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Characterization of the Economic Growth of Côte d'Ivoire from 1960 to 2021: An Application of the Bai-Perron Multiple Break Test Approach

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Abstract

The objective of this work is to characterize the economic growth of Côte d'Ivoire over the period from 1960 to 2021. It is justified by the series of economic, institutional and governance, or economic policy shocks that the country has experienced since its accession to independence. In fact, these shocks can have effects that could upset economic activity at any time. With time series data on the Gross Domestic Product (GDP), capital, labor, and trade openness covering the period of the study, we use the Bai-Perron multiple break test applied to a Solow-type economic growth model in open economy. The results show a maximum of five significant break dates at the 5% threshold. These dates are 1971, 1981, 1990, 1999 and 2010. They determine six structural regimes during which the elasticities of the gross domestic product in relation to the exogenous variables change.

Keywords

Economic Growth, Bai-Perron Multiple Break Test Approach, Structural Change, Côte d'Ivoire

1. Introduction

Economic growth has always been one of the most important issues on the agenda of national governments and international economic and financial institutions alike. This great interest is justified by the place economic growth occupies in the development process. Indeed, without economic growth, any development process seems impossible. Only the creation of additional wealth can improve the well-being of the population.

The example of developed countries illustrates the importance of growth in the development process. As economic growth began and progressed slowly across Europe, this largely explains why development began in Western Europe before spreading to other regions of the world (Perkins et al., 2006). The underdeveloped countries experienced a delayed start to growth after the Second World War and remain undeveloped to this day. As a result, countries that experienced economic growth earlier are much further ahead in the development process than countries that experienced economic growth later (Perkins et al., 2006).

However, the dynamics of growth are often hampered by various phenomena that can even alter its trajectory. These phenomena could include oil crises, falling commodity prices, changes in economic policies, changes in political regimes, political crises, armed conflicts or wars, etc.

Côte d'Ivoire's experience of economic development shows that the country's economy, like that of most developing countries, especially in Sub-Saharan Africa, has suffered a number of shocks (Domergue, 2003). Thus, after spectacular growth since independence in 1960, the Ivorian economy experienced an unprecedented slump in 1980, a period marked by a drastic drop in world prices for the main agricultural products on which the economy is based. According to World Development Indicators (2022), Côte d'Ivoire's growth rate, which was 10.90% in 1977, fell to 2.39% in 1979, before dropping to −10.96% in1980. According to Tano (2008), the world price of cocoa, for example, after reaching high levels in the 1970s, has remained unstable since the end of that decade, with a downward trend. In 1994, the CFA franc (Communauté Financière Africaine) was devalued. From 1999 onwards, Côte d'Ivoire entered a spiral of politico-military crises, with a military coup, followed by the partition of the country in two after the 2002 elections, and ending with the politico-military crisis following the 2010 presidential elections.

With this in mind, it is important to examine the behavior of economic growth over the period from 1960 to 2021: have the shocks that have occurred had significant effects, to the point of modifying the trajectory of economic growth, or have the effects remained insignificant or rapidly transitory, to the point of leaving the trajectory of growth unchanged? The aim of this study is therefore to characterize the economic growth of Côte d'Ivoire from 1960 to 2021. Specifically, the aim is firstly to determine the dates of breaks in the growth process and then to estimate the growth models according to the estimated breakpoints, and secondly to specify the nature of the events or shocks that characterize each structural regime of the study period. The methodology used is based on the Bai-Perron multiple break test applied to Solow's (1956) growth model. The method used to estimate the models, relative to the estimated breakpoints, is the least-squares method with breakpoints. The main findings of the study are that Ivorian growth is structurally unstable, with a maximum of 5 breakpoints. The contributions of the different variables in the model differ from one structural regime to another. Ivorian economic growth is generated by a random walk with no drift.

The present study is organized around three sections. Section 2 reviews the literature on rupture tests. The methodological approach is presented in Section 3. Section 4 deals with results and discussions.

2. Literature Review

2.1. History of Rupture Testing

According to Uctum (2007), a precise definition of structural change is not proposed in the literature, as Maddala and Kim (1999) note, however, the statistical phenomenon commonly associated with it is the modification of the values taken by all or some of the parameters of a linear model. Stability or breakpoint tests are used to detect structural changes in a regression model. They are used to demonstrate the stability or otherwise of an econometric model. One of the most important of these tests is the Bai-Perron test, which detects the existence of several unknown breakpoints in a model, thus making it possible to analyze the stability of the parameters of an econometric model.

The study of the stability of econometric models has been the subject of numerous developments in the econometric literature. The works that laid the foundations for studies of structural change problems can be traced back to Quandt (1958), Chow (1960) and Barten and Bronsard (1970), for whom the stability test was conducted in relation to a date known in advance, after which a break with the pre-date regime was assumed. The work of Brown, Durbin, and Evans (1975), in the context of so-called cumulative sum tests, analyzes structural and punctual changes without considering a known break date in advance.

