Causality between economic growth and changes of the real exchange rate in Côte d'Ivoire

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This study aims to analyze the relationship between changes in the real effective exchange rate and economic growth in Côte d'Ivoire. The autoregressive distributed lag (ARDL) approach and the Toda-Yamamoto causality test were used. The data cover the period 1980 to 2012. The results conclude the existence of a long-term relationship between economic growth and variation in the real effective exchange rate and the gross fixed capital formation. Furthermore, the results of causality test confirm the existence of bidirectional causality between the long-term misalignment and economic growth in Côte d'Ivoire. Thus, the Ivorian authorities have to observe and follow the evolution of real effective exchange rate by controlling the level and the evolution of the macroeconomic fundamentals of the economy (real GDP, productivity, terms of trade, net external position, etc...) simultaneously and this within a global framework of West Africa of Economic and Monetary Union (WAEMU).

Key words: ARDL, causality, growth, real exchange rate

INTRODUCTION

The relation between the exchange rate and economic growth is both descriptive and normative (Ito and Krueger, 1999). The exchange rate is one of the main channels which determine the relation between external trade and the growth of an economy (Busson and Villa, 1997). Yet very few studies in the context of approaches to the growth have granted a place for a theoretical formalization of the long term relationship between real exchange rate and growth. Lahreche-Révil (1999) raised that the theoretical explanations, when they exist, do not permit in general, to report the long-term influence of real exchange rate on the growth and development process, as approaches on which they rest do not permit. Yet, when empirical studies undertaking in developed countries as well as in emergent and developing ones reveal a significant relationships between the variability of exchange rate and economic growth (Danladil and Uba, 2016; Vieira et al., 2013). The misalignment of the exchange rate, often unfavorable overvalued activities exchangeable, is widely discussed in economic performance studies and is considered harmful (Vieira and MacDonald, 2010). This is why the exchange rate and its possible mismatch received special attention as a major source of macroeconomic imbalances whose correction is one of the crucial conditions to improve economic performance and macroeconomic stability (Domac and Shabsigh, 1999). Concerning West Africa, few studies have analyzed the relationship between
exchange rate and economic growth. The works of Klaub (1998) conducted in 14 countries in sub-Saharan Africa from 1980 to 1996 show that one of main reasons of the weak economic performance is the overvaluation of their currencies. Those of Diop and Fall (2011), starting from a dynamic stochastic general equilibrium model at the presence of nominal rigidities, find that the fixed and intermediary exchange regimes should be preferred by the ECOWAS countries. Diaw and Ka (2012), using the GMM methodology for estimating have shown that the effect of exchange rate flexibility on growth is more important than the fixed exchange rate regime.

Danladil and Uba (2016), over the period 1980 to 2013, indicates that the volatility of the exchange rate negatively and significantly impact on economic growth in Nigeria and Ghana. Of all these studies, few have focused on the specific cases of countries. Côte d'Ivoire is not on the sidelines of that reality. Furthermore, contrary to the existing reviews we include two independent variables into the model so that to account for the modes of transmission of the variations of exchange rate growth. This is the variation in degree of misalignment during the previous period to capture the effects of competitiveness exchange rate and a variable to include a series of effects produced by a relatively permanent or prolonged divergence between the real exchange rate and his long-term equilibrium value. According to Harris (2001), there are two effects of variations in the real exchange rate namely misalignment and competitiveness.

Our study seeks to examine the causal relationship between changes in the real exchange rate and economic growth. It is quite conceivable that this structural relation is compatible with a model of long-term growth where causality is bidirectional.

METHODOLOGY AND DATA

Misalignment determination model of the real effective exchange rate

The misalignment is the gap observed as compared to his long term equilibrium value. We will firstly estimate the equilibrium value of REER of the CFA. Secondly we will calculate the misalignment. Our model for determining the equilibrium real exchange rate is based on the work of Edwards (1988). Our model is as follows:

\[
\ln(REEX)_t = \alpha + \beta Z_t + \varepsilon_t
\]

(1)

With \( Z = Z(lpr, llot, lopen, ifr, nep) \) the vector of fundamentals (Chhana, 2013) to better capture the evolution of the real effective exchange rate. Where \( lpr \) is the logarithm of the productivity of growth, \( llot \) is the logarithm of the terms of trade, \( lopen \) is the logarithm of the degree of openness, \( ifr \) is the interest rate of France, and \( nep \) is not external position.

