

FRACTIONAL INTEGRATION IN THE WEST AFRICAN ECONOMIC AND MONETARY UNION

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ABSTRACT

This paper examines the time series behavior of three variables (GDP, Price level of Consumption and Population) in the eight countries that belong to the West African Economic and Monetary Union (WAEMU), which are Benin, Burkina Faso, Côte d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal and Togo. The reason for carrying out this study lies in the considerable heterogeneity that can be perceived in the data from these countries. We conduct a long memory and fractional integration modeling framework and we also identify potential breaks in the data. The aim of the study is to perceive up to which degree the eight West African countries that belong to the same monetary union follow the same economic patterns of stability. Testing for mean reversion we only found strong evidence of it in the case of Senegal for the Price level of Consumption, and in the cases of Benin, Burkina Faso and Senegal for GDP.

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1. Introduction

This study examines the time series behavior of three variables (GDP, Price level of Consumption and Population) in the eight countries that belong to the West African Economic and Monetary Union (WAEMU), which are Benin, Burkina Faso, Côte d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal and Togo. We conduct a long memory and fractional integration modeling framework and we identify potential breaks in the data. Additionally, we also conduct a cointegration analysis of the GDP and inflation levels of each of the countries belonging to the union. The aim of the study is to perceive up to which degree the eight West African countries that belong to the same monetary union follow the same economic patterns of stability.

The main motivation for this work is to analyze the economic evolution of several countries which have shared the same monetary policy and currency, yet have performed and developed in different ways during the last decades. We examine if the different statistical properties in the series can explain the different patterns observed in the economic performances of the referred countries. