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Cécile Couharde
Issiaka Coulibaly
Olivier Damette

UMR 7235

Université de Paris Ouest Nanterre La Défense
(bâtiments T et G)
200, Avenue de la République
92001 NANTERRE CEDEX

Tél et Fax : 33.(0)1.40.97.59.07
Email : nasam.zaroualete@u-paris10.fr

université Paris Ouest Nanterre La Défense

Misalignments and Dynamics of Real Exchange Rates in the CFA Franc Zone[*]

Cécile Couharde[†] **Issiaka Coulibaly**[‡] **Olivier Damette**[§]

Abstract: In this paper, we analyse currencies' misalignments of the CFA zone countries and the adjustment process of their real effective exchange rates towards their equilibrium level over the period 1985-2007. To this end, we firstly estimate, using panel cointegration techniques, a long term relationship between the real effective exchange rate and economic fundamentals. Secondly, we estimate a panel smooth transition error correction model in order to take into account non linearities in the convergence process of real exchange rates towards their equilibrium level. Two main results emerge from our analysis. Firstly, the real appreciation of effective exchange rates in the CFA zone countries from the 2000s did not translate, in 2007, into a real overvaluation comparable to that occurring before the devaluation of the CFA franc in 1994. However, some countries are exceptions, indicating a strong heterogeneity within the CFA zone. Finally, the convergence process of real effective exchange rates towards their equilibrium level also differs substantially between country groups. These results tend to show the difficulty to apply a single exchange rate policy in the CFA zone and rather call for further coordination and policy harmonization between the countries.

JEL codes: C23, F31, O1.
Key words: CFA zone, misalignments, panel smooth transition model

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[†] Corresponding author: Cécile Couharde, EconomiX-CNRS, University of Paris Ouest Nanterre La Défense, 200 avenue de la République, 92001 Nanterre, France. Telephone: +33 (0) 1 40 97 78 80. Fax: +33 (0) 1 40 97 71 42. E-mail: cecile.couharde@u-paris10.fr

[‡] Department of Economics, Erudite, University of Paris Est Créteil, Créteil 94010, France. E-mail: issiaka1.coulibaly@etu.u-pec.fr

[§] Department of Economics, Erudite, University of Paris Est Créteil, Créteil 94010, France. E-mail: olivier.damette@u-pec.fr

1. Introduction

The recent crisis has highlighted the growth of global economic tensions and the slide toward international trade and currency wars; it has also revived the debate on using the exchange rate in order to improve competitiveness and to accelerate the exit from the crisis. For the countries of the CFA[1] zone, this issue is not a new one: it had already arisen in the first half of the nineties. Indeed, the magnitude of the crisis at that time raised major concerns about the peg of their currencies to the French Franc and finally led them to devalue the CFA Franc. If this devaluation contributed to the recovery of the area, then again questions about competitiviness have raised since the 2000s. In particular, because of its peg to the euro, the CFA Franc has appreciated considerably over the last decade. Between 2000 and 2010, the dollar has lost 43% of its value against the euro, and therefore against the CFA Franc. Currency appreciation may present a major drawback if it induces a real overvaluation that penalizes external competitiveness. Coudert et al. (2011) show that the anchor currency is not neutral: their estimates of equilibrium exchange rates for the CFA zone economies reveal that the CFA Franc tends to be overvalued in periods when the euro is strong. Now the issue of overvaluation is particularly acute in these economies. Indeed, export sectors often play a key role because of the narrowness of their domestic market, a low diversification of their production and the weakness of their human capital and technological potential. Thus for these countries, growth largely relies on export sectors which are the main source of foreign currency, the main provider of public revenues, and the main sectors attracting FDI (Elbadawi et al., 1999). Given the current difficulties faced by the area, some consider the peg to the euro as a potential source of overvaluation and the question of a new devaluation is re-emerging now. For others, the effects of devaluation are, however, uncertain as the exchange rate policy cannot entirely deal with structural problems faced by the area.

Several studies have attempted to address the issue of misalignment's currencies in the Franc CFA zone. The underlying theoretical framework is usually based on equilibrium exchange rates approaches which consist in checking if real exchanges rates are in line with fundamentals, i.e. close to their equilibrium values. At the empirical level, estimates rely, in general, on a reduced form equation of the real effective exchange rate using mostly panel

[1] The CFA franc zone includes the countries of the West African Economic and Monetary Union (Benin, Burkina Faso, Ivory Coast, Guinea Bissau, Mali, Niger, Senegal, and Togo) and the countries of the Central Africa Economic and Monetary Community (Cameroon, Gabon, Equatorial Guinea, Congo, Central African Republic, and Chad). The appellation CFA franc means: "Communauté Financière Africaine" for the WAEMU members countries and "Coopération Financière en Afrique Centrale" for CAEMC's members countries.

data cointegration methods, given the small size of samples.[2] Real exchange rate and their fundamentals are found to be cointegrated and have a stable long-run equilibrium relation. Nevertheless, fewer studies have focused on the short run dynamics of the real exchange rate in the CFA countries, i.e. the convergence process along which the real exchange rate converges to its long-run equilibrium value. Moreover, when this dynamics issue is analyzed, the short run dynamics is assumed to be linear and symmetric (Elbadawi et al., 2009). However, several works show that the assumption of linearity may be quite restrictive. Flood and Taylor (1996) suggest that the adjustment to equilibrium may instead depend on the magnitude of the deviation from the equilibrium as well as on changes in underlying economic fundamentals. On the theoretical level, economists have proposed different explanations of nonlinearity in exchange rate dynamics. For example, Dumas (1992) explains the non linear adjustment process of exchange rates towards the purchasing power parity (PPP) by the existence of transaction costs in goods and services markets. Behaviours of market and of policy makers can also induce a rapid convergence process of exchange rates towards equilibrium when deviations are large, while exchange rates may not converge or may converge slowly and unstably when deviations are small (Taylor and Peel, 2000). Most of researches in this area examine nonlinearities in the deviations of exchange rates from an equilibrium level suggested by monetary fundamentals. More recent works (Lopez-Villavicencio and Mignon, 2010) apply nonlinear panel models to the short run dynamics of real exchange rates, in a theoretical framework where their equilibrium level is defined by real fundamentals. Following a Behavioural Equilibrium Exchange Rate (BEER) approach, they show that the convergence process of real exchange rates toward their equilibrium level depends on the size of misalignments in emerging economies of the G20 countries.

The issue of nonlinearity is particularly relevant to the CFA zone countries. Elbadawi et al. (2005) underline some inertia in the adjustment process of the real exchange rate in the CFA and the RMA (Rand Monetary Area) zones, two monetary unions of Sub-Saharan Africa. They argue that economies with inflexible exchange rate regimes and rigid labour markets are likely to be characterized by nominal rigidities, which in turn, could dampen their automatic adjustment towards equilibrium. The issue is also crucial to policy-makers of the CFA zone in determining the opportunity and the extent of devaluation. Indeed, we may expect that the

[2] However, some studies use single equations in order to estimate equilibrium exchange rates. See Baffes et al. (1997) in their study of Côte d'Ivoire and Burkina Faso ; Roudet et al. (2007) test the robustness of their equilibrium exchanges rates' estimates for the WAEMU countries by using both time series econometrics and panel cointegration techniques. Also, Chudik and Mongardini (2007) apply both methods on a set of 36 Sub-Saharan Africa countries; they show that the panel method is more robust and leads to better results.

more overvaluation's episodes will be persistent and significant, the more a correction of the CFA Franc will be required.

This article fits in these researches by addressing the opportunity of a nominal devaluation for the CFA zone. In particular, we investigate the following two questions. Has the appreciation of the CFA franc since the 2000s resulted in an overvalued real exchange rate on a scale comparable to that observed before the 1994 devaluation? How do real effective exchange rates converge toward their equilibrium level? But it distinguishes itself by several ways. Firstly, we use the most recent panel data unit roots and cointegration techniques to study the relationship between real effective exchange rates and their economic fundamentals. All previous studies rest upon first generation unit roots and cointegration tests that assume cross sectional independence among panel units. But, given several specificities shared by the CFA countries (peg to the same anchor currency, strong exposure to shocks), we also run second generation unit root and cointegration tests that relax the assumption of cross sectional independence as well as unit root tests that enable to accommodate structural breaks. Finally, we apply a Panel Smooth Transition Regression (PSTR) model, as proposed by González et al. (2005), to the short-run dynamics of real effective exchange rates. In particular, we follow the approach developed by Lopez-Villavicencio and Mignon (2010) and Béreau et al. (2010) in order to check if the convergence process of real exchange rates acts differently when misalignments are in different regimes.

Our results firstly demonstrate that the real appreciation of effective exchange rates in CFA zone countries from the 2000s did not translate, in 2007, into a real overvaluation comparable to that occurring before the devaluation of the CFA Franc in 1994. However, there are country-specific exceptions, indicating a strong heterogeneity within the CFA zone. Secondly, our estimates support the idea that the convergence process of real effective exchange rates towards their equilibrium level also differs substantially between country groups. Indeed, only the WAEMU countries seem to be prone to persistent overvaluation.

The remaining of the article is organized as follow: section 2 outlines the theoretical framework and provides a brief literature review on equilibrium exchange rates approaches in developing economies. Section 3 presents the methodology used in order to estimate equilibrium exchange rates and displays misalignments results. Section 4 discusses the process of convergence of real effective exchange rates to their equilibrium value. Section 5 concludes and draws some policy implications for the CFA zone countries.

2. Equilibrium exchange rates in CFA zone countries

Among the models of real equilibrium exchange rate (REER thereafter), some deal more specifically with the dynamics of the real exchange rate in developing economies (Edwards, 1994; Elbadawi, 1994; Hinkle and Montiel, 1999). These models highlight the role played by a number of fundamentals in determining equilibrium exchange rates, following models of industrialized economies. In particular, from these theoretical models, a reduced equation of real exchange rate can be derived, in conformity with the so-called Behavioral Equilibrium Exchange Rate (BEER) approach. These models, since they take into account several specificities of developing economies, generally include some fundamentals that are usually omitted in the determination of equilibrium exchange rates of industrialized countries and emerging economies.

2.1. Theoretical background

Most models consider a small open economy with two sectors (tradables and non-tradables) in which the REER is the internal real exchange rate that ensures both internal and external balances[3] (see for example Montiel, 1999). Internal balance holds when markets for labour and non-traded goods clear:

$$y_N(q,\xi) = c_N + g_N = (1-\theta)qc + g_N, \quad \partial y_N / \partial q < 0, \quad \partial y_N / \partial \xi < 0 \qquad (1)$$

With q the internal real exchange rate defined by the domestic price of tradables in terms of domestic price of non-tradables goods[4], y_N, the supply of non-tradables consistent with full employment ; c, total private consumption measured in terms of tradables goods ; θ, the share of spending on traded goods ; g_N, government spending on non-tradables, and ξ, a productivity shock in favour of the tradable sector.

