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Unemployment and economic growth in Cote D'ivoire: A disaggregated approach to growth using the Shapley decomposition

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Abstract

This study analyzes the responsiveness of unemployment to the variation in production in Côte d'Ivoire over the period 1980-2019. By using three approaches of Okun's law (model in difference, model in gap, and disaggregated growth model), we estimate long-term and short-term relationships via error correction models (ECM). The first two approaches highlight the weak link between economic growth and unemployment. The third approach, based on the Shapley decomposition, shows that this low responsiveness of unemployment to the variation in production is essentially due to the fact that final consumption and public expenditure, which largely explain the variability of unemployment, have a very low impact on the unemployment rate. This results from the extroverted nature of the Ivorian model of economic growth. The study recommends that public authorities relocate the production of most consumer goods and equipment, step up policies to promote local industries aimed at replacing certain imported consumer goods and equipment, and strengthen the public procurement and contracts policy in favor of local businesses.

Keywords: Aggregate demand, Error correction model, Okun's law, Shapley decomposition, Unemployment.

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Contents

Contribution of this paper to the literature
We analyze, for the first time, the responsiveness of unemployment to growth in Côte d'Ivoire by using three approaches of Okun's law: model in difference, model in gap, disaggregated growth model. The results highlight a low responsiveness of unemployment to growth, essentially due to final consumption and public expenditure.

1. Introduction

As the economic leader in French-speaking West Africa, Côte d'Ivoire posted an average annual growth rate of around 8.8% over the last decade (Ivorian Ministry of Economy and Finance, 2019). Over the same period, the unemployment rate, taking into account the potential workforce, underemployment and precarious work, increased to 25.3% (ENV, 2015). It is therefore that the economic dynamism experienced by the country is not sufficiently reflected in the labor market in terms of job creation. Economic growth therefore does not seem to be a factor in reducing unemployment, unlike Okun's law which stipulates a negative correlation between economic growth and unemployment. Karim and Aomar (2016) have shown that Okun's law is not verified in Côte d'Ivoire. Studies explains the invalidity of Okun's law. Kouakou et al. (2019) explain this insignificant link between economic growth and unemployment in Côte d'Ivoire over the period 1980-2014 by the abnormal periods of socio-political crisis.

Other studies instead invoke a growth model that is not very favorable to job creation. This is the case of N'Guessan (2018) who, by estimating Okun's relation, by sector of activity, over the period 1996-2016, shows that the non-validity of Okun's law is explained by the predominance of the agricultural sector, which creates little employment. While Okun's Law has been explored in Côte d'Ivoire using the sectoral distribution of gross domestic product GDP (supply side) approach, it has not yet been explored from a demand perspective. Our study intends to fill this void. Such an analysis could make it possible, on the one hand, to identify the components of domestic demand that drive Ivorian growth, and on the other hand, to determine the effect of these components on unemployment.

The contribution of this paper to the existing literature is twofold. First, to the best of our knowledge, this is the first study that explores Okun's law from a demand perspective in Côte d'Ivoire. Second, this study is the first to analyze Okun's Law in sub-Saharan Africa by disaggregating growth according to the components of aggregate demand and using the Shapley decomposition to determine the contributions of the components of demand to unemployment variability.

The rest of this study is organized as follows: after reviewing the theoretical and empirical literature on Okun's law (section 1), we present the estimation methods of our econometric equations (section 2). We then give the estimation results with their interpretations (section 3). Section 4 concludes the paper.

2. Related Literature Review

The studies that have analyzed the validity and robustness of Okun's relation generally show that in developed countries (DC), growth is a factor of job creation and therefore of reduction of the unemployment rate (Ball, Leigh, & Lougani, 2013; Stephan, 2014). Studies that test Okun's law in developing countries (DCs) generally obtain contrasting results. Lal et alii. (2010) using an error correction model to analyze the link between growth and unemployment in Asian countries over the period 1980-2006, conclude that Okun's relationship is not valid there. Bouaziz and El Andari (2015) use models in gap and in difference to analyze the cointegration between production and unemployment over the period 1990-2014 in Tunisia. Their results confirm Okun's Law with a coefficient around - 0.7. This result contrasts with those reported by Moosa (1999) who advocate that the relationship is negative but not significant in Tunisia. In Egypt, studies by Alhdiy et alii. (2015) find no link between unemployment and economic growth for the period 2006-2013. Indeed, they note the lack of a long-term relationship between growth and unemployment due to the predominance of capital-intensive sectors. Babalola et al. (2013) studies reveal a positive relationship between unemployment and real GDP from 1980 to 2012 in Nigeria.

Some studies explain the weak link between production and unemployment by disintegrating the GDP according to a sectoral distribution. The underlying idea is the variability in the elasticity of employment from one sector to another, with activity sectors having a different predisposition to job creation. Crivelli et al. (2012) estimate employment-production elasticities on an unbalanced panel of 167 developed and developing countries over the period 1991-2008. They show that the service sector has a higher employment elasticity compared to the agricultural sector and manufacturing industry. Therefore, the greater the share of the service sector in GDP, the greater the magnitude of the Okun coefficient. In Cameroon, over the period 1960-2014, Ningaye et al. (2015) highlight a greater elasticity of total employment to GDP in services (2.11) compared to the industrial sector (0.5) and to the entire economy (0.41). In Ghana, Baah-Boateng (2016) shows that the low correlation between unemployment and the growth rate is largely explained by the low growth of sectors with high employment capacity, such as agriculture, as well as 'evolution of the mining and hydrocarbons sector.

Regarding the specific case of Côte d'Ivoire, the results of Karim and Aomar (2016) show that Okun's law is not verified there. Kapsos (2005) shows that the elasticities of employment over the period 1991-2000 are higher in the agricultural sector (0.87) and the service sector (0.61). The industrial sector has the lowest production employment intensity (0.48). N'Guessan takes up the study on Côte d'Ivoire and shows, but over the period 1996-2016, that the elasticity of employment to production is lower in the agricultural sector. He thus explains the weak link between growth and unemployment in Côte d'Ivoire by the predominance of the agricultural sector, which destroys more jobs due to the increase in agricultural productivity.

In addition to the decomposition of GDP according to a sectoral distribution, studies explain the weak link between production and unemployment by disintegrating GDP according to the components of aggregate demand. This is the approach of Anderton et alii. (2014) who exploit the possibility of decomposing GDP growth according to the contributions of final consumption, investment, exports and imports, to conduct an analysis on euro area countries over the period 1996-2013. They thus show that unemployment is more sensitive to changes in the consumption component, and weakly elastic to movements in foreign trade variables. Consumer spending is on services, which by their nature are very employment intensive. With regard to foreign trade, their low impact on unemployment is due to the fact that exported goods are dominated by manufactured products (75% of exported goods) requiring little labor and have an extremely high import content.

Examining the case of Malta from 2000 to 2016, Micallef (2017) shows that the weakness of the growth-unemployment link is due to the fact that unemployment is more sensitive to private consumption followed by exports of goods and services while consumption and investments have a low impact on unemployment due to their low share in GDP. In Morocco, over the period 1999 to 2016, Badr et al. (2018) shows a low reactivity of unemployment to variations in production. This is due to the fact that unemployment depends on the contributions of final demand essentially driven by investment and imports (40.7% of the variability of cyclical unemployment). Final consumption, the main lever of the Moroccan economic model, has an insignificant impact on unemployment.

To our knowledge, this approach by Anderton et al. (2014) applied to the euro zone, to the case of Malta and to Morocco, has not yet been adapted to the case of sub-Saharan Africa, which rather favors the sectoral distribution of GDP approach. We apply the disaggregated growth approach of Anderton et al. (2014) in the case of Côte d'Ivoire to deepen our knowledge of the causes of the weak effect of growth on unemployment in that country.

3. Model Specification, Data Description and Preliminary Tests

3.1. Model Specification

Our study consists of testing Okun's relationship in Côte d'Ivoire using three models: a model in difference, a model in gap and a disaggregated growth model according to the method of Anderton et al. (2014).

Model in Difference: The approach in difference relates the observed variations in unemployment (Δu_t) to variations in real GDP[1] ($\Delta RGDP_t$).

$$\Delta u_t = \beta \Delta RGDP_t + \varepsilon_t \qquad (1)$$

The coefficient β measures how much unemployment changes in percentage when real GDP changes by 1%.

Model in Gap: This approach in gap links the cyclical unemployment $(u_t - u_n)$ to the gap between real output $RGDP_t$ and its potential level $RGDP_p$. Here, the natural unemployment rate u_n is determined exogenously[2].

$$\frac{RGDP_t - RGDP_p}{RGDP_p} = \mu(u_t - u_n) + \varepsilon_t \qquad (2)$$

The coefficient μ measures how much the output gap varies when the gap in the unemployment rate varies by 1%. The values of the potential unemployment rate and the potential real GDP are estimated using the Hodrick-Prescott filter[3] and different smoothing parameters: 100, 400 and 500. The use of different smoothing parameters makes it possible to reduce the subjectivity due to the choice of parameter and obtain robust results.