After these works, those that follow now consider as unknown the break dates that are the subjects of estimation. Moreover, they no longer assume the existence of a single break date, but the existence of several break dates, i.e. multiple regimes of structural change. The works that consecrate this new orientation are those of Yao (1988) and Yao and Au (1989), who study the estimation of the number of changes in the mean of a sequence of variables using Bayesian Information Criteria (BIC). Garcia and Perron (1996) study the case of two changes in an econometric model using a Wald test. Quandt-Andrews generalizes Chow's (1960) test by no longer testing for the presence of a single a priori known breakpoint, but for the presence of one or more unknown points in a sample for a specified equation, based on a test statistic that synthesizes those of Chow's test. Following the work of Liu, Wu, and Zidek (1997) and Andrews, Lee, and Ploberger (1996), Bai and Perron (2003) address estimation and inference problems in a very general linear model allowing for the presence of several structural changes. Bai (1997) and Bai and Perron (1998a) extend the Quandt-Andrews framework by considering multiple unknown breakpoints. Bai and Perron (2003) discuss practical estimation problems in more detail and present simulation results on the small-sample properties of estimators, tests and procedures for selecting the number of changes. Bai and Perron (1998a) modify Bai's (1997) approach by considering that at each stage of the test the number of breakpoints under the null hypothesis is obtained by a global minimization of the sum of squares of residuals.

2.2. Some Studies Based on the Application of Bai-Perron Tests

The rupture tests of Bai and Perron (1998a, 2003) have been used in a wide variety of fields. Here, we present some of the applications. Papell, Murray, and Ghiblawi (2000) use Bai and Perron's multiple structural break tests to estimate natural unemployment rates for 19 OECD countries from 1955 to 2011. The main exception is the USA, where long-term unemployment rose in the 1970s and fell in the 1980s. Furthermore, Rao and Rao (2009), applying the test of Bai and Perron (1998a, 2003), found that the Fijian economy became more energy-efficient after the 1981-1983 oil crisis. Mensi, Hammoudeh, and Yoon (2014) show that although oil price and yield series are volatile in nature, they are significantly less so when Bai and Perron's (1998, 2003) methodology is applied to allow for structural breaks, with break dates largely coinciding with the announcement of a decision to "cut" or "maintain" OPEC (Organization of the Petroleum Exporting Countries) production. In other words, much of the volatility can be explained by structural breaks where a particular period of greater or lesser volatility is triggered by an OPEC policy decision (Mensi, Hammoudeh, & Yoon, 2014). Le Bihan (2004) applies Bai and Perron's (1998a) various tests for structural change and confirms the existence of a significant break in French trend growth around 1973, at the time of the first oil shock, with no significant break detected in the period after 1974.

These various studies apply the Bai-Perron multiple break test essentially within the framework of a univariate analysis in the analysis of a break in the trend. Such an approach conceals the impact of potential explanatory variables on the variable of interest on the one hand, and ignores changes in the contributions of important explanatory variables to the formation of the explained variable on the other. Using a multiple breakpoint test applied to a multiple regression, this study aims not only to identify breakpoints, but also to distinguish, for each regime, those variables whose contributions to the formation of the dependent variable are statistically significant. So, unlike the application of the Bai-Perron test in a univariate framework, the approach used in this study has the advantage of being able to give an economic interpretation to breakpoints found to be significant.

3. Methodology

This section presents the data used in this study and its source and describes the model.

3.1. Data

Table 1 describes the variables used in the model. They are taken from the World Bank's World Development Indicators (2022) for the period from 1960 to 2021.

Table 1. Descriptive table of model variables.

Variables	Symbols	Descriptions	Periods
GDP	Y	Gross domestic product deflated by the consumer price index	1960-2021
Capital	K	Gross fixed capital formation deflated by the consumer price index	1960-2021
Labor	L	Workforce	1960-2021
Trade Openness	O	Volume of trade in goods and services obtained by dividing the sum of imports and exports deflated by the consumer price index	1960-2021

Source: Authors' calculations.

3.2. Models

Since the aim of our study is to analyze the instabilities involved in the process of achieving growth in Côte d'Ivoire. Our approach is based on Solow's (1956) growth model applied to an open economy, the simplest form of which is represented by a Cobb-Douglas production function:

$$Y_t = AK_t^{\alpha} L_t^{\beta} O_t^{\gamma} \tag{1}$$

where Y_t is real GDP, K_t is gross capital formation, L_t is number of workers, O_t is trade openness, A is a constant. The parameters α, β and γ are elasticities to be estimated.

Applying the natural logarithm to model 1, we obtain:

$$\log(Y_t) = \log(A) + \alpha \log(K_t) + \beta \log(L_t) + \gamma \log(O_t) \tag{2}$$

Let us use lower-case letters to denote the logarithms of model (2). We obtain:

$$y_t = \delta + \alpha k_t + \beta l_t + \gamma o_t + \varepsilon_t \tag{3}$$

where y is the logarithm of GDP, k is the logarithm of capital, l is the logarithm of the number of workers and o is the logarithm of trade openness.

We are only interested in the long-term relationship between the different variables in the model, as specified in (2) or (3). We consider this general linear model with m breaks or changes or $m + 1$ structural change regimes. It is assumed that all model parameters are subject to change. The model is therefore pure structural change. The model with m breaks is written as:

$$\begin{aligned} y_t &= \alpha_1 + \delta_1 k_t + \beta_1 l_t + \gamma_1 o_t + \varepsilon_t, \quad t = 1,\cdots,T_1 \\ y_t &= \alpha_2 + \delta_2 k_t + \beta_2 l_t + \gamma_2 o_t + \varepsilon_t, \quad t = T_1,\cdots,T_2 \\ &\vdots \\ y_t &= \alpha_m + \delta_m k_t + \beta_m l_t + \gamma_m o_t + \varepsilon_t, \quad t = T_m,\cdots,T \end{aligned} \tag{4}$$

where y_t is the time-dependent variables and k_t, l_t and o_t are the time-independent variables. $(\alpha_j, \delta_j, \beta_j, \gamma_j)_{j=1,\cdots,m}$ is the vector of coefficients and ε_t the error term at time t. The dates $(T_1,\cdots,T_m)$ are the dates of change. They are unknown in the Bai-Perron test (Bai & Perron, 1997, 1998a) and form a partition such that $1 < T_1 < \cdots < T_m < T$. Perron (1997) defines the following block-diagonal matrix:

