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An Empirical Analysis of Long-Term Fundamentals of Real Exchange Rate in WAEMU

Nahoussé DIABATE[1]
[1]*Department of Economics and Development, Université Alassane Ouattara, Bouaké (Cote d'Ivoire), 01 Bp V 18 Bouaké 01*

Abstract: *The aim of our study was to highlight the long-term explanatory factors for the dynamism of the real effective exchange rate in the WAEMU. To get to the end, we used a standard neoclassical model of small open economy to which we made modifications. The Pooled-Mean Group (PMG) methodology for panel data was also used. Our annual data come from the World Bank, the IMF and the BCEAO. These data cover the period 1980-2017. It appears that the fundamentals of the real effective exchange rate in WAEMU are GDP per capita, the terms of trade, the trade balance and foreign direct investment. We recommend strengthening the industrial fabric of the WAEMU countries through the promotion of an incentive tax policy and the diversification of exports. These results negatively affect the maintenance of the fixed exchange rate regime in WAEMU.*
Key Word*: Pooled-Mean Group Methodology, Balassa-Samuelson model (BS), Real effective exchange rate, WAEMU*
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I. Introduction

The most widely used theoretical framework for interpreting real exchange rates is the Balassa-Samuelson (BS) model. However, empirical studies on the determinants of the real effective exchange rate (REER) present mixed, if not contradictory, results. It is therefore necessary to continue studies in this area (Comunale, 2019; Gantman and Dabós, 2018).

The first generation of New Keynesian models provided the dominant paradigm in international economics. It was developed by the fundamental contributions of Mundell (1963) and Fleming (1962), as well as Obstfeld and Rogoff (1995). According to the "new open macroeconomy", the volatility of the real exchange rate can be explained by non-monetary factors. These factors relate to productivity shocks, demand shocks and labor supply shocks. Despite the fact that a feedback mechanism between the real exchange rate and its determinants seems to exist, the evidence on the theoretical and empirical front remains inconclusive. This article therefore explores the role of economic fundamentals in explaining the long-term movements of the TCER in the WAEMU. To illustrate how a set of fundamentals influence the REER, we will consider a neoclassical model of small open economy as in Comunale (2019), when the supply and demand factors affect the REER. Thus, our theoretical and empirical model follows the "theory of the transfer problem". To this end, it is the main focus of the study which looks more at the role of net foreign assets, the trade balance and current accounts and therefore on how to rebalance them via the REER. Using data covering the period 1980-2017, this study mainly uses a homogeneous and cointegrated panel framework. In fact, according to Debrun et al., (2005), the terms of trade convergence is relatively stronger between the WAEMU countries. Furthermore, Houssa (2008) found strong homogeneity of supply shocks in the ECOWAS region, while the WAEMU countries are distinguished by a strong correlation of demand shocks. It should be noted that ECOWAS has fifteen (15) States, eight of which belong to the West African Economic and Monetary Union (UEMOA).

This article contributes to the literature according to several axes: First, it specifically considers the WAEMU as a homogeneous group of developing countries using data updated until 2017. Second, it uses the econometric technique Pooled Mean Group (PMG) to estimate the long-term elasticities of the panel in the context of the WAEMU. This second axis is explained by the fact that this approach includes homogeneous and cointegrated panel methods. Finally, we use the estimation results to get an idea of the relative importance of these different determinants in the explanation of the evolution of the REER.

The rest of the article is structured as follows. Section 2 presents the methodology used. Section 3 analyzes the data and discusses the empirical results. Section 4 concludes and provides some recommendations for economic policies.

II. Presentation Of The Methodology

We present the basic model of our study as well as the estimation method.

Basic model

To illustrate how a set of fundamentals influences the real effective exchange rate (REER), we begin by considering a standard neoclassical model of small open economy, as in Comunale (2019) based on Lane and Milesi-Ferretti (2004). In this model, the output of the market goods sector Y_T can be sold on world markets at a price P_T^x defined in units of imported product. This price can be considered as the terms of the exchange. Labor is supplied only to the non-profit sector. Our representative agent maximizes an objective function V_i subject to a budgetary constraint. The agent consumes market and non-market goods and can invest in a real international bond A (denominated in units of tradable goods) with an exogenous real return r. In this configuration, the price index Pt is given by the following equation (1):

$$P_t = \left[\gamma + (1-\gamma)P_{N,t}^{1-\theta}\right]^{\frac{1}{1-\theta}} \qquad (1)$$

where $P_{N,t}$ is the price of non-traded goods at time t and is equal to wages, γ the relative weight of the traded goods (M) in total consumption and θ the elasticity of constant substitution between traded and non-traded goods. The real exchange rate is defined as the ratio of the national consumer price index (CPI) to the foreign CPI. In the model, the foreign price level is assumed to be one. The actual exchange rate defined depends on the terms of trade. In this model of small open economy, we can calculate the first order conditions, then the equilibrium analysis gives the long-term relationship in reduced form between the REER and its fundamentals. The variation of the REER, in logarithm, is as follows:

$$\begin{aligned}\log(\mathrm{TCER}) = (1-\gamma)\log(\mathrm{P_N}) = (1-\gamma)\Omega + \tfrac{(1-\gamma)\lambda r}{\gamma}\tfrac{A}{Y_0} + (1-\gamma)\lambda\log(\mathrm{Y_T}) \\ +(1-\gamma)\lambda\log(\mathrm{P_T^x}) = \alpha + \beta_1 A/Y_0 + \beta_2\log(\mathrm{Y_T}) + \beta_3\log(\mathrm{P_T^x})\end{aligned} \qquad (2)$$

where Ω is a constant (called $\boldsymbol{\alpha}$ later in our specification) and the parameter $\lambda = (1+\sigma)/[(1-\gamma)\theta + (\gamma + \theta)\sigma$ with σ as elasticity of intertemporal substitution.

