to a VAR with a single lag, VAR(1).

Table C3 reports F statistics for testing the validity of these simplifications. The F statistic tests the null hypothesis indicated by the model to the right of the arrow against the maintained hypothesis indicated by the model to the left of the arrow. The p-value or the tail probability associated with the realized value of the F statistic is also reported. For CEMAC, the simplification to a VAR with 2 lags, VAR(2), is statistically valid, whereas the simplification to a VAR with a single lag, VAR(1) is rejected at the 5 percent significance level. For WAEMU, the simplification to a VAR with a single lag, VAR(1), is accepted at the 5 percent level. Hence, we proceed with the analysis using the VAR(2) model for CEMAC, and the VAR(1) model for WAEMU.

Table C4 reports diagnostic tests on the residuals for the VAR(2) model for CEMAC and the VAR(1) model for WAEMU. The diagnostic tests consist of an F-test for the null hypothesis that there is no residual serial correlation, a chi-square test for the null hypothesis of normality of the residuals, and a chi-square test for the null hypothesis that there is no residual heteroskedasticity. The realized values

<sup>24</sup> The estimated BFDIR coefficients for WAEMU (CEMAC) are 0.012 (0.018) with t-statistics 1.17 (1.42). The rest of the fundamentals are virtually unchanged with or without BFDIR.

<sup>25</sup> Impulse dummies take the value of 1 at year “X” and zero otherwise.

<sup>26</sup> Cameroon started oil production in 1976, which reached its peak in 1985. Since then, oil production steadily declined through the mid 1990s.

<sup>27</sup> We thank David Hendry for his suggestions on the inclusion of dummy variables.



of the various test statistics and the associated tail probabilities are given in columns three and four respectively.<sup>28</sup> Statistically, the VAR models appear well-specified, with no rejections of the null hypothesis from the various test statistics at the 5 percent significance level. The VAR residuals appear normal, homoskedastic, and serially uncorrelated.<sup>29</sup>

Next, we employ recursive estimation techniques and conduct Chow tests in order to test for model constancy/stability. The basic idea behind recursive estimation is to fit the VAR to an initial sample of  $M-1$  observations, and then fit the VAR to samples of  $M$ ,  $M+1$ , ..., up to  $T$  observations, where  $T$  is the total sample size. Figures C2a and C2b show the results from recursively estimating the CEMAC and WAEMU VARs, respectively. Specifically, the Figures show recursively estimated Chow statistics, which are shown for each equation of the VAR (denoted  $Ndn$ ) and for the VAR system as a whole (denoted  $Ndn$  CHOWs). For a given plot and year, the Chow statistic tests the null hypothesis that the coefficients estimated up to that year are the same as those estimated for the entire sample. The Chow statistics are scaled so that the significant critical values become a straight line at unity. That is, if the given plot exceeds unity at any point in time, this indicates a rejection of the null hypothesis of model stability at that point. The results from the various plots strongly suggest that the VARs are stable at the 1 percent significance level.<sup>30</sup>

In summary, the above analysis indicates that the VARs for CEMAC and WAEMU are empirically well behaved and hence are suitable starting points for the cointegration analysis. The cointegration analysis proceeds in several steps: testing for the existence of cointegration, interpreting and identifying the relationship(s), inference tests on the coefficients from theory and weak exogeneity. Testing permits reduction of the unrestricted general model to a final restricted model without loss of information.

Table C5 presents the initial test for cointegration for the CEMAC and WAEMU samples. The table reports the trace statistic and its associated p-values. For both the CEMAC and WAEMU samples, the null hypothesis that there are zero cointegrating vectors versus the alternative that there are more than zero cointegrating vectors is soundly rejected. Furthermore, the null that there are at most one cointegrating vector versus the alternative that there are more than one cointegrating vector is not rejected at the 5 percent significance level. Overall, the cointegration tests indicate the presence of one cointegrating vector for each sample.

## **B. Estimation of the Equilibrium Exchange Rate**

### **The Long Run and Short Run Relationships**

The cointegration analysis suggests that there exists a long-run relationship between the REERs and their identified fundamentals for both the CEMAC and WAEMU regions. Table 1 contains the results from estimating the VARs/VECMs in equation (3) for the CEMAC and WAEMU samples. The table is divided into two panels, with the top panel reporting estimates for the cointegrating vectors (the  $\beta$ 's) together with their t-statistics, and the bottom panel reporting the feedback coefficients estimates

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<sup>28</sup> For more details on the test statistics, see Doornik and Hendry (2001).

<sup>29</sup> The diagnostic tests mentioned in the text are tests performed on each equation of the VAR separately.

Vector/system tests performed on the entire system yield the same results as those for the single-equation tests.

<sup>30</sup> See Doornik and Hendry (2001) for more details on the various Chow tests.

(the  $\alpha$ 's) and their t-statistics. The resulting cointegration equations are consistent with the predictions from economic theory, as the estimated coefficients (all representing elasticities) have the expected signs and are strongly significant.

The *long-run* relationship between the REER and the fundamentals variables is shown in the top panel of Table 1. For both the CEMAC and WAEMU samples: (i) the terms-of-trade are positively correlated with the REER indicating a that an improvement in terms-of-trade would result in an appreciation of the long-run EREER through a possible wealth effect; (ii) government consumption has a positive (appreciating) impact on the REER suggesting that most government spending is directed towards nontradables; (iii) the relatively high long-term impact of technological progress (proxied by the relative real GDP per capita) confirms the Ballasa-Samuelson effect; (iv) investment is negatively correlated with the REER confirming the hypothesis that investment increases spending towards traded goods; and (v) increases in openness are associated with depreciation of the REER through increases in imports.

In order to get an idea of the marginal impact of the fundamentals' coefficients we examine the models' elasticities and investigate the effect of a one percent increase in the fundamentals on the REERs of the two regions. Specifically,

For CEMAC, a 1 percent increase in

- the terms-of-trade is associated with a 0.70 percent appreciation of the REER
- the level of government consumption as share to GDP is associated with a 0.41 percent appreciation of the REER
- technological progress is associated with a 0.59 percent appreciation of the REER

Table 1. Results of Cointegration Estimation  
Dependent Variable: ln(Real Effective Exchange Rate)

Specification:	Sample	
	CEMAC	WAEMU
<i>Estimates of the cointegrating relationships</i>		
ln(terms of trade)	0.70 *** (9.04)	0.58 *** (5.16)
ln(government consumption)	0.41 *** (2.71)	0.69 *** (13.24)
ln(technological progress)	0.59 *** (15.60)	0.26 *** (5.08)
ln(investment)	-0.21 ** (2.50)	-0.28 *** (4.35)
ln(openness)	-0.24 ** (2.36)	-0.18 *** (2.72)
Constant	1.57	1.42
<i>Estimates of the short term coefficients</i>		
D[ln(real effective exchange rate)]	-0.12 ** (1.96)	-0.24 *** (2.93)
D[ln(terms of trade)]	0.26 (1.45)	-0.15 (0.99)
D[ln(government consumption)]	0.26 (1.36)	0.51 *** (6.13)
D[ln(technological progress)]	-0.21 (1.19)	0.09 (0.44)
D[ln(investment)]	0.33 *** (3.22)	0.05 (0.75)
D[ln(openness)]	-0.06 (0.35)	0.05 (0.30)
Half-life of deviation	5.6	2.9

Notes:

1. Three asterisks and two asterisks, denote statistical significance at the 0.01 and 0.05 levels, respectively; t-statistics in parenthesis.

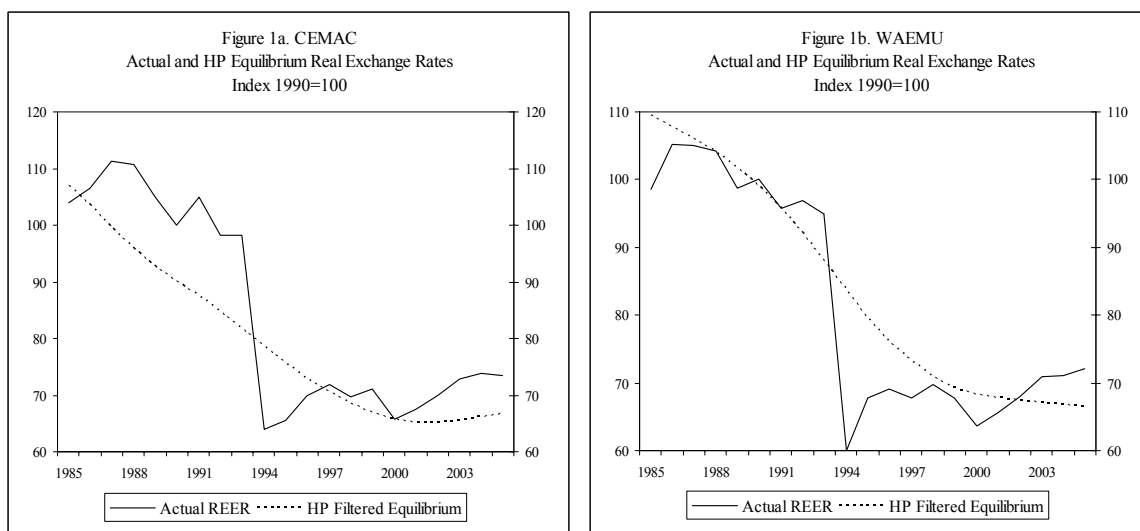
2. The speed of adjustment coefficient is derived from the error correction model.