$$\bar{Z} = \begin{pmatrix} Z_1 & & \\ & \ddots & \\ & & Z_{m+1} \end{pmatrix} \quad (5)$$

with $Z_i = \left(Z_{T_{i-1}+1}, \cdots, Z_{T_i}\right)'$. $\bar{Z}$ partitions diagonally $Z = (Z_1, \cdots, Z_T)$ to the m-partition $(T_1, \cdots, T_m)$. Thus, in matrix form, the multiple linear regression model with pure structural change can be written as:

$$Y = \bar{Z}\Theta + \epsilon \quad (6)$$

where $Y = (y_1, \cdots, y_T)'$, $\Theta_j = (\theta_1', \cdots, \theta_{m+1}')'$ with $\theta_j = (\alpha_j, \delta_j, \beta_j, \gamma_j)_{j=1,\cdots,m}$ and $\epsilon = (\varepsilon_1, \cdots, \varepsilon_T)'$. Perron (1997) defines $\bar{Z}^0$ as the diagonal partition of Z to the m-partition $(T_1^0, \cdots, T_m^0)$ corresponding to the true break dates. Thus, the data-generating process, in the case of pure structural change, is given by:

$$Y = \bar{Z}^0\Theta^0 + \epsilon \quad (7)$$

The aim is then to estimate the unknowns $(\Theta_1^0, \cdots, \Theta_{m+1}^0, T_1^0, \cdots, T_m^0)$ under the hypothesis $\Theta_i^0 \neq \Theta_{i+1}^0$ $(1 \leq i \leq m)$ (Perron, 1997).

To ensure that the estimates have interesting asymptotic properties, Perron (1997) imposes certain constraints on the regressors and errors. Some postulates are purely technical in nature and impose no constraints in practice. Others, on the other hand, limit the applicability of the results to certain classes of models. The postulates defined by Perron (1997) are summarized as follows:

- The first specifies that the breakpoints are asymptotically distinct and that segment (or regime) grows in proportion to the total sample size.
- The second specifies that there are enough observations around the breakpoints for them to be identified.
- The third guarantees the applicability of OLS (Ordinary Least Squares) for all m-partitions $(T_1, \cdots, T_m)$ such that $T_i - T_{i-1} \geq q$ the dimension of the vector of regressors is subject to change. This assumption can be avoided by using an estimation method based on generalized inverses.
- The fourth standard postulate for linear regression models specifies that we cannot have integrated variables (with autoregressive unit root). It does, however, allow for variables with a deterministic trend, where the time index is deflated by T. Thus, for linear trend, $g(t) = a + b(t/T)$.
- The fifth postulate concerns the nature of the errors in relation to that of the regressors. On the one hand, it addresses models where there are no lagged dependent variables in the regressors, and in this case, the conditions on the residuals allow a very general class of temporal correlation and heteroscedasticity. On the other hand, it addresses the case where lagged dependent variables are allowed as regressors. In such a case, there can be no autocorrelation of errors, although a certain degree of heteroscedasticity is permitted.

3.3. Model Estimation

The multiple break test developed by Bai and Perron (1998a) relies on Ordinary

Least Squares (OLS) estimation based on the sum of squared error minimization. Thus, for a m-partition $\left(T_1,\cdots,T_m\right)$, OLS estimates of θ_j are obtained by minimizing the sum of squared residuals (Perron, 1997).

3.4. Bai-Perron Multiple Break Test and Model Estimation for Different Regimes

This section is devoted to procedures for testing the stability of the parameters of the model presented in the previous section. This procedure begins with the traditional Chow's test, in which we assume a single break at a given, known date. The test statistic is given by:

$$F_T^{Chow}\left(T_1\right)=\frac{T-2q-p}{q}\left(\frac{SCR_{1,T}-SCRA_{T1}}{SCRA_{T1}}\right) \quad (8)$$

where $SCR_{1,T}$ represents the sum of squared residuals for the no-break model estimated for dates 1 to T. $SCRA_{T1}$ represents the sum of squared residuals for the model with one or more parameters broken at date T_1. q is the number of parameters subject to breakage and p is the number of parameters assumed to be stable. The statistic follows a Fisher distribution at q and $T-2q-p$ degrees of freedom at finite distance if the errors are independent, identically distributed and follow a normal distribution.

To abandon the requirements of predefining competing break dates, Quandt (1960) modifies the basis of Chow's test to consider the F statistic with the largest value above the possible break dates. Bai and Perron (1998a, 1998b) have proposed a sequential approach to estimating the number of breaks. First, the stability hypothesis of the model is tested against the presence of a break. If stability is rejected, a break is imposed, and the null hypothesis of one break is tested against the alternative hypothesis of two breaks, using the statistic $supF\left(\frac{m+1}{m}\right)$ given by:

$$SupF=MaxF\left(\frac{T_1}{T}\right)_{T_1=T_{Min},\cdots,T_{Max}} \quad (9)$$

$$F\left(\frac{T_1}{T}\right)=qF_T^{Chow}=T-2q-p\left(\frac{SCR_{1,T}-SCRA_{T1}}{SCRA_{T1}}\right) \quad (10)$$

Another way of writing the test statistic, numerically equivalent to the previous one, is as follows:

$$F\left(\frac{T_1}{T}\right)=\frac{T-2q-p}{T}\hat{\delta}'R'\left[R'\hat{V}\left(\hat{\delta}'\right)R'\right]^{-1}R\hat{\delta} \quad (11)$$

where $\hat{\delta}$ is the vector of estimated parameters, R a matrix such that under the null hypothesis of stability $R\hat{\delta}=0$ and $\hat{V}\left(\hat{\delta}\right)$ is the estimated variance of $\hat{\delta}$. This statistic follows a chi-square distribution with q degrees of freedom, under the assumption of independent, identically distributed errors, with no restrictions on the distribution followed.