Okun's Law assumes that over the analyzed period, the country has a normal growth rate (Blanchard, 2017). That's why it's important to capture any possible structural breaks in the economy, so that the results avoid overestimation or underestimation. We consider the dummy variable $cris$ that captures the effect of serious socio-politic crisis experienced by Côte d'Ivoire in 2011. Formally, we have.

$$crise_t = \begin{cases} 1 \text{ if } t = 2011 \\ 0 \text{ otherwise} \end{cases} \qquad (3)$$

From Equations 1 and 2, we introduce the dummy variable to obtain respectively.

$$\Delta u_t = \beta \Delta RGDP_t + \gamma cris_t + \varepsilon_t \qquad (4)$$

$$\frac{RGDP_t - RGDP_p}{RGDP_p} = \mu(u_t - u_n) + \delta cris_t + \varepsilon_t \qquad (5)$$

Disaggregated Model: This approach relates the observed variations in unemployment Δu_t to variations in the components of aggregate demand. Denoting $W(Z_i)$ the contribution of component Z_i to real GDP growth, real GDP growth is the sum of the contributions of each component:

$$\Delta RGDP = \sum_{i=1}^{n} W(Z_i) \qquad (6)$$

Noting θ_Z the weight of the component Z in the real GDP with $\theta_Z = Z_0 / RGDP_0$, we have: $W(Z_i) = \theta_{Z_i} \times \Delta Z_i$, where it comes from.

$$\Delta RGDP = \sum_{i=1}^{n} \theta_{Z_i} \times \Delta Z_i \qquad (7)$$

Real GDP is the sum of final household consumption (HC), investment in fixed capital (I), stocks variation (SV), public expenditure (PE), exports (X) from which we subtract imports (M)[4]. Formally, we have:

$$RGDP = HC + I + PE + SV + X - M \qquad (8)$$

Assuming $SV = 0$, we have.

$$RGDP = HC + I + PE + X - M \qquad (9)$$

Using Equation 6, GDP growth is written in terms of the contribution of each component of aggregate demand, as follows.

$$\Delta RGDP = \theta_{HC}\Delta HC + \theta_I \Delta I + \theta_{PE}\Delta PE + \theta_X \Delta X + \theta_M \Delta M \qquad (10)$$

Finally, the disaggregated model is written.

$$\Delta u_t = \beta_1 \theta_{HC}\Delta HC_t + \beta_2 \theta_I \Delta I_t + \beta_3 \theta_{PE}\Delta PE_t + \beta_4 \theta_X \Delta X_t + \beta_4 \theta_M \Delta M_t + \varepsilon_t \qquad (11)$$

Where the β_i are the coefficients attached to the contributions of the demand components.

3.2. Description of Variables

The data of our study cover the period 1980-2019, and are extracted from the database of international institutions (World Bank, *BCEAO*), the « *direction de la conjoncture et de la prévision économiques (DCPE)*», the *« Institut National de la Statistique (INS)»*. It is known that aggregate real GDP data is problematic in African countries, as a lot of the economy is informal, and data is collected by international agencies using a common currency. This leads to known Laspeyres-Paasche issues. In order to increase the paper's contribution tremendously we use instead

[1] Equation 1 needs not have a constant, given that it is expressed in percentage and differences.
[2] Equation 2 needs not have a constant, given that it is expressed in percentage and differences.
[3] The natural rate u_n in Equation 2 is time-variant if an HP filter is used, i.e. we use the (time-variant) trend from the HP filter decomposition. Same with the natural level of real GDP.
[4] These components of the final demand are considered in real terms and not nominal terms.

measures of economic growth based on survey data (Young, 2012). It is for this reason that we use the survey data of the INS. We summarize the description of the variables, the expected signs and the source of the data in the Table 1:

Table 1. Data sources.

Variables	Description	Expected signs.	Sources
Model in difference			
U	Unemployment rate	Explained variable	INS (2019) and World Bank (2019)
RGDP	Real gross domestic product	-	INS (2019)
Model in gap			
RGDP	Real gross domestic product	Explained variable	INS (2019)
U	Unemployment rate	-	INS (2019) and World Bank (2019)
Disaggregated model			
U	Unemployment rate	Explained variable	INS (2019) and World Bank (2019)
HC	Houshold consumption	-	BCEAO (2019)
I	Gross fixed capital formation	-	BCEAO (2019)
PE	Public expenditures	-	BCEAO (2019)
X	Exports	-	BCEAO (2019)
M	Imports	+	BCEAO (2019)

Note: (-): Negative impact of the variable on the unemployment rate; (+): Positive impact of the variable on the unemployment rate.

4. Econometric Methodology

4.1. Preliminary Tests: Stationarity and Cointegration Tests

First of all, we test the stationarity of the different variables via the Augmented Dickey and Fuller (1979) and Phillips and Perron (1988). These tests put forward the null hypothesis of non-stationarity of the series against the alternative hypothesis of stationarity of the series. The results conclude that the variables of the three models are all integrated of order 1.

Since the variables are integrated in the same order, there is a presumption of cointegration between the variables. For the models in difference and in gap, the presence of a single explanatory variable requires performing an Engle and Granger (1987) cointegration test because we assume only one cointegration relation. This test is done in two steps. The first consists of estimating the cointegration relation (long term relation) and then testing the stationarity of the residue. If the residue is stationary in level, then there is cointegration between the variables. For the disaggregated model, at least one cointegration relationship is assumed, which requires performing the Johansen (1988) cointegration test. In the case of cointegration, the test of the trace and that of the maximum eigenvalue indicate the number of relations of cointegration.

The results of the cointegration tests show that there is a cointegration relationship in the models in difference and in gap, and two cointegration relationships in the disaggregated model. We therefore use an error correction model (ECM) which allows us to model long-term and short-term dynamics in order to obtain more reliable results. The estimation of the ECM takes place in two stages: first, to estimate the long-term relation by the Ordinary Least Squares (OLS) and to test the stationarity of the residue; then estimate the error correction model itself by the OLS. This model is valid if and only if the coefficient of the lagged residue (restoring force) of the relation is significant and negative.

4.2. The Shapley Decomposition Method

We will also use the Shapley decomposition method of R^2 in order to isolate the effects of each component of aggregate demand on aggregate R^2. The use of Shapley's method is important in that it allows us to know by how much percentage changes in each component of demand explain movements in unemployment. Indeed, it determines the marginal contributions of each factor to the overall R^2 in two ways. The first is to subtract from the overall R^2 the R^2 obtained when the variable of interest is omitted from the regression. The second way is to estimate the R^2 of a regression including only the variable of interest. The average of these two possibilities gives the Shapley contribution of the variable of interest.

4.3. Correlation Matrix

For the disaggregated model, it is useful to highlight the correlation coefficients between the explanatory variables in order to avoid any multicollinearity problem. The correlation matrix is given in the Table 2:

Table 2. Correlation matrix of the disaggregated model.

Variables	U	HC	I	PE	X	M
U	1					
HC	0.067	1				
I	0.346	0.611	1			
PE	0.130	0.731	0.589	1		
X	0.227	0.197	0.183	0.124	1	
M	0.220	0.620	0.491	0.429	0.424	1

Source: BCEAO (2019), INS (2019) and World Bank (2019) databases.

The correlation matrix generally shows a weak and positive correlation between the explanatory variables. However, strong correlations exist between the variables HC and I (0.6109), HC and PE (0.731), I and PE (0.589). The VIF (Variance Inflation Factor) test shows that multicollinearity is moderate.

4.4. Presentation of the Results

For the three estimated models, the diagnostic tests (normality, non-autocorrelation and homoscedasticity of the residues) and complement test (stability test) establish the validity of the OLS estimation method. The results of the estimates of the long-term relationship and that of the short-term dynamics of the model in difference are summarized in the Table 3.

Table 3. Model in difference estimation results (long term and short term relationships).

Variables	**Long term relationship**	**Short term relationship**
	Coefficients	**Coefficients**
$\Delta RGDP$	-0.001** (0.007)	
Dummy	-0.202 (0.816)	-0.074 (0.888)
$\Delta(\Delta RGDP_t)$		-0.0003** (0.012)
Residu (-1)		-1.076** (0.000)
R^2	0.186	0.176
Adjusted R^2	0.141	0.104
Prob. (F-statistic)	0.025	

Note: (**) significance at the 5% threshold, the values in brackets are the p-values.
Source: BCEAO (2019), INS (2019) and World Bank (2019) databases.