The external balance is defined, in turn, by the long term condition of external sustainability, i.e. the steady equilibrium value of the net external position:

$$\dot{f} = b + z + rf = y_T(q,\xi) - g_T - (\theta + \phi)c + z + rf = 0, \quad \partial y_T / \partial q > 0, \quad \partial y_T / \partial \xi > 0 \qquad (2)$$

[3] Knowing that the exogenous variables have reached their equilibrium values and that economic policies are sustainable.

[4] An increase in q stands for a real depreciation.

With f, the net foreign asset ; b , the trade balance ; z, net transfers, measured in prices of tradables goods ; ϕ, transaction costs associated with private spending on long-term determined by the foreign inflation rate, π_w ; r, real interest earned on the net external position.

The REER, q^*, corresponds to the internal real exchange rate leading to the simultaneous achievement of internal balance (1) and external balance (2):

$$q^* = q^*\left[g_N, g_T, \left(r^* \underset{-}{f^*} + z\right), \pi_W, \xi\right] \tag{3}$$

With * denoting long run equilibrium value

2.2. What determinants of the real equilibrium exchange rate in CFA zone?

From the previous model, several factors explaining the long-run equilibrium level of the real exchange rate can be derived: the productivity differential in favour of the tradable sector, public expenditure on non-tradable and tradable goods, the foreign inflation rate, international transfers or the real interest earned on net foreign balance.

The productivity differential in favour of tradable goods refers to the “Balassa-Samuelson” effect. Increased productivity in the tradable sector leads to higher wages in this sector (to maintain equality with international prices). This induces a rise in relative prices in the non-tradable sector, where productivity has not increased, and an appreciation of the REER. Usually models specified for developing economies (Edwards, 1994; Elbadawi, 1994) and for the CFA zone countries (Baffes et al., 1999; Roudet et al., 2007) consider public spending as an another factor affecting equilibrium exchange rates. However, its impact is ambiguous since it depends on its distribution between tradables and non-tradables. An increase in public expenditure in non-tradables induces an excess demand in that market and must be offset by an appreciation of the REER. Conversely, higher public spending in the tradable sector leads to a deterioration in the trade balance: a depreciation of the REER is therefore necessary to restore external balance. Capital inflows (interest earned on the investment position, international transfers), as that they can relax the constraint on trade in goods and services, lead to an appreciation of the REER. Generally, in the case of developed economies, capital flows are approximated by the net external position. However, alternative variables that could also account for these flows[5] can be found in studies relative to the CFA zone countries. For example, Dufrenot and Yehoue (2005) take into account in their estimates of real equilibrium exchange rate equilibrium, for a sample of 64 developing countries, the net income from abroad and official development assistance. Aydin (2010) takes as determinants of capital flows in Sub-Saharan economies, the net external position, the official development assistance and private transfers measured by remittances from workers. Other studies seek to estimate a current account equilibrium balance. Elbadawi and Soto (2005, 2008) estimate the sustainable level of current account by regressing from panel data imports over exports, the official development assistance, the debt service, and the change in external debt. Baffes et al. (1999), in turn, measure the external balance, by taking into account the limited access of developing economies to international financial markets. In their framework, the external equilibrium is approximated by the trade balance in volume and adjusted from the terms of trade.

The previous model can be extended to three sectors, with tradables splitted between exported and imported goods. The relevant real exchange rate is no more the internal real exchange rate but instead the external real exchange rate which measures the price competitiveness of the domestic economy vis-à-vis its trade partners. With this extension other explanatory variables of equilibrium exchange rates which are particularly relevant for CFA zone countries can been highlighted as trade policy and terms of trade (Baffes et al., 1999; Edwards, 1994; Elbadawi, 1994). The effect of trade liberalization (reduction of import tariffs or export subsidies) depreciates the real exchange rate equilibrium in the long term. The impact of the terms of trade is ambiguous since they exert different effects on the REER. Thus, a rise in exportable goods price has a positive income effect, which combined with a substitution effect in supply, causes an appreciation of the REER. However, consumers can be encouraged to substitute their consumption basket in the non-traded goods by imported goods which become cheaper. This substitution effect from the demand side results in a depreciation of the REER. A simplifying assumption usually made is to assume that the income effect dominates the substitution effect from the demand side or that commodities are entirely exported. Under these hypotheses, the impact of commodities prices on domestic demand can be omitted (De Gregorio and Wolf, 1994) and an improvement in the terms of trade leads to an appreciation of the REER.

[5] Roudet et al. (2007) excludes capital flows considered as negligible in their estimation of equilibrium exchange rates of the WAEMU countries.

3. Estimation of real equilibrium exchange rates

To estimate the equilibrium exchange rates of CFA countries, we use - like most of studies developed in this area - the BEER approach.[6] In this framework, the REER is the solution of a long run relationship between real exchange rate and economic fundamentals as specified by the following equation:

$$LREER_{it} = U_i + \beta_1 LTOT_{it} + \beta_2 LPROD_{it} + \beta_3 LOPEN_{it} + \beta_4 LDEP_{it} + \beta_5 NFA_{it} + \varepsilon_{it} \quad (4)$$

Where subscripts i and t represent respectively country and time indexes, U_i and ε_{it} are country-specific intercepts and disturbance terms, $LREER$ denotes the real effective exchange rate, $LTOT$ the terms of trade, $LPROD$ the relative per capita productivity, $LOPEN$ the degree of openness, $LDEP$ public spending relative to GDP, NFA the net foreign position relative to GDP and ε_{it} the error term. The coefficients β represent the parameters to be estimated. All variables are in logarithm, except the net foreign position.

3.1. Data

Our study covers 13 countries of the CFA zone: Benin, Burkina Faso, Ivory Coast, Guinea Bissau, Mali, Niger, Senegal, Togo, Cameroon, Gabon, Equatorial Guinea, Congo, Central African Republic, and Chad.[7] The data are annual and cover the period from 1985 to 2007. Real effective exchange rates are calculated using real bilateral exchange rates of the top ten trading partners of each country[8], weighted by their share in foreign trade of the country over the period 1999-2007. Bilateral exchange rates are extracted from the database World Development Indicators (WDI) of the World Bank while shares of partners' countries are calculated using data of the Direction of Trade Statistics (International Monetary Fund). Terms of trade are calculated in a similar fashion to that developed by Cashin et al. (2004) and employed by Coudert et al. (2011). They are defined as a weighting price of the three main export commodities for each country, deflated by the price index of manufactured exports of OECD countries. Commodities prices are extracted from the database International

[6] For developing and emerging economies, it is generally more convenient to use the BEER approach for estimating equilibrium exchange rates. The FEER approach requires to estimate trade elasticity's and to calculate the potential output of the various countries concerned, which is often made difficult by the lack of data availability. Therefore, apart from some studies of the International Monetary Fund (Aydın, 2010; Abdih and Tsangarides, 2006), most studies on CFA countries rely on the BEER approach.
[7] Guinea Bissau is not taken into account insofar as it is a member of WAEMU since 1997.
[8] See Appendix, Table A.

Financial Statistics of the International Monetary Fund. Weights are calculated over the period 2005-2007 and are derived from commodity trade flows available from the International Trade Center[9]. For oil exporters, the terms of trade reflect only oil prices, deflated by the same foreign index price. The Balassa effect is measured by relative living standards (PPP GDP per capita), which are considered as a proxy for relative productivity differences between sectors. PPP GDP per capita data are taken from the World Bank's World Development Indicators (WDI) database; Calculations for weights are identical to those used for real effective exchange rates. Finally, the openness rate is measured by the share of imports and exports in GDP. Import and export data is obtained from the database WDI as well as public spending data. Net external positions come from the database developed by Lane and Milesi-Ferretti (2007).[10]

3.2. Estimating the long run relationship

We determine first the order of integration of each variable and then test the existence of a cointegration relationship by applying non-stationary panel methods. Indeed, the use of panel data has the distinct advantage of allowing working with small sample size in the temporal dimension - as is often the case in African countries - and thus to overcome the classic problem of low power tests in small sample.

In order to analyse the time properties of the variables, we mobilize several unit root tests[11] and in particular the so-called second (2^{nd}) and third (3^{rd}) generation tests. These latter tests present the advantage of taking into account, respectively, the dependence between countries and the presence of break points in the stochastic process of the series. We justify this choice by several specificities shared by the countries of our sample. Indeed, the strong correlation between real effective exchange rates, explained by their peg to the same anchor currency, means that the inter-individual independence assumption underlying the first generation tests may be no relevant.[12] Moreover, these countries are characterized by a strong exposure to common shocks (devaluation or structural adjustment plan in 1994, terms of trade’s shocks).

[9] www.intracen.org

[10] http://www.imf.org/external/pubs/ft/wp/2006/data/wp0669.zip

[11] We have run several tests before using tests of second and third generations. These tests are the inter-individual dependency test of Pesaran (CD), the Breush-Pagan test (LM test) and the LM test of the number of breakpoints developed by Carrion et al. (2005). The results of these tests are reported in table B (Cross section dependence tests of all variables) and table C (breaks dates of the REER by country and the optimal number of break) in the Appendix.

[12] See for instance O’Connel (1998) and Westerlund (2005) for details about this invalidity.

3rd generation tests are then mobilized to check the existence of structural breaks. We only consider unit root tests that have the best properties in finite samples i.e. that remain relatively strong with a limited number of observations: 1rst generation tests of Im et al. (2003) and Madalla and Wu (1999); 2nd generation tests of Pesaran (2007) and Choi (2002), and the 3rd generation test developed by Carrion et al. (2005) which takes into account both inter-individual dependence and the existence of structural breaks. From an econometric point of view, 2nd generation panel unit root tests account for cross sectional dependence by assuming a common factor representation: $x_{it} = \lambda_i' F_t + \mu_{it}$ where F_t is a vector of unobserved common factors. In this general specification, the number of factor is supposed to be unknown. λ_i' is a vector of factor's coefficients by country, i.e. the country specific sensitivity to the common components. μ_{it} is the idiosyncratic error term. Particularly, the tests of Choi (2002) and Pesaran (2007) assume that there is one common factor. Choi's test supposes that countries have the same sensibility to the common factor ($\lambda_i = \lambda$) while Pesaran's test suggests that countries can react differently to the common component ($\lambda_i = \lambda_i$ while $i = 1$ à 13). Choi's test consists in testing the unit root from a transformation of the observed series x_{it}, allowing to eliminate inter-individual correlations and possible components of deterministic trend. Pesaran's test consists in adding to the standard well-known IPS test, the mean and the lagged mean of the observed series (respectively $\bar{x}_{it}$ and $\bar{x}_{it-1}$) which is sufficient to filter asymptotically the effects of unobserved common component when the number of countries tends to infinity. Finally, the Carrion $LM(\lambda)$ test is a generalization of the univariate KPSS test usually computed in time series (and of the Hadri (2000) test in panel) for the case of multiple structural breaks. Thus this test allows the presence of multiple breaks (the number of break is unknown) under the null hypothesis of stationarity and does not impose the independence of cross section in the errors terms through boostraping. Table 1 summarizes the results of these different tests.