The procedure is repeated for increasing m and stopped as soon as the stability hypothesis, conditional on m breaks, cannot be rejected.

Two versions of this sequential break number test procedure actually exist. The first (Bai & Perron, 1998a, 1998b) is based on sequential breakpoint determination, while the second (Bai, 1999) is based on simultaneous breakpoint determination. In the first version, the break-up date obtained at the first stage of the procedure is retained when a second breakpoint is tested. This approach is based on a theoretical property established by Bai (1997): sequential estimation of breakpoints leads to convergent estimation of breakpoint dates (Le Bihan, 2004).

The second approach is based on the simultaneous estimation of all break dates. For each fixed number m of breaks, the m break dates $(T_1, \cdots, T_m)$ are freely selected (Le Bihan, 2004). Bai (1999) proposes a test based on the likelihood ratio of models with m and $m + 1$ breaks (Le Bihan, 2004). However, the distribution of the statistic is only established for independent, identically distributed residuals. We therefore restrict ourselves here to the sequential determination of break dates (Le Bihan, 2004). Based on the number of significant breaks, we apply the ordinary least squares method with break to determine the various estimators for each structural change regime. For L breakpoints, using OLS (Ordinary Least Squares) with break, we determine $L + 1$ equations, each of which gives estimates of the model's various coefficients.

4. Results, Analysis and Discussion

4.1. Study Results

The different variables in the model—GDP, capital, labor volume and the country's openness to the outside world—all follow a log-normal distribution. They are all integrated into order 1. **Table 2** shows the descriptive statistics for all the variables in the study.

Table 2. Descriptive statistics of variables.

	GDP (Y)	CAPITAL (K)	LABOR (L)	TRADE OPENNESS (O)	LOG(Y)	LOG(K)	LOG(L)	LOG(O)
Average	2.82E+08	53544070	5171206	1.62E+08	19.37	17.62	15.41	18.82
Median	2.58E+08	40301983	4556638	1.53E+08	19.36	17.51	15.33	18.84
Maximum	5.86E+08	1.37E+08	8805622	2.89E+08	20.18	18.73	15.99	19.48
Minimum	98258605	14641715	3347665	50748980	18.40	16.50	15.02	17.74
Deviation	1.12E+08	32582505	1634591	61510490	0.415	0.60	0.31	0.42
Skewness	0.648747	0.859321	0.603536	0.175871	-0.33	0.125	0.31	-0.53
Kurtosis	3.001875	2.550015	2.08752	2.00854	2.81	1.96	1.71	2.67
Observations	62	62	62	62	62	62	62	62
Jarque-Bera	4.349028	8.153568	5.914915	2.859017	1.20	2.93	5.29	3.23
Probability	0.113663	0.016962	0.051951	0.239427	0.55	0.23	0.07	0.20
Sum Sq. Dev.	7.71E+17	6.48E+16	1.63E+14	2.31E+17	10.49	22.21	5.71	10.67

Source: Authors' calculations.

In our study, we are interested in the long-term relationship between the different variables. The results relating to the stationarity of the study variables are shown in **Table 3**.

Table 3. Results of the augmented Dickey-Fuller stationarity test.

		ADF in level		ADF in first difference		
Variables	Models	t-Statistics	Critical probability	t-Statistics	Critical probability	ADF test results
Log(Y)	No constant, no trend	1.747	0.98	−6.03***	0.000	I(1)
	Constant	−1.617	0.468	−6.25***	0.000	
	Constant and trend	−2.013	0.582	−6.2***	0.000	
Log(K)	No constant, no trend	1.226	0.942	−6.81***	0.000	I(1)
	Constant	−1.282	0.633	−6.894***	0.000	
	Constant and trend	−1.451	0.835	−6.839***	0.000	
Log(O)	No constant, no trend	8.625	1	−1.953**	0.049	I(1)
	Constant	2.743	1	−6.09***	0.000	
	Constant and trend	−2.224	0.468	−6.834***	0.000	
Log(L)	No constant, no trend	8.626	1	−1.953**	0.049	I(1)
	Constant	2.743	1	−6.09***	0.000	
	Constant and trend	−2.224	0.468	−6.834***	0.000	

Note: *** and ** indicate the significance level at 1% and 5%, respectively. Source: Authors' calculations.

The results of the linear regression, relating the logarithm of GDP to the logarithms of the other variables mentioned above, to highlight the long-term relationship are shown in **Table 4**.

Table 4. OLS model estimation results for the period 1960-2021.

	Constant	Log(K)	Log(L)	Log(O)
Coefficients	−0.9238 (0.7259)	0.1283*** (0.0368)	0.4054*** (0.0462)	0.6263*** (0.0540)
P-value	0.2082	0.0010	0.0000	0.0000

Note: Values in parentheses are standard deviations; *** indicates the significance level at 1%. Source: Authors' calculations.

The various coefficients are significantly different from 0 at the 1% level. For the period 1960-2021, all else being equal, it can be seen that, on average, when:

- Trade openness increases by 1% Real GDP increases by 0.63%;
- Labor increases by 1%, GDP increases by 0.40%;
- Capital increases by 1%, GDP increases by 0.12%.