In the long-term relationship, the Okun coefficient (model in difference) is significant at the 5% level. The Okun coefficient has the expected sign but is very low at -0.001. The short-term relationship also displays a statistically significant and negative Okun coefficient at the 5% level (-0.0003). The coefficient of the residue (-1.076) is negative and significant at the 5% level. Therefore, the error correction model is valid. Following a shock, the unemployment rate returns to its equilibrium value after eleven months and five days ($1/\delta = 1/1.076$). Okun's law is valid in the short and long term but the link between economic activity and the labor market is very weak: a 1% increase in real GDP induces a decrease in the unemployment rate from 0.0003% to short term and 0.001% to long term.

The Table 4 presents the estimation results of the model in gap.

Table 4. Model in gap estimation results according to smoothing parameters 100, 400 and 500 of the Hodrick-Prescott filter (Long term and short term relationships).

Variables	**Coefficients (Long term relationship)**			**Coefficients (Short term relationship)**		
	100	**400**	**500**	**100**	**400**	**500**
$(u_t - u_n)$	-0.021 (0.169)	-0.025 (0.082)	-0.028 (0.065)			
$\Delta(u_t - u_n)$				-0.009 (0.440)	-0.011 (0.403)	-0.012 (0.383)
Resid (-1)				-0.568** (0.001)	-0.55** (0.001)	-0.556** (0.001)
Dummy	------	-0.064 (0.237)	-0.063 (0.246)	-0.085 (0.125)	0.972*** (0.078)	0.097*** (0.085)
R^2	0.051	0.116	0.124	0.345	0.330	0.329
Adjusted R^2	0.025	0.067	0.075	0.287	0.271	0.270
Prob (F- statistic)	0.169	0.108	0.093	0.002	0.003	0.003

Note: (**) significance at the 5% threshold, the values in brackets are the p-values.
Source: BCEAO (2019), INS (2019) and World Bank (2019) databases.

In the long term, the model in gap is not significant. In the short term, the coefficient of the residual which represents the restoring force of the unemployment rate towards its equilibrium is negative and significant at the 5% level (δ_{100} = -0,568; δ_{400} = -0,55 et δ_{500} = -0,556), the error correction model is therefore valid. The Okun coefficient has the expected negative sign but is not significant at the 5% level. Okun's Law is not valid in the short and long term.

The Table 5 presents the estimation results of the disaggregated model.

In the disaggregated model, the coefficient of the lagged residue (restoring force) is negative and significant at the 5% threshold. The error correction model is therefore valid. Following a shock, the unemployment rate returns to its equilibrium value after about a year and 1 day (1/(coefficient of the residual) = 1/0.9595). In long-term and short-term relationships, the Fisher statistic has a probability (0.000) less than 0.05, which reflects their overall significance at the 5% level. In the long term, aggregate demand explains 53.19% of the variations in the unemployment rate while in the short term, it explains 69.31%.

In the long term and in the short term, except for exports, the model variables are statically significant at the 5% or 10% level. In the long run and in the short run, final consumption and public expenditure have a significant and negative effect on the unemployment rate while gross fixed capital formation and imports positively affect the unemployment rate. A 1% increase in final consumption reduces unemployment by around 0.002% in the long run and 0.002% in the short run. A 1% increase in public expenditure reduces unemployment by around 0.004% in the long term and 0.007% in the short term. A 1% increase in gross fixed capital formation increases the unemployment rate by about 0.002% in the long run and 0.003% in the short run. A 1% increase in imports generates an increase in the unemployment rate of about 0.003% in the long run and 0.004% in the short run.

Table 5. Disaggregated model estimation results (long term and short term relationships).

Variables	Long term relationship		Short term relationship	
	Coefficients	Probability	Coefficients	Probability
ΔHC_t	-0.002**	0.002		
ΔI_t	0.002***	0.058		
ΔPE_t	-0.004**	0.049		
ΔX_t	0.0003	0.748		
ΔM_t	0.003**	0.006		
Dummy	0.881	0.281		
R^2	0.532	-------		
R^2 Ajusté	0.444	-------		
F-statistic	6.061	0.000		
$\Delta(\Delta HC_t)$			-0.002**	0.000
$\Delta(\Delta I_t)$			0.003 **	0.001
$\Delta(\Delta PE_t)$			-0.007**	0.000
$\Delta(\Delta X_t)$			0.001**	0.131
$\Delta(\Delta M_t)$			0.004**	0.000
Resid(-1)			-0.959**	0.000
Dummy			0.981	0.198
R^2			0.693	-------
Adjusted R^2			0.622	-------
F-statistic			9.682	0.000

Note: The values in brackets are the p-values (**) significance at the 5% threshold, (***) significance at the 10% threshold.
Source: BCEAO (2019), INS (2019) and World Bank (2019) databases.

The Table 6 gives the results of the Shapley decomposition in long-term and short-term relationships:

Table 6. Shapley decomposition.

Variables	Shapley R^2 (Long term)	Shapley R^2 (Short term)	Shapley R^2 (Average)	Average share in GDP
HC	22.801%	16.391%	19.595%	68.912%
I	3.940%	13.310%	8.621%	15.432%
PE	17.110%	14.431%	15.765%	16.404%
X	1.580%	13.722%	7.652%	--------
M	7.761%	11.473%	9.615%	--------
(X-M)	--------	--------	--------	3.951%

Source: BCEAO (2019), INS (2019) and World Bank (2019) databases.

The Shapley decomposition highlights the contribution of each component of aggregate demand to overall R^2. The results show that final consumption, which represents a share of 68.9% in the real GDP, alone explains 19.595% of movements in unemployment, followed by public expenditure (15.765%), imports (9.615%), gross fixed capital formation (8.62%) and finally exports (7.65%). Thus, unemployment movements depend on the contributions of aggregate demand to growth. In other words, the components of aggregate demand contribute to the variability of unemployment.

4.5. Interpretation and Discussion of the Results

The results show that either Okun's law is not valid in Côte d'Ivoire (model in gap), in accordance with the results of Karim and Aomar (2016) and Kouakou et al. (2019) or Okun's law is valid but with a very weak or almost non-existent link between economic growth and unemployment (model in difference), thus confirming the study of N'Guessan (2018). Ivorian economic growth is therefore struggling to create jobs in order to absorb the flow of job seekers entering the labor market each year. The disaggregated model, developed to identify the source of the low reactivity of unemployment to variations in production, shows the following results: final consumption and public expenditure reduce unemployment very slightly, while gross fixed capital formation and imports increase it very weakly. In contrast, exports have no effect on unemployment.

The Shapley decomposition reveals that we can explain the low reactivity of unemployment to variations in production, by the fact that the variability of unemployment depends essentially on final consumption, the main lever of the Ivorian economic model, and on public expenditure (all two represent 35.36% of the variability of unemployment). However, these two components of aggregate demand have a significant but very weak effect on unemployment. These results differ from those of Badr et al. (2018) on Morocco where the low reactivity of unemployment to variations in production is due to the fact that unemployment depends on the contributions of final demand essentially driven by investment and imports (40.7% of the variability of cyclical unemployment).

The low responsiveness of final consumption and public expenditure on unemployment could be explained by the fact that they mainly relate to consumer goods and capital goods that are not produced locally. In 2018, consumer and equipment goods consumed and invested in Côte d'Ivoire and not produced locally, represented 49.4% and 18.18% of imported goods respectively (Directorate General of the Economy, 2018). The Ivorian model of growth, driven by final consumption and public expenditure and highly extroverted, does not reduce unemployment because it does not sufficiently benefit the local production system.

5. Final Remarks

This study analyzes the reactivity of unemployment to the variation in production in Côte d'Ivoire using three Okun's law approaches: the approach in difference, the approach in gap and the disaggregated growth approach. These three approaches analyze long-term and short-term relationships via error correction models from time series data covering the period 1980-2019. If the first two approaches made it possible to highlight the weak link between economic growth and unemployment, the third approach made it possible to identify the source of this weak reactivity of unemployment to the variation in production.

This weak responsiveness of unemployment to the variation in production in Côte d'Ivoire is mainly due to the fact that final consumption and public expenditure, which largely explain the variability of unemployment there, have a very low impact on the unemployment rate. They therefore do not help create enough jobs. Final consumption and public expenditure are mostly on goods and equipment not produced locally, reflecting the extroverted nature of economic growth. In other words, Okun's law works poorly in Côte d'Ivoire because of the extroversion of the Ivorian economy. This therefore requires a structural reorientation of the economy aimed at the relocation of production. This may involve stepping up policies to promote local industries aimed at replacing certain imported consumer goods and equipment. The public authorities can also strengthen the public procurement policy and award more public contracts to local businesses.