- investment as share to GDP is associated with a 0.21 percent depreciation of the REER
- openness is associated with a 0.24 percent depreciation of the REER

For WAEMU, a 1 percent increase in

- the terms-of-trade is associated with a 0.58 percent appreciation of the REER
- the level of government consumption as share to GDP is associated with a 0.69 percent appreciation of the REER
- technological progress is associated with a 0.26 percent appreciation of the REER
- investment is associated with a 0.28 percent depreciation of the REER
- openness is associated with a 0.18 percent depreciation of the REER

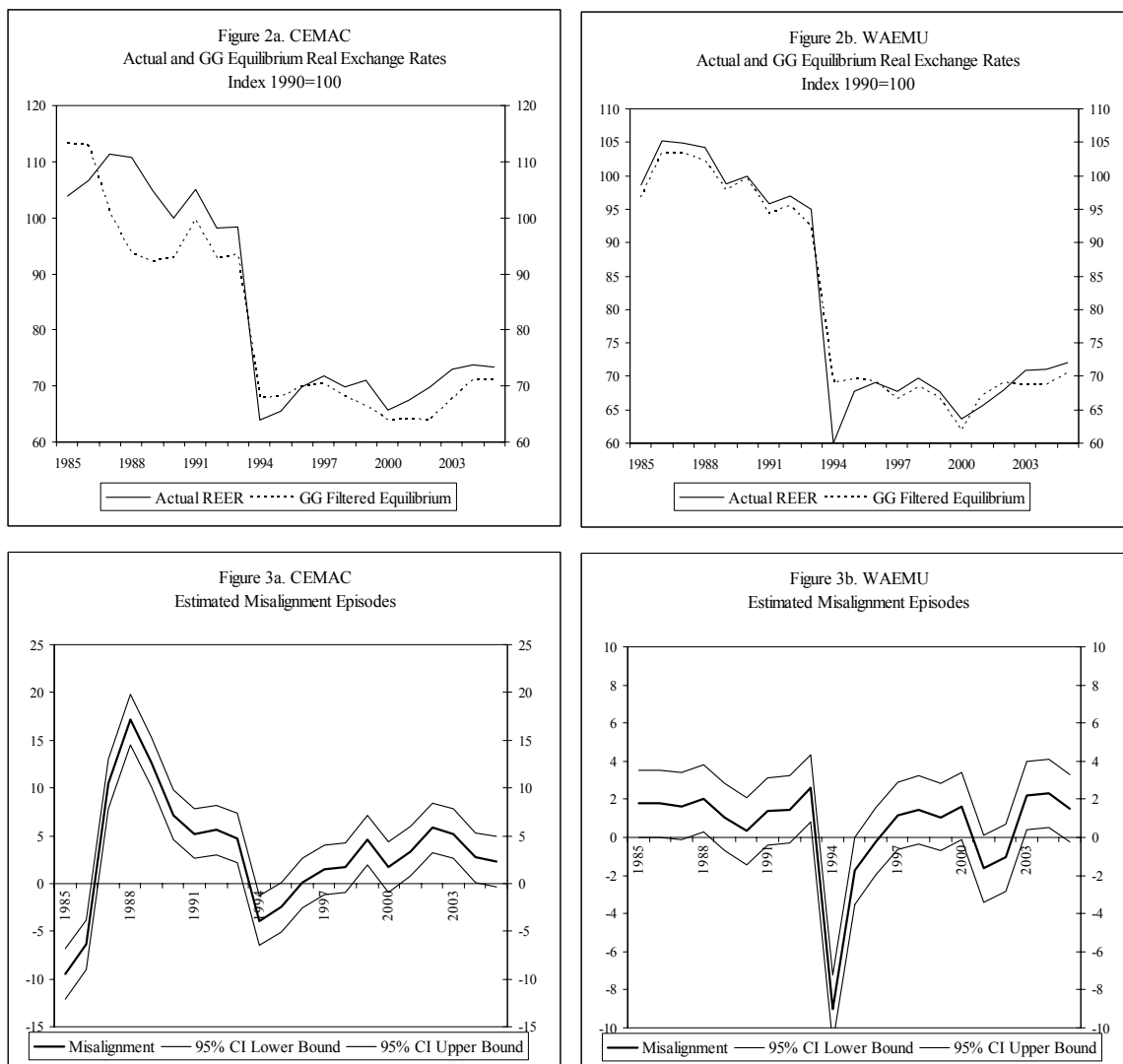
The bottom panel of Table 1 shows the feedback coefficients for the cointegrating vectors, or the *short-run* relationship of the LREER and its fundamentals. Some are estimated to be insignificantly different from zero which suggests that these fundamentals are *not* weakly exogenous with respect to the parameters of the cointegrating relationship, and in the face of any deviation from the long-run equilibrium these variables jointly respond and move the system back to equilibrium. Furthermore, the feedback coefficient for the DLREER equation is negative and significantly different from zero (for both CEMAC and WAEMU), suggesting stability of the error correction mechanism.



### Misalignment and Speed of Adjustment

The two long-run relationships obtained by estimating the equation of the REERs with their fundamentals above permits the calculation of the EREER. Therefore, the EREER can be defined as the level of REER that is consistent in the long-run with the equilibrium values of the fundamentals. Based on the results of the cointegration regressions, the equilibrium EREERs were computed using the long-term components of the fundamentals. As discussed in earlier sections, we use two methods

to derive the permanent component of the fundamentals: the HP filter (used for illustrative purposes only) and the GG decomposition (which is more theoretically attractive).<sup>31</sup> Then, we estimate the misalignment episodes and their statistical significance using the GG decomposition.



Figures 1a and 1b display the evolution of the actual and the estimated EREER rate for the CEMAC and WAEMU regions, respectively, for the period 1985-2005 using the HP filter. Figures 2a and 2b apply the GG decomposition to construct the estimated EREER rate for CEMAC and WAEMU, respectively. Interestingly, while the HP filter method carries no theoretical basis, EREERs estimated using the HP method are very close to the ones estimated by the theoretically attractive GG decomposition (especially for CEMAC). Figures 3a and 3b estimate the misalignments for CEMAC

<sup>31</sup> As discussed, the choice of the degree of smoothing is arbitrary with larger (smaller) factors generating smoother (less smooth) equilibrium real exchange rate paths. As a robustness check, the equilibrium real exchange rates in Figures 1a and 1b are derived by applying to the explanatory variables an HP filter based on the average of five smoothing factors (10, 30, 50, 100, and 300).

and WAEMU, respectively, along with the error bands using equation (9) in order to identify statistically significant misalignment episodes.

The actual WAEMU and CEMAC REERs went through a period of overvaluation prior to 1994 (with the actual REERs well above the equilibrium level in the case of CEMAC, but less so for WAEMU), which suggests that the 1994 CFA devaluation was warranted. After 1994 and a few years of “correction” both the CEMAC and WAEMU REERs remained, in principle, above their equilibrium levels for the rest of the period of analysis as a result of changes in the fundamentals, which differed for the two regions. In particular, the CEMAC REER temporarily exceeded its equilibrium level in 1999, and then again during the period 2001-04, with statistically significant misalignments during those episodes. In the case of WAEMU, there were no statistically significant misalignments after the devaluation until a short period in 2003-04. Finally, in 2005, our analysis shows that while both the CEMAC and WEAMU REERs were slightly above their estimated long-run equilibrium levels, none of these overvaluations were statistically significant. This suggests that at end 2005, both the CEMAC and WAEMU REERs were broadly in line with their long-run equilibrium values.

Taking the latter period of the sample (2000-2005), it is useful to analyze the contribution of each of the fundamentals to the appreciation of the REERs.<sup>32</sup> For WAEMU, in the period 2001-2005, the REER appreciated by about 12 percent as a result of increases in the terms-of-trade and government consumption (accounting for an appreciation of the equilibrium real exchange rate in the order of about 9 percent each), while the increases in investment and openness and decreases in the productivity index contributed to REER depreciations of 2, 1, and 3 percent, respectively. In the case of CEMAC, the 13 percent appreciation of the REER in the 2001-05 period can be decomposed to an appreciation of about 23 percent as a result of increases in terms-of-trade, and a depreciation caused by government consumption and productivity decreases (2 and 7 percent, respectively) and openness increase (about 1 percent).