Overall, first-generation unit root tests indicate that that all variables are integrated of order one. Tests of 2nd and 3rd generations lead to the same conclusions, except the degree of openness which appears to be stationary.[13] This result contrasts with previous studies on the

[13] Choi's test also leads to reject the presence of a unit root for public spending. However, the test of Pesaran (CD) does not confirm the presence of inter-individual dependence and therefore the use of test Choi. In addition, CIPS tests conclude to the character I (1) of this series.

CFA zone. In these studies, as only first generation tests are used, the degree of openness is found I(1) and then appeared as an explanatory variable in the long run relationship (Roudet et al., 2007; Dufrenot and Yehoue, 2005; Abdih and Tsangarides, 2006, etc..).[14]

Table 1. Unit roots tests

Variables	1st generation		2nd generation			3rd generation
	Im and al.	Madalla and Wu	Pesaran	Choi		Carrion et al.
	IPS	Z_{MW}	$CIPS^*$	***Pm***	***Z***	$LM(\lambda)$
TCER	1.76 (0.96)	18.33 (0.86)	-2.29 (0.49)	-1.93 (0.97)	1.66 (0.95)	20.43 (0.00)
TOT	2.31 (0.99)	67.79 (0.00)	-2.74 (0.07)	-0.98 (0.84)	3.61 (0.99)	29.17 (0.00)
PROD	0.23 (0.59)	15.96 (0.94)	-2.68 (0.10)	0.16 (0.45)	-0.63 (0.27)	19.57 (0.00)
NFA	4.77 (1.00)	12.95 (0.98)	-2.52 (0.22)	-1.74 (0.96)	2.24 (0.99)	15.85 (0.00)
OPEN	-0.62 (0.27)	70.15 (0.00)	-1.93 (0.27)	10.50 (0.00)	-5.61 (0.00)	0.02 (0.49)
DEP	-1.26 (0.10)	41.78 (0.03)	-2.41 (0.34)	3.56 (0.00)	-2.46 (0.01)	8.85 (0.00)

Notes: trends and individual constants are introduced in all specifications[15], except for the variable OPEN. The values in brackets are the associated probabilities.

The test of Carrion et al. (2005), based on the KPSS test, tests the null hypothesis of stationarity, unlike the other tests presented here.

We then consider in the long run relationship the only variables that share the same order of integration with the real effective exchange rate: the terms of trade, productivity shocks, the net foreign asset position and public expenditure. The existence of a cointegration relationship is tested by using firstly the now well-known Pedroni's (1999, 2004) tests and the recent Westerlund (2007, 2008) tests. These tests are similar to Engle and Granger (1987)'s test in the time series context and lead to a unit root test on the residues of the cointegration model. Pedroni (1999, 2004) proposes seven statistics to test the null hypothesis of no cointegration. But the alternative hypothesis depends on the dimension considered. The within dimension implies that the cointegration vector is homogeneous across countries while the between dimension supposes that the vector is heterogeneous across countries. Thus, the four "within dimension" statistics (panel statistics) are more restrictive than the three "between dimension" statistics (group statistics). Pedroni's statistics are reported in the table 2 below. Globally, they lead to reject the null hypothesis of no cointegration. Since we find evidence of cross-sectionally correlation among our variables, we then run the cointegration tests developed by Westerlund (2008) and Westerlund and Edgerton (2007). The Westerlund cointegration test (2008), based on the Durbin-Hausman principle, is very similar to the panel unit root test with

[14] However, it is possible that the degree of openness has a short-term effect on the real exchange rate. In other words, the degree of openness may influence the dynamics of exchange rate but not its equilibrium level.
[15] Results still hold with alternative specifications.

common factors. It consists here in estimating a common component from the regression errors of the equation (5) and then deriving the test on the residual idiosyncratic component. As Westerlund (2008) explains, because the test is constructed under the assumption of a unit root in the idiosyncratic errors, the null hypothesis is the absence of cointegration, while the alternative is that there are at least some countries for which there is a cointegrated relationship. The Westerlund and Edgerton test (2007) appears to be a good complement as it was developed on the null hypothesis that takes cointegration for the panel as a whole. Cross-sectional dependence is taken into account by boostraping. We first test the presence of cointegration *via* the Westerlund test (2008) (DH_g and DH_p) and then check this result using the Westerlund and Edgerton's test (2007) (LM_N^+) for the whole panel. The results, presented in table 2, show that we can reject the null hypothesis of the absence of cointegration regarding the Westerlund test. Indeed, there are some countries that exhibit a long run or equilibrium relationship between the real exchange rate and its covariates. Results of the Westerlund and Edgerton test also lead to accept the null hypothesis of a cointegration relationship for the panel as a whole. Finally, first and second-generation cointegration tests provide clear support of a long-run cointegration relationship between the real exchange rate and its fundamentals.

Table 2. Cointegration tests

Tests	*Statistics*	*Value*	P-value
Westerlund (with one factor)	DH_g	24.98	0.00
	DH_p	29.01	0.00
Westerlund (with five factors)	DH_g	12.72	0.00
	DH_p	14.98	0.00
Westerlund and Edgerton (with constant only)	LM_N^+	13.18	0.16[a]
Westerlund and Edgerton (with constant and trend)	LM_N^+	15.12	0.39[a]
Pedroni	v-Statistic Panel	-1.08	0.86
	rho-Statistic Panel	1.38	0.91
	PP-Statistic Panel	-2.04**	0.02
	ADF-Statistic Panel	-1.36*	0.08
	rho-Statistic Group	2.74***	0.00
	PP-Statistic Group	-2.54***	0.00
	ADF-Statistic Group	0.76	0.78

Note: [a] refers to bootstrap p-values., **, ***, indicates the rejection of the null hypothesis of no cointegration at the 10%, 5% and 1% significance level, respectively.*

After having demonstrated the existence of a long run relationship, we finally estimate the cointegrating vector between real effective exchange rates and macroeconomic fundamentals. To this end, we implement the estimator Dynamic Ordinary Least Squares (DOLS) in panel data developed by Kao and Chiang (2000) and Mark and Sul (2003) as it outperforms both the OLS and fully modified OLS estimators. Indeed, although the OLS estimator of the cointegrating vector is super-convergent, the distribution of coefficients is asymptotically biased and depends on nuisance parameters associated with the presence of unit roots. Thus, usual tests are not valid and OLS is not optimal for inference. In addition, Kao and Chiang (2000) show that in finite sample size distortions from the DOLS estimator are lower than those of OLS and FMOLS and that DOLS performs well in cointegrated panels. Compared to these latest estimators which suppose homogeneous coefficients in both short and long runs, the DOLS approach also presents the advantage to consider heterogeneous coefficients in the short run, while being homogeneous in the long run. According to several papers, this seems to be more pertinent in the context of equilibrium exchange rate studies (see Lopez-Vallavicencio, 2006).

Neglecting leads and lags, the results of the estimation are summarized by the following equation:

$$\underset{}{\hat{LREER}_{it}} = \hat{U}_i + \underset{(7.97)}{0.33 LPROD_{it}} + \underset{(5.60)}{0.19 LTOT_{it}} + \underset{(14.17)}{0.34 LDEP_{it}} + \underset{(1.95)}{0.07 NFA_{it}} \qquad (5)$$

The coefficients are statistically significant[16] and their signs are consistent from what is expected, meaning that the theoretical model is relevant for the countries of our sample. In particular, an increase of the terms of trade leads to an appreciation of the equilibrium exchange rate, suggesting that the substitution effect is lower than the income effect in the CFA zone. Our estimated value is similar to the one of Elbadawi et al. (2009). A rise in government spending implies an appreciation of the equilibrium exchange rate. This result is consistent with the empirical literature on CFA and others developing countries that usually finds that government spending is dominated by non-tradable goods. The estimated coefficient is lower, compared to other studies, but is similar in magnitude to the one found by Mongardini and Rayner (2009). Our results also confirm the existence of the Balassa-Samuelson effect in the CFA zone since an increase of the productivity gap between tradable

[16] Values in brackets are the associated t statistics.

and non-tradable goods implies an appreciation of the equilibrium exchange rate. Finally, an improvement of the net foreign position also leads the equilibrium exchange rate to appreciate, but its estimated coefficient is small which is also in accordance with most previous findings (see Aydın, 2010; Elbadawi et al., 2009; Mongardini and Rayner, 2009; etc...).

3.2. Misalignments

The equilibrium value of the real exchange rate is derived from the estimated cointegration relationship summarized by equation (5). In most cases, it is calculated by taking into account the permanent component (estimated using a Hodrick-Prescott filter) of fundamentals. The permanent component, insofar as it is supposed to capture the sustainable level of fundamentals, seems to be more consistent with the concept of equilibrium exchange rates. Then misalignments can be deduced from the difference between the observed values of real effective exchange rates and their equilibrium values. However, as pointed out by Elbadawi et al. (2008), this method to calculate misalignments, when the latter are estimated in panel data, can lead to permanent distortions (under or overvaluation) of the real exchange rate.[17] Therefore, these authors propose an alternative method that has the advantage to overcome this problem and thus avoid misspecifications of misalignments. This method consists in constraining to zero the expected misalignment of each country over the sample period; in order words, this method assumes that the real exchange rate adjusts always, more or less rapidly, towards its equilibrium value, in accordance to the concept of cointegration and misalignment. In this paper, we choose this method in order to assess misalignments.