Then, $(1-\gamma)$ is the weight assigned to the consumption of non-traded goods in the utility function, P_N is the price of non-traded goods in terms of tradable, A can represent the stock of net external assets (AEN), Y_T is the tradable T, Y_0 is the total output and P_T^x represents the terms of trade. In the model, all the coefficients must be positive. As a result, the real exchange rate grows with net foreign assets (AEN) (the "transfer problem" variable in the model), tradable output and the terms of trade. From this specification, we derive the following model (3):

$$\log\left(TCER_{i,t}\right) = \alpha_i + \frac{\beta_{i,1}AEN_{i,t}}{Y_{i,t}} + \beta_{i,2}\log\left(M_{i,t}\right) + \beta_{i,3}\log\left(TE_{i,t}\right) + \epsilon_{i,t} \qquad (3)$$

with $Y_{i,t}$ representing gross domestic product, $M_{i,t}$ is considered a Balassa-Samuelson indicator and $TE_{i,t}$ represents the terms of trade. Indeed, the Balassa-Samuelson effect occurs when the relative prices of non-tradable goods or services increase, due to the increase in the productivity of marketers. The differences in productivity growth between the tradable and non-tradable sectors explain the observed differences in relative prices. The last two are log and taken relative to the main partners (see also Ricci et al., 2013). The model presented here is a standard neoclassical model of simple small open economy, mainly for clarity and conciseness. However, a two-country general equilibrium model is rather presented in Galstyan (2015) based on Obstfeld and Rogoff (1996). This is similar to the idea of Benigno and Thoenissen (2003), but the authors also examine the problem of transfers using the balance of trade.

The linear log approximation of the system around the reference index and the empirical configuration considered seems very comparable to our equation (3) where the TCER depends on the terms of trade, the variable of the transfer problem and the measures productivity in tradable and non-tradable sectors.

In what follows, we explain in more detail the role of each of the transfer variables and of the Balassa-Samuelson proxy.

The "transfer problem" theory states that when net foreign assets are non-zero, adjustments to the long-term real exchange rate would be necessary to rebalance the net foreign assets. A creditor country should experience a real appreciation (a loss of competitiveness) due to the increase in the consumption of non-tradable goods under a fixed regime (Galstyan, 2015). The expected sign for the net foreign assets is positive. This leads to a deficit in the trade balance in the trade sector. The trade balance is considered as a cumulative flow variable in the period when the net foreign asset is non-zero. The sign of the coefficient on the trade balance should then be negative as in Comunale (2019).

For the Balassa-Samuelson effect, as indicated in Lane and Milesi-Ferretti (2004), GDP per capita can in any case be used as an indirect indicator of the relative levels of market production in the absence of data on sectoral financing. It is important to remember that this proxy represents not only productivity (Galstyan and Lane, 2009 and Comunale, 2019), but also a substitute for the effect linked to demand and also to educational and demographic factors (Egert and Lahreché- Revil, 2003). In our analysis, we also provide other proxy variables for the Balassa-Samuelson effect, based on the relative productivity in tradable and non-tradable, as in Galstyan (2015) and Comunale (2019). Finally, we examine the truly exogenous variables of the Balassa-Samuelson theory: total factor productivity (PTF), following Benigno and Thoenissen (2003), de Berka et al. (2018) and Comunale (2019).

For our analysis, we calculate the coefficients relating to the determinants of the REER. First, on the basis of the log-linearized model of Comunale (2019) based on Lane and Milesi-Ferretti (2004), we structure our basic model for determining the fundamentals of the TCER, as in equation (4):

$$tcer_{i,t} = \mu_i + \beta_i^{'} X_{i,t} + \varepsilon_{i,t} = f(bc_{i,t}, ide_{i,t}, pibh_{i,t}, te_{i,t}) \qquad (4)$$

In addition to the trade balance (bc), terms of trade (te) and per capita GDP ($pibh$), as in the Comunale (2019) model, we have included foreign direct investment (ide). Indeed, Edwards (1989) suggests that the inclusion of foreign direct investment in the theory of determination of the REER results from supply effects, supply which depends on the relative intensity of the different factors. Thus, the expected sign is a priori ambiguous. However, for a developing country whose investments make it possible to import goods, we can obviously witness a depreciation of the REER and therefore the expected sign may be negative.

Estimation method

The Pooled-Mean Group (PMG) methodology will help us in the estimation of our model. For this, we will do the stationarity tests as well as the cointegration test. Concerning unit root tests, we will use the tests of Breitung (2000) and Im et al. (2003) (IPS). It should be noted that Breitung's (2000) test takes into account the uniformity of an autoregressive unit root. In the alternative hypothesis, the autoregressive coefficient remains unchangeable for all individuals. This test brings us to two probable solutions, one of which would be the acceptance of the assumption of a unit root for all series and the other, the rejection of the assumption of a unit root for all series. This is one of the main shortcomings of this test. Indeed, the probability of taking into account an autoregressive root common to all the individuals in the panel is minimal when we reject the unit root. The test by Im et al. (2003) is timely to correct its weaknesses. It should be noted that this test explains the heterogeneity (Hurlin and Mignon, 2007). As for the cointegration test, numerous tests have been set up, in this case the tests for absence of cointegration on panel data proposed by Pedroni (1995, 1997, 1999, 2004), Kao (1999) and Bai and Ng (2001). These tests are residual tests similar to the tests proposed by Engle and Granger (1987) in the context of time series. Pedroni (1995, 1997) for his part, proposed various cointegration tests in two stages. The objective of these tests is to better grasp the null hypothesis of the absence of intra-individual cointegration for both homogeneous and heterogeneous panels in the presence of a single explanatory variable in cointegration relationships. Pedroni (1999, 2004) exposes within it an extension to the case where cointegration relationships include more than two variables. For this, he sets up a number of tests which are precisely seven (7). The latter are based on the estimation of the residual of the long-term model. His tests assess heterogeneity through parameters that may differ between individuals. Thus, under the alternative hypothesis, there exists a cointegration relation for each individual. Furthermore, the parameters of this cointegration relationship are not necessarily the same for each of the individuals in the panel (Hurlin and Mignon, 2007). At this stage, there are two estimation methods: the Group Mean Panel Fully Modified OLS method (GM-FMOLS) and the Pooled-Mean Group method (PMG). The GM-FMOLS methodology corresponds to the Engel-Granger approach. For the latter, the estimation by country can be made by OLS when there is a cointegration relationship between the dependent variable and its fundamentals. For non-stationary panels, however, Pedroni (2000) demonstrates that OLS estimators are asymptotically biased. Despite these flaws, it would be wise to note that this method has advantages which reside in solving problems of endogeneity, different forms of omitted variables and measurement of errors. This technique also allows taking into account the heterogeneity of long-term parameters between countries, in which case the estimated parameters are interpreted as the mean values of the cointegration vector. The use of the GM-FMOLS approach then makes it possible to formally test the existence of a cointegration relationship.