The misalignment corresponds to the deviation of the current real exchange rate to its equilibrium value defined by the fundamental equilibrium values. These can be calculated using the Hodrick-Prescott filter (Yasser and Tsangarides, 2006).

The misalignment of the real exchange rate is determined as follows:

\[
\ln\text{mesal}_t = \ln\text{TCER}_t - \ln\text{TCRE}_t
\]

With \( \text{mesal} \) is misalignment of the real exchange rate.

Basic model

To empirically analyze the relationship between economic growth and the real exchange rate in Côte d'Ivoire, an augmented neoclassical model of production function (the exchange rate is not in principle an argument of the neo-classical production function, but its incorporation allows to take into account the factors affecting output, but which are not captured by the factors \( K \) and \( L \)) was used:

\[
Y_t = F(A_t, N_t, K_t, TCER)
\]

(2)

Where \( Y_t \) denotes real GDP to year \( t \); \( N_t \) is the labor force; \( K_t \) is the stock of physical capital; \( REER \) is the real effective exchange rate and \( A_t \) is the total factor productivity reflecting the level of technology and efficiency of the economy.

By dividing the Equation (2) by \( N_t \) and using a functional form of Cobb-Douglas, we get the real per capita GDP \( (Y/N) \), function of capital stock per capita \( (K/N) \) and real exchange rate:

\[
\frac{Y}{N} = F\left(\frac{K}{N}, \text{TCER}\right) \iff \frac{Y}{N} = F\left(\frac{K}{N}, \text{TCER}\right)
\]

Which give:

\[
\frac{Y}{N} = A_t \left(\frac{K}{N}\right)^{\beta_1} \left(\text{TCER}\right)^{\beta_2}
\]

We pose:

\[
y = \ln\left(\frac{Y}{N}\right); k = \ln\left(\frac{K}{N}\right), \text{tcer} = \ln(\text{TCER})
\]

(3)

Moreover, according to Harris (2001), there are two effects of change in the real exchange rate namely misalignment \( (\text{mesl}) \) and competitiveness \( (\text{mesc}) \). Thus, we lay that:

\[
\text{TCER} = f(\text{meslt, mesc})
\]

(4)

The productive function becomes:

\[
y_t = \beta_0 + \beta_1 k_t + \beta_2 \text{mesc}_t + \beta_3 \text{meslt}_t + \mu_t
\]

(5)

With \( y_t \) is log of real GDP per capita, \( k_t \) is the logarithm of gross fixed capital formation per capita as a proxy for capital stock per capita, \( \text{mesc} \) is the logarithm of the change in the index of misalignment during previous period, and \( \text{meslt} \) is the logarithm of the long-term misalignment (Harris, 2001).
Theoretically the signs of the parameters $\beta_2$, $\beta_3$ should be negative because a misalignment of the exchange rate should have a negative effect on growth (Harris, 2001). Regarding $\beta_1$ the sign should be positive because an increase in the capital stock per capita is expected to have a positive effect on the growth of real GDP per capita (Palakiyem, 2016).

Estimation method

This method shall also be applied to the model of determining real exchange rate of equilibrium. Most studies of causality relationship favor the VAR modeling. However, the implementation of this approach requires that the series be integrated into the same order. But in most macroeconomic series this condition is not satisfied (Nelson and Plosser, 1982). In reaction to this inadequacy, Pesaran et al. (2001) defined the approach of Auto Regressive Distribution Lag (ARDL). But this method requires that the explained variable not be over I(1). Two sets of critical values, lower and upper bound values, for large sample data sets are developed by Pesaran et al. (2001). Narayan (2005) reports small sample critical values. Given the nature of our sample, we will use critical values of Narayan (2005).