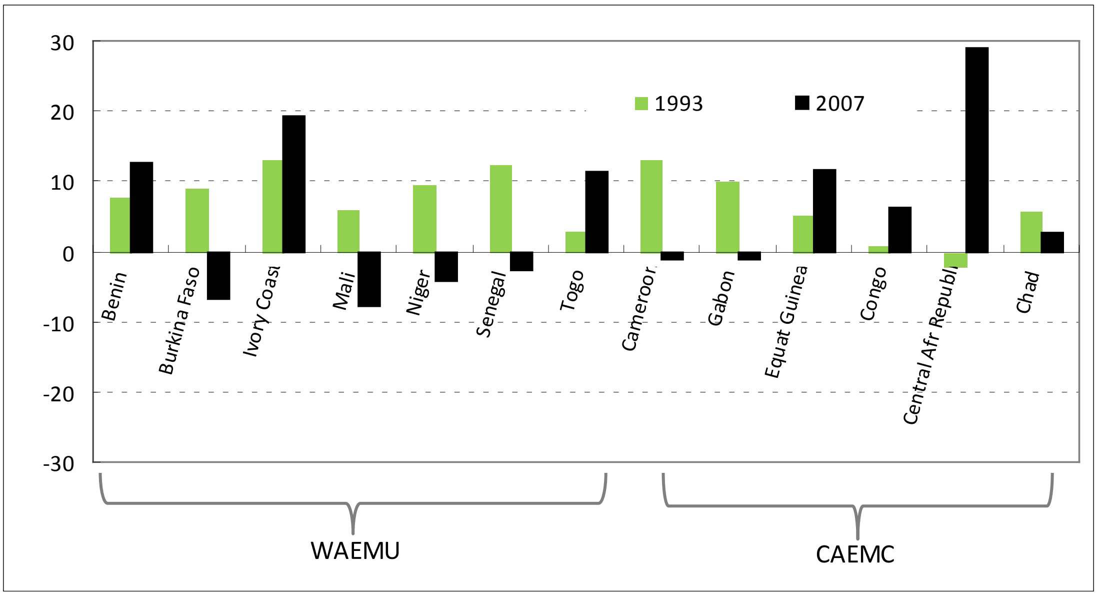
Figure 1 reports the percentage of misalignments in 2007 and 1993 (before the devaluation of the CFA Franc) for comparison. Figures A1 and A2 in Appendix display respectively the evolution of real effective exchange rates (observed and equilibrium) and of misalignments over the sample period and for the 13 considered countries of the CFA zone.

For the whole CFA zone, the misalignments observed in 1993 and 2007 lead to mixed results. Only some countries experience in 2007 an overvaluation higher than the one observed before the devaluation of the CFA Franc. Moreover, there is no clear distinction between the two monetary unions of the zone: the Central Africa Economic and Monetary Community

[17] We encountered the same problem when we calculated misalignments of the countries in our sample. These countries are also included in the study by Elbadawi et al. (2008). For more details, cf. the paper of these authors.

(CAEMC) and the West African Economic and Monetary Union (WAEMU). Abdih and Tsangarides (2006) calculate confidence intervals for real exchange rates of the CAEMC and WAEMU countries and conclude that they were close to their equilibrium values in 2005. Our results suggest the same conclusion, with values slightly higher: the simple mean (i.e. non weighted) of misalignments is respectively 8% for the CAEMC, 3% for the WAEMU and 5% for the whole CFA.

Figure 1. Misalignments in 1993 and 2007 (in %)



Note: A positive (resp. negative) corresponds to an overvaluation (resp. undervaluation)

Among the CAEMC countries, which are oil exporters, only Equatorial Guinea, Congo and Central African Republic are characterized, in 2007, by an overvaluation of their currencies higher than in 1993. Except Central African Republic which is non-oil exporter, the CAEMC economies have benefited from an improvement of their terms of trade from the 2000s that allows them to record a stable or an appreciation of their equilibrium exchange rates (Appendix, Figure A1). Overall, even if those countries have seen their real exchange rate appreciating since the 2000s, the appreciation has been moderate for Cameroon, Gabon and Chad. So this explains why misalignments of their currencies exhibit in 2007 a rather low magnitude. The WAEMU countries are, for their part, mainly exporters of agricultural commodities (cotton, coffee or cocoa). Three of these economies (Benin, Ivory Coast and Togo) suffer from a continued depreciation of their REER that results in 2007 by a real overvaluation of their currencies on a scale comparable to or well above that ones found in

1993. The other countries have benefited, like CAEMC members, from an improvement or a stability of their REER. Combined with a moderate real appreciation, this has resulted in a low real undervaluation of their currencies in 2007. In total, the real appreciation of currencies observed in the CFA zone countries from the 2000s does not seem to have translated in 2007 by a real overvaluation, on a scale comparable to that occurring before the devaluation of the CFA franc in 1994. In 2007, currencies are characterized by rather small misalignments. However, this movement is not general: some countries (Ivory Coast, Central African Republic and to a lesser extent Chad and Togo) undergo significant overvaluation in 2007 compared to 1993. These results are close to those found by previous studies that reveal also a real overvaluation for the four countries mentioned above (Ivory Coast, Central African Republic, Chad and Togo). On the other side, currencies of Burkina Faso, Mali and Senegal are found to be clearly undervalued. The rest of the CFA countries record mixed situations depending on the studies.[18] (see Chudik and Mongardini, 2007; Mongardini and Rayner, 2009; Roudet et al., 2007; Elbadawi et al., 2009). Finally, the assessment of misalignments reveals a strong heterogeneity and the lack of a convergence process between the CFA zone countries.

4. The adjustment process of real effective exchange rates to their equilibrium value

Despite several articles devoted to currency's misalignments in Sub-Saharan Africa, very few analyze the convergence process of the real exchange rate toward its equilibrium level, i.e. its short term dynamics.[19] To take into account this dynamic adjustment, we estimate a panel-based vector error correction model (VECM). The classical VECM, that we firstly estimate, suppose that the adjustment process is linear and with a constant rate. These assumptions seem however too restrictive. Indeed, several theoretical arguments, which are particularly relevant for the CFA zone countries, can justify the nonlinear dynamics of real exchange rates: changes in economic policy regime, the behaviour of some macroeconomic variables that do not necessarily react instantaneously to macroeconomic fluctuations (e.g., price rigidity), the presence of macroeconomic shocks such as terms of trade shocks. Moreover,

[18] Congo's misalignment is not reported in the quotes papers. The reader can refer to the paper of Francis (2009). Niger is only studied in Roudet et al. (2007).

[19] To our knowledge only Elbadawi and Soto (2005), through the Pooled Mean Group estimator (PMG) of Pesaran (1999), have tried to interpret the short-run dynamics of exchange rates in SSA.

evidence of nonlinearities can be observed in the evolution of real effective exchange rates of our sample. Indeed, they are characterized by persistent distortions from their equilibrium value (see Appendix, Figure A2). In order to take into account potential asymmetries, persistence and nonlinearities in the dynamics of real exchange rates in the CFA Franc zone, we also estimate a nonlinear panel-based VECM following the approach developed by Lopez-Villavicencio and Mignon (2010), Béreau et al. (2010).

4.1. The linear dynamics of real exchange rates

We consider a linear Error Correction Model (ECM) described by the following equation:

$$\Delta LTCER_{it} = \alpha_i + \theta MES_{it-1} + \lambda_1 \Delta LTOT_{it} + \lambda_2 \Delta LPROD_{it} + \lambda_3 \Delta LDEP_{it} + \lambda_4 \Delta NFA_{it} + \varepsilon_{it} \qquad (6)$$

With Δ, the difference operator and MES_{it-1}, the lagged value of the misalignment.

We first test the endogeneity of the variation of REER by estimating equation (6), in dynamic form by the method of instrumental variables (MVI) and the generalized method of moments (GMM). Given the small individual size of the panel (13 countries), estimation results from GMM are not retained. As the coefficient associated with the lagged value of the endogenous variable is not significant, we use the within estimator to estimate the linear VECM.

The coefficients of equation (6) are estimated using the panel OLS estimator[20] for the whole CFA zone and for each monetary union of the zone (WAEMU and CAEMC). Results are reported in Table 3. They show that in the short term, an improvement of terms of trade leads to a depreciation of the real effective exchange rate (about 11% for a 1% increase). An increase of 1% of public expenditure and of 1 point of the net foreign position induces an appreciation of respectively 6% and 13% of the real effective exchange rate. Regarding productivity differentials, they exert no significant impact. Moreover, the estimated average adjustment parameter is -0.26 for the whole CFA zone. This value is close to -0.20 obtained by Elbadawi et al. (2009) who estimate an error-correction for a world panel comprised by annual data for 83 countries for 1980-2004, including 36 Sub Saharan African economies. Considering only Sub Saharan African countries, Mongardini and Rayner (2009) find error correction parameters between -0.28 and -0.17, which is also in line with our estimations.

[20] The model was also estimated by one-step method of Pesaran (Pooled Mean Group). The results, available upon request, are very similar, except the coefficient associated with public spending.

These estimated coefficients values suggest that, overall, real effective exchange rates converge relatively slowly toward their equilibrium levels, suggesting some inertia in their adjustment process.

Table 3. Within estimation

Variables	CFA zone	CAEMC	WAEMU
ΔMES_{it-1}	-0.26***	-0.27***	-0.23***
$\Delta LTOT_{it}$	-0.11***	-0.10***	-0.11***
$\Delta LPROD_{it}$	-0.08	-0.04	-0.23*
$\Delta LDEP_{it}$	0.06***	0.05*	0.08**
ΔNFA_{it}	0.13***	0.11***	0.17***

*Note: ***, ** and * mean respectively that the variable is significant at 1%, 5% and 10%.*

Some difference in the adjustment process between the WAEMU and the CAEMC economies can be highlighted. The estimated error correction parameter for the WAEMU (-0.23) is lower than the one found for the CAEMC (-0.29). Thus, real effective exchange rates converge to their equilibrium value more quickly in the CAEMC than in the WAEMU. This result is supported by most of previous studies on this area. For example, Elbadawi et al. (2005) report the estimated error correction term of five WAEMU and two CAEMC countries[21] and show that the mean adjustment parameter of the WAEMU (-0.13) is lower than one of the CAEMC (-0.23). This difference could be explained by specific features: smaller and less rigid economies of the CFA zone, like Chad, adjust relatively faster than others, such as Ivory Coast (see Elbadawi et al., 2005; Elbadawi and Soto, 1997; Baffes et al., 1999). Mongardini and Rayner (2009) also highlight that the adjustment process is faster in oil exporters than in non oil countries. This could then explain the observed difference between the two zones as the CAEMC countries are mainly oil exporters unlike the WAEMU countries.[22]

[21] Burkina Faso, Bissau Guinea, Ivory Coast, Senegal and Togo for the WAEMU; Gabon and Chad for the CAEMC. However, the means reported here exclude Ivory Coast and Togo. Indeed, Ivory Coast has a positive adjustment parameter 0.09 and Togo, according to the authors, has a very high implausible adjustment parameter -0.83. Moreover, Roudet et al. (2007) find the same value (-0.13) for all WAEMU economies by using Johansen time series method.