Based on the PMG estimate implemented by Pesaran, Shin and Smith (1999), we can deduce that this constrains the long-term coefficients to be identical to that of the error correction model. However, the long-term coefficients may differ from the variances of the errors. This estimator is constructed under the assumption of heterogeneity of the short-term coefficients and homogeneity of the long-term slope coefficients (Pesaran et

al. 1999). The initial conditions are treated as fixed or random and the long-term coefficients are a non-linear combination of the short-term coefficients.
The basis of the Pooled-Mean Group calls for the estimation of the ARDL (autoregressive distributed lag) model of order (p_i, q_i).

$$\Delta y_{it} = \emptyset_i y_{it-1} + \beta_i x_{it} + \sum_{j=1}^{p_i-1} \omega_{ij} \Delta y_{it-j} + \sum_{j=0}^{q_i-1} \delta_{ij} \Delta x_{it-j} + \alpha_i + \varepsilon_{it} \qquad (5)$$

where y_{it} is the dependent variable, x_{it} the vector of the explanatory variables, α_i is the coefficient which captures the country specificity, ω_{ij} and δ_{ij} represent the coefficients of the short term dynamics relative to each country and ε_{it} is the error term of the model.

The long-term coefficients are assumed to be identical for all countries. Thus, if $\emptyset_i$ is significantly negative, we can then conclude that there is a long-term relationship between the independent variable and the explanatory variables.

The PMG approach is essentially a version of the panel procedure of the ARDL model. It consists of estimating the ARDL model by maximum likelihood, which can be rewritten as an error correction model (ECM). The estimation of this model simultaneously evokes the intra and inter dimensions. Pesaran, Shin and Smith (1999) have not proposed a formal cointegration test. However, they derived asymptotic properties for both the estimation of the stationary and non-stationary series regressors.

Unlike the GM-FMOLS estimator which is a modified OLS estimator, the Pooled Mean Group (PMG) estimator is a maximum likelihood estimator. In principle, the GM-FMOLS estimator should require few assumptions and should tend to be more robust (Fernandez, Osbat & Schnatz, 2004). In particular, Pedroni (2000) finds that GM-FMOLS estimators often have powerful properties for small panels whose sample size (T) is greater than the number of individuals (N). Pedroni also notes that when the cointegration vector is homogeneous, the performance of the estimation by MG-FMOLS is better than that of the Intra estimator for small samples. However, if the long-term cointegration vector is homogeneous across the different individuals, the estimation by PMG is relatively efficient compared to that of GM-FMOLS.

III. Data and presentation of results

After presenting a detailed analysis of the data from our study, we present the results of the statistical tests as well as those of the empirical estimate of the real effective exchange rate.

Data analysis

In this article, we use the annual data covering the period 1980-2017. It should be noted that these data come from the World Bank database (WDI, 2019), International Financial Statistics (IFC) from the International Monetary Fund (IMF) and annual reports from the Central Bank of African States West (BCEAO). We use the UEMOA zone, namely Benin, Burkina Faso, Ivory Coast, Mali, Niger, Senegal and Togo. As the data relating to Guinea Bissau was not available for the entire period of our study, we decided to subtract this country from our sample. The relative data on the TCER that we use comes from the WDI database. Indeed, many other methods of measuring the TCER are used (Sarantis, 2012; Desruelle, 1997), but like Yu and Niu, 2019, we find that these methods do not differ much from those of the TCER in the WDI database. . Table 1 shows the description of the variables used in the model.

Table no 1: Description of the variables

Variables	Symbol	Measures	Expected sign
Real effective exchange rate (2010 = 100)	tcer	Real effective exchange rate calculated from nominal effective exchange rates (NEER) adjusted for inflation differentials with trading partners. NEERs are calculated as geometric weighted averages of the bilateral exchange rates of the major trading partners.	
Foreign direct investment	ide	Total level of net inward foreign direct investment	+/-
Trade balance	bc	Exports – imports	-
Terms of trade	te	Ratio between the price index of exports and that of imports, expressed according to the base year 2000	+
GDP per capita	pibh	GDP divided by the number of inhabitants of a country	+

Source: Author from economic literature
Table 2 presents the descriptive statistics of the variables used.

Table no 2: Descriptive statistics

Variable	Observations	Mean	Std, Dev	Min	Max
TCER	266	108,9678	19,11433	76,92107	155,8739
IDE	266	1,45e+08	2,03e+08	-3,67e+08	1,01e+09
BC	266	-4,90e+08	0,35e+09	-8,17e+09	3,92e+09
TE	266	127,0283	38,76404	21	260
PIBH	266	751,2555	391,9569	311,8916	2059,278

Source: Author's calculations based on data from WDI (2019), SFI and BCEAO

The observations are the same for all variables. The minimum and maximum values suggest the existence of possible outliers. We can also note that the standard deviations are very important justifying a logarithmic transformation of the model. Thereafter, we will analyze the correlation between the variables of our model because some variables can be explained between them. According to Gujarati (1995), the strong correlation between the variables could be an annoyance for the meaning of these variables. They must be deleted from the chosen model.