Our ARDL model considering the real gross domestic product per capita as dependent variable then appears as follows:

$$
\Delta y_t = \beta_0 + \sum_{i=1}^{n} \beta_{1i} \Delta y_{t-i} + \sum_{i=0}^{n} \beta_{2i} \Delta k_{t-i} + \sum_{i=0}^{n} \beta_{3i} \Delta mesc_{t-i} + \sum_{i=0}^{n} \beta_{4i} \Delta mesl_{t-i} + \alpha_1 y_{t-1} + \alpha_2 k_{t-1} + \alpha_3 mesc_{t-1} + \alpha_4 mesl_{t-1} + \varepsilon_t
$$

(6)

In this equation, $\Delta$ denotes the first difference operator, $\varepsilon_t$ is the error term that is a white noise, $n$ is the maximum number of lags selected, $\beta_0$ is constant. The parameters that range from $\alpha_1$ to $\alpha_4$ characterize long-term balance between the variables while the coefficients $\beta_1$ to $\beta_4$ represent short period of the balance between the series studied; $n$ is determined by AIC and SC information criteria. It corresponds to the delay which minimizes these criteria. To test for the absence of cointegration, Pesaran et al. (2001) conducted the following test:

$$
H_0 = \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 0 \text{ (Absence of cointegration)}
$$

against the alternative hypothesis: (cointegration Presence) using Fisher tests (or Wald) following non-standard law (Motabelli and Ghorbani, 2009).

Recourse to Wald test or the F statistic allows testing the significance of the variable correction model (ECM). The asymptotic distribution of this test (Fisher respectively) is not standardized under the null hypothesis of no cointegration between variables. It is important to test must be made considering each variable as endogenous. It is important to test the exogenous nature of each variable in the Equation 6. Given that, we have 4 variables in our equation, we must verify the weak exogeneity condition of regressors. In other words, firstly, estimate Equation 6 with dependent variable $\Delta mesc$ and test

$$
H_0 = \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 0
$$

secondly, estimate Equation 6 with dependent variable $\Delta mesl$; and fourth estimate Equation 6 with dependent variable $k$. If null hypothesis of no cointegration is accepted for mesl, mesc, k and rejected to $y$ then ARDL approach will be valid.

If the variables in question are cointegrated as per the cointegration test results then the implication is that there exists causality in at least one direction. After establishing cointegration status between economic growth and variation in the real effective exchange rate and the gross fixed capital formation, the study uses the Granger causality test (Granger, 1969) to determine short-run and long-run causal relationships between these variables. The study uses the following error-correction specification to test for causality:

$$
\Delta y_t = \beta_0 + \sum_{i=1}^{n} \beta_{1i} \Delta y_{t-i} + \sum_{i=0}^{n} \beta_{2i} \Delta k_{t-i} + \sum_{i=0}^{n} \beta_{3i} \Delta mesc_{t-i} + \sum_{i=0}^{n} \beta_{4i} \Delta mesl_{t-i} + \lambda EC + \varepsilon_t
$$

(7)

$$
\Delta mesl_t = \beta_0 + \sum_{i=1}^{n} \beta_{1i} \Delta mesl_{t-i} + \sum_{i=0}^{n} \beta_{2i} \Delta k_{t-i} + \sum_{i=0}^{n} \beta_{3i} \Delta mesc_{t-i} + \sum_{i=0}^{n} \beta_{4i} \Delta y_{t-i} + \lambda EC + \varepsilon_t
$$

(8)

$$
\Delta k_t = \beta_0 + \sum_{i=1}^{n} \beta_{1i} \Delta k_{t-i} + \sum_{i=0}^{n} \beta_{2i} \Delta y_{t-i} + \sum_{i=0}^{n} \beta_{3i} \Delta mesc_{t-i} + \sum_{i=0}^{n} \beta_{4i} \Delta mesl_{t-i} + \lambda EC + \varepsilon_t
$$

(9)

$$
\Delta mesc_t = \beta_0 + \sum_{i=1}^{n} \beta_{1i} \Delta mesc_{t-i} + \sum_{i=0}^{n} \beta_{2i} \Delta k_{t-i} + \sum_{i=0}^{n} \beta_{3i} \Delta y_{t-i} + \sum_{i=0}^{n} \beta_{4i} \Delta mesl_{t-i} + \lambda EC + \varepsilon_t
$$

(10)

Where $\lambda$ measures the speed of adjustment towards the long-run equilibrium; $ECT_{t-i}$: error correction term lagged 1 period (this shows that changes in the dependent variable are function of level of disequilibrium in the co-integrating relationship).

It is now appropriate to examine the causality relationships.
between these variables across the approach of Toda and Yamamoto (1995).