The real exchange rate can deviate from its equilibrium value as a result of changes in the fundamentals or due to temporary factors. Depending on the cause of the misalignment, the real exchange rate will converge towards a new equilibrium level or return from its temporary position to the original equilibrium value. The estimates derived in this study suggest very different speeds of adjustment for the two regions. For the CEMAC region, on average, about 0.12 percent of the gap is eliminated every year, which implies that, in the absence of further shocks, about half the gap would be closed within 5.6 years. However, for the WAEMU region, the adjustment is a faster, with 0.24 percent of the gap is eliminated every year implying that, in the absence of further shocks about half the gap would be closed within 2.9 years, almost half the time estimated for CEMAC. However, larger deviations (such as the ones caused by the 1994 devaluation) may take much longer to absorb. In comparison to other studies, both the WAEMU and CEMAC adjustment speeds are reasonable.<sup>33</sup>

Impulse response functions show how a shock to one of the fundamentals directly affects the fundamental itself and is transmitted to all of the other endogenous variables through the dynamic

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<sup>32</sup> This analysis is based on estimated elasticities and cumulative variable changes estimates, similar to the “sources of growth” accounting. Due to the associated residuals, magnitudes of the REER appreciations may not be directly comparable to those presented in Tables C1a and C1b.

<sup>33</sup> Mathisen (2003), and Cashin, Cespedes and Sahay (2003) estimate an adjustment speed with half-life of less than a year for Malawi; MacDonald and Ricci (2003) estimate a half-life of 2 to 2.5 years for South Africa; Rogoff (1996) estimates the longer half-life of 3 to 5 years.

(lag) structure of the VAR. Figures C4a and C4b trace the effect of a one-time one standard deviation shock to one of the innovations on current and future values of the fundamentals on the impulse (and accumulated) response functions of the real effective exchange rate.<sup>34</sup> For both CEMAC and WAEMU, the accumulated impulse response functions are consistent with the theoretical priors described in the long-run coefficients: positive investment and openness shocks have a long run depreciating effect on the exchange rate while the opposite is true for a positive terms-of-trade, government consumption and productivity shocks. In addition, and in line with the findings of adjustment speed above, the WAEMU non-accumulated impulse response functions stabilize in a much shorter period, in about half the time it takes the CEMAC impulse response functions to stabilize.

Our analysis has pointed out that although the paths of the two regions' equilibrium exchange rates have evolved similarly, there are important differences in the marginal impacts of the fundamentals as well as the speed of adjustment to equilibrium in response to shocks. This suggests that changes in the fundamentals may have differentiated impacts on the real effective exchange rates of the two regions, and in a situation of a sustained and protracted misalignment, these differences may potentially require an exchange rate adjustment in one region and not the other. However, based on the fact that we do not find evidence for any significant misalignments, there is no need for an immediate adjustment in the level of the peg. At the same time, in the context of overall sound macroeconomic policies, strong commodity prices, increasing reserve levels, limited capital flows, and cautiously optimistic market assessments, there are no immediate macroeconomic imbalances that would call for correction through an exchange rate adjustment.

## V. CONCLUSION

Using a dynamic model of a small open economy and the Johansen cointegration methodology, the WAEMU and CEMAC regions' equilibrium real effective exchange rates are analyzed and an assessment is made as to whether the movements in the aggregate real exchange rates are consistent with the underlying macroeconomic fundamentals. We show that much of the long-run behavior of the real effective exchange rates can be explained by fluctuations in the terms-of-trade, government consumption, investment, openness and productivity. Based on the estimated paths of the WAEMU and CEMAC equilibrium real effective exchange rates, there is a clear pattern of overvaluation before 1994 (suggesting that the exchange rate adjustment was warranted). The recent real appreciation of the CFA exchange rate has brought the CEMAC and WAEMU REERs above their underlying long-run equilibrium values as evident from the short periods of temporary overvaluations in the latter part of the period. Nevertheless, in 2005, the current levels of the real effective exchange rates are in line with the estimated equilibrium real effective exchange rate paths, without any statistically significant misalignment. Finally, the analysis shows that, in the absence of further shocks, real exchange rate deviations from their equilibrium levels due to temporary factors are expected to revert to equilibrium about twice as fast in WAEMU than CEMAC.

A complete analysis of the environment that impacts the short term sustainability of the CFA franc arrangement requires an examination of possible pressures on balance of payments flows and reserve levels, losses of competitiveness, unfavorable market perceptions, and sustained deviations from equilibrium exchange rates. For the latter, fixed exchange rate regimes can be sustainable in theory,

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<sup>34</sup> Generalized impulses are used. As described by Pesaran and Shin (1998), this method constructs an orthogonal set of innovations that does not depend on the VAR ordering.

as long as actual deviations from long-term equilibrium rates are small and mean reverting. In contrast, if deviations are one-sided and build up to a longer-term significant misalignments, it is generally argued that, in addition to demand side management policies, real exchange rate action may be needed to restore balance.<sup>35</sup>

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<sup>35</sup> Results in the literature point to the fact that only significant misalignments which are sustained for protracted periods of time could lead to currency crises. See, for example, JP Morgan (2000), and Sarno and Taylor (2002).

<b>Box 1: Key Dates and Background of the CFA Zone</b>		
1945	CFA franc creation	CFAF/FRF rate fixed at CFAF 1 = FRF 1.70
1948	FRF devaluation	CFAF 1 = FRF 2.00
1958	Institution of new FRF	CFAF 1 = FRF 0.02 or FRF 1 = CFAF 50
1959	BCEAO and BEAC creation	Côte d'Ivoire, Benin, Burkina Faso, Mauritania, Niger, Senegal create BCEAO; Cameroon, Central African Republic, Congo, Gabon and Chad create BEAC
1963	WAEMU enlargement	Togo joins the West African CFA zone
1973	WAEMU reduction	Mauritania leaves the West African CFA zone
1984	WAEMU enlargement	Mali joins the West African CFA
1985	CEMAC enlargement	Equatorial Guinea joins the Central African CFA zone
1994	CFAF devaluation	CFAF 1 = FRF 0.01 or FRF 1 = CFAF 100
1997	WAEMU enlargement	Guinea-Bissau joins the West African CFA zone
1999	Euro creation	Euro replaces FRF at FRF 6.55957 = € 1; CFAF pegged to the euro at CFAF 655.957 CFAF = € 1

### Background

The value of the CFA franc is currently fixed against the euro (previously against the French franc), with France guaranteeing the CFA franc's convertibility. As a counterpart to the guarantee, France is represented on the board of the two central banks. The creation of the euro did not have major implications for the CFAF zone, apart from the replacement of the peg to the French franc by the euro, and the need to inform the Council of Economic and Financial Affairs (ECOFIN) about any change in parity. The agreement between the French Treasury and the CFA zone members does not oblige the European Central Bank to support the peg.

Within the zone, monetary policy is similar and the value of the currency is the same. Strictly speaking, there are two different currencies called CFAF, the West African CFA franc, and the Central African CFA franc. The arrangement requires that both monetary unions maintain coverage of at least 20 percent of narrow money in the form of euros. To strengthen the monetary union, group members are also required to adhere to convergence criteria. Reserves in each zone are pooled and two thirds of each zone's reserves are to be held with the French treasury. The CFA franc was devalued only once, in 1994, when a 50 percent adjustment in the nominal rate reversed domestic and external disequilibria that had built up since the mid 1980s.

<sup>1</sup>In fact, they are only distinguished by the meaning of the abbreviation CFAF. In the West African union, CFAF stands for franc de la Communauté Financière de l'Afrique; and in the Central Africa Union, CFAFF stands for franc de la Coopération Financière Africaine.



### Variable Definitions and Sources

The datasets for both the CEMAC and WAEMU samples consist of annual observations for the period of 1970-2004. The regional aggregate variables for CEMAC and WAEMU were constructed using the national annual observations and GDP weights. Equatorial Guinea joined CEMAC in 1985 and was excluded from analysis (also because of poor quality data). Similarly, Guinea Bissau was excluded from the WAEMU average as it joined the union in 1997.

The countries' real effective exchange rate prior to 1980 was unavailable in the INS database and was constructed based on CPI indices from the *World Economic Outlook* are partner weights re-normalized. The "foreign" variable (used for the calculation of the productivity proxy) was calculated as the re-normalized weighted average of the five trading partners based on the INS weights for the real effective exchange rate. For CEMAC the partner countries (weights) were: France (0.43), United States (0.15), Germany (0.13), Japan (0.11), Italy (0.10), and Belgium (0.08). For WAEMU, the partner countries (weights) were: France (0.42), Germany (0.15), United States (0.14), Japan (0.11), Italy (0.10), and the Netherlands (0.09).