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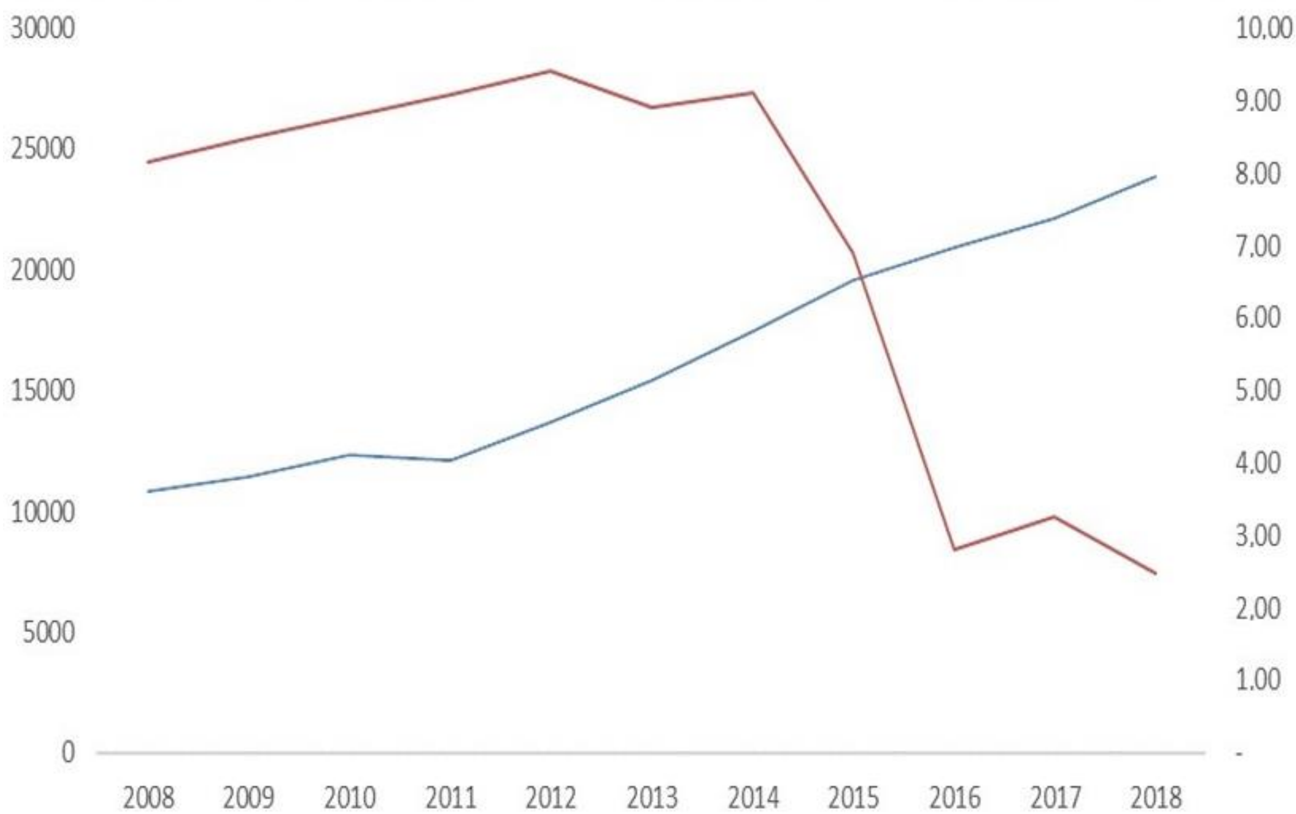
Appendix

Appendix 1 presents the comparative evolution of real GDP growth ant unemployment rate in Côte d'Ivoire over the period 1980-2019.



Appendix 1. Comparative evolution of real GDP growth and unemployment rate.

Note: Red color: Unemployment rate; Blue color: Real GDP growth.
Source: World Bank (2019) and INS (2019).

Appendix 2 presents the results of unit root tests.

Appendix 2. Stationarity tests results.

Table A1. Stationarity tests results: Model in difference.

Variables	ADF		PP		Decision
	In level	In first difference	In level	In first difference	
U	-0.646 (0.431)	-4.318 (0.000)	-0.586 (0.457)	-4.310 (0.000)	I(1)
RGDP	-3.331 (0.999)	-3.783 (0.028)	9.903 (1.000)	-3.747 (0.031)	I(1)
u (Gap)	-0.646 (0.431)	-4.318 (0.000)	-0.586 (0.457)	-4.310 (0.000)	I(1)
RGDP (Gap)	-3.331 (0.999)	-3.783 (0.028)	9,903 (1.000)	-3.747 (0.031)	I(1)
HC	8.967 (1.000)	-6.278 (0.000)	9.234 (1.000)	-6.363 (0.000)	I(1)
I	3.475 (0.9997)	-4.499 (0.005)	4.16 (1.000)	-4.222 (0.01)	I(1)
PE	2.493 (0.996)	-4.005 (0.016)	4.858 (1.000)	-4.005 (0.016)	I(1)
X	-2.280 (0.434)	-2.461 (0.015)	-2.28 (0.434)	-2.539 (0.012)	I(1)
M	-1.621 (0.766)	-3.573 (0.000)	-1.986 (0.596)	-4.623 (0.000)	I(1)

Note: The values in brackets are the Mackinnon p-values.
Source: BCEAO (2019), INS (2019) and World Bank (2019) databases.

Appendix 3 exhibits the results of cointegration test.

Appendix 3. Cointegration tests results.

Table A2. Stationarity of the residual: Model in difference.

Residue	ADF (in level)	PP (in level)	Conclusion
ε_t	-5.548** (0.000)	-5.642 (0.000)	I (0)

Note: (**) significance at the 10% threshold, the values in brackets are Mackinnon's p-values.
Source: BCEAO (2019), INS (2019) and World Bank (2019) databases.

Mackinnon's p-value (0.000) is less than 5%, so we reject the null hypothesis of the existence of a unit root for the residue. The residue is therefore stationary in level, hence the presence of a cointegrating relation.

Table A3. Stationarity of the residual: Model in gap.

Residue	100		400		500	
	ADF	PP	ADF	PP	PP	ADF
ε_t	-2.665 (0.009)	-2.672 (0.009)	-0.304 (0.003)	-3.236 (0.002)	-3.616 (0.000)	-3.072 (0.003)
	I (0)		I (0)		I (0)	

Source: BCEAO (2019), INS (2019) and World Bank (2019) databases.

The ADF and PP unit root tests show p-values less than 0.05. The null hypothesis of the presence of a unit root in level is rejected at the 5% threshold. The residuals are therefore stationary in level, hence the presence of a cointegration relation.

Table A4. Johansen cointegration test: Disaggregated model.

Trace test	Maximum eigenvalue test
0.000** (190.289)	0.000** (78.691)
0.000** (111.597)	0.002** (48.871)
0.062 (62.725)	0.152 (27.839)
0.251 (34.886)	0.604 (15.343)
0.258 (19.543)	0.342 (12.845)
0.377 (6.698)	0.377 (6.698))

Note: The values in brackets are the t-statistics, (**): Significance at the 10% threshold.
Source: BCEAO (2019), INS (2019) and World Bank (2019) databases.

The trace test and the maximum eigenvalue test indicate the existence of two cointegrating relations. The variables are therefore cointegrated. However, we will estimate a cointegrating relation.

Table A5. Stationarity of the residual: Disaggregated model.

Residue	ADF (In level)	PP (In level)
ε_t	-5.108 (0.000)	-9.681 (0.000)
	I (0)	I (0)

Note: The values in brackets are Mackinnon's p-values.
Source: BCEAO (2019), INS (2019) and World Bank (2019) databases.

The ADF and PP unit root tests show p-values less than 0.05. The null hypothesis of the presence of a unit root in level is rejected at the 5% threshold. The residues are therefore stationary in level.

Appendix 4 shows the descriptive statistics.

Appendix 4. Descriptive statistics.

Table A6. Descriptive statistics of the variables: Model in difference.

Variables	Observation	Mean	Standard deviation	Minimum	Maximum
RGDP	40	11 766.551	9217.297	1782.812	34298.890
U	40	5.545	2.216	2.311	9.410

Source: BCEAO (2019), INS (2019) and World Bank (2019) databases.

Table A7. Descriptive statistics of the variables: Model in gap.

Variables	Observation	Mean	Standard deviation	Minimum	Maximum
RGDP	40	11 766.55	9217.297	1782.8	34298.89
U	40	5.545	2.216	2.311	9.410

Source: BCEAO (2019), INS (2019) and World Bank (2019) databases.