All the variables—capital, labor and trade openness—are therefore significant at the 1% level in the formation of GDP.

The basic statistical tests on the errors, together with the regression performed, are shown in **Table 5**.

Table 5. Basic statistical test results for the estimated model.

Statistical tests	Statistics	value	P-value	Conclusion at 5% threshold
Error normality	Jarques-Bera	0.2097	0.9004	Errors are normally distributed
Overall significance	Fisher	354.99	0.000	Globally significant model
Heteroskedasticity	White	4.37	0.0003	Errors are heteroskedastic
	LM Test	26.71	0.0016	Errors are heteroskedastic
Autocorrelation	F-Statistic	30.21	0.000	Errors are autocorreleted
	LM Test	21.48	0.000	Errors are autocorreleted
Specification	F-Statistic 1	0.21	0.652	The models are well specified
	F-Statistic 2	3.06	0.055	The models are well specified

Source: Authors' calculations.

The errors follow a normal distribution for a threshold of 5%. The model is globally significant at the 5% threshold. Only the constant is not significant. White's test and the Lagrange multiplier test show that the errors are heteroscedastic at the 5% threshold. Moreover, errors are auto correlated at the 5% threshold. However, the model remains well specified, as shown by the results of the Ramsey specification test for 1 and 2, respectively, as the number of fitted terms. Finally, we note that around 95% of GDP variations are explained by the model. From a statistical point of view, the long-term relationship highlighted by the model can therefore be validated.

To ensure that the estimates have interesting asymptotic properties, let's refer to the results relating to the postulates that Perron (1997) imposes on regressors and error. The first three postulates are purely technical in nature and do not impose any constraints in practice. The fourth standard postulate for linear regression models specifies that there can be no integrated variables. The individual variables in the model are integrated into order 1. However, the individual variables each have a significant deterministic trend, where the time index is deflated by $T = 62$ (**Table 6**).

Table 6. Results of deflated trend significance test.

	Constants	T/62
Log(K)	17.1565*** (0.1406)	0.9085*** (0.2406)
P-value	0.00	0.00
Log(O)	18.4307*** (0.0912)	0.7771*** (0.1561)
P-value	0.00	0.00
Log(L)	14.8842*** (0.0126)	1.0380*** (0.0216)
P-value	0.00	0.00
Log(Y)	18.8519*** (0.0739)	0.0166*** (0.0020)
P-value	0.00	0.00

Note: Values in parentheses are standard deviations; *** indicates the significance level at 1%. Source: Authors' calculations.

Furthermore, the model does not include the lagged dependent variable in the list of regressors. Thus, the autocorrelation and heteroscedasticity revealed by the tests in **Table 4** are authorized for the Bai-Perron test. The constraints imposed on the regressors and errors are all respected. Perron (1997) thus guarantees interesting asymptotic properties for the estimates. The results of the main Bai-Perron tests applied to the above-estimated model are shown in **Table 7**.

Table 7. Bai-Perron multiple rupture test results.

Bai-Perron tests of $L + 1$ vs. L sequentially determined break				
	Estimated number of breaks	Estimated break dates	F-statistic	Critical value
With identical distribution of errors each regime	2	1985-1994	26.978	18.11
With identical distribution of errors each regime	2	1985-1994	35.168	18.11
Bai-Perron tests of $L + 1$ vs. L globally determined breaks				
	Estimated number of breaks	Estimated break dates	F-statistic	Critical value
With identical distribution of errors within each regime	3	1987-1996-2013	23.038	18.93
With different error distributions within each regime	3	1987-1996-2013	49.725	18.93

Continued

	Compare information criteria for 0 to M globally determined breaks			
	Estimated number of breaks	Estimated break dates	Minimum Schwarz criterion	Minimum LWZ criterion
Schwarz criterion selected breaks	3	1987-1996-2013	−4.909	−4.009
LWZ criterion selected breaks	0	No termination date	−4.474	−4.295

Source: Authors' calculations.

Bai-Perron's main multiple rupture tests indicate a number of ruptures ranging from 0 to 5, depending on the method. The sequential $L + 1$ against L change test indicates 2 break points. The first occurred in 1985 and the second in 1994. The global $L + 1$ against L changes indicate 3 breakpoints: 1987, 1996 and 2013. This last result is in line with the global determination method of the 0 versus M changes test based on the comparison of information criteria. In fact, it indicates 3 breakpoints for the Schwarz criterion, but 0 breakpoints for Liu, Wu, and Zidek's (1997) criterion.

Table 8 shows the test results for the overall determination of L versus 0. Based on the largest number of statistically significant breakpoints, the results indicate 5 breakpoints. Considering a sequential approach, i.e. testing from 1 to the maximum number of breakpoints until the null hypothesis cannot be rejected, there are 5 breakpoints. In both cases, the statistically significant breakpoints are 1971, 1981, 1990, 1999 and 2010. The approach of maximizing the test statistic results in 3 breakpoints, whether the statistic is weighted (WDmax) or not (UDmax). In the latter case, the statistically significant breakpoints are 1987, 1996 and 2013.

Table 8. Results of the Bai-Perron test for the overall determination of L rupture vs. 0.

Global L Breaks vs. None						
Global L Breaks vs. None	Estimated number of breaks	Estimated break dates	With identical error distribution		With heterogeneous error distribution	
			Statistics F	Critical value	Statistics F	Critical value
Sequential F-statistic determined breaks	5	1971; 1981; 1990; 1999; 2010	29.04	9.09	30.54	9.09
Significant F-statistic largest breaks	5	1971; 1981; 1990; 1999; 2010	51.73	9.09	54.4	9.09
UDmax determined breaks	3	1987; 1996; 2013	48.96	16.37	51.1	16.37
WDmax determined breaks	3	1987; 1996; 2013	65.13	17.83	67.98	17.83

Source: Authors' calculations.