The variables acronyms, definitions and sources are as follows:

<b>LREER</b>	Natural logarithm of the real effective exchange rate <i>Source: Information Notice System (INS) and staff calculations.</i>
<b>LNCGR</b>	Natural logarithm of public consumption expenditure to GDP <i>Source: World Economic Outlook (WEO).</i>
<b>LTTT</b>	Natural logarithm of terms-of-trade <i>Source: World Economic Outlook (WEO).</i>
<b>LNIR</b>	Natural logarithm of gross capital formation to GDP <i>Source: World Economic Outlook (WEO).</i>
<b>LPROD</b>	Natural logarithm of real per capita GDP relative to main trade partners, normalized to 1 in 2000 with weights as discussed above <i>Source: World Economic Outlook (WEO).</i>
<b>LOPEN</b>	Sum of Exports and Imports to GDP <i>Source: World Economic Outlook (WEO).</i>
<b>BFDIR</b>	Net foreign direct investment (current prices) to GDP <i>Source: World Economic Outlook (WEO).</i>

Table C1a. WAEMU Real Effective Exchange Rate and its Components  
(in percent)

	Jan 1994- Dec 1998	Jan 1999- Dec 2000	Jan 2001- Dec 2005
Period percentage change			
Real effective exchange rate	35.4	-8.8	9.4
Nominal effective exchange rate	13.2	-8.2	7.0
Relative Price Index	25.4	0.0	0.6
Cumulative percentage change			
Real effective exchange rate	31.0	-8.9	11.5
Nominal effective exchange rate	12.7	-8.3	8.5
Relative Price Index	23.0	0.9	0.5

Source: IMF, INS and Fund staff calculations.

Table C1b. CEMAC Real Effective Exchange Rate and its Components  
(in percent)

	Jan 1994- Dec 1998	Jan 1999- Dec 2000	Jan 2001- Dec 2005
Period percentage change			
Real effective exchange rate	51.2	-11.3	13.4
Nominal effective exchange rate	15.2	-8.7	7.1
Relative Price Index	31.8	-2.3	5.8
Cumulative percentage change			
Real effective exchange rate	42.9	-9.8	16.3
Nominal effective exchange rate	14.4	-7.4	10.0
Relative Price Index	28.7	-1.8	6.2

Source: IMF, INS and Fund staff calculations.

Table C2. Unit Root Tests  
for Variables in Levels and Differences

Variable	Lags	t-ADF	p-value	1% level	5% level	10% level
CEMAC						
ln(REER)	0	-0.99	0.75	-3.63	-2.95	-2.61
Dln(REER)	0	-6.09	0.00 ***	-3.63	-2.95	-2.61
ln(TTT)	0	-1.97	0.30	-3.63	-2.95	-2.61
Dln(TTT)	0	-5.70	0.00 ***	-3.63	-2.95	-2.61
ln(NCGR)	0	-2.91	0.05	-3.63	-2.95	-2.61
Dln(NCGR)	0	-7.12	0.00 ***	-3.63	-2.95	-2.61
ln(NIR)	0	-1.67	0.44	-3.63	-2.95	-2.61
Dln(NIR)	0	-6.10	0.00 ***	-3.63	-2.95	-2.61
ln(PROD)	0	-0.85	0.79	-3.63	-2.95	-2.61
Dln(PROD)	0	-4.91	0.00 ***	-3.63	-2.95	-2.61
ln(OPEN)	0	-1.62	0.46	-3.63	-2.95	-2.61
Dln(OPEN)	0	-5.76	0.00 ***	-3.63	-2.95	-2.61
WAEMU						
ln(REER)	0	-1.41	0.57	-3.63	-2.95	-2.61
Dln(REER)	0	-6.61	0.00 ***	-3.63	-2.95	-2.61
ln(TTT)	0	-2.51	0.12	-3.63	-2.95	-2.61
Dln(TTT)	0	-5.80	0.00 ***	-3.63	-2.95	-2.61
ln(NCGR)	1	-1.54	0.50	-3.63	-2.95	-2.61
Dln(NCGR)	0	-3.52	0.01 **	-3.63	-2.95	-2.61
ln(NIR)	0	-2.69	0.09	-3.63	-2.95	-2.61
Dln(NIR)	0	-5.13	0.00 ***	-3.63	-2.95	-2.61
ln(PROD)	1	-0.29	0.92	-3.63	-2.95	-2.61
Dln(PROD)	0	-3.62	0.01 **	-3.63	-2.95	-2.61
ln(OPEN)	0	-2.42	0.14	-3.63	-2.95	-2.61
Dln(OPEN)	0	-6.34	0.00 ***	-3.63	-2.95	-2.61

Notes:

1. D denotes the difference operator.

2. For a given variable x, the augmented Dickey-Fuller equation has the following form:

$$\Delta x_t = \pi x_{t-1} + \sum_{i=1}^p \theta_i \Delta x_{t-i} + a + \varepsilon_t$$

where  $\varepsilon_t$  is a white noise disturbance. For a given variable, the table reports the number of lags on the dependent variable, p, chosen using the Schwartz information criterion, and the augmented Dickey-Fuller statistic, t-ADF, which is the t-ratio on  $\pi$ . The statistic tests the null hypothesis of a unit root in x, i.e.  $\pi = 0$ , against the alternative of stationarity. The table also reports the critical values at the 1 percent and 5 percent significance levels.

3. The symbols \*\* and \*\*\* denote rejection of the null hypothesis at the 5 percent and 1 percent critical values, respectively.

Table C3. Tests for Model Reduction

Model reduction	Statistic	Value	p-value
CEMAC			
VAR(3) to VAR(2)	F(36,15)	1.14	0.407
VAR(3) to VAR(1)	F(72,22)	1.64	0.096
VAR(2) to VAR(1)	F(36,42)	2.07	0.012 **
WAEMU			
VAR(3) to VAR(2)	F(36,24)	1.38	0.205
VAR(3) to VAR(1)	F(72,33)	1.56	0.081
VAR(2) to VAR(1)	F(36,51)	1.53	0.080

Notes:

1. The CEMAC VARs include the variables: LREER, LTTT, LNCGR, LNIR, LPROD, LOPEN, a constant, and five dummy variables for 1994, 2001, 1978, 1976, and 1985; the WAEMU VARs include the variables: LREER, LTTT, LNCGR, LNIR, LPROD, LOPEN, a constant, and three dummy variables for 1994, 1974-1979, and 2003.
2. The F statistic tests the null hypothesis indicated by the model to the right of the arrow against the maintained hypothesis given by the model to the left of the arrow. The tail probabilities associated with the values of the F statistic are reported under p-Value.
3. The symbol \*\* denotes rejection of the null hypothesis at the 5 percent critical value.

Table C4. Diagnostic Tests for the Residuals

Test and Equation	Statistic	Value	p-value
CEMAC			
<i>AR 1-2 test</i>			
LREER	F(2,13)	0.81	0.467
LTTT	F(2,13)	1.21	0.329
LNCGR	F(2,13)	0.57	0.580
LNIR	F(2,13)	2.25	0.145
LPROD	F(2,13)	0.99	0.397
LOPEN	F(2,13)	1.98	0.178
<i>Normality test</i>			
LREER	Chi <sup>2</sup> (2)	5.82	0.054
LTTT	Chi <sup>2</sup> (2)	0.33	0.849
LNCGR	Chi <sup>2</sup> (2)	1.07	0.587
LNIR	Chi <sup>2</sup> (2)	5.18	0.075
LPROD	Chi <sup>2</sup> (2)	0.53	0.766
LOPEN	Chi <sup>2</sup> (2)	2.65	0.266
<i>Hetero test</i>			
LREER	Chi <sup>2</sup> (24)	21.25	0.624
LTTT	Chi <sup>2</sup> (24)	18.01	0.803
LNCGR	Chi <sup>2</sup> (24)	24.87	0.413
LNIR	Chi <sup>2</sup> (24)	24.28	0.446
LPROD	Chi <sup>2</sup> (24)	24.91	0.411
LOPEN	Chi <sup>2</sup> (24)	21.78	0.593
WAEMU			
<i>AR 1-2 test</i>			
LREER	F(2,23)	0.09	0.915
LTTT	F(2,23)	3.04	0.067
LNCGR	F(2,23)	1.75	0.196
LNIR	F(2,23)	0.57	0.573
LPROD	F(2,23)	1.97	0.163
LOPEN	F(2,23)	1.83	0.184
<i>Normality test</i>			
LREER	Chi <sup>2</sup> (2)	0.21	0.899
LTTT	Chi <sup>2</sup> (2)	2.60	0.273
LNCGR	Chi <sup>2</sup> (2)	2.80	0.247
LNIR	Chi <sup>2</sup> (2)	5.82	0.054
LPROD	Chi <sup>2</sup> (2)	1.93	0.381
LOPEN	Chi <sup>2</sup> (2)	0.80	0.671
<i>Hetero test</i>			
LREER	Chi <sup>2</sup> (12)	7.88	0.795
LTTT	Chi <sup>2</sup> (12)	19.95	0.068
LNCGR	Chi <sup>2</sup> (12)	5.03	0.957
LNIR	Chi <sup>2</sup> (12)	25.48	0.051
LPROD	Chi <sup>2</sup> (12)	8.54	0.742
LOPEN	Chi <sup>2</sup> (12)	12.98	0.371

Notes:

1. The CEMAC VAR includes 2 lags on each variable (LREER, LTTT, LNCGR, LNIR, LPROD, LOPEN), a constant, and five dummy variables for 1994, 2001, 1978, 1976, and 1985; the WAEMU VAR includes a single lag on each variable (LREER, LTTT, LNCGR, LNIR, LPROD, LOPEN), a constant, and three dummy variables for 1994, 1974-1979, and 2003.