The average real GDP value is 11,766.55 billion with a dispersion around the average of 9,217.297 billion. This shows a high variability of real GDP over the period 1980 to 2019. It admits a minimum of 1782.8 billion. The average unemployment rate is around 5.545%. The minimum (respectively maximum) unemployment rate is 2.31% (respectively 9.41%). The unemployment rate has a weak distribution around the average, i.e. 2.216%.

Table A8. Descriptive statistics of the variables: Disaggregated model.

Variables	Observation	Mean	Standard deviation	Minimum	Maximum
U	40	5.545	2.216	2.311	9.420
ΔHC_t	39	313.563	332.936	-239.428	1150.89
ΔI_t	39	50.576	123.102	-219.308	429.685
ΔPE_t	39	43.892	76.557	-76.549	242.165
ΔX_t	39	72.781	124.997	--156.886	388.571
ΔM_t	39	63.363	142.565	-326.184	620.034

Source: BCEAO (2019), INS (2019) and World Bank (2019) databases.

Household final consumption has an average contribution to growth of 313.563 with a maximum (minimum) contribution of 1150.89 (-239.428). On average, gross fixed capital formation contributes to growth to the tune of 50,576 and shows a dispersion of 123,102. The maximum (minimum) value of this contribution is 429.685 (--219.308). Both exports and imports have an average contribution to growth of 72.78 and 63.363 respectively. Also, public expenditure presents a contribution to growth of 43,892. Observation of descriptive statistics conclude that household consumption contributes more to the continued growth of exports and imports. However, note that the contributions to the growth of external demand and final consumption are highly dispersed (332.936 for private consumption; 124.997 and 142.565 for external demand). Compared to the latter, public expenditure shows little dispersion around the average (76.557).

Appendix 5 shows the VIF test.

Appendix 5. VIF test.

The decision rule is: If the average of the VIF is equal to 1, there is no multicollinearity. If the average of the VIF is between 1 and 5, the multicollinearity is moderate. If the average of the VIF is greater than 5 then there is a strong multicollinearity. The test results contained in the table below show that the multicollinearity is moderate.

Table A9. Variance inflation factor (VIF) analysis.

Variable	VIF	1/VIF
ΔHC	2.970	0.336
ΔPE	2.361	0.424
ΔI	1.811	0.553
ΔM	1.992	0.503
ΔX	1.231	0.813
Mean VIF	2.071	0.483

Appendix 6 shows the theoretical principle of Shapley decomposition.

Appendix 6. Shapley decomposition of R^2.

<u>Example</u>

$$y = \alpha + b_1 x_1 + b_2 x_2 + e$$

$$S_{x_1} = \frac{1}{2}[R^2(\alpha + b_1 x_1 + b_2 x_2 + e) - R^2(\alpha * + b *_2 x_2 + e *) + R^2(\alpha ** + b **_1 x **_1 + e **)]$$

$$S_{x_2} = \frac{1}{2}[R^2(\alpha + b_1 x_1 + b_2 x_2 + e) - R^2(\alpha ** + b **_1 x_1 + e **) + R^2(\alpha + b *_2 x *_2 + e *)]$$

Case of this study

Variables	Marginal effect on overall R^2
HC	$\frac{1}{2}[R^2_{(\alpha+\beta_1\theta_{CF}*\Delta CF_t+\beta_2\theta_{FBCF}*\Delta FBCF_t+\beta_3\theta_G*\Delta G_t+\beta_4\theta_X*\Delta X_t+\beta_5\theta_M*\Delta M_t+\varepsilon_t)} + R^2_{(\alpha+\beta_1\theta_{CF}*\Delta CF_t+\varepsilon_t)} - R^2_{(\alpha+\beta_2\theta_{FBCF}*\Delta FBCF_t+\beta_3\theta_G*\Delta G_t+\beta_4\theta_X*\Delta X_t+\beta_5\theta_M*\Delta M_t+\varepsilon_t)}]$
I	$\frac{1}{2}[R^2_{(\alpha+\beta_1\theta_{CF}*\Delta CF_t+\beta_2\theta_{FBCF}*\Delta FBCF_t+\beta_3\theta_G*\Delta G_t+\beta_4\theta_X*\Delta X_t+\beta_5\theta_M*\Delta M_t+\varepsilon_t)} + R^2_{(\alpha+\beta_2\theta_{FBCF}*\Delta FBCF_t+\varepsilon_t)} - R^2_{(\alpha+\beta_1\theta_{CF}*\Delta CF_t+\beta_3\theta_G*\Delta G_t+\beta_4\theta_X*\Delta X_t+\beta_5\theta_M*\Delta M_t+\varepsilon_t)}]$
PE	$\frac{1}{2}[R^2_{(\alpha+\beta_1\theta_{CF}*\Delta CF_t+\beta_2\theta_{FBCF}*\Delta FBCF_t+\beta_3\theta_G*\Delta G_t+\beta_4\theta_X*\Delta X_t+\beta_5\theta_M*\Delta M_t+\varepsilon_t)} + R^2_{(\alpha+\beta_3\theta_G*\Delta G_t+\varepsilon_t)} - R^2_{(\alpha+\beta_2\theta_{FBCF}*\Delta FBCF_t+\beta_1\theta_{CF}*\Delta CF+\beta_4\theta_X*\Delta X_t+\beta_5\theta_M*\Delta M_t+\varepsilon_t)}]$
X	$\frac{1}{2}[R^2_{(\alpha+\alpha+\beta_1\theta_{CF}*\Delta CF_t+\beta_2\theta_{FBCF}*\Delta FBCF_t+\beta_3\theta_G*\Delta G_t+\beta_4\theta_X*\Delta X_t+\beta_5\theta_M*\Delta M_t+\varepsilon_t)} + R^2_{(\alpha+\beta_4\theta_X*\Delta X_t+\varepsilon_t)} - R^2_{(\alpha+\beta_2\theta_{FBCF}*\Delta FBCF_t+\beta_3\theta_G*\Delta G_t+\beta_4\theta_{CF}*\Delta CF_t+\beta_5\theta_M*\Delta M_t+\varepsilon_t)}]$
M	$\frac{1}{2}[R^2_{(\alpha+\alpha+\beta_1\theta_{CF}*\Delta CF_t+\beta_2\theta_{FBCF}*\Delta FBCF_t+\beta_3\theta_G*\Delta G_t+\beta_4\theta_X*\Delta X_t+\beta_5\theta_M*\Delta M_t+\varepsilon_t)} + R^2_{(\alpha+\beta_5\theta_M*\Delta M_t+\varepsilon_t)} - R^2_{(\alpha+\beta_2\theta_{FBCF}*\Delta FBCF_t+\beta_3\theta_G*\Delta G_t+\beta_4\theta_X*\Delta X_t+\beta_1\theta_{CF}*\Delta CF_t+\varepsilon_t)}]$

Appendix 7 presents the different validation tests.

Appendix 7. Model validation tests.

Error autocorrelation test

The presence or absence of autocorrelation can be detected by the Durbin-Waston, Ljung-Box and Breusch-Godfrey tests. If the error terms are correlated, we will use the Cochrane Orcutt method to correct for the autocorrelation problem.

Table A10. Autocorrelation test.

Autocorrelation test of order 1 (Breusch-Godfrey)	Model in difference	Model in gap			disaggregated model
		Smoothing parameter			
		100	400	500	
Long term	0.151	0.000	0.000	0.000	0.065
Short term	0452	0.036	0.0417	0.041	0152

Note: if p-value <0.05, autocorrelation is present at the 5% level.
Source: BCEAO (2019), INS (2019) and World Bank (2019) databases.

- Heteroscedasticity test of errors terms

The error heteroskedasticity test can be performed using White test.

Table A11. Heteroskedasticity test.

heteroskedasticity test (White)	Model in difference	Model in gap			Disaggregated model
		Smoothing parameter			
		100	400	500	
Long term	0.411	0.261	0.551	0.750	0.452
Short term	0.012	0.110	0 .352	0.681	0.203

Note: In the presence of heteroskedasticity of errors, we will use the robust least squares method. Decision: p-value <0.05, the errors are heteroscedastic at the 5% threshold.
Source: BCEAO (2019), INS (2019) and World Bank (2019) databases.

- Tests of normality of errors and of model stability

The test of normality of the errors and that of stability of the model will be done respectively by the tests of Jarque-Bera and that of Cusum.