Table 9 summarizes the estimated break dates according to the number of breaks statistically significant at the 5% threshold.

Table 9. Estimated break dates by number of estimated break.

Number of breaks	Estimated break dates				
1	1994				
2	1987	1996			
3	1987	1996	2013		
4	1973	1987	1996	2013	
5	1971	1981	1990	1999	2010

Source: Authors' calculations.

For one statistically significant break, the estimated date is 1994. For two significant breakpoints, we have 1987 and 1996, for 3 breakpoints the estimated dates are 1987, 1996 and 2013. For 4 significant breakpoints, the corresponding dates are 1973, 1987, 1996 and 2013. Finally, for the maximum number of significant breakpoints, i.e. 5 points, we have 1971, 1981, 1990, 1999 and 2010. So, we define six regimes 1960-1970, 1971-1980, 1981-1990, 1991-1998, 1999-2009, 2010-2021, whose configuration is summarized in a principal component analysis (**Figure 1**). The active variables are those of the regression model. The active individuals are the years from 1960 to 2021. The illustrative variables are the different regimes resulting from the estimated breakpoints.

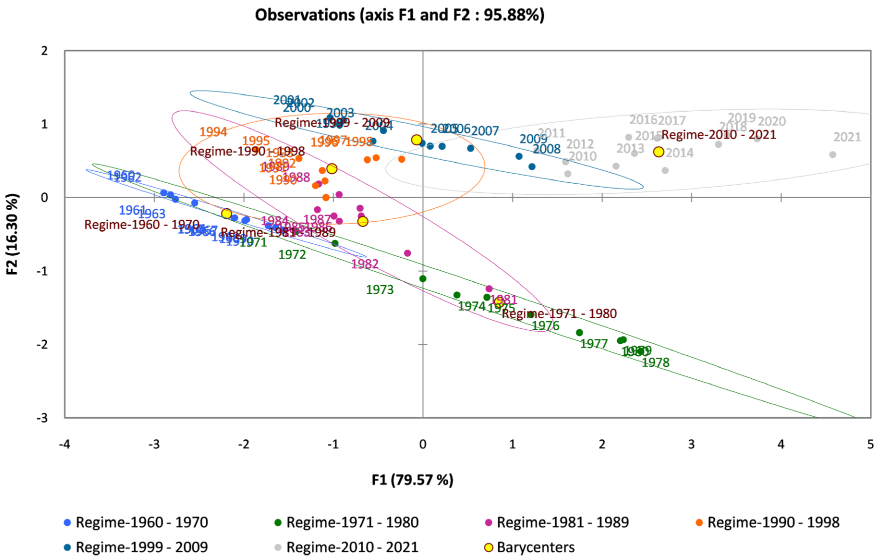

Figure 1. Factor analysis of economic activity from 1960 to 2021. Source: Authors' calculations.

There is considerable heterogeneity between the regimes of structural change represented by the spherical shapes. Regimes with a spherical, elongated shape of the cloud of individuals (years) are characteristic of economic activities generally evolving upwards over the regime periods. With the exception of the 1990-1998 regime, the other regimes have elongated cloud shapes. In addition, clouds from different regimes sometimes intersect; this is characteristic of individuals from different regimes who are close in terms of economic activity as measured by the different variables in the study. Thus, the late 60s and early 70s remained relatively unchanged in terms of economic activity. The real break came in 1973, the year of the first oil crisis. The years 1974 and 1981 (of the 1971-1980 and 1981-1989 regimes, respectively) are very similar. The 2010-2021 regime is essentially found in the North-East quadrant, with the second half of the years in the 1999-2009 regime, while those in the first half in the North-West quadrant, corresponding to the years just after the 2002 crisis. The data on economic activity is more dispersed for the 90-98 regime, and the years for this regime are practically all located in the North-West. Analysis by the regimes' centers of gravity would indicate, on average, a difference in economic activity from one regime to another.

Table 10 shows the results of OLS estimation with break, where model estimates are obtained according to the 5 estimated maximum significant break dates.

Table 10. Estimation of the model according to plans by MCOs with ruptures.

Regimes		*C*	LOG(*K*)	LOG(*L*)	LOG(*O*)
1960-1970	Coefficients	−1.471 (28.567)	0.027 (0.112)	0.361 (1.898)	0.788*** (0.189)
	P-values	0.956	0.812	0.850	0.000
1971-1980	Coefficients	0.164 (11.238)	0.363*** (0.111)	0.399 (0.837)	0.353*** (0.090)
	P-values	0.988	0.002	0.636	0.000
1981-1989	Coefficients	−36.471*** (9.837)	0.302*** (0.064)	2.743*** (0.532)	0.457*** (0.163)
	P-values	0.001	0.000	0.000	0.008
1990-1998	Coefficients	19.158 (27.693)	0.588 (0.369)	−1.892 (1.691)	1.032** (0.485)
	P-values	0.493	0.12	0.270	0.04
1999-2009	Coefficients	8.455 (7.128)	0.302*** (0.076)	−0.093 (0.551)	0.379*** (0.105)
	P-values	0.243	0.000	0.867	0.001
2010-2021	Coefficients	−11.007** (5.037)	0.228* (0.120)	1.592*** (0.341)	0.077 (0.219)
	P-value	0.035	0.066	0.000	0.729

Note: ***, ** and * indicate statistical significance levels of 1%, 5% and 10%, respectively. Source: Authors' calculations.