The correlation matrix gives a first idea of the direction of the relationships between the variables studied. Table 3 highlights the correlation of the variables used in our model.

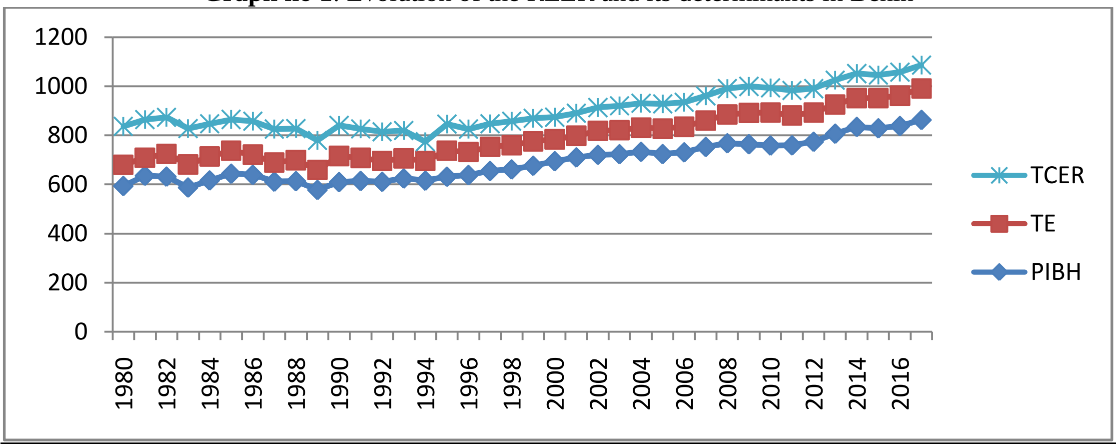
Table no 3: Variables correlation matrix

	tcer	ide	bc	te	Pibh
tcer	1,0000				
ide	-0,3850	1,0000			
bc	0,0202	-0,0381	1,0000		
te	0,1680	0,1737	0,0504	1,0000	
pibh	-0,1221	0,3325	0,1387	0,2834	1,0000

Source: Author's calculations based on data from WDI (2019), SFI and BCEAO

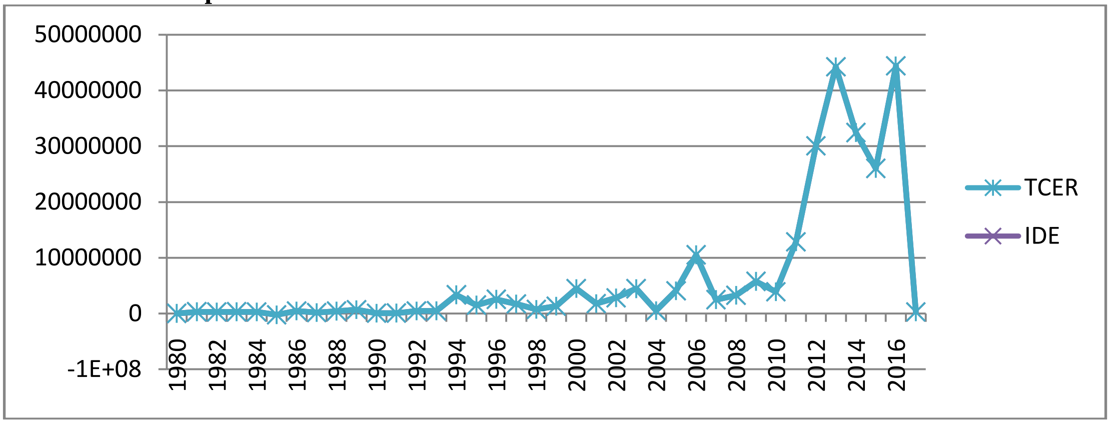
Graphs 1 to 7 below show the evolution of the determinants of the real effective exchange rate in WAEMU. Analysis of the graphs reveals the existence of a relationship between the real effective exchange rate and its determinants in WAEMU. Thus, an empirical study should make it possible to confirm whether this probable relationship is significant in the long term.

Graph no 1: Evolution of the REER and its determinants in Benin



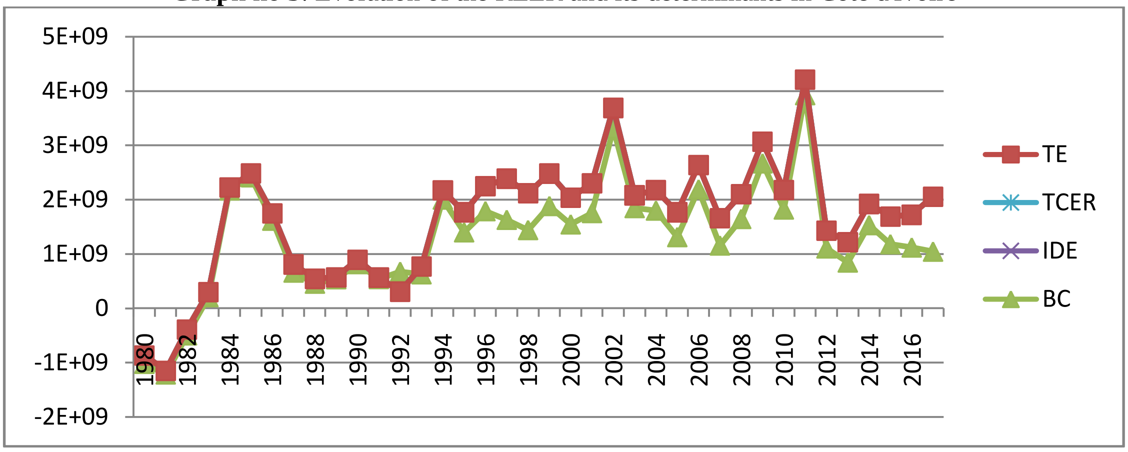
Source: Author using data from WDI (2019), SFI and BCEAO