Model in difference (long term relationship)

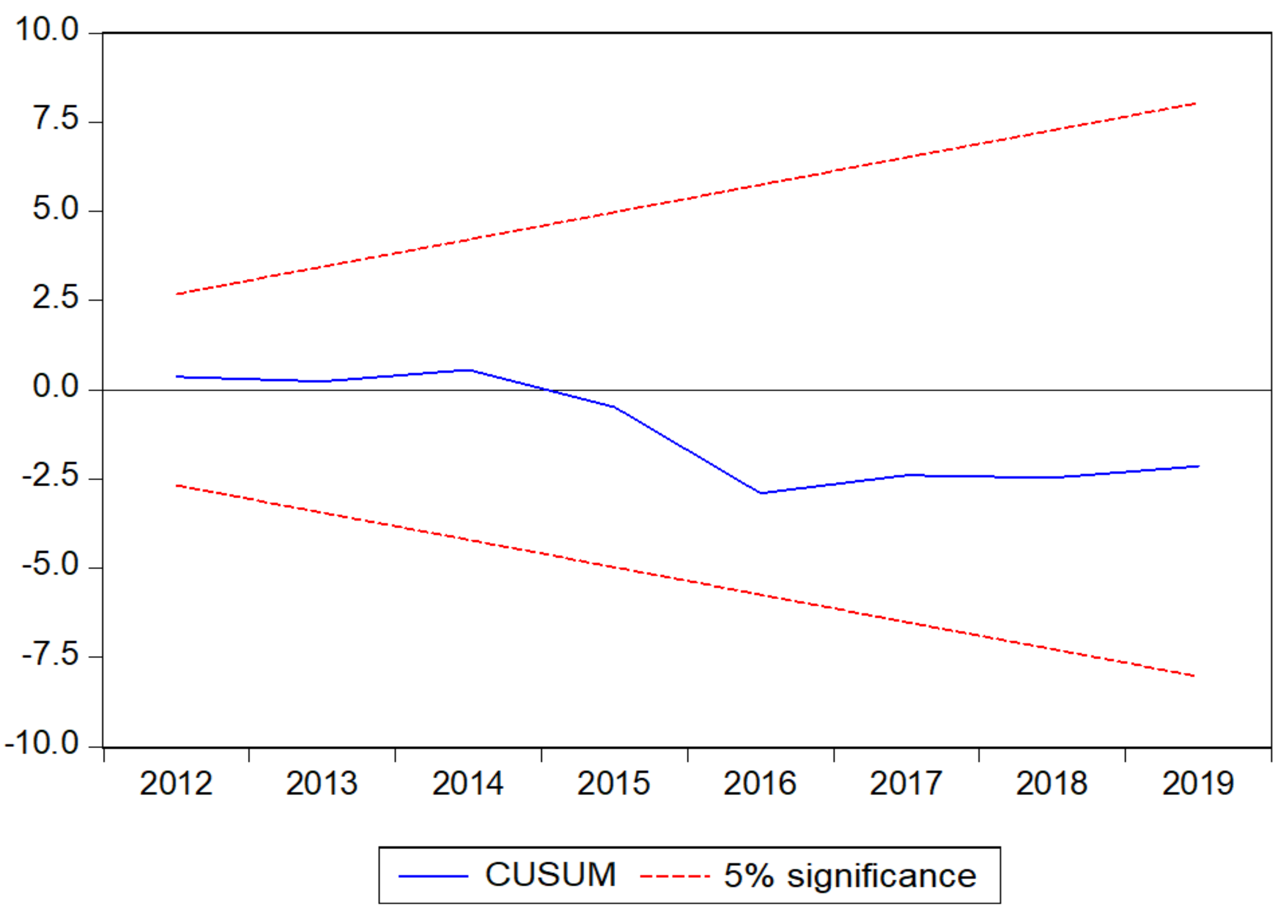


Figure 1A. CUSUM tests for model in difference.

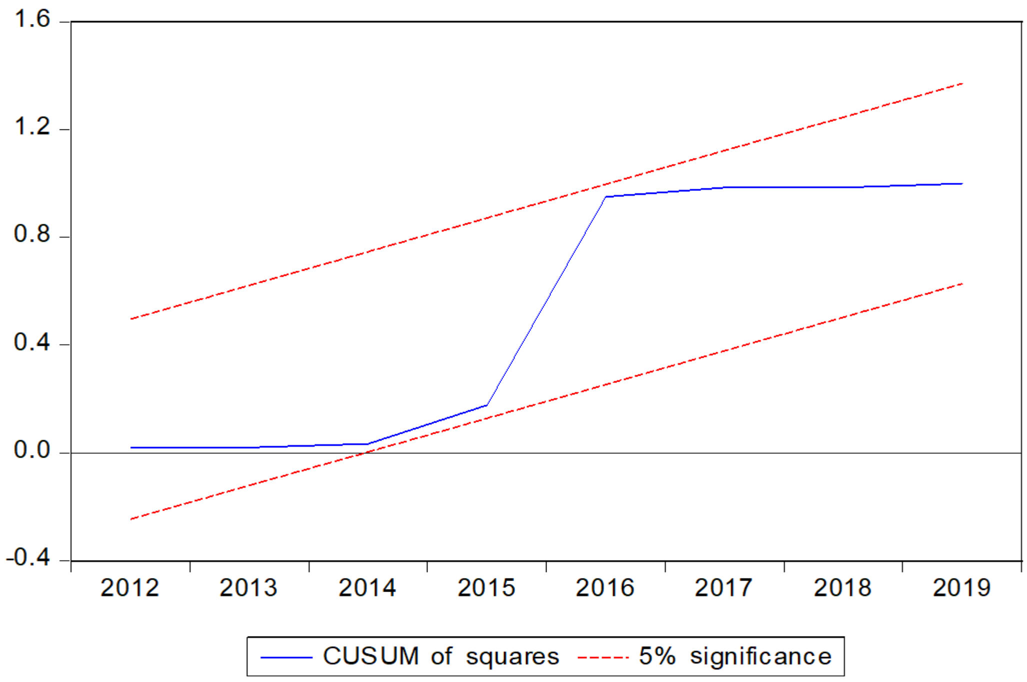


Figure 2A. CUSUM tests for model in gap.

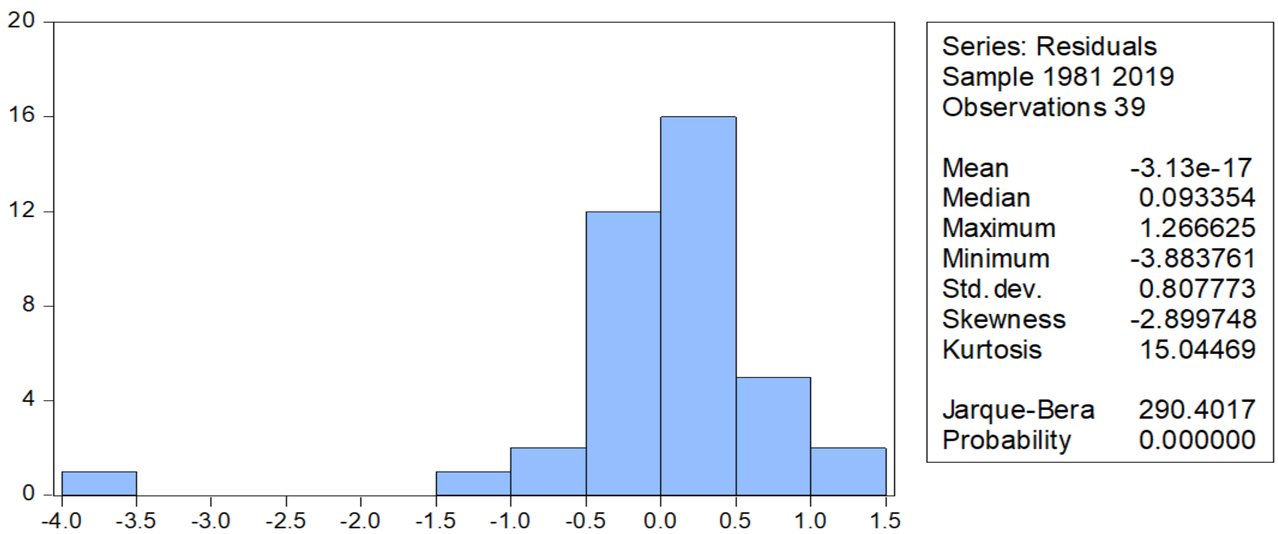


Figure 3A. Normality test for model in difference.

The errors term follows a normal distribution.