Table C5. Johansen Cointegration Tests

Number of hypothesized Cointegrating Equations: CEMAC	Eigenvalue	Statistic	p-value
None	0.85	99.79	0.02 **
At most 1	0.64	55.63	0.40
At most 2	0.50	32.34	0.60
At most 3	0.40	16.57	0.68
At most 4	0.16	4.71	0.84
At most 5	0.03	0.63	0.43

The *Trace* test indicates 1 cointegrating eqn(s) at the 0.05 level.

Number of hypothesized Cointegrating Equations: CEMAC	Eigenvalue	Max-Eigen Statistic	p-value
None	0.85	44.16	0.01 **
At most 1	0.64	23.29	0.52
At most 2	0.50	15.77	0.69
At most 3	0.40	11.86	0.57
At most 4	0.16	4.08	0.84
At most 5	0.03	0.63	0.43

The *Max-eigenvalue* test indicates 1 cointegrating eqn(s) at the 0.05 level.

Number of hypothesized Cointegrating Equations: WAEMU	Eigenvalue	Statistic	p-value
None	0.83	99.82	0.02 **
At most 1	0.54	49.03	0.68
At most 2	0.38	26.73	0.86
At most 3	0.26	12.78	0.90
At most 4	0.12	4.17	0.88
At most 5	0.01	0.31	0.58

The *Trace* test indicates 1 cointegrating eqn(s) at the 0.05 level.

Number of hypothesized Cointegrating Equations: WAEMU	Eigenvalue	Max-Eigen Statistic	p-value
None	0.83	50.79	0.00 ***
At most 1	0.54	22.30	0.60
At most 2	0.38	13.95	0.82
At most 3	0.26	8.60	0.86
At most 4	0.12	3.87	0.87
At most 5	0.01	0.31	0.58

The *Max-eigenvalue* test indicates 1 cointegrating eqn(s) at the 0.01 level.

Notes:

1. The CEMAC VAR includes 2 lags on each variable (LREER, LTTT, LNCGR, LNIR, LPROD, LOpen), a constant, and five dummy variables for 1994, 2001, 1978, 1976, and 1985; the WAEMU VAR includes a single lag on each variable (LREER, LTTT, LNCGR, LNIR, LPROD, LOpen), a constant, and three dummy variables for 1994, 1974-1979, and 2003.
2. \*\* (\*\*\*) denotes rejection of the null hypothesis at the 5% (1%) significance level.