The Ivorian economy's production function over the entire study period from 1960 to 2021 depends significantly on capital, labor and foreign trade in goods and services. However, this function remains structurally highly unstable, with several key dates at which changes have taken place.

With five statistically significant breakpoints, we obtain six regimes. The contributions of the model's various exogenous variables differ from one regime to another. For the first regime, running from 1960 to 1970, the variable with the highest statistical contribution to gross domestic product at the 5% threshold is the volume of trade in goods and services (*O*). When the volume of trade increases by 1 point, gross domestic product rises by 78.8%, the other variables—capital and labor—being statistically insignificant in this regime, all else being equal.

For the second regime, from 1971 to 1980, the variables contributing most to GDP formation at the 5% threshold were capital formation (*K*) and the volume of foreign trade (*O*). When capital increases by one point, GDP rises by 36.3%, all else being equal. When foreign trade in goods and services increases by 1%, GDP rises by 0.35%, all else being equal. The contribution of trade to wealth creation under this regime is less than that recorded under the first regime, where trade contributed twice as much to GDP formation.

The third regime, 1981-1989, is characterized by a significant contribution, at the 5% level, of all the model's explanatory variables to GDP formation. The most significant contribution in this regime is made by the labor factor (*L*), with the model indicating that, all else being equal, a 1% increase in the labor factor leads to a 2.74% increase in GDP. As for capital, a 10% increase in this factor also leads to a 3.01% increase in GDP. With regard to foreign trade, a 10% increase in foreign trade in goods and services would lead to a 4.5% rise in GDP. Even so, this contribution remains lower than that of trade to GDP over the 1960-1970 period.

For the 1990-1998 period, the contribution of foreign trade is the only significant one at the 5% threshold. This contribution for this period is 1.03, around 3 and 2.5 times greater than that recorded for the 1960-1970, 1971-1980 and 1981-1989 periods, respectively.

Over the period 1999-2009, only capital and openness had a significant impact on GDP formation at the 5% threshold. Capital contributions remained relatively unchanged compared to 1971-1980 and 1981-1989.

Finally, for the period 2010-2021, only labor has remained significant, accounting for 5% of GDP. However, at the 10% threshold, a significant contribution from capital could also be taken into account.

4.2. Analysis and Discussions

In view of all these results, several analyses can be made. Economic growth is made up of capital, labor and openness. All other things being equal, a 1% increase in trade openness leads on average to a 0.63% increase in GDP, a 1% increase in labor leads to a 0.40% increase in GDP, and a 1% increase in capital leads to a 0.13% increase in GDP. The strongest average contribution to GDP growth comes from trade openness, measured by the volume of imports and exports. However, Côte d'Ivoire's economic growth is structurally unstable over the period from 1960 to 2021. The main rupture dates estimated could be based on certain economic and politico-military phenomena that have punctuated the Ivorian economic sphere.

Indeed, the first regime from 1960 to 1970 was essentially characterized by trade in goods and services with the outside world, which was dominated by trade in agricultural products, mainly focused on exports of the coffee-cocoa binomial. The role played by export crops in the Ivorian economy would therefore have marked essentially this first period, when export revenues constituted the country's main source of income.

The second period, from 1971 to 1980, marked the fundamental role played by capital and foreign trade in the Ivorian economy. Not only did this decade inherit from the previous one an industrial base whose capital was predominantly French, but it also saw world prices for the main agricultural products soar. Coffee prices multiplied by 7 in 1975 and 1977, and cocoa by 4 between 1975 and 1977. This financial upturn prompted the country to opt for state-led projects to create capital-intensive industries.

The period from 1981 to 1989 is the only one over which the model's various exogenous variables all had a significant impact at the 5% threshold on gross domestic product. This was the period after the 1980 crisis, when the world prices of the main agricultural exports fell drastically. This was the period that saw a series of structural adjustment programs designed to stem the crisis. In view of the estimation results obtained over this period, the Structural Adjustment Programs that were implemented had a positive impact on economic growth. These results seem to be confirmed by Jarret and Mahieu (1991), for whom the year 1985 seems to confirm the successful passage to recovery following the implementation of Structural Adjustment Programs. Public establishments posted a net operating profit, and the State budget showed a surplus. The current account deficit fell from 383 billion in 1981 to 27.8 billion in 1984; in 1985, the balance of current payments showed a surplus of 31 billion CFA francs (Jarret & Mahieu, 1991).

Over the period 1990-1999, only trade openness is significant in explaining gross domestic product. This was a crucial period for Côte d'Ivoire. In political terms, the beginning of this period marked the end of the single-party system, the start of a multi-party system and the death of Côte d'Ivoire's first president. In economic terms, it began with the stabilization program, followed by the devaluation of the CFA franc in 1994. The stabilization program and the devaluation of the CFA franc could justify the significance of the trade openness variable alone over the period 1990-1998. Indeed, following the devaluation, exports of goods and services increased and imports, which had become more expensive, fell, resulting in a positive trade balance and higher GDP.

For the period 1999-2009, only the variables capital and trade openness are significant at the 5% level. The key political events of this period, which could lead to a structural break from the previous period, were the military coup of 1999 and the politico-military crisis of 2002, which split the country in two. The embargo was another major event of this period.

The 2010-2021 period sees labor and capital as the only statistically significant factors in GDP formation, at the 5% and 10% thresholds, respectively. The beginning of this period marks the presidential elections of 2010, which were followed by a deep political-military crisis. But it was also a period of strong capital accumulation. Several major projects were undertaken during this period. These mainly involved the construction of roads, freeways, bridges, stadiums, universities and so on. Programs to integrate young people and empower women were also launched.