Graph no 2: Evolution of the REER and its determinants in Burkina Faso



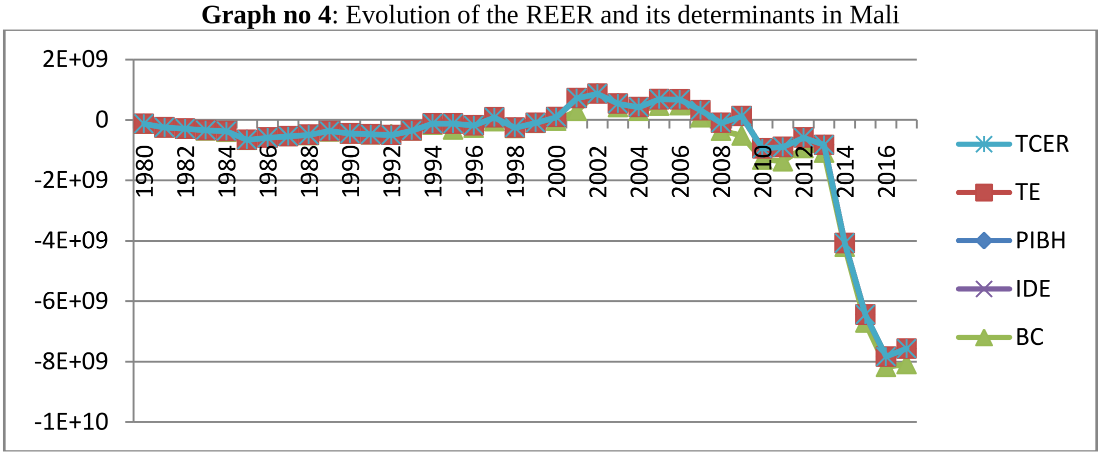
Source: Author using data from WDI (2019), SFI and BCEAO

Graph no 3: Evolution of the REER and its determinants in Côte d'Ivoire



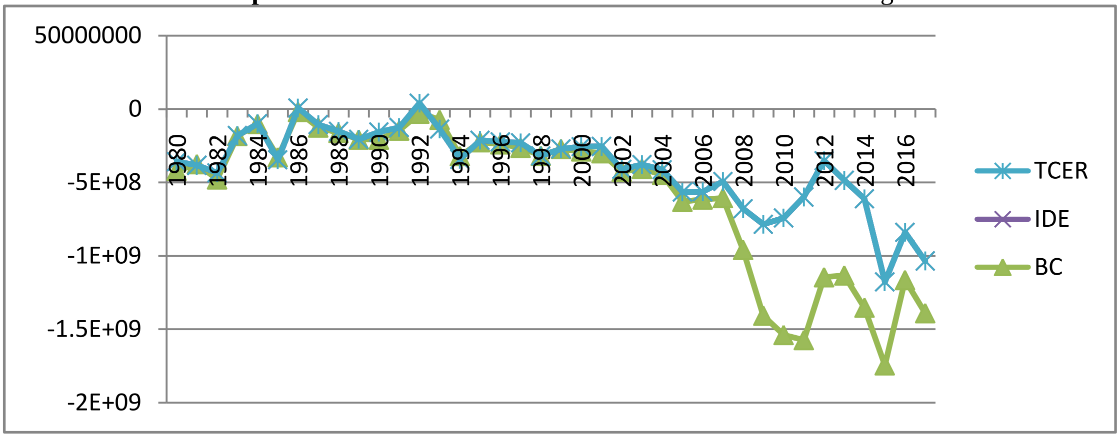
Source: Author using data from WDI (2019), SFI and BCEAO

Graph no 4: Evolution of the REER and its determinants in Mali



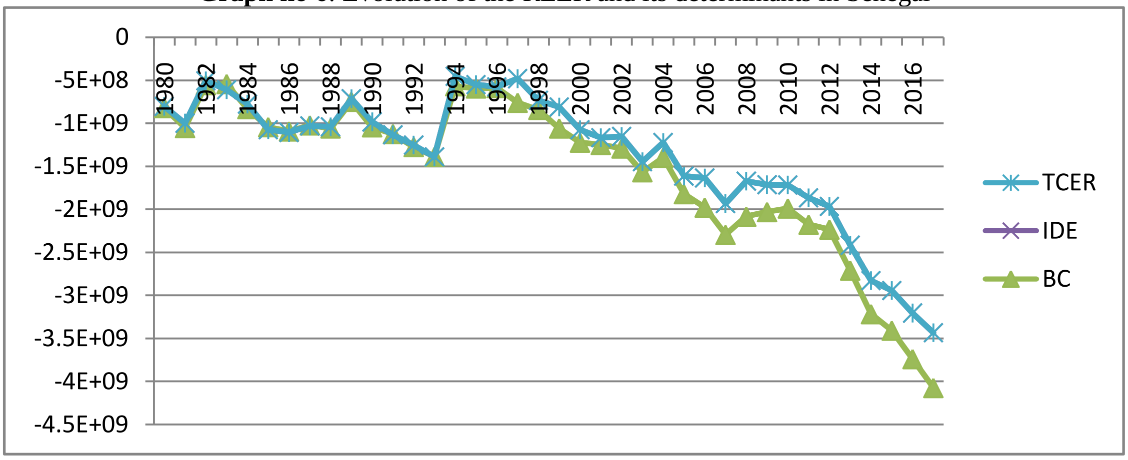
Source: Author using data from WDI (2019), SFI and BCEAO