The Toda and Yamamoto causality test

The approach suggested by Engle and Granger (1987) is the most used in the economic literature. However, its implementation can lead to significant bias. The approach proposed by Toda and Yamamoto (1995) compensates the shortcomings of this approach.

\[ X_t = \omega + \sum_{i=1}^{m} \theta_i X_{t-i} + \sum_{i=m+1}^{m+d_{\text{max}}} \theta_i X_{t-i} + \sum_{i=1}^{m} \delta_i Y_{t-i} + \sum_{i=m+1}^{m+d_{\text{max}}} \delta_i Y_{t-i} + v_1 \]

\[ Y_t = \psi + \sum_{i=1}^{m} \phi_i Y_{t-i} + \sum_{i=m+1}^{m+d_{\text{max}}} \phi_i Y_{t-i} + \sum_{i=1}^{m} \beta_i X_{t-i} + \sum_{i=m+1}^{m+d_{\text{max}}} \beta_i X_{t-i} + v_1 \]

Where \( X \) = growth rate of real gross domestic product per capita, \( Y \) is the effects of the change in the real exchange rate; \( \omega, \psi, \theta_i, \delta_i, \phi_i, \beta_i \) are the parameters of the system.

The null hypothesis of no causality of real growth rate per capita in the real exchange rate can be expressed in the form:

\[ H_0: \delta_i = 0, \forall i = 1, 2, \ldots , m. \]

The data

The study’s data cover the period 1980 to 2014. They are from the World Development Indicators of the World Bank website. Table 1 presents the variables and source of the data.

EMPIRICAL RESULTS AND INTERPRETATION

Unit root tests and cointegration

The results concerning the model for determination of the equilibrium real exchange rates are presented in Appendix Tables 1 to 5 and Figures 1 and 2. This first requirement for time series econometrics analysis is to subject each time series to stationary or unit root tests. The two methods employed for this test were Augmented Dickey-Fuller (ADF) and Kwiatkowski, Phillips, Schmidt, Shin (KPSS) tests. The KPSS test hypothesizes stationarity as null hypothesis while the ADF test poses the hypothesis of the presence of unit root as null hypothesis. Thus, for the ADF test, if the calculated statistic is greater than the critical value, the series is non-stationary, while the series will be declared in the case of stationary KPSS test. The results of these tests are presented in Table 1. The results show that the variables are the most integrated of order one (1), as indicated by the critical values the 5% level. Only the MESI variable is stationary in level while the series y, k and mesl are stationary in first differences. Hence, VAR models will add only one extra lag (that is, \( d_{\text{max}} = 1 \)) for the implementation of the causality test. Table 2 summarizes the results of ADF, KPSS tests.

This result invites us to test the possible existence of cointegration relationship. The number of optimal delays corresponds to the minimum value of Akaike (AIC) and Schwarz (SC) information criterion (Table 3). The results indicate an appropriate lag length of one.

After determining the lag length we proceed to the cointegration test. Table 4 presents cointegration test results. The F-statistics obtained from the equations were compared to Narayan (2005) critical values. The results show that there is a long-term relationship between economic growth and variation in the real effective exchange rate and the gross fixed capital formation (7.295 is higher than the upper critical bound at 1, 5 and 10% critical values as indicated in Table 4). From the results of Table 4 we may consider that there is one cointegration relationship between growth and variations of misalignment of exchange rate and capital stock.

The estimation results (Table 5) confirm the long-term relationship, the restoring force is negative and no statistically zero. In addition, Fisher p-value associated with the statistic indicates that our model is globally significant at the 95% confidence level. And also, the exogenous variables of the model explain 85% GDP per capita developments. Now we will proceed to validation test of our model.

Residues diagnostic tests

On the one hand, tests for the validity of our model consisting in testing normality, homoscedasticity, absence of autocorrelation and stationarity from our residues confirm the robustness of our model (Table 6). On the other hand, the estimated relationships are
### Table 1. Description of variables and sources of data.