Model in difference (short term relationship)

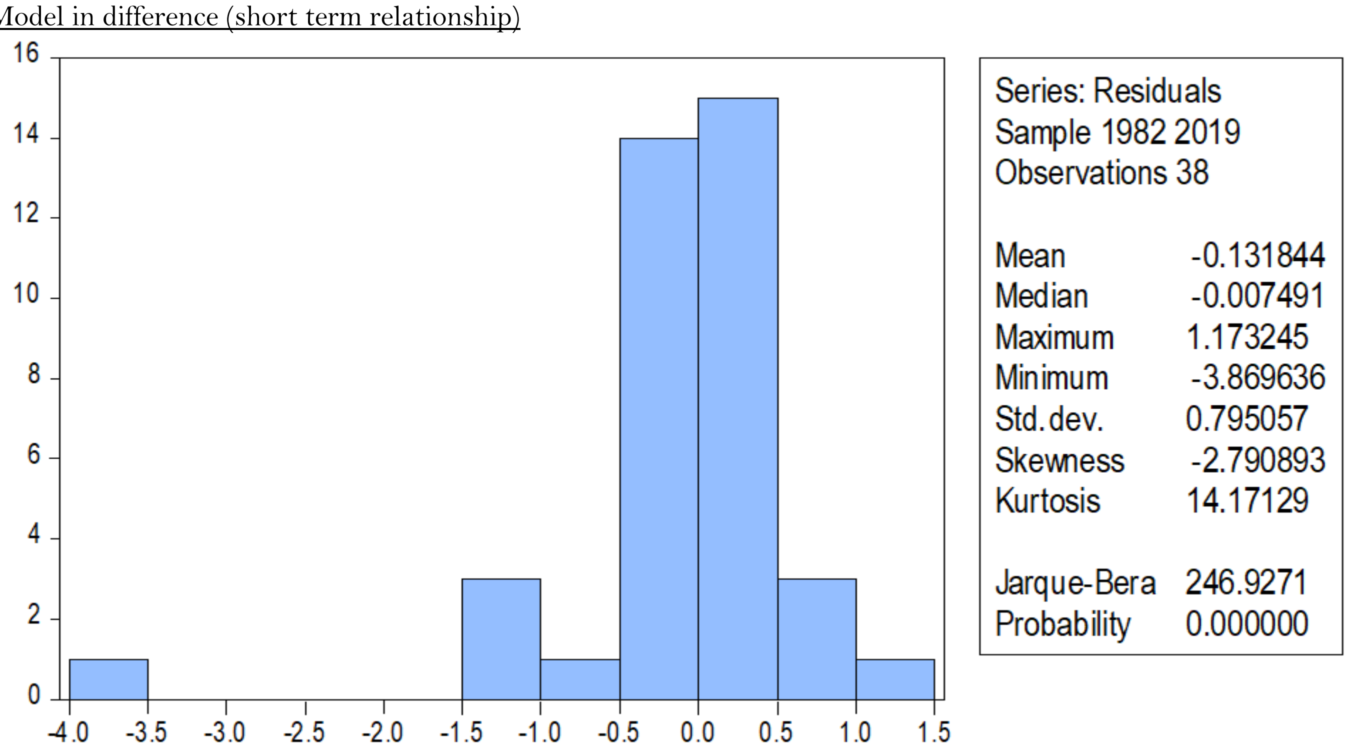


Figure 4A. Normality test for model in gap.

The errors term follows a normal distribution.

Disaggregated model (long-term relationship)

The errors term follows a normal distribution.

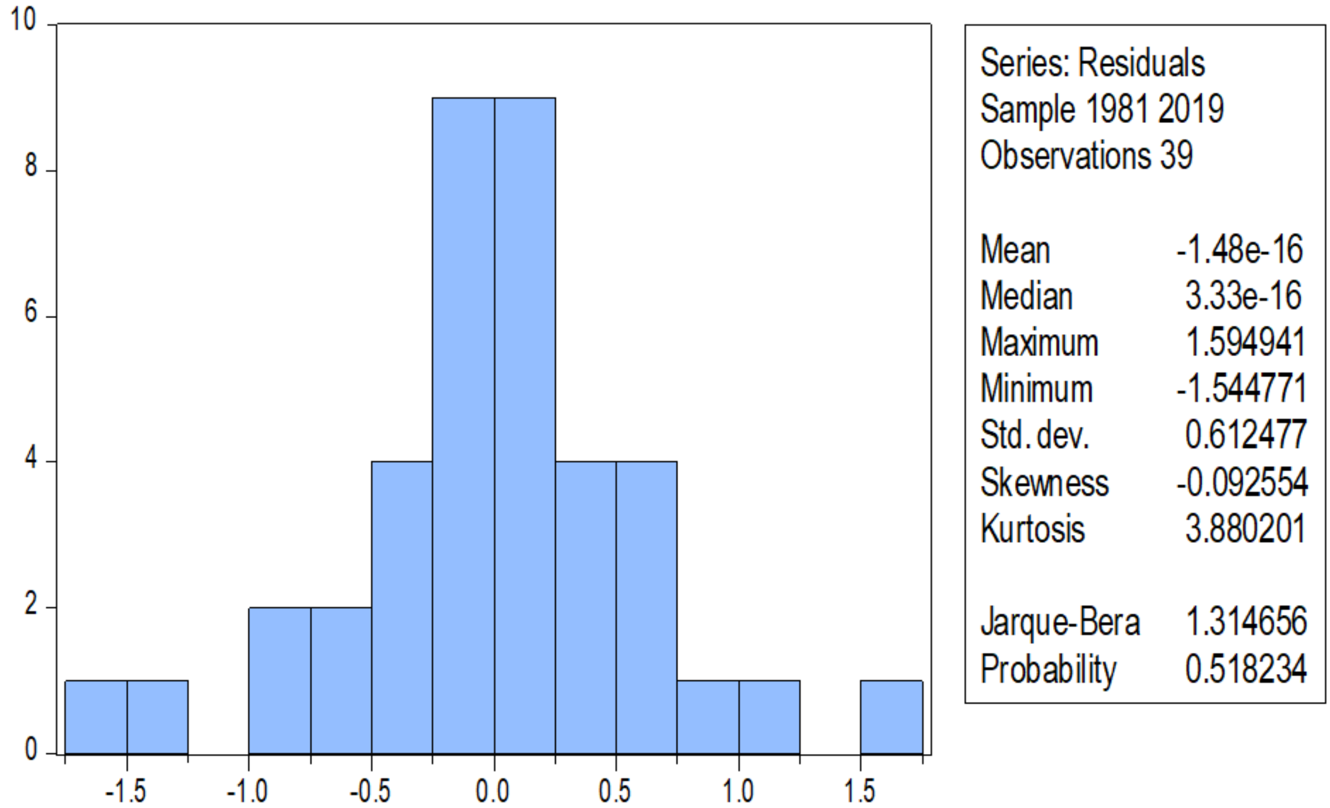


Figure 5A. Normality test for disaggregated long-term model.