Graph no 5: Evolution of the REER and its determinants in Niger



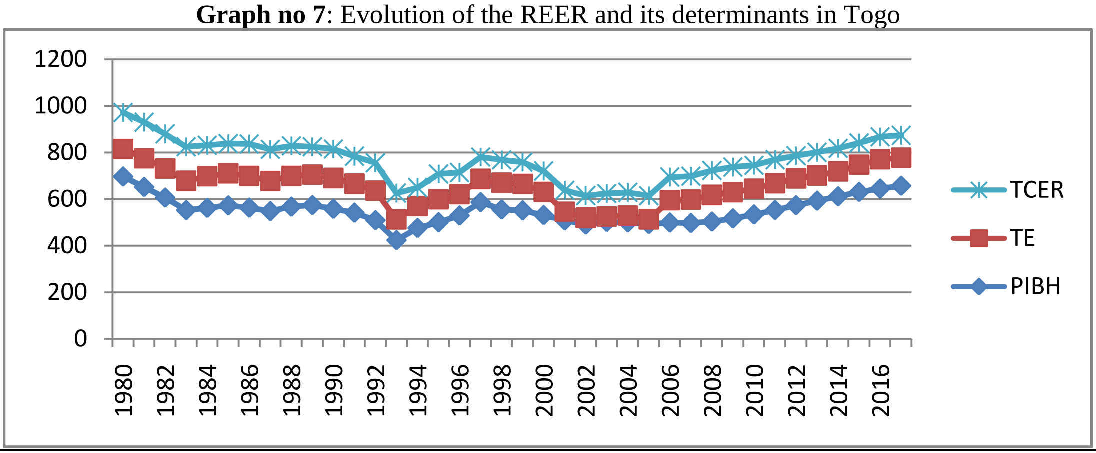
Source: Author using data from WDI (2019), SFI and BCEAO

Graph no 6: Evolution of the REER and its determinants in Senegal



Source: Author using data from WDI (2019), SFI and BCEAO

Graph no 7: Evolution of the REER and its determinants in Togo



Source: Author using data from WDI (2019), SFI and BCEAO

Statistical test results

The IPS and Breitung tests were carried out simultaneously to demonstrate the robustness of the conclusions. IPS tests will be decisive because, in the presence and absence of serial correlation, the IPS statistic is more powerful with a well specified number of delays (Hurlin and Mignon, 2007).

Table no 4: Results of stationarity tests

	Betruing		IPS		Decision
	Statistical value	**p-value**	**Statistical value**	**p-value**	
tcre	-2,4056	0,000	-2,7853	0,000	Stationary
Dide	-10,2398	0,000	-10,1128	0,000	Stationary
Dbc	-10,1027	0,000	-9,2419	0,000	Stationary
Dte	-7,2141	0,000	-8,9908	0,000	Stationary
Dpibh	- 6,9084	0,000	-8,1122	0,000	Stationary

Source: Author's calculations based on data from WDI (2019), SFI and BCEAO

On the five variables, the null hypothesis of the presence of unit root was retained except for the real effective exchange rate (tcer) which is stationary at level. We can then suspect a cointegration relationship between the different variables.

Given the size of our sample, among the different cointegration tests for panel data, it is that of Kao (1999) that is chosen. Let us recall that the Kao (1999) test starts from the null hypothesis of absence of cointegration. With a test statistic of – 4,53 and associated probability of 0.00, we reject the null hypothesis of no cointegration. There is therefore a cointegration relationship between the effective real exchange rate and its fundamentals including foreign direct investment, the terms of trade and the trade balance and GDP per capita.

Table no 5: Result of the cointegration test

Test	**Test statistic**	**P-value**	**Conclusion**
Cointegration test	-4,53	0,00	Existence of cointegration

Source: Author's calculations based on data from WDI (2019), SFI and BCEAO

We can therefore present and analyze the results of estimation of long-term fundamentals of real effective exchange rate in WAEMU.

Determination of long-term fundamentals of real effective exchange rate in WAEMU

To estimate the relationship between the real effective exchange rate and its fundamentals, we used a panel error correction model technique, using the Pooled Mean Group method developed by Pesaran, Shin and Smith (1999). The estimation results are presented in two phases, namely the long-term and short-term determinants of the real effective exchange rate in WAEMU. However, in the case of our study, we expose the results of the long-term estimation. The results of the estimation of the ARDL model by the Pooled Mean Group technique are presented as follows in Table 6 below.

Table n 6: Results of estimation of long-term fundamentals of TCER in WAEMU

tcer	**Coef.**	**T**	**P>|t|**	**[95% Conf.**	**Interval]**
pibh	0,37	6,00	0,000	0,0281356	1,3505817
ide	0,01	5,09	0,000	-0,220253	0,2422138
bc	-3,87	-3,31	0,001	-6,199315	-1,555073
te	0,79	3,79	0,000	0,0709228	0,1813515

Source: Author's calculations based on data from WDI (2019), SFI and BCEAO

The results of the estimate show that the fundamentals of the real effective exchange rate in WAEMU are GDP per capita, terms of trade, trade balance and foreign direct investment.

Gross domestic product per capita (pibh) positively and significantly influences the real effective exchange rate in WAEMU. This is because a 1% increase in gross domestic product per capita results in an appreciation of the real effective exchange rate of 0,37%. This result agrees with that of Comunale (2019), which highlights the positive effect of gross domestic product on the real effective exchange rate in the European Union.

With regard to the trade balance (bc), an increase of 1% reduces the real effective exchange rate by 3,87% in WAEMU. This negative effect shows that the percentage of imports devoted to capital goods is low. However, it is the latter which constitute the pillar of the industry which is the foundation of the increase in exports. Indeed, as our data indicates, the trade balances of the WAEMU economies, with the exception of Côte d'Ivoire, are structurally in deficit. And this structural feature of WAEMU causes the real effective exchange rate to depreciate over the long term. Moreover, this result is in line with that of Comunale (2019) obtained in the case of the European Union.