| Variable | Description                                                                 | Sources                                                                                     |
|----------|------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|
| REER     | Real effective exchange rate                                                  | World Development Indicators of the World Bank website                                      |
| TOT      | Terms of trade $T = \frac{[\text{price index for export} / \text{import prices index}]}{100}$ | World Development Indicators of the World Bank website                                      |
| OPEN     | Economic openness $[(X + M) / 2] \times 100$                                | World Development Indicators of the World Bank website                                      |
| IFR      | Interest rate in France                                                       | World Development Indicators of the World Bank website                                      |
| NEP      | Net external position                                                        | World Development Indicators of the World Bank website                                      |
| PR       | Productivity: The ratio of GDP and the number of workers (Chnaia, 2013)      | World Development Indicators of the World Bank website                                      |
| Y        | Gross domestic product per capita                                            | World Development Indicators of the World Bank website                                      |
| K        | Stock of gross fixed capital formation per capita                            | World Development Indicators of the World Bank website                                      |
| MESLT    | Misalignment: measured using an average weighting of decreasing misalignments previous five years, weighting from 5/15 form immediately preceding year to 1/15 for the fifth year (Harris, 2001) | World Development Indicators of the World Bank website                                      |
| MESC     | Competitiveness: measured by the variation of the index of misalignment during the previous period. (Harris 2001) | Author's calculation based on data from the World Development Indicator of the World Bank |

### Table 2. Results of the stationarity tests.

| Variable | In level                  | In first differences               |
|----------|---------------------------|-----------------------------------|
|          | ADF                       | KPSS                             | ADF                       | KPSS                             |
| Y        | -3.050**(-2.983)          | 0.281** (0.146)                  | -3.541** (-2.983)       | 0.0615 (0.146)                  |
| K        | -2.982(-2.983)            | 0.257** (0.146)                  | -3.868** (-2.983)       | 0.0721 (0.146)                  |
| Mesc     | -6.511** (-2.980)        | 0.0345 (0.146)                   | -9.286** (-2.983)       | 0.0136 (0.146)                  |
| Meslt    | -2.596 (-2.983)          | 0.108 (0.146)                    | -7.087** (-2.983)       | 0.0469 (0.146)                  |

*Rejection of the null hypothesis at 5%; the value on bracket is critical value at 5%.

### Table 3. VAR lag Length selection criteria.

| Lag | LogL   | LR      | FPE      | AIC       | SC       | HQ       |
|-----|--------|---------|----------|-----------|----------|----------|
| 0   | -249.239 | NA      | 146.4360 | 16.3380   | 16.52304 | 16.39832 |
| 1   | -136.238 | 189.5501* | 0.283579* | 10.07988* | 11.00503* | 10.38145* |
| 2   | -121.5238 | 20.88479 | 0.326308 | 10.16283 | 11.82810 | 10.70566 |

*Lag order selected by the criterion.

### Table 4. Bounds test for cointegration analysis.

| Dependent variable | F-Statistic | CV at 10% [K=3; T=33] | CV at 5% [K=2; T=33] | CV at 1% [K=2; T=33] | Remarks |
|--------------------|-------------|-----------------------|----------------------|----------------------|---------|
| Δy                 | 7.295       | 2.644                 | 3.548                | 3.198                | 4.202   | 4.578   | 5.864   | Yes     |
| Δmesc              | 3.205       | 2.644                 | 3.548                | 3.198                | 4.202   | 4.578   | 5.864   | No      |
| Δmeslt             | 3.051       | 2.644                 | 3.548                | 3.198                | 4.202   | 4.578   | 5.864   | No      |
| K                  | 2.796       | 2.644                 | 3.548                | 3.198                | 4.202   | 4.578   | 5.864   | No      |

Source: Nayaran (2005): Critical values for the bounds test: Case II: restricted intercept and no trend.
Table 5. Estimating result.

| Dependant variable | ARDL (1 1 0 1) selected based on AIC | Coefficients | T-Ratios | p-value |
|--------------------|-------------------------------------|--------------|----------|---------|
| Constant           | 0.3153876                           | 1.17         | 0.253    |
| y(-1)              | -0.069487                           | -3.71        | 0.009    |
| k(-1)              | 0.4939505                           | 2.62         | 0.013    |
| mesc(-1)           | -0.1612658                          | -0.44        | 0.667    |
| meslt(-1)          | -3.268291                           | -2.66        | 0.0011   |
| D.y(-1)            | 0.411637                            | 2.89         | 0.010    |
| D.k(-1)            | 0.0751863                           | 2.56         | 0.017    |
| D.mesc(-1)         | 0.055657                            | 0.803578     | 0.43     |
| D.meslt(-1)        | 0.0969709                           | 0.27         | 0.790    |

Model criteria

| Test                      | Chi²      | Prob> chi² |
|---------------------------|-----------|------------|
| Normality test            | 0.04      | 0.9802     |
| Heteroskedasticity (ARDL) | 0.352     | 0.7291     |
| Breusch Godfrey LM test   | 0.278     | 0.5983     |
| Breusch-Pagan             | 0.07      | 0.7901     |
| Ramsey RESET              | 1.19      | 0.3366     |

Table 6. Diagnostic statistics.

stable overall. CUSUM tests and CUSUM square test (Figures 1 and 2) does not reveal sources of apparent instability. The stability hypothesis cannot be rejected.