[22] Only the study of Abdih and Tsangarides (2006) leads to an opposite conclusion. Using time series method, the authors find that the adjustment path of the real exchange rate to its equilibrium value is faster in the WAEMU than in the CAEMC. Their results show that the half of shocks on real exchange rate is absorbed in the WAEMU in 3 years while 7 years is required in the CAEMC.

4.2. Nonlinear dynamic adjustment

As previously noted, in the CFA zone countries, real exchange rates show some inertia in the convergence process to their long-run values. However, this result has been found, assuming that this convergence process was linear. In order to investigate more deeply this issue, we now check if the hypothesis of linearity is relevant for the CFA zone countries and more particularly if the dynamics of real exchange rates in these countries varies according to the nature of misalignments. To capture this potential non linearity, we develop a Panel Smooth Transition Regression (PSTR) model (González et al., 2005) which allows the dynamics of real exchange rates to vary from one regime to another, depending on the value (threshold) of a transition variable, identified here by misalignments.[23] In these models, the transition from one regime to another is smooth or gradual because of some inertia (due to transaction costs, to uncertainty or rigidity).[24] We then apply this specification to equation (6) of the previous section. In the context of two regimes, the model can be described as follows:

$$\Delta LTCER_{it} = \alpha_i + \beta_0' x_{it} + \beta_1' x_{it} g(MES_{it-1}, \gamma, c) + \varepsilon_{it} \qquad (7)$$

Here, $\Delta LTCER_{it}$ is the first difference of real exchange rates with $i = 1,\dots,N$ countries and $t = 1,\dots,T$ time periods. α_i is a vector of individual fixed effects; x_{it} the vector of dimension k of explanatory variables (the terms of trade, the relative per capita productivity, the degree of openness, public spending relative to GDP, net foreign position relative to GDP). β_0' and ($\beta_0' + \beta_1'$) represent respectively the coefficients associated with explanatory variables in the first and second regimes. ε_{it}, the error term independently and identically distributed. $g(MES_{it-1}, \gamma, c)$ is the transition function which can be specified by the following logistic function of order m:

$$g(MES_{it-1}, \gamma, c) = \left[1 + \exp\left(-\gamma \prod_{j=1}^{m} \left(MES_{it-1} - c_j\right)\right)\right]^{-1} \qquad (8)$$

[23] While the transition variable can be chosen among several variables (see Béreau et al; 2010), it can also be chosen in accordance with economic theory. Currency's misalignment is considered here as the transition variable as we can expect that the adjustment process of the real exchange rate towards its equilibrium value depends on the amplitude of the misalignment

[24] Instead of a Panel Transition Regression (PTR) model. These models, introduced by Hansen (1999), have the same features of PSTR models but allow the regression coefficients to change suddenly or abruptly when moving from one regime to another.

This function is a continuous function of the transition variable MES_{it-1} and normalized to be bounded between 0 and 1. c is the threshold parameter ($c_1 < c_2 < \dots < c_j$) and $\gamma > 0$ the smoothness parameter, i.e. the speed of transition from one regime to another one (the highest this parameter is, the more sudden is the transition).[25] According to Gonzalez et al. (2005), the transition function can be of order one (logistic function) or order two (quadratic function) in order to capture the non linearities derived from the regime switching. For $m = 1$, the model implies that the two extreme regimes are associated with high and low values of the transition variable (MES_{it-1}) with a single monotonic transition of the coefficients from β'_0 to $\beta'_0 + \beta'_1$ as MES_{it-1} increases, where the change is centered around c_1 (see Appendix, Figure A3).

The methodology used to estimate the PSTR is sequential. We first test the null hypothesis of homogeneity by imposing $H_0 : \gamma = 0$ or $H_0^1 : \beta'_1 = 0$ against the PSTR specification. The associated tests are not standard tests because of the presence of nuisance parameters which are unidentified (like the parameter c) under both null hypothesis. Following the methodology of Luukkonen et al. (1988), Gonzålez et al. (2005) proposed to test the null hypothesis of ($H_0 : \gamma = 0$) and to replace the function $g(MES_{it-1}, \gamma, c)$ by its first-order Taylor expansion around $\gamma = 0$, in order to overcome the problem of nuisance parameters. After reparameterization, this leads to consider the following regression:

$$\Delta LTCER_{it} = \alpha_i + \beta_0'^{*} x_{it} + \beta_1'^{*} MES_{it-1} + \dots + \beta_m'^{*} MES_{it-1}^{m} + \varepsilon_{it}^{*} \qquad (9)$$

Where $\beta_0'^{*}, \dots, \beta_m'^{*}$ are multiples of γ and $\varepsilon_{it}^{*} = \varepsilon_{it} + R_m \beta_1' x_{it}$; R_m is the remainder term of Taylor expansion. Thus, the linearity test leads to test $H_0^{*} : \beta_0'^{*} = \dots = \beta_m'^{*} = 0$ in equation (9). The test of homogeneity consists in applying the LM-test developed by Gonzålez et al. (2005): $LM = TN(SSR_0 - SSR_1)/SSR_0$ with SSR_0 is the sum of squared residuals of the model with fixed effects and SSR_1 is the sum of squared residuals of the alternative equation (PSTR model with two regimes). However, the authors derive a Fisher LM-test which has better

[25] Thus, when γ tends to infinity, the transition function collapses to an indicator function and the PSTR model corresponds to a PTR model from Hansen (1999) described by an abrupt change from one regime to one other. When γ tends to zero, the transition function g becomes constant and the model reduces to a usual panel linear regression model with fixed effects and homogenous coefficients. When γ is in the interval $]0, \infty[$, the function, the slope coefficient is a weighted average of β_0 and β_1 and the coefficients may be not directly interpretable.

properties in finite sample and is asymptotically distributed as a $F(mk, TN - N - m(k+1))$: $LM = \frac{(SSR_0 - SSR_1)/mK}{SSR_0/(TN - N - mK)}$. Results of the Fisher LM-test are reported in table 4. They show that the hypothesis of homogeneity is rejected for the variable misalignment and evidence a two-regime model ($r = 1$).

Next we have to determine the order m of the logistic function. Following Granger and Teräsvirta (1993)'s and Teräsvirta (1994)'s methodology, Gonzålez et al. (2005) proposed a sequential test for choosing between $m = 1$ or $m = 2$. We apply this test to the equation (9) below, considering also the case $m = 3$. Firstly, we test the null hypothesis $H_0^* : \beta_0'^* = \ldots = \beta_m'^* = 0$. If it is rejected, we test $H_{03}^* : \beta_2'^* = 0$, $H_{02}^* : \beta_2'^* = 0 | \beta_3'^* = 0$ and $H_{01}^* : \beta_1'^* = 0 | \beta_3'^* = \beta_2'^* = 0$. Then, we choose $m = 2$ if the rejection of H_{02}^* is the strongest one; otherwise we select $m = 1$. The results are shown in Table D of the Appendix. They evidence a logistic function ($m = 1$) for all samples considered[26], meaning that two extreme regimes are at work and are associated with high and low values of deviations from equilibrium. In order words, as in Lopez-Villavicencio and Mignon (2010), the type of asymmetry distinguishes between high or low misalignments.

Thus we proceed to estimating the following Panel Smooth Transition Error Correction Model:

$$\begin{aligned}\Delta LTCER_{it} &= \alpha_i + \theta^0 MES_{it-1} + \lambda_1^0 \Delta LTOT_{it} + \lambda_2^0 \Delta LPROD_{it} + \lambda_3^0 \Delta LDEP_{it} + \lambda_4^0 \Delta NFA_{it} \\ &\quad + \left[\theta^1 MES_{it-1} + \lambda_1^1 \Delta LTOT_{it} + \lambda_2^1 \Delta LPROD_{it} + \lambda_3^1 \Delta LDEP_{it} + \lambda_4^1 \Delta NFA_{it}\right] g\left(MES_{it-1}, \gamma, c\right) + \varepsilon_{it}\end{aligned}$$
(10)

λ_i^0 et λ_i^1 with ($i = 1,\ldots,4$) are the coefficients of the explanatory variables of the first and second regime; θ^0 and $(\theta^0 + \theta^1)$ represent the coefficients of the error correction term of respectively the linear and the non linear regimes. These latest parameters are the interest parameters of this study.

[26] Béreau et al. (2010) proposed an alternative method by using the Schwarz's criterion (BIC). They suggest choosing the function that minimises this criterion. Applying this method leads to the same conclusion: m=1.

The estimation's step is a relative application of the fixed effects estimator. It consists to demeaning variables by removing individual-specific means before applying the nonlinear least squares to obtain the coefficient's estimations.

Finally, we evaluate the quality of the regression. Gonzålez et al. (2005) suggest two tests: the parameters constancy over time test and the no remaining nonlinearity test. The first one reduces to the stability test of the parameters usually performed in time series studies. However, considering the small time dimension of panel studies, this test is not very relevant (see Gonzålez et al., 2005). The second test allows checking if some nonlinearity, which is not taken into account in the estimated model, remains. This test also permits to choose the adequate value of the parameter r (the number of regimes). There again, the process of choosing the value of r is sequential. Firstly, we compare the one regime model (homogeneous model, $r=0$) to the two regimes model ($r=1$). Then, if we accept the hypothesis of non homogeneity in the first step, we compare the two regimes model to the three regimes model ($r=2$). Results of this test are reported in the table 4 below. They show that the null hypothesis of $r=1$ is accepted for all samples, since the associated probabilities are higher than 5%.

Table 4. Linearity and no remaining nonlinearity tests with misalignment as threshold variable.

Hypothesis	CFA Zone		CAEMC		WAEMU	
	Fisher LM stat	P.value	Fisher LM stat	P.value	Fisher LM stat	P.value
H0: r=0 versus H1: r=1	4.94	0.00	3.076	0.01	2.357	0.04
H0: r=1 versus H1: r=2	1.198	0.31	1.139	0.34	0.35	0.88

Note: The first line corresponds to the non linearity test and the second allows testing the no remaining nonlinearity also call no remaining heterogeneity in the panel context. Briefly, this last test permit to choose the number of regimes of the model (r=1 or 2). In this case we accept r=1.

Table 5 reports the values of key parameters from the estimation: the error correction term, the threshold value and the speed of adjustment.