Figure C1a. CEMAC: Cointegration Variables

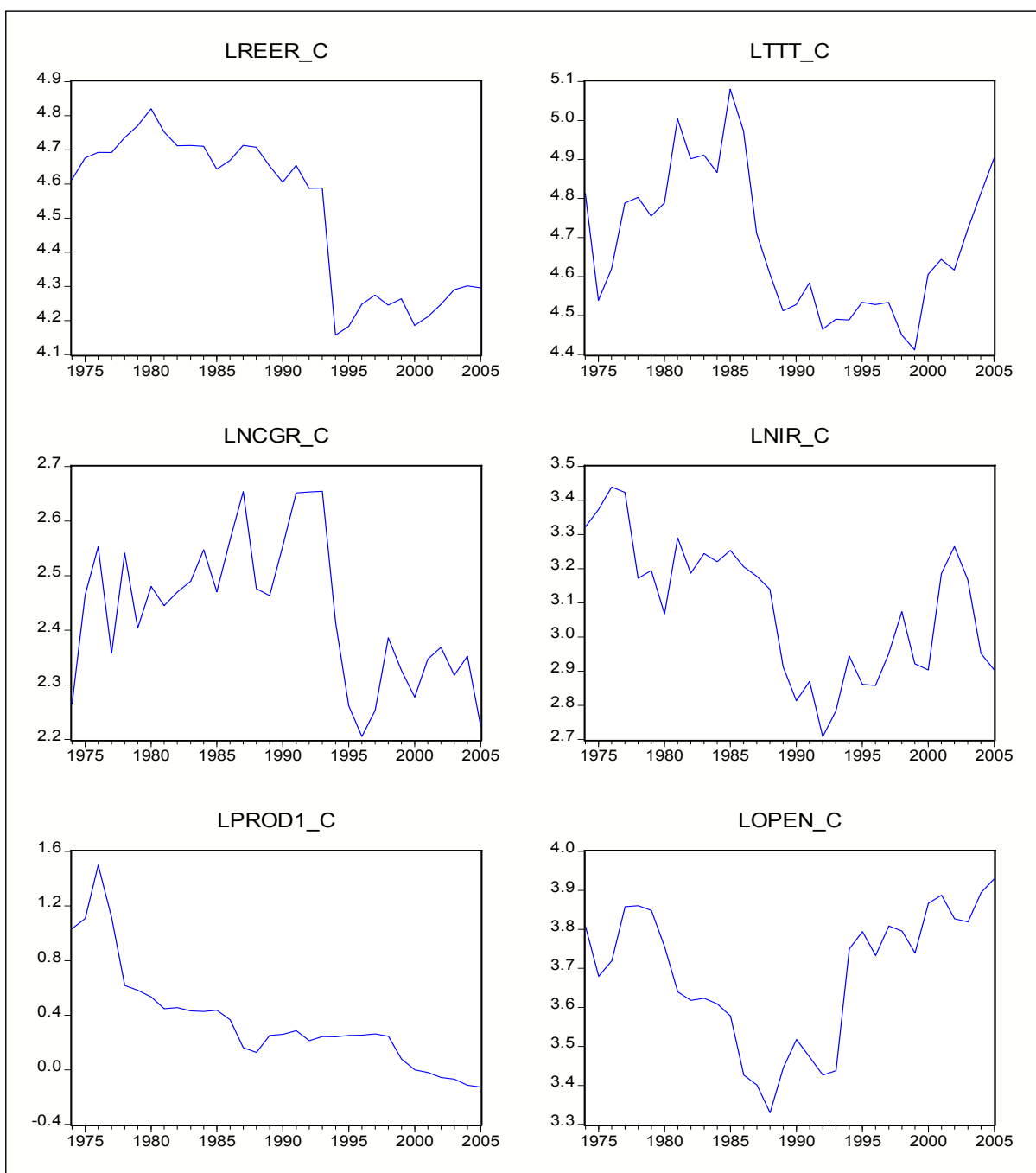
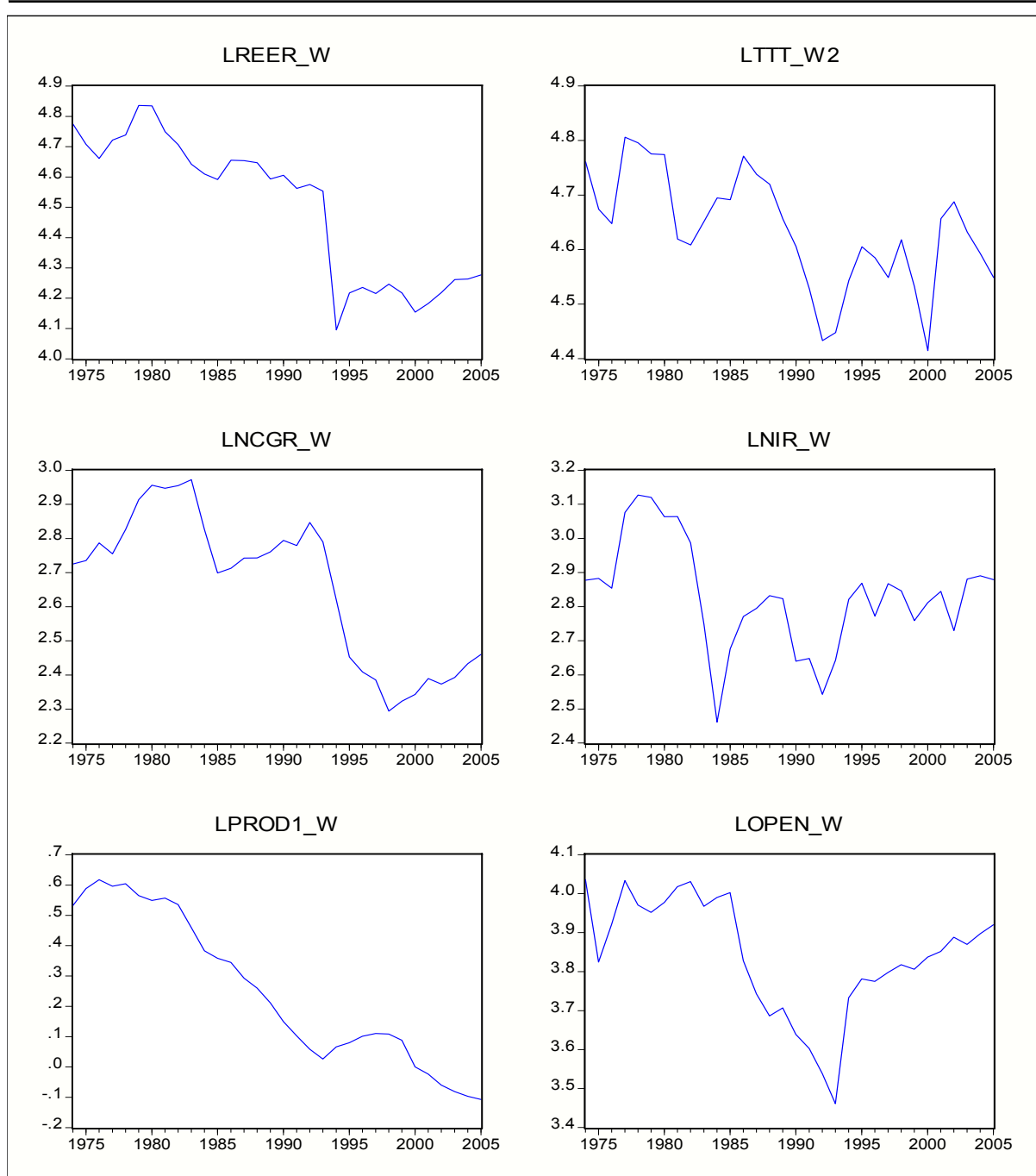
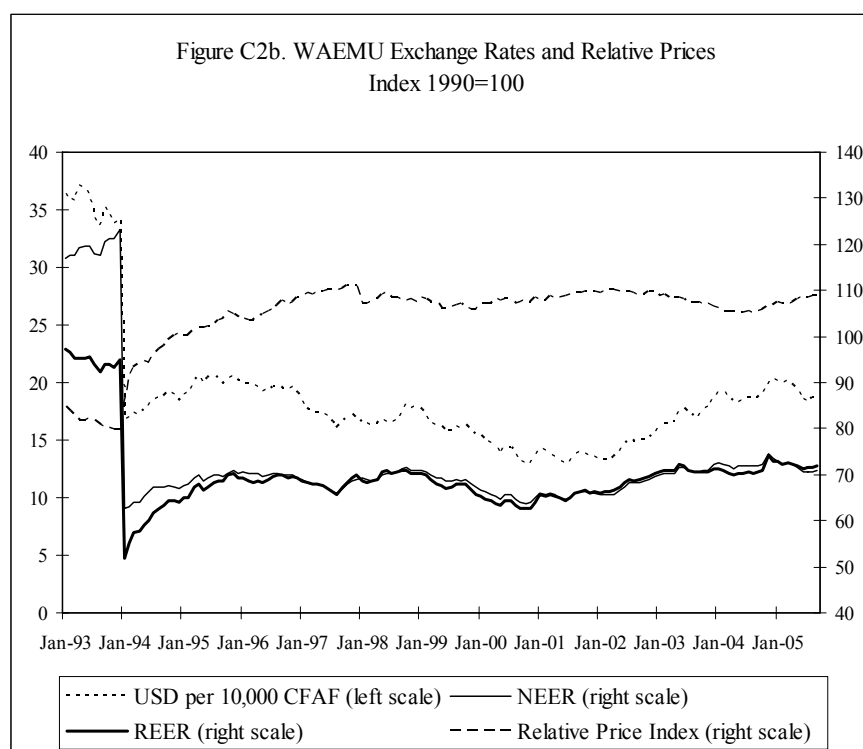
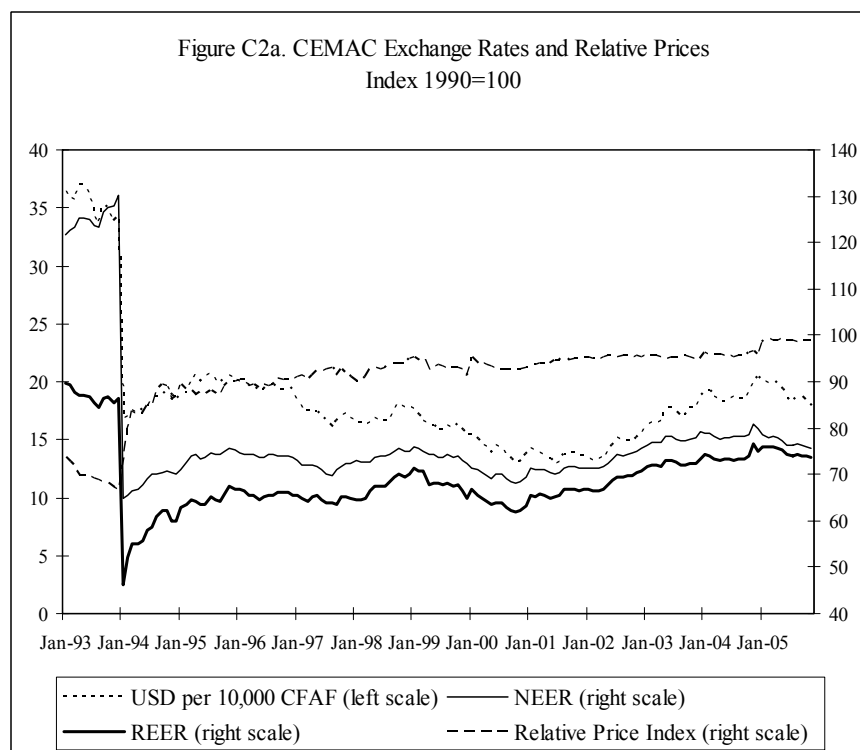