Toda-Yamamoto causality test

Once the optimal delay determined by the VAR level and the order of maximum integration known, the final step in this study is to see if variations in the exchange rate verify Granger Cause economic growth by Fisher Hypothesis using the Toda and Yamamoto causality test. The empirical results of Granger Causality test based on Toda and Yamamoto (1995) methodology, following the chi-square distribution with 3 degrees of freedom in accordance with the appropriate lag length, is estimated through WALD test and reported in Table 7. The results show bidirectional causality between variations in the real exchange rate and growth in Côte d’Ivoire.

Results interpretation

The results from the estimation of our model indicate that economic growth depends negatively on the long-term misalignment at the 5% (-3.2683)**. In addition, the short-term misalignment (competitiveness) has no effect in both the short and long term. Despite this established fact, these results highlight the adverse effects of the variation of the real effective exchange rate on economic growth in Côte d’Ivoire. This negative impact can be seen on productivity via the effect of variations in the exchange rate.

According to Harris (2007), the real exchange rate influences the productivity growth in the short term and long term. These results confirm those of Berg and Miao (2010) who argue that the misalignment of the real exchange rate implies macroeconomic imbalances which are themselves bad for growth. These conclusions are also consistent with theories according to which a prolonged misalignment of the real effective exchange rate tends to reduce economic growth (Vieira and MacDonald (2010), Rodrik (2008)). It therefore appears that appropriate measures should be taken to avoid persistent misalignments in Côte d’Ivoire. Furthermore, there is bidirectional causality between GDP per capita and the long-term misalignment. This could be explained by the fact that in Côte d’Ivoire, economic growth in the
long term is not accompanied by an increase in productivity which would tend to increase the real effective exchange rate.

The capital stock per capita positively impacts the economic growth in the 5% level (0.49395)** at short and long term. Our results confirm the predictions of neoclassical theory as to the importance of capital stock as a determinant of economic growth in Côte d'Ivoire. Also, we find a bidirectional causality between these two economic variables in Côte d'Ivoire (p-value = 0.000).
Table 7. Toda-Yamamoto causality test.

| Null hypothesis | Stat du Khi-Deux | p-value | Granger causality          |
|-----------------|------------------|---------|---------------------------|
| y does not cause meslt | 14.62           | 0.0022** | Unidirectional Causality   |
| meslt does not cause y | 2.17            | 0.5369 |                           |
| y does not cause meslt | 17.69           | 0.0005*** | Bidirectional Causality   |
| meslt does not cause y | 9.11            | 0.0278** |                           |
| y does not cause k | 34.68            | 0.0000*** | Bidirectional Causality   |
| k does not cause y | 33.54            | 0.0000*** |                           |

***,**,***Significance at the 5 and 1%, respectively.

CONCLUSION AND POLICY SUGGESTION

The major objective of this study has been to analyse the relationship between changes in the real effective exchange rate and economic growth in Côte d’Ivoire. To achieve it, we used data from the World Bank on the real effective exchange rate, the Gross Domestic Product and Gross fixed capital formation covering the period 1980 to 2012. The ARDL approach (Narayan, 2005) and the Toda-Yamamoto causality test allowed us to free ourselves of biases that could be due to the sample size. Thus, we came to the conclusion that there is a long-term relationship between variations in the real effective exchange rate, economic growth and the gross fixed capital formation. In the long run, changes in the real effective exchange rate (the long-term misalignment) have a significant negative impact on economic growth in Côte d’Ivoire. Furthermore, the results of causality test confirm the existence of bidirectional causality between the long-term misalignment and economic growth in Côte d’Ivoire. The existence of causality from growth in long term misalignment shows that economic growth in the long term is not accompanied by an increase in productivity. On the economic front, any policy aimed at stabilizing the exchange rate has a positive impact on the Ivorian economy. Moreover, the Ivorian authorities should emphasize the transfer of technology in their strategy of attracting foreign investment in order to increase productivity.