Table 5. Estimated PSTR with two regimes and m=1

	Regime 1		Regime 2		Transition	
	θ^0	T-stat	$\theta^0+\theta^1$	T-stat	γ	c
CFA Zone	-0.29	-4.19	-0.28	-4.24	33.72	0.03
CAEMC	-0.29	-2.79	-0.37	-3.55	36.22	0.02
WAEMU	-0.32	-1.97	-0.18	-2.20	8.01	-0.13

Note: The Schwarz's criterion (BIC) was used to choose the form of the transition function that is to say the adequate value of parameter m (logistic or quadratic).

For the CFA zone, the estimated threshold value is 0.03 and identifies the two following regimes: a first regime corresponding to undervalued real exchanges rates and also real exchange rates for which overvaluation is below the threshold of 3%; This regime is distinct from the second one where real overvaluation is more than 3%. But, our findings suggest a strong symmetry in terms of adjustment between these two regimes as the estimated correction terms are fairly close (-0.29 against -0.28). Thus, when real exchange rates are undervalued or overvalued, there is a similar convergence process towards the equilibrium level. While real exchange rates' adjustment is comparable between the two regimes in the overall CFA zone, results for the two specific areas (CAEMC and WAEMU) reveal strong differences. The dynamics of real exchange rates in the CAEMC countries is characterised by the same two regimes as in the CFA zone: a first regime corresponding to undervalued exchange rates (misalignment below the threshold of 2%) and a second regime of overvalued exchange rates (misalignment above 2%). Nevertheless, for this area, the estimated error correction coefficients show that the adjustment is increasing slightly in the second regime (overvaluation). Thus, when the real exchange rate is above the threshold (overvalued), there is a convergence process towards the equilibrium level, while in case of undervaluation, the adjustment process, while being effective, seems to be slower. This result highlights the asymmetric property of real exchange rates' adjustment towards their equilibrium level and may reflect that the misalignment of the real exchange rate is not neutral on the degree of pass-trough from nominal exchange rate to inflation. For the WAEMU zone, the threshold is much lower (-13%). Moreover, the results show a stronger asymmetry for these countries as the correction term is much lower in the second regime (overvaluation regime) than in the first one (undervaluation regime). In other words, only real exchanges rates undervalued more than 13% converge towards their equilibrium level; otherwise, they do adjust but very slowly. The low threshold value can be explained by the fact that, in some countries of the WAEMU (Burkina Faso, Mali, Niger and Senegal) real exchange rates have not converged towards their equilibrium value but have recorded instead a stable and rather slight undervaluation, since the CFA Franc's devaluation of 1994 (Appendix, Figure A2). Finally, the adjustment parameter is lower in the WAEMU (-0.18) than in the CAEMC (-0.37) as in the linear case. Indeed, real exchange rates of the CAEMC countries converge to their equilibrium exchange rates in both regimes. On the contrary, in the WAEMU zone, real exchange rates, while converging more quickly than in the CAEMC countries in case of undervaluation, are strongly rigid when they are overvalued. Theoretically this feature of the WEAMU countries could be explained by the existence of hysteresis effects (in trade and/or in labour market, inter alia) induced by overvalued exchange rates which impede the adjustment path of fundamentals towards their equilibrium level. Moreover, as currencies are pegged, external imbalances must be corrected by internal adjustment which can be more difficult than a flexible exchange rate adjustment. In particular, the speed with which domestic prices can adjust downward in case of overvaluation (and the degree to which they do) may be a critical factor in the WAEMU zone. The discrepancies between the two zones can be observed from Figure A3 in Appendix in which the transition function is plotted against the value of the gap between misalignment and the threshold parameter. Clearly, results show that the slope parameter is higher in the CAEMC countries than in the WAEMU countries, suggesting that the former react more rapidly to an overvaluation and are also able to correct it more quickly. On the contrary the transition from the overvaluation regime to the undervaluation tends to be smoother in the CAEMC zone.

5. Conclusion

The real appreciation observed in currencies of the CFA zone over the last decade has reopened the discussion on the opportunity of a new devaluation of the CFA Franc. This issue has also come in a world context of currency tensions induced by the recent crisis. To investigate this issue, we have analysed and assessed currency's misalignments of 13 CFA zone countries and the convergence process of their real effective exchange rates to their equilibrium levels over the period 1980-2007. Equilibrium real exchange rates have been derived from a set of fundamentals which appear the most relevant for CFA countries, following the BEER approach. Using non stationary panel econometrics, our results show that the real appreciation of effective exchange rates in CFA zone countries from the 2000s did not translate, in 2007, into a real overvaluation comparable to that occurring before the devaluation of the CFA franc in 1994. However, some countries experience significant overvaluation, reflecting a high heterogeneity and the lack of a convergence process within the CFA Franc zone.

While the stable long-run relationship between real exchange rates and other macroeconomic variables may serve as a guideline for exchange rate policy, the short-run dynamics is also crucial to policy-makers in determining the timing and extent of a potential intervention. To this end, we have investigated more deeply the adjustment process of real effective exchange rates towards their equilibrium levels, by estimating an error correction model in panel data. We have first assumed a linear dynamic process of real exchange rates, and then we have applied a smooth transition model to the adjustment process. This last specification allows the dynamics of real exchange rate to be nonlinear, which is likely in the CFA countries given the evolution of misalignments. Indeed, our results highlight the existence of two distinct regimes, an undervaluation regime and an overvaluation regime, whatever the considered zone. However, there are marked differences in the convergence process of real exchange rates between country groups. In the CAECM countries, real effective exchange rates tend to converge to their equilibrium level more quickly when they are overvalued. On the contrary, real exchange rates of the WAEMU countries must record a higher undervaluation in order to ensure a return to macroeconomic equilibrium; otherwise they converge very slowly towards their equilibrium level. Accordingly, a nominal devaluation seems to be appropriate only for the WAEMU zone which seems more prone to persistent overvaluations.

Overall, our results highlight the strong heterogeneity between the countries of the CFA zone. They tend to show the difficulty to apply a single exchange rate policy in the considered zone and rather call for further coordination and policy harmonization between the countries.

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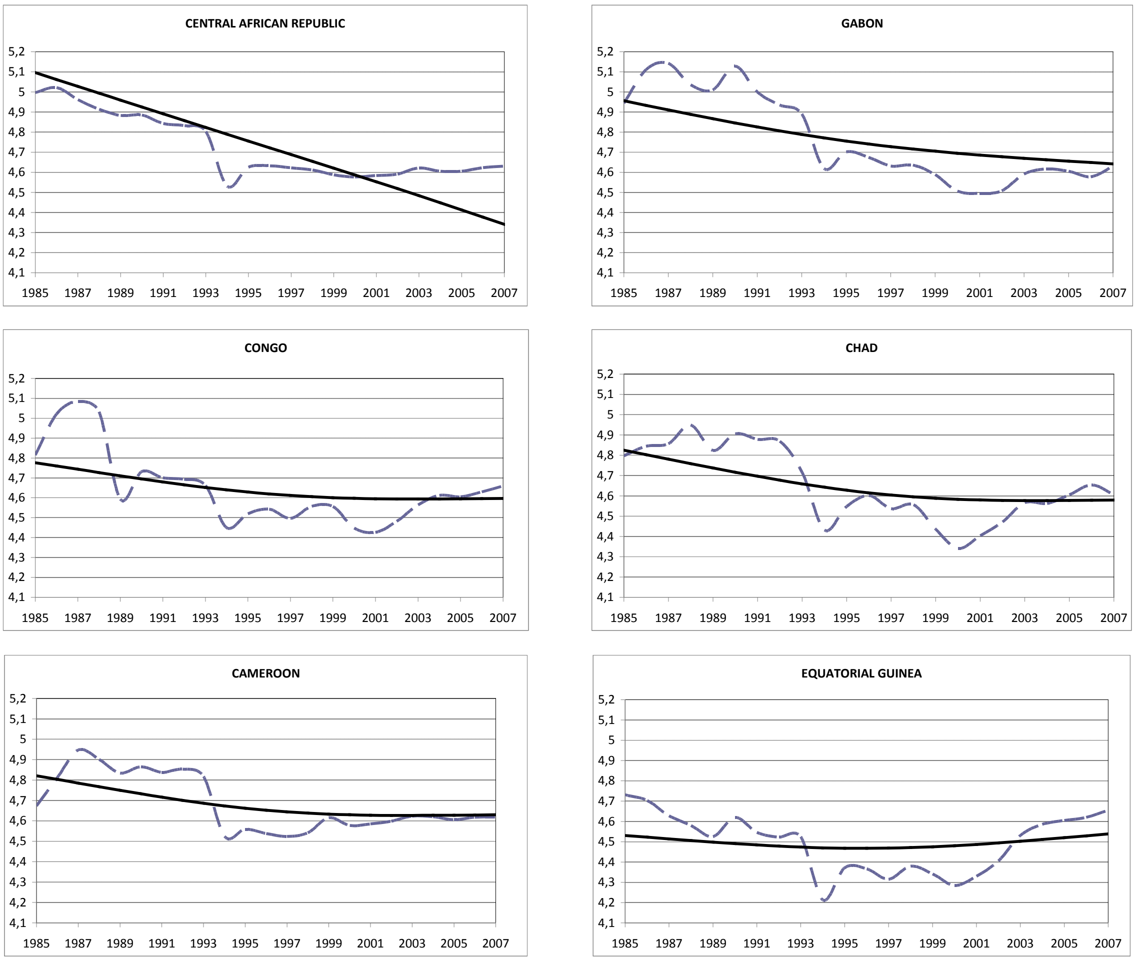
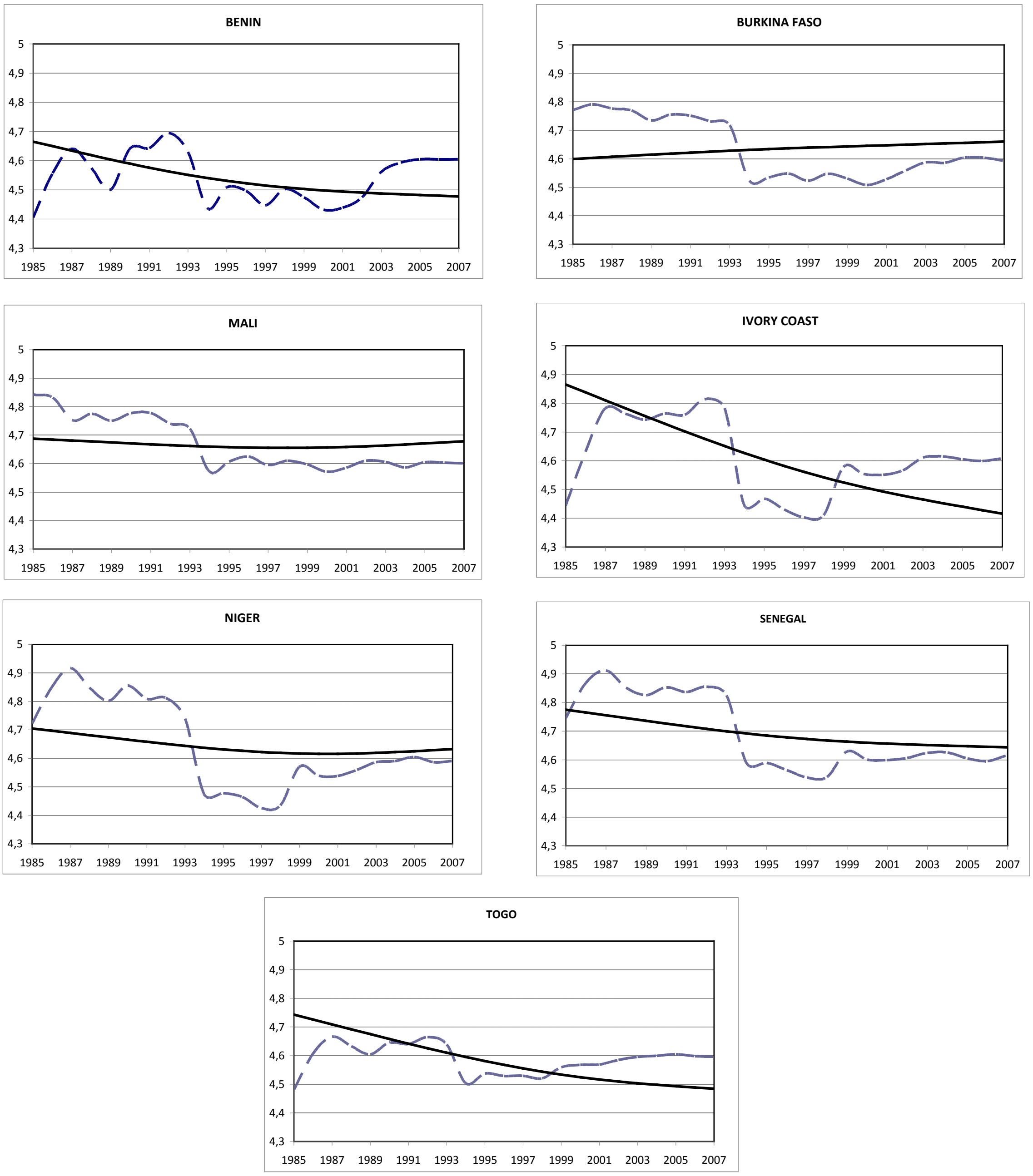
Appendix