Figure C1b. WAEMU: Cointegration Variables







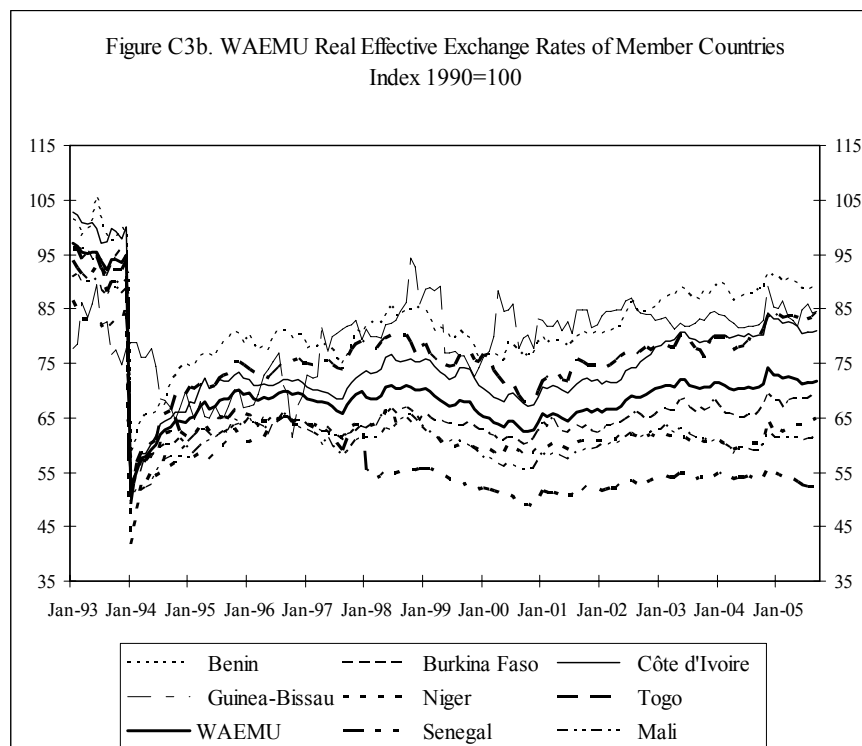
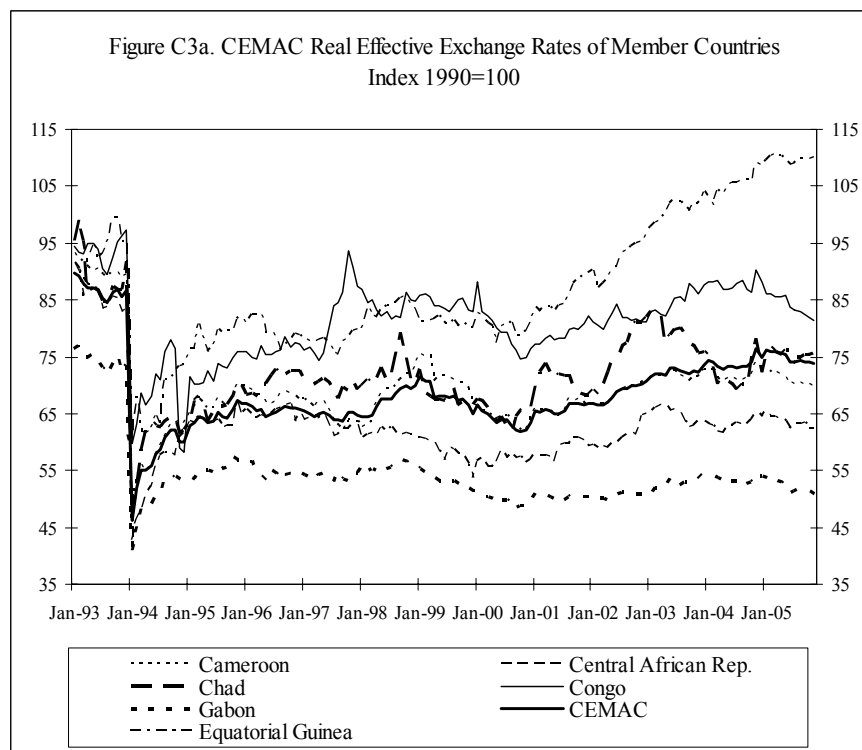


Figure C4a. CEMAC: Impulse Response Functions

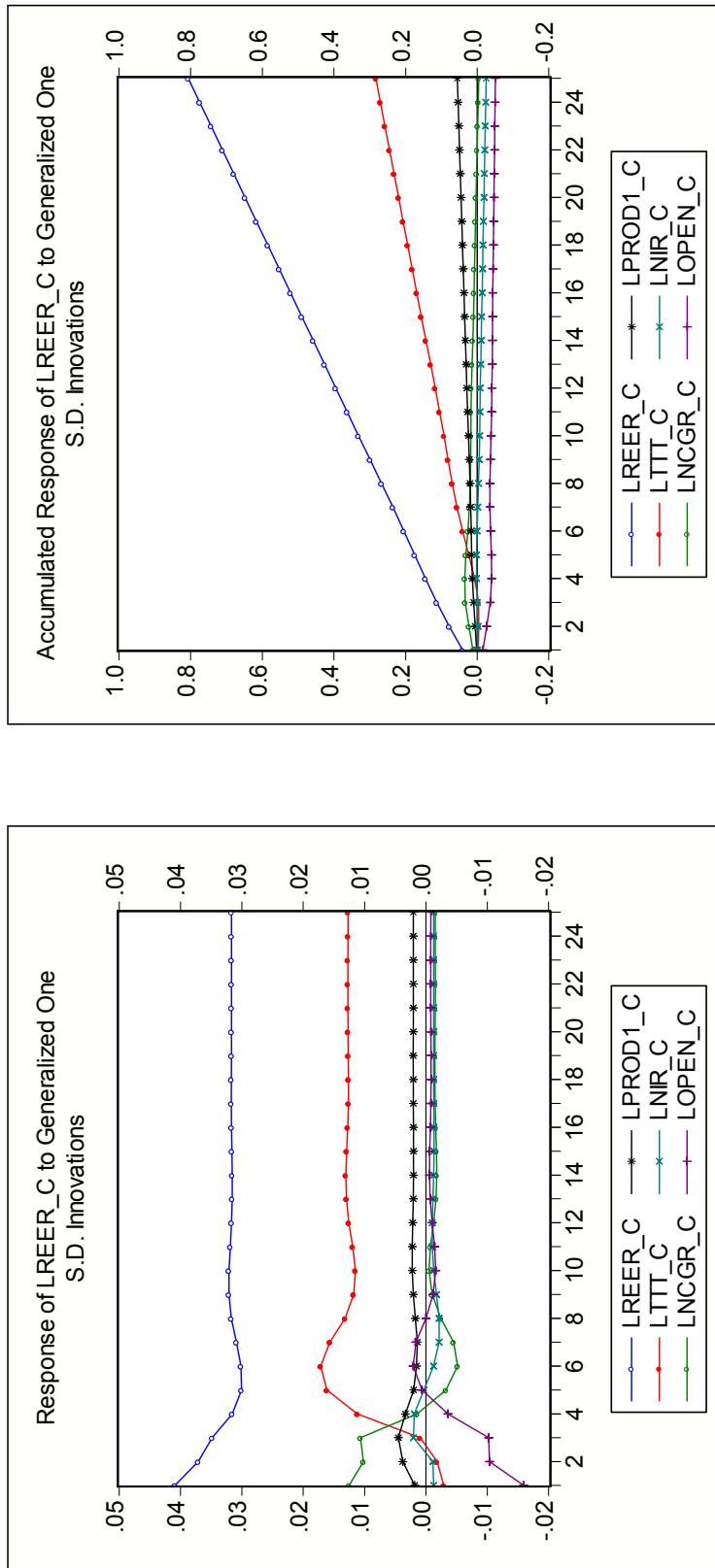


Figure C4b. WAEMU: Impulse Response Functions

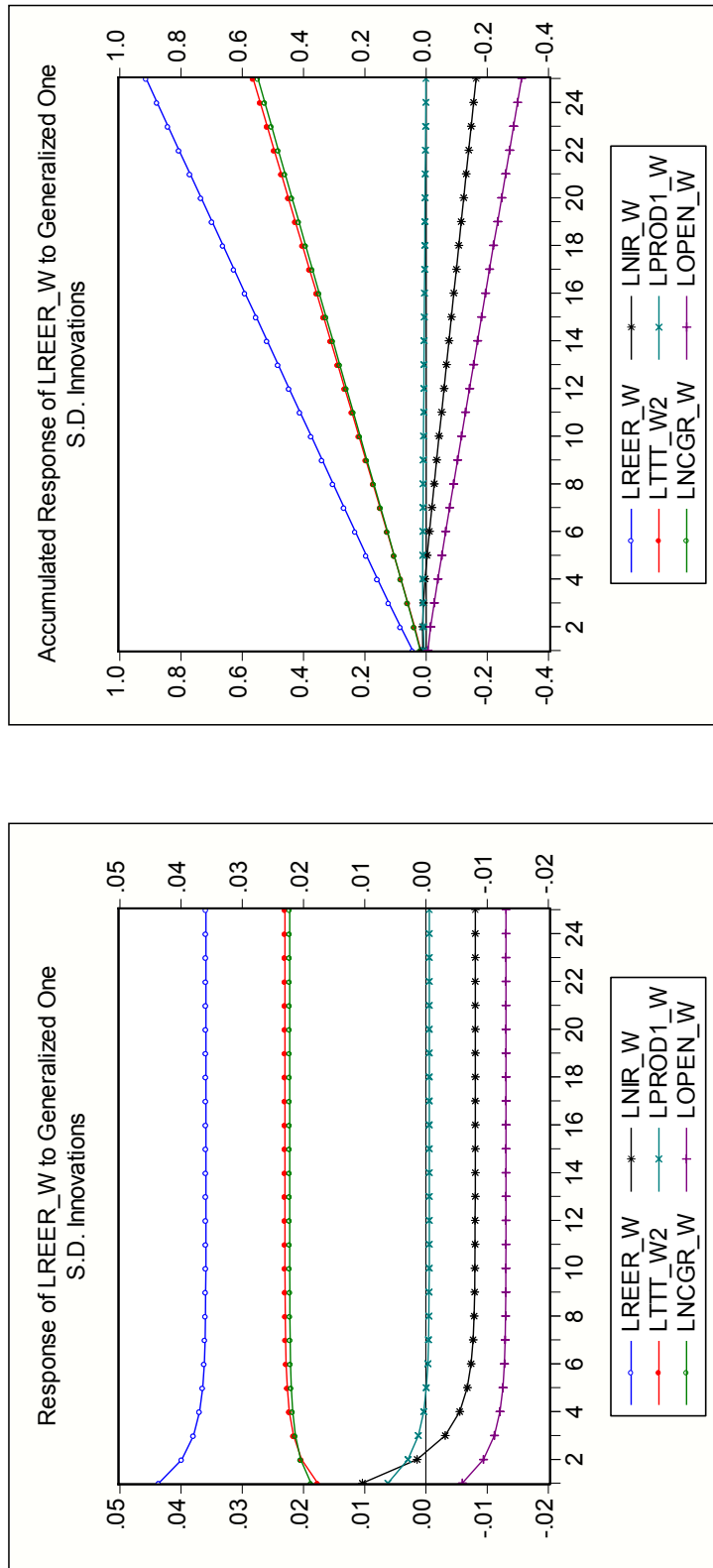


Figure C5a. CEMAC: Model Stability Tests (Recursive Chow Tests)