Generally speaking, Côte d'Ivoire's economy has been structured according to the rhythm of purely economic external shocks, purely political internal shocks that have followed one another from the country's independence to the present day, and economic policies. Before 1990, when the single party prevailed, the economic shocks that occurred were the first and second oil shocks of the 70s, and the fall in world prices of the main agricultural products at the end of the 70s. In terms of economic policies, these were essentially the three structural adjustment programs implemented in the 80s.

Furthermore, the dates of the end of the multi-party era seem to be closely aligned with the cycle of maximum electoral mandates granted under the constitution: 1990, 1999, and 2010 for the following periods 1990-1998, 1999-2009 and 2010-2021. While the single-party era was marked by shocks of an essentially economic nature, the multi-party era appears to be characterized mainly by various politico-military events that could be the cause of structural changes in economic activity in Côte d'Ivoire.

The results in **Table 11** indicate that the Ivorian GDP-generating process is a DS (Difference Stationary) process. The first analysis is that the presence of unit roots implies that, at least in part, cyclical impulses are made up of permanent shocks. In other words, the influence of a shock permanently affects the level of the observed variable. This is the persistence property of shocks in DS processes.

Thus, the successive shocks from 1960 to 2021, the oil shocks of the 70s, the drops in world prices, the effects of the SAPs (Structural Adjustment Programs) of the 80s, and the political and military crises that occur in the wake of presidential elections, all have a permanent negative impact on GDP. The effects of these

Table 11. Results of stationarity tests for Log(GDP).

Type of Model		ADF in level				ADF first difference		Type of Process (TS or DS)
		t-Statistics	Critical threshold values at 5%	Critical threshold values at 10%	Critical probability	t-Statistics	Critical probability	
No constant, no trend	Unit root	1.747	−1.95	−1.61	0.980	−6.03	0.000	I(1)
Constant	Unit root	−1.617	−2.91	−2.59	0.468	−6.25	0.000	
	Constant	1.654	2.8		2.500			
Constant and trend	Unit root	−2.013	−3.48	−3.17	0.582	−6.20	0.000	
	Constant	2.047	3.42		3.110			
	Trend	1.225	3.14		2.800			

Source: Authors' calculations.

shocks do not disappear, despite the few episodes of growth related to the economic policies implemented, until another shock occurs and so on. Such an evolution of GDP prevents it from returning to a certain long-term trend, such as that recorded during the first two decades after the country gained independence. In other words, the level of GDP in the current year depends on its value in the previous year, to which a random term is added, making growth totally random: $y_t = y_{t-1} + \varepsilon_t$ or $\Delta y_t = \varepsilon_t$.

On the strength of the above, we can see that the Ivorian economy is highly unstable. This makes it difficult to plan and implement economic and social development programs.

5. Conclusion

The aim of the study was to characterize the economic growth of Côte d'Ivoire over the period from 1960 to 2021. At the end of the study, it appears that capital, labor and trade openness are all significant at the 1% threshold for GDP formation, with elasticities of 0.13, 0.40 and 0.63, respectively. However, these contributions underwent enormous changes over the study period. In other words, the economic growth of Côte d'Ivoire proved to be structurally unstable. The Bai-Perron multiple break test revealed five significant maximum breakpoints, i.e. six regimes, at which the various exogenous variables in the model did not all make the same contribution to GDP formation.

The trade openness variable remained a significant contributor to real GDP formation over the first 5 regimes, with a higher elasticity of GDP in relation to trade openness for the 1990-1998 regime (1.03), followed by the 1960-1970 regime (0.79), compared with an average of 0.63 for the period from 1960 to 2021. For the elasticities of GDP in relation to labor, the most significant at the 5% threshold are those recorded for the periods from 1981 to 1989 and from 2010 to 2021. Over the period from 1981 to 1989, the elasticity of GDP in relation to labor is 2.74, compared with an average of 0.40 for the period from 1960 to 2021 as a whole, which is around seven times higher than the average for the period from 1960 to 2021.

For the second period from 2010 to 2021, the contribution of labor to GDP formation is around 1.6, i.e. around 4 times higher than the average for the period from 1960 to 2021. As for the elasticities of GDP in relation to capital, the most significant at the 5% threshold are those for the 1971-1980, 1981-1989 and 1999-2009 regimes, and at the 10% threshold for the period from 2010 to 2021. The various elasticities of GDP in relation to capital for these different periods are 0.36, 0.30, 0.30, and 0.23, respectively, compared with an average of around 0.13 for the entire study period.

From the principal correspondence analysis, the growth achieved was heterogeneous from one regime to another, although some years, even under different regimes, appear similar. In addition, various institutional and economic policy events occurred during the different regimes identified by the least squares method with breaks: the oil crises of 1974 and 1976, the fall in agricultural commodity prices in 1980, the structural adjustment programs and stabilization programs of the 1980s, the stabilization programs at the start of the 1990s and devaluation in 1994.

For the last two periods, 1999-2009 and 2010-2021, it is essentially political and military factors that seem to have intervened and left their mark. In view of the structural changes, assessed through the instability, over the study period, of GDP elasticities in relation to the various variables in the model, and also in view of the various important events that occurred during the study period, the question of the process that generates economic growth proved to be a DS process without drift. Thus, the shocks that occurred and the policies implemented during the growth process had effects on growth that were not transitory but rather permanent, making the growth of the Ivorian economy uncertain.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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