Figure A1a. Real effective exchange rate (observed and equilibrium level), CAEMC countries



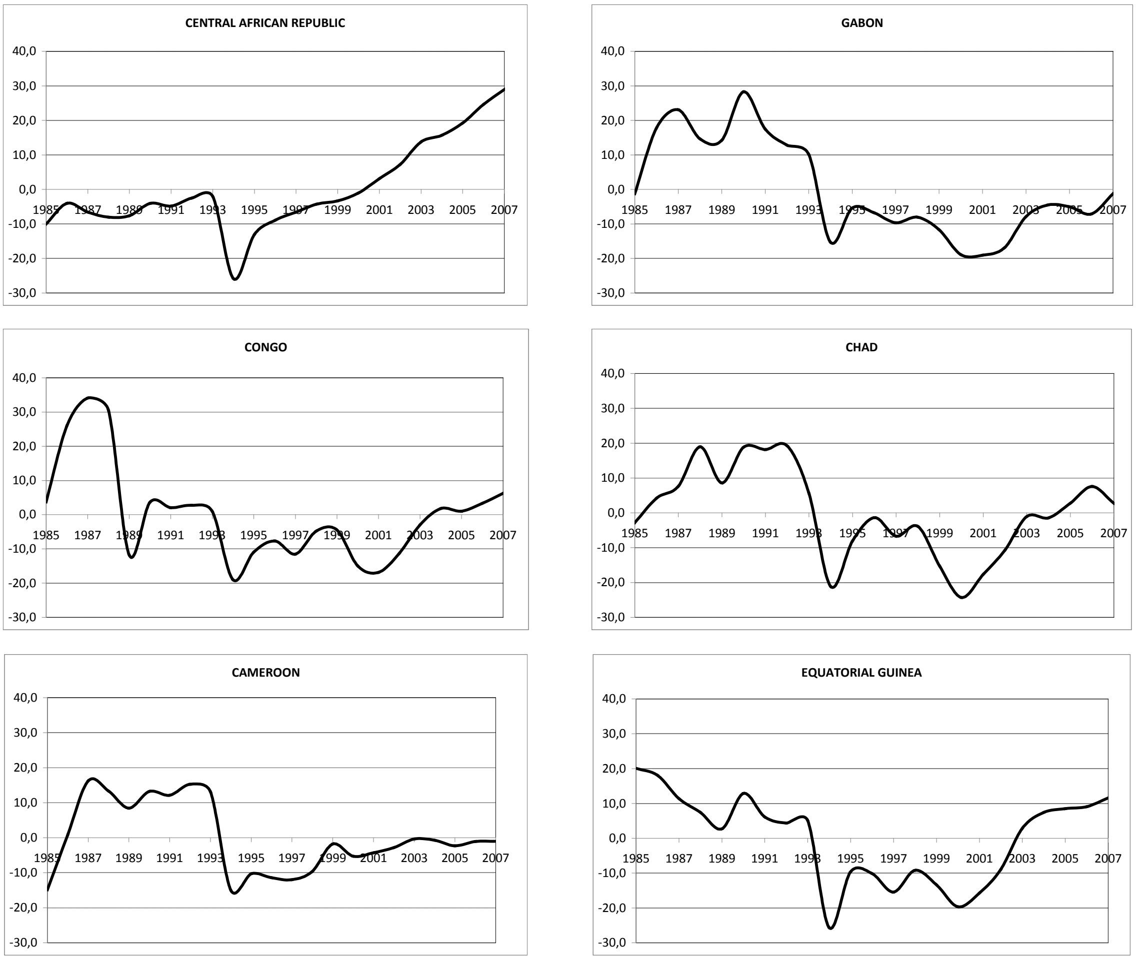
Note: An increase (resp. decrease) of the real effective exchange rate indicates an appreciation (resp. depreciation).

Figure A1b. Real effective exchange rate (observed and equilibrium level), WAEMU countries



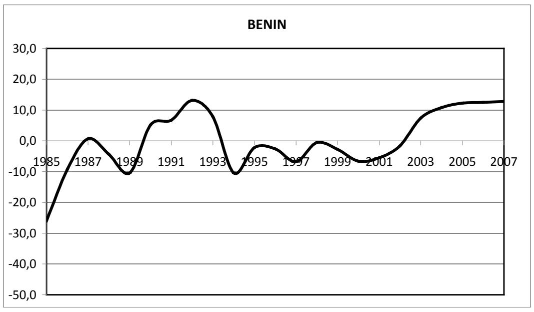
Note: An increase (resp. decrease) of the real effective exchange rate indicates an appreciation (resp. depreciation).

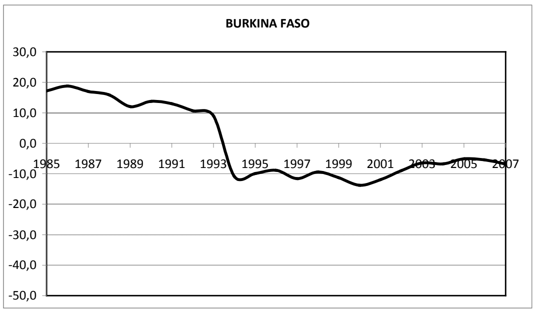
Figure A2a. Misalignments in CAEMC countries

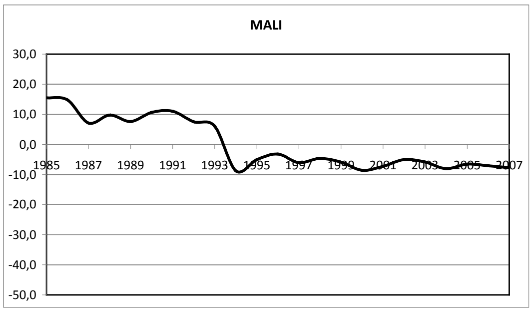


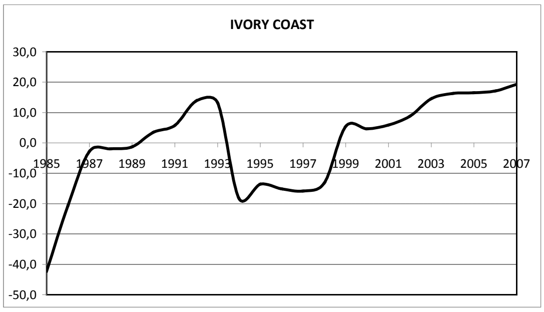
Note: A positive (resp. negative) value corresponds to an overvaluation (resp. undervaluation).

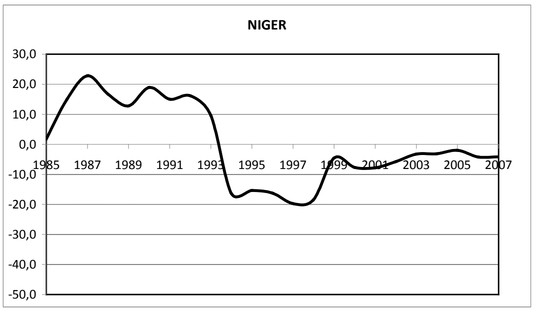
Figure A2b. Misalignments in WAEMU countries

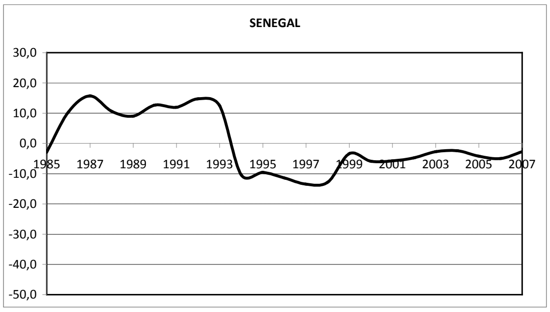


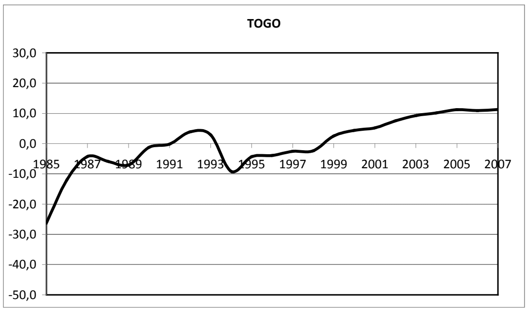












Note: A positive (resp. negative) value corresponds to an overvaluation (resp. undervaluation).