Conflicts of Interests

The authors have not declared any conflict of interests.

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### APPENDIX

Table 1. The stationarity tests.

| Variable | In level ADF | In level KPSS | In first difference ADF | In first difference KPSS |
|----------|--------------|---------------|-------------------------|--------------------------|
| Lpr      | -3.171* (-2.983) | 0.316** (0.146) | -3.707* (-2.983) | 0.0623 (0.146) |
| Ltot     | -3.340* (-2.980) | 0.12 (0.146) | -3.799* (-2.986) | 0.033 (0.146) |
| Louv     | -1.123 (-2.983) | 1.341** (0.146) | -4.654* (-2.983) | 0.0781 (0.146) |
| Ifr      | -2.48 (-2.983) | 0.317** (0.146) | -4.473* (-2.983) | 0.013 (0.146) |
| Pen      | 0.553 (-2.983) | 0.281** (0.146) | -5.787* (-2.983) | 0.0332 (0.146) |
| Ltcera   | -2.268* (-2.983) | 0.136 (0.146) | -3.707* (-2.983) | 0.0497 (0.146) |

*Rejection of the null hypothesis at 5%; the value on bracket is critical value at 5%.

Table 2. VAR lag order selection criteria results.

| Lag | LogL | LR      | FPE      | AIC       | SC        | HQ       |
|-----|------|---------|----------|-----------|-----------|----------|
| 0   | -1047.85 | NA      | 1.36e+22 | 67.99031  | 68.26785  | 68.08078 |
| 1   | -892.1550 | 241.0758 | 6.31e+18 | 60.26806  | 63.35994  | 60.90137* |
| 2   | -848.1536 | 51.09837* | 5.00e+18 | 60.26806  | 63.35994  | 60.92799 |

Table 3. Bounds test for cointegration analysis.

| Dependent variable | F-Statistic | 10% level [K=3; T=33] | 5% level [K=2; T=33] | 1% level [K=2; T=33] | Remarks |
|--------------------|-------------|-----------------------|----------------------|----------------------|---------|
| Δreer              | 10.6074     | 2.367                 | 3.447                | 2.863                | 4.077               | 3.990               | 5.516               | Yes |

Source: Narayan (2005): Critical values for the bounds test; Case 11: Restricted intercept and no trend; Narayan (2004 a, b) generates and reports new sets of critical values for small sample sizes.

Table 4. Diagnostic statistics.

| Test                  | Chi² | Prob> chi² |
|-----------------------|------|------------|
| Normality test        | 0.352| 0.34700    |
| Heteroskedasticity (ARDL) | 0.011| 0.9153     |
| Breusch Godfrey LM test | 0.002| 0.9648     |
| Breusch-Pagan         | 0.46 | 0.5638     |
| Ramsey RESET          | 0.04 | 0.8542     |
Table 5. Long-term estimate.

| ARDL (1, 1, 0, 1, 1, 1) selected based on AIC | Long run estimates of ARDL model |
|---------------------------------------------|----------------------------------|
| Ouv                                         | 1.349378                         |
| Ion                                         | 0.4022018                        |
| lfr                                         | 10.7146                          |
| Pr                                          | 0.0640644                        |
| Pen                                         | -6.08e-06                        |
| Constant                                    | -77.71951                        |
| **Model criteria**                          |                                  |
| R^2                                         | 0.637707                         |
| Adj R^2                                     | 0.43844585                       |
| F(11,20)                                    | 3.20                             |
| SBC                                         | -2.390                           |
| AIC                                         | -2.881                           |
| Prob> F                                     | 0.0116                           |
| DW                                          | 1.944603                         |

***,**,*Significant at the 1, 5 and 10%, respectively.

Figure 1. CUSUM test

**Interpretation:**

Null hypothesis: The model is structurally stable during the study period.
Alternative hypothesis: The model is structurally unstable during the study period.
The curve of CUSUM (in blue) does not exceed the confidence intervals (corridors that are in red color). There is no structural break in our study. The model is structurally stable throughout the study period.
Figure 2. CUSUM of squares test.

Interpretation:
Null hypothesis: The model is punctually steady;
Alternative hypothesis: the model is punctually unstable.
The curve of CUSUM of Square (in blue) does not exceed the confidence intervals (in the red corridors). There is no zone of instability (point instability) in the model. The model coefficients are punctually stable throughout the study period.