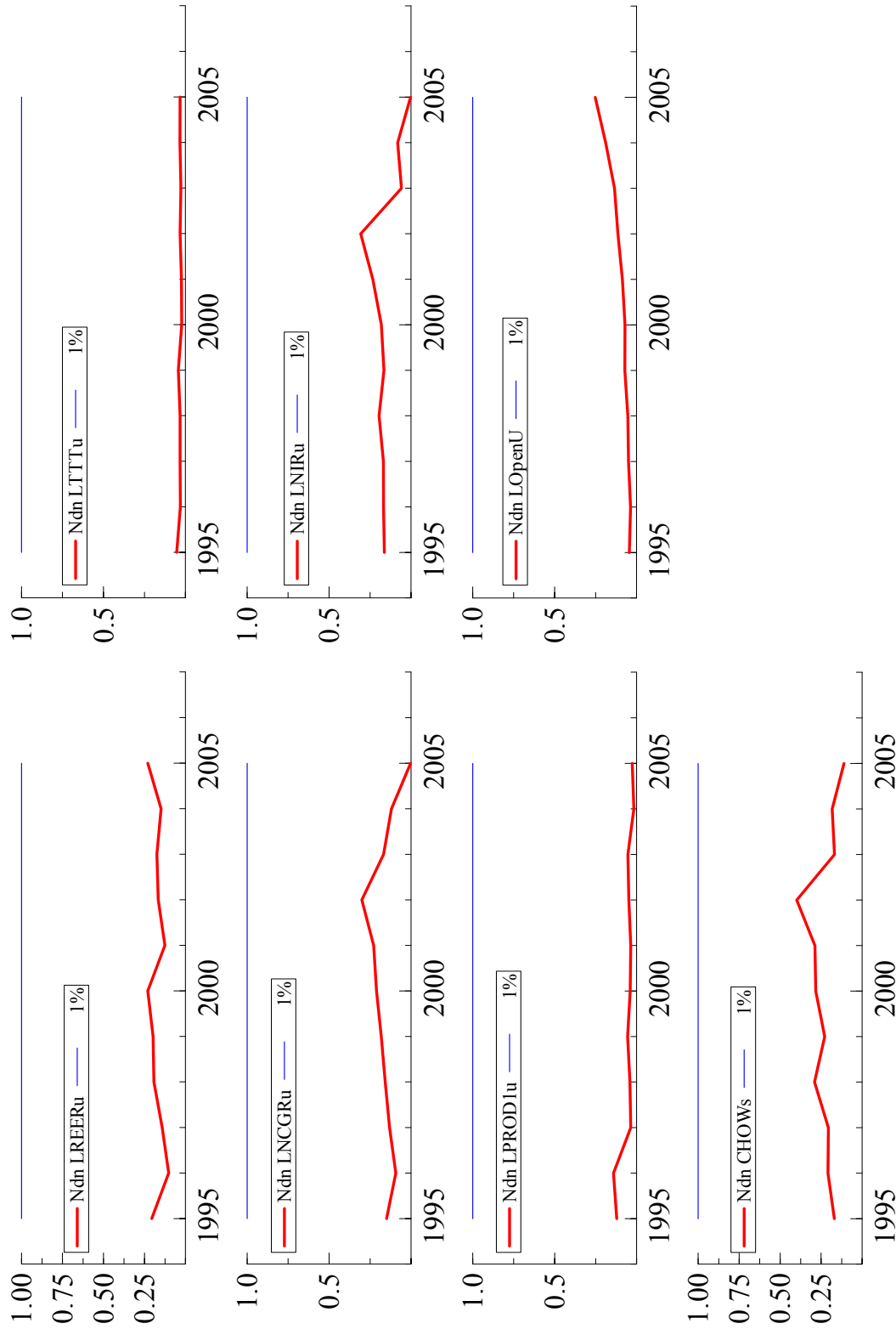
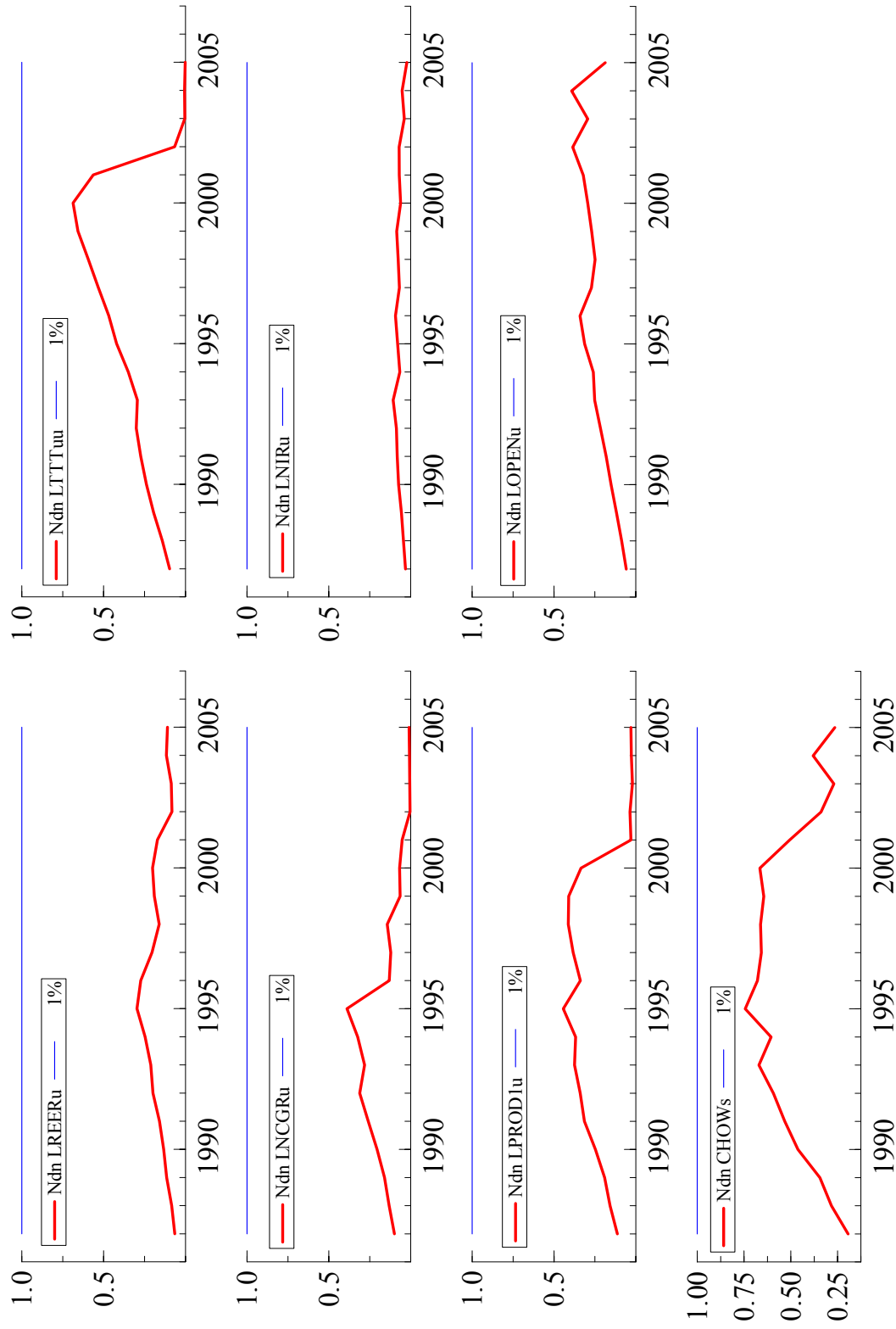


Figure C5b. WAEMU: Model Stability Tests (Recursive Chow Tests)



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