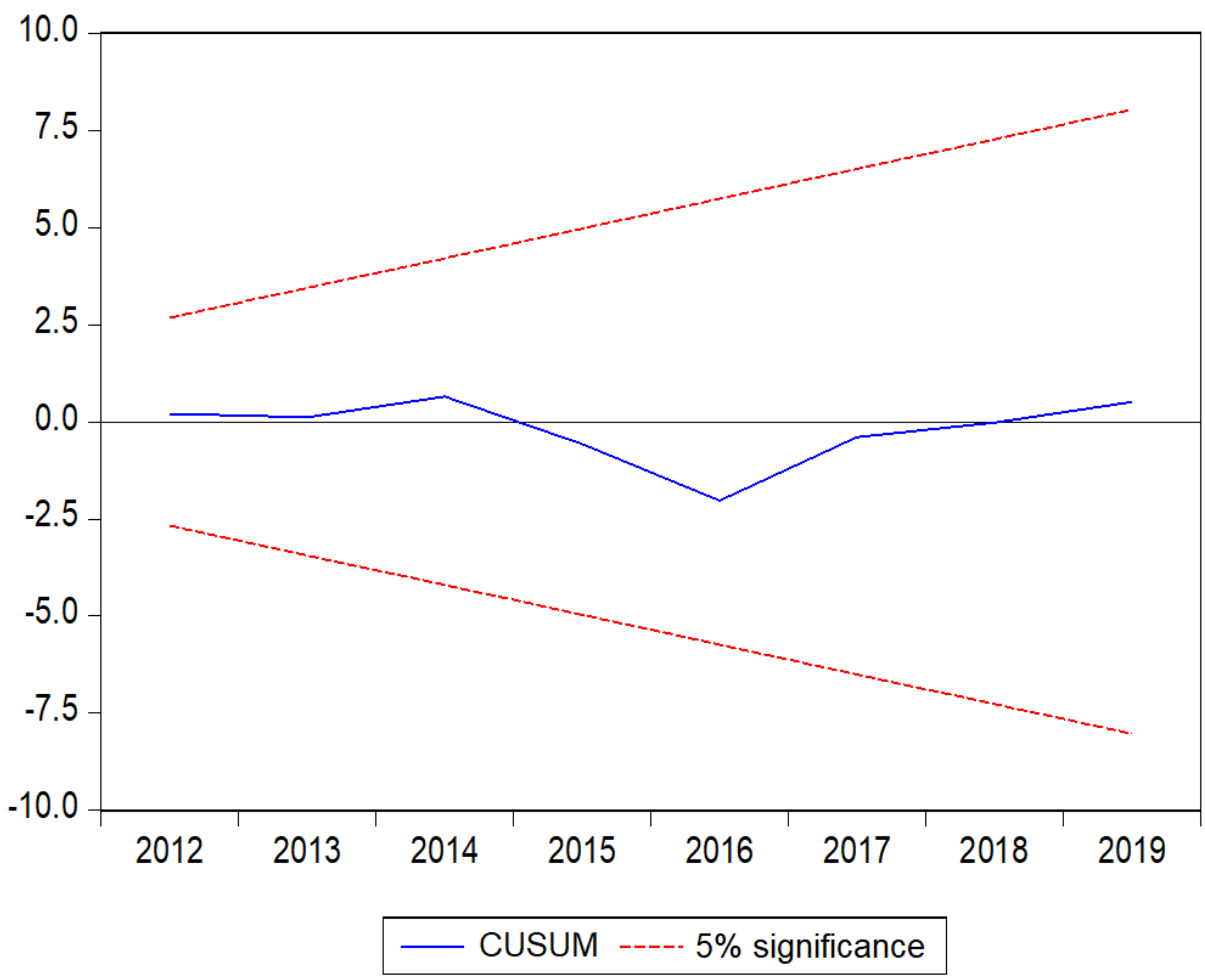


Figure 6A. Cusum test for disaggregated long-term model.

The stability of the model is confirmed by the Cusum test but rejected by the Cusum squared test : the curve leaves the corridor precisely between 1997 and 2016, hence the need to introduce a dummy variable in order to stabilize the model.

Disaggregated model (short term relationship)

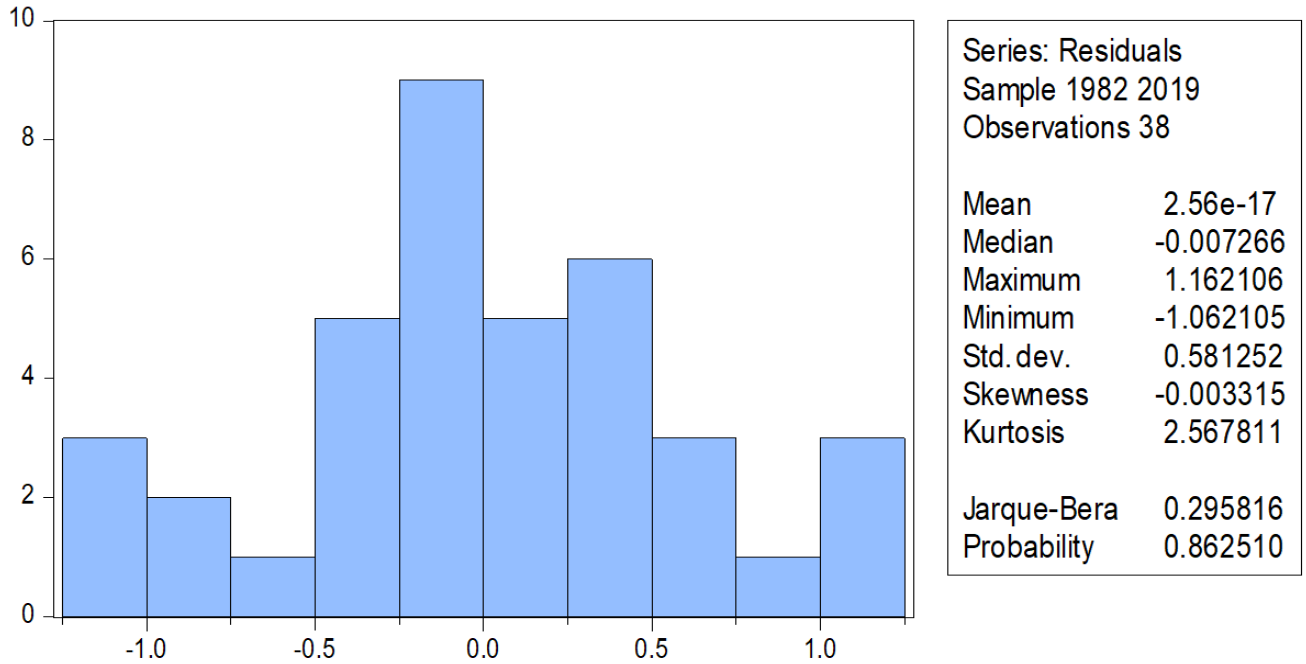


Figure 7A. Normality test for disaggregated short-term model.

The errors term follows a normal distribution.

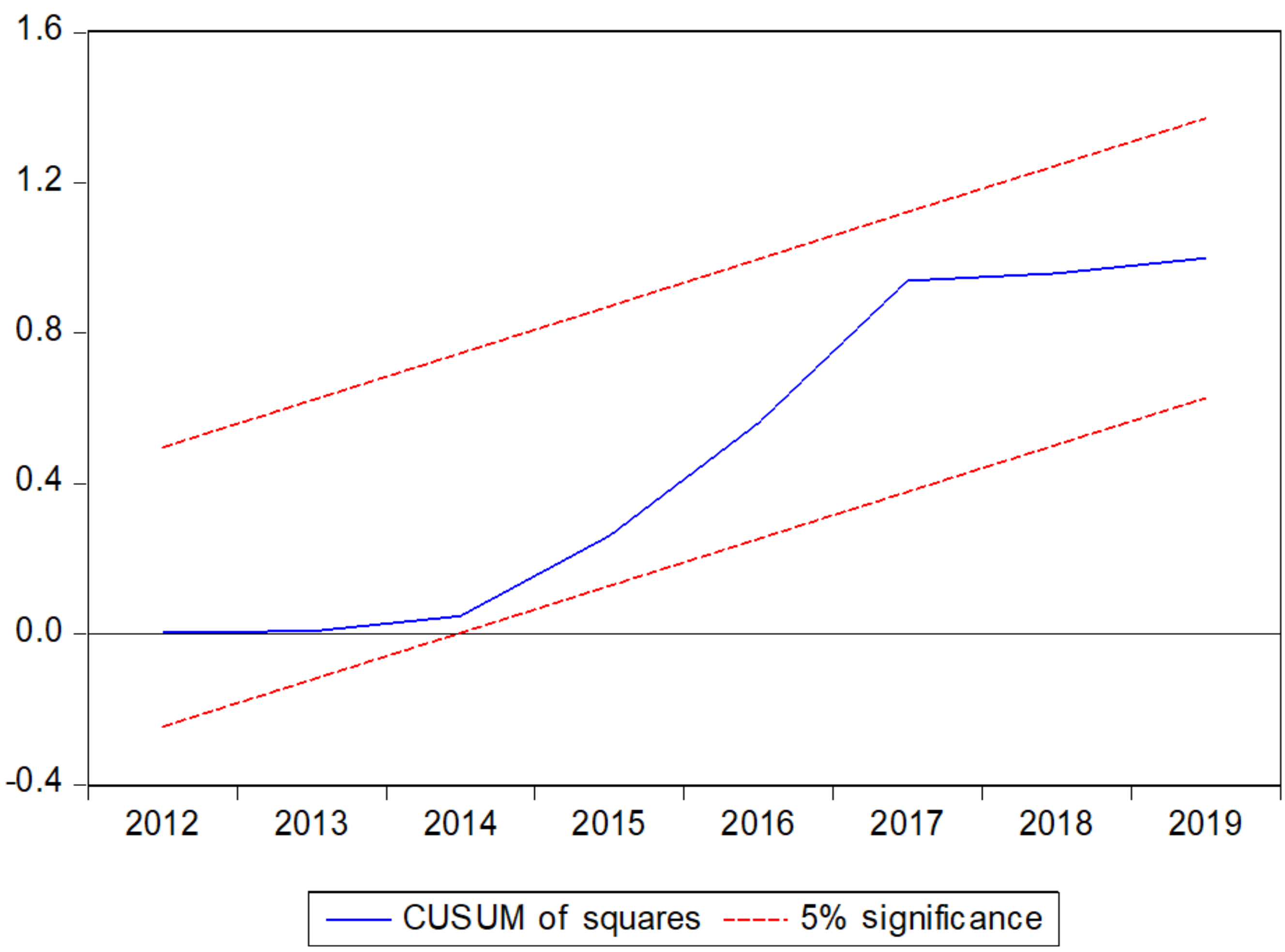


Figure 8A. Cusum test for disaggregated short-term model.