In addition, our empirical analysis shows that the terms of trade (te) significantly appreciate the real effective exchange rate in WAEMU. That is, a 1% increase in the terms of trade (te) results in a 0,79% increase in the real effective exchange rate in WAEMU. This result is purely theoretical considering the fact that a rise in the prices of exported goods, all other things being equal, increases the demand for the national currency. We are therefore witnessing a valuation of the exchange rate.

Furthermore, we obtain a positive effect of foreign direct investment (IDE) on the real effective exchange rate in WAEMU. This is justified by the fact that a 1% increase in foreign direct investment leads to a 0,01% appreciation of the real effective exchange rate. This result has theory as proof, since foreign direct investment makes it possible to acquire capital goods. These, in turn, will help increase production capacity for export in the long run.

IV. Conclusion And Recommendations

At the end of our study, we can retain that the field of both theoretical and empirical literature on the relationship between the real effective exchange rate and its fundamentals is vast. Indeed, despite the different methodological approaches used, the general observation is that there is a significant relationship between the real exchange rate and its fundamentals.

The purpose of this study was to identify the significant fundamentals of the dynamism of the real effective exchange rate in the WAEMU. This is how our results have shown that the real effective exchange rate is influenced by the evolution of its fundamentals. It is therefore imperative for the WAEMU economies to strengthen their industrial fabric. Since this strengthening will allow these economies to benefit from trade liberalization. This has a positive impact on the trade balance of these countries. However, to achieve this result, WAEMU countries will have to promote an incentive tax policy. This will generate an improvement in their productivity. However, the success of this measure requires the implementation of a policy of export diversification. The immediate effect of these measures will be to improve the terms of trade for these economies. These results undermine the thesis that less advanced economies should adopt fixed exchange rate regimes in the sense that it is difficult for them to properly manage alternative exchange systems.

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Annex

A1: Betruing and IPS stationarity test results

. xtunitroot breitung pibh		
Breitung unit-root test for pibh		
Ho: Panels contain unit roots	Number of panels	= 7
Ha: Panels are stationary	Number of periods	= 38
AR parameter: Common	Asymptotics: T,N	-> Infinity
Panel means: Included		Sequentially
Time trend: Not included	Prewhitening: Not	Performed
Statistic	p-value	
lambda 3.5424	0.9998	
. xtunitroot breitung te		
Breitung unit-root test for te		
Ho: Panels contain unit roots	Number of panels	= 7
Ha: Panels are stationary	Number of periods	= 38
AR parameter: Common	Asymptotics: T,N	-> Infinity
Panel means: Included		Sequentially
Time trend: Not included	Prewhitening: Not	Performed
Statistic	p-value	
lambda -1.0128	0.1556	
. xtunitroot breitung bc		
Breitung unit-root test for bc		
Ho: Panels contain unit roots	Number of panels	= 7
Ha: Panels are stationary	Number of periods	= 38
AR parameter: Common	Asymptotics: T,N	-> Infinity
Panel means: Included		Sequentially
Time trend: Not included	Prewhitening: Not	Performed
Statistic	p-value	
lambda 0.8055	0.7897	
. xtunitroot breitung tcer		
Breitung unit-root test for tcer		
Ho: Panels contain unit roots	Number of panels	= 7
Ha: Panels are stationary	Number of periods	= 38
AR parameter: Common	Asymptotics: T,N	-> Infinity

Panel means: Included		Sequentially
Time trend: Not included	Prewhitening: Not	Performed
Statistic	p-value	
lambda -2.4056	0.0081	
. xtunitroot breitung ide		
Breitung unit-root test for ide		
Ho: Panels contain unit roots	Number of panels	= 7
Ha: Panels are stationary	Number of periods	= 38
AR parameter: Common	Asymptotics: T, N	-> Infinity
Panel means: Included		Sequentially
Time trend: Not included	Prewhitening: Not	Performed
Statistic	p-value	
lambda 0.1383	0.5550	
. gen dpibh=d.pibh		
(7 missing values generated)		
. gen dte=d.te		
(7 missing values generated)		
. gen dide=d.ide		
(7 missing values generated)		
. gen dbc=d.bc		
(7 missing values generated)		
. xtunitroot breitung dbc		
Breitung unit-root test for dbc		
Ho: Panels contain unit roots	Number of panels	= 7
Ha: Panels are stationary	Number of periods	= 37
AR parameter: Common	Asymptotics: T,N	-> Infinity
Panel means: Included		Sequentially
Time trend: Not included	Prewhitening: Not	Performed
Statistic	p-value	
lambda -10.1027	0.0000	
. xtunitroot breitung dide		
Breitung unit-root test for dide		
Ho: Panels contain unit roots	Number of panels	= 7
Ha: Panels are stationary	Number of periods	= 37
AR parameter: Common	Asymptotics: T,N	-> Infinity
Panel means: Included		Sequentially
Time trend: Not included	Prewhitening: Not	Performed

Statistic	p-value
lambda -10.2398	0.0000

. xtunitroot breitung dte

Breitung unit-root test for dte

Ho: Panels contain unit roots	Number of panels	= 7
Ha: Panels are stationary	Number of periods	= 37
AR parameter: Common	Asymptotics: T,N	-> Infinity
Panel means: Included		Sequentially
Time trend: Not included	Prewhitening: Not	Performed

Statistic	p-value
lambda -7.2141	0.0000

. xtunitroot breitung dpibh

Breitung unit-root test for dpibh

Ho: Panels contain unit roots	Number of panels	= 7
Ha: Panels are stationary	Number of periods	= 37
AR parameter: Common	Asymptotics: T,N	-> Infinity
Panel means: Included		Sequentially
Time trend: Not included	Prewhitening: Not	Performed

Statistic	p-value
lambda -6.9084	0.0000

. xtunitroot ips tcer

Im-Pesaran-Shin unit-root test for	Tcer
Ho: All panels contain unit roots	Number of panels = 7
Ha: Some panels are stationary	Number of periods = 38
AR parameter: Panel-specific	Asymptotics: T,N -> Infinity
Panel means: Included	Sequentially
Time trend: Not included	
ADF regressions: No lags included	
	Fixed-N exact critical values
Statistic	p-value 1% 5% 10%
t-bar -2.4544	-2.290 -2.070 -1.950
t-tilde-bar -2.2976	
Z-t-tilde-bar -2.7853	0.0027