Figure A3. Transition functions

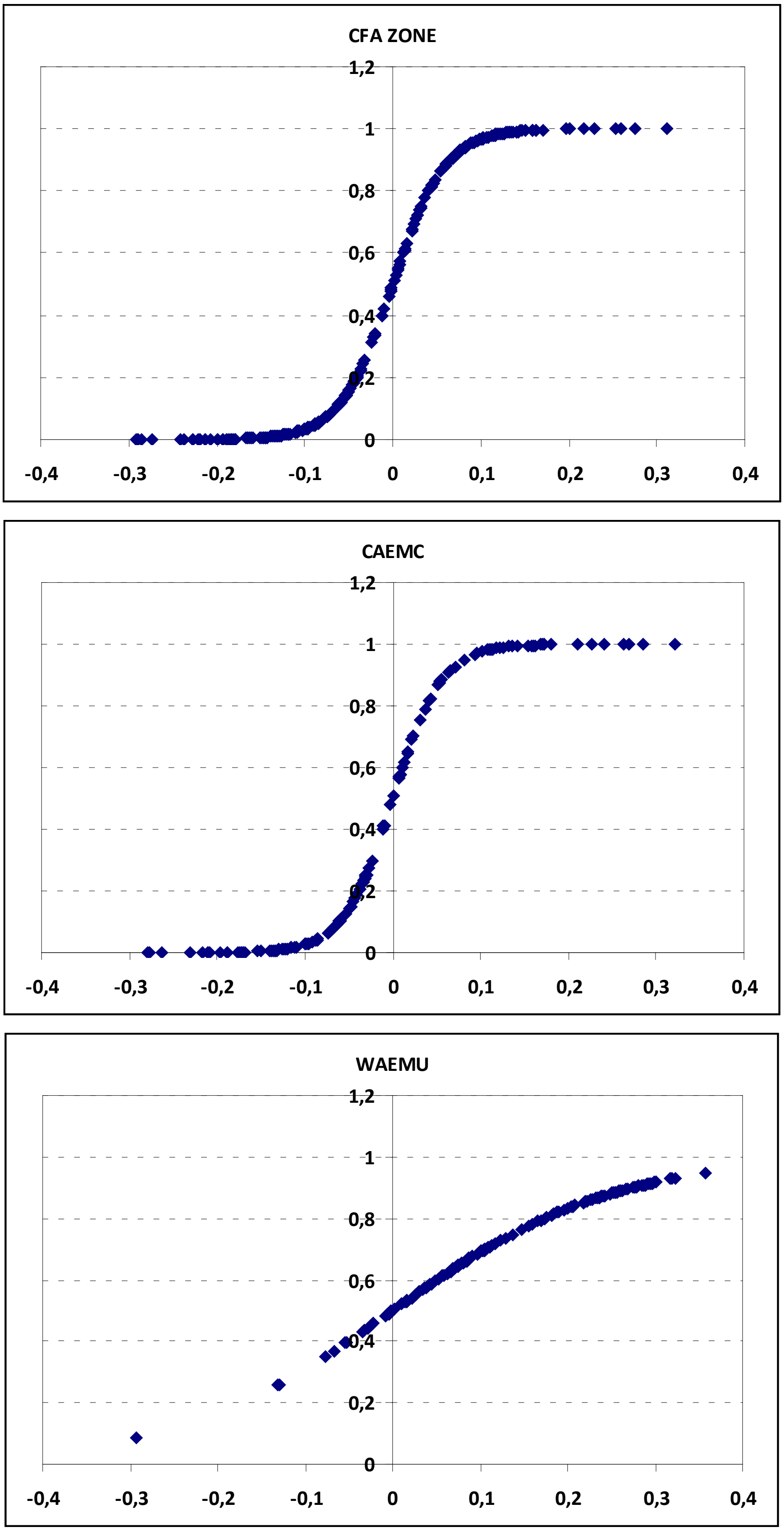


Table A. Main partners of CFA zone

BENIN		**BURKINA FASO**		**IVORY COAST**		**GUINEA BISSAU**		**MALI**	
Partners	weight	Partners	weight	Partners	weight	Partners	weight	Partners	weight
Chine	30.4	Ivory Coast	18.9	France	18.7	India	22.8	France	12.0
France	9.1	France	18.9	Nigeria	12.9	Portugal	11.7	Ivory Coast	10.2
United States	6.5	Chine	6.7	Netherlands	8.2	Senegal	11.4	Senegal	9.6
Thailand	5.5	Singapore	3.7	United States	6.4	Brazil	7.1	China	5.3
India	5.1	Togo	3.7	Germany	3.5	Nigeria	5.4	Germany	3.8
Malaysia	3.7	Belgium	3.6	Italy	3.3	Italy	4.4	Belgium	2.8
Netherlands	3.1	Italy	3.0	Spain	2.8	Thailand	3.6	South Africa	2.3
Ivory Coast	2.9	India	2.5	England	2.7	Uruguay	3.4	India	1.9
Belgium	2.9	Ghana	2.5	Chine	2.3	Chine	2.9	Italy	1.8
Ghana	2.4	Libya	2.5	Burkina Faso	2.0	Netherlands	2.7	United States	1.8

NIGER		**SENEGAL**		**TOGO**		***CAMEROON***	
Partners	weight	Partners	weight	Partners	weight	Partners	weight
France	21.5	France	19.5	France	12.5	France	16.2
Nigeria	12.2	Nigeria	7.3	China	7.9	Spain	10.5
United States	7.4	India	5.2	Ghana	7.4	Italy	10.4
China	6.9	Mali	4.6	Benin	5.1	Nigeria	6.0
Ivory Coast	5.1	Thailand	4.1	Netherlands	4.8	Netherlands	5.9
French Polynesia	4.1	Spain	4.0	Burkina Faso	4.7	China	5.8
Japan	3.0	Italy	4.0	Ivory Coast	3.9	United States	5.7
Belgium	2.8	Chine	3.8	Nigeria	3.5	Belgium	3.6
Netherlands	2.6	Ivory Coast	3.0	India	3.1	South Korea	3.0
Algeria	2.1	Germany	2.5	Belgium	3.1	England	2.9

CENTRAL AFRICAN REPUBLIC		***CONGO REPUBLIC***		***GABON***		***GUINEA EQUATORIALE***		***CHAD***	
Partners	weight	Partners	weight	Partners	weight	Partners	weight	Partners	weight
Belgium	20.4	United States	26.7	United States	31.0	United States	24.3	United States	62.1
France	13.9	China	22.9	France	19.9	China	16.9	France	7.5
Cameroon	5.4	France	9.1	China	9.3	Spain	15.5	China	6.3
United States	5.2	South Korea	4.7	Trinidad et Tobago	2.4	France	5.8	Cameroon	3.9
Netherlands	4.4	India	3.1	Spain	2.4	Japan	4.5	Germany	2.0
Spain	3.6	Italy	2.8	Italy	2.0	Italy	4.3	Portugal	1.8
China	2.8	North Korea	2.1	Japan	1.9	Canada	3.2	Japan	1.7
Italy	2.6	Germany	1.6	Netherlands	1.8	Portugal	3.0	Netherlands	1.2
South Korea	2.4	Netherlands	1.5	Germany	1.6	Netherlands	2.9	Belgium	1.1
Democratic Republic of Congo	2.2	Brazil	1.5	South Korea	1.4	South Korea	2.4	Saudi Arabia	1.1

Note: Weights (in %) correspond to the share of partner in the total trade of each CFA country. CAEMC countries in italics

Table B. Cross Section Dependance Tests

Statistics	TCER	TOT	PROD	NFA	OPEN	DEP	Critical Value at 5%	Critical Value at 1%
LM test	1006.34	129.09	111.42	400.30	281.83	110.74	99.62	109.96
CD test	31.04	3.24	6.08	17.05	14.71	0.11	1.96	2.58

Note: LM test is asymptotically distributed as chi-squared with ((13(13-1))/2) degrees of freedom and the Pesaran's CD test follows a Gaussian centered reduced. However the LM test is adapted only to the large time dimension ($T \to \infty$) and fixed number of country (N) when the Pesaran's test is suitable to a large individual dimension of panel ($N \to \infty$) and sufficient large time dimension.*

When the value of the statistics is lower than the critical values, we can reject the null hypotheses of cross section independence between countries.

Table C. The breaks dates for the REER by country and the optimal break point

Countries	1st date	2nd date	Number of Optimal Break*
Benin	1993	1987	1
Burkina Faso	1993	2001	2
Central African Republic	1993	1996	1
Cameroon	1993	1987	2
Chad	1993	1998	2
Congo	1988	1993	2
Equatorial Guinea	1993	2002	2
Gabon	1993	1987	1
Ivory Coast	1993	1987	2
Mali	1993	1989	1
Niger	1993	1987	2
Senegal	1993	1987	2
Togo	1993	1987	2

*Note: * We chose 2 maximum breaks points. The optimum break date is chosen by considering the modified Schwarz information criterion (LWZ) of Liu, Wu, and Zidek (1997) which performs better than the Bayesian information criterion BIC when individual trends are included in the specification according to Carrion and al. [2005].*

Table D. Tests for choosing m, the type of non linearity (with maximum m=3)

	CFA Zone	CAEMC	WAEMU
$H_0^* : \beta_0'^* = \ldots = \beta_m'^* = 0$	4.37 (0.0000)	3.56 (0.0001)	0.99 (0.4659)
$H_{03}^* : \beta_2'^* = 0$	4.64 (0.0005)	3.40 (0.0068)	0.22 (0.9515)
$H_{02}^* : \beta_2'^* = 0 \vert \beta_3'^* = 0$	2.89 (0.0147)	3.31 (0.0079)	0.60 (0.7005)
$H_{01}^* : \beta_1'^* = 0 \vert \beta_3'^* = \beta_2'^* = 0$	4.84 (0.0003)	2.95 (0.0153)	2.27 (0.0506)

Note: values in brackets are the associated probabilities (P-values).