. xtunitroot ips ide

Im-Pesaran-Shin unit-root test for	Ide
Ho: All panels contain unit roots	Number of panels = 7

Ha: Some panels are stationary	Number of periods = 38
AR parameter: Panel-specific	Asymptotics: T,N -> Infinity
Panel means: Included	sequentially
Time trend: Not included	
ADF regressions: No lags included	
	Fixed-N exact critical values
Statistic	p-value 1% 5% 10%
t-bar -2.0295	-2.290 -2.070 -1.950
t-tilde-bar -1.8178	
Z-t-tilde-bar -1.1932	0.1164
. xtunitroot ips bc	
Im-Pesaran-Shin unit-root test for	Bc
Ho: All panels contain unit roots	Number of panels = 7
Ha: Some panels are stationary	Number of periods = 38
AR parameter: Panel-specific	Asymptotics: T,N -> Infinity
Panel means: Included	sequentially
Time trend: Not included	
ADF regressions: No lags included	
	Fixed-N exact critical values
Statistic	p-value 1% 5% 10%
t-bar -0.6867	-2.290 -2.070 -1.950
t-tilde-bar -0.6195	
Z-t-tilde-bar 2.7828	0.9973
. xtunitroot ips te	
Im-Pesaran-Shin unit-root test for	Te
Ho: All panels contain unit roots	Number of panels = 7
Ha: Some panels are stationary	Number of periods = 38
AR parameter: Panel-specific	Asymptotics: T,N -> Infinity
Panel means: Included	sequentially
Time trend: Not included	
ADF regressions: No lags included	
	Fixed-N exact critical values
Statistic	p-value 1% 5% 10%
t-bar -1.4822	-2.290 -2.070 -1.950
t-tilde-bar -1.4493	
Z-t-tilde-bar 0.0294	0.5117
. xtunitroot ips pibh	

Im-Pesaran-Shin unit-root test for	Pibh
Ho: All panels contain unit roots	Number of panels = 7
Ha: Some panels are stationary	Number of periods = 38
AR parameter: Panel-specific	Asymptotics: T,N -> Infinity
Panel means: Included	sequentially
Time trend: Not included	
ADF regressions: No lags included	
	Fixed-N exact critical values
Statistic	p-value 1% 5% 10%
t-bar -0.6544	-2.290 -2.070 -1.950
t-tilde-bar -0.5533	
Z-t-tilde-bar 3.0027	0.9987
. xtunitroot ips dbc	
Im-Pesaran-Shin unit-root test for	Dbc
Ho: All panels contain unit roots	Number of panels = 7
Ha: Some panels are stationary	Number of periods = 37
AR parameter: Panel-specific	Asymptotics: T,N -> Infinity
Panel means: Included	sequentially
Time trend: Not included	
ADF regressions: No lags included	
	Fixed-N exact critical values
Statistic	p-value 1% 5% 10%
t-bar -6.3079	-2.290 -2.070 -1.950
t-tilde-bar -4.2376	
Z-t-tilde-bar -9.2419	0.0000
. xtunitroot ips dide	
Im-Pesaran-Shin unit-root test for	Dide
Ho: All panels contain unit roots	Number of panels = 7
Ha: Some panels are stationary	Number of periods = 37
AR parameter: Panel-specific	Asymptotics: T,N -> Infinity
Panel means: Included	sequentially
Time trend: Not included	
ADF regressions: No lags included	
	Fixed-N exact critical values
Statistic	p-value 1% 5% 10%
t-bar -7.3581	-2.290 -2.070 -1.950
t-tilde-bar -4.4997	
Z-t-tilde-bar -10.1128	0.0000

. xtunitroot ips dte	
Im-Pesaran-Shin unit-root test for	Dte
Ho: All panels contain unit roots	Number of panels = 7
Ha: Some panels are stationary	Number of periods = 37
AR parameter: Panel-specific	Asymptotics: T,N -> Infinity
Panel means: Included	sequentially
Time trend: Not included	
ADF regressions: No lags included	
	Fixed-N exact critical values
Statistic	p-value 1% 5% 10%
t-bar -5.9478	-2.290 -2.070 -1.950
t-tilde-bar -4.1620	
Z-t-tilde-bar -8.9908	0.0000
. xtunitroot ips dpibh	
Im-Pesaran-Shin unit-root test for	dpibh
Ho: All panels contain unit roots	Number of panels = 7
Ha: Some panels are stationary	Number of periods = 37
AR parameter: Panel-specific	Asymptotics: T,N -> Infinity
Panel means: Included	sequentially
Time trend: Not included	
ADF regressions: No lags included	
	Fixed-N exact critical values
Statistic	p-value 1% 5% 10%
t-bar -5.3805	-2.290 -2.070 -1.950
t-tilde-bar -3.8976	
Z-t-tilde-bar -8.1122	0.0000

A2 : Kao cointegration test results

. xtcointtest kao tcer ide bc te pibh	
Kao test for cointegration	
Ho: No cointegration	Number of panels = 7
Ha: All panels are cointegrated	Number of periods = 38
Cointegrating vector: Same	Kernel: Bartlett
Panel means: Included	Lags: 3.59 (Newey-West)
Time trend: Not included	Augmented lags: 1
AR parameter: Same	
	Statistic p-value
Modified Dickey-Fuller t	-24.1143 0.0000

Dickey-Fuller t	-16.0214	0.0000
Augmented Dickey-Fuller t	-4.5309	0.0002
Unadjusted modified Dickey-Fuller t	-45.8521	0.0000
Unadjusted Dickey-Fuller t	-19.9841	0.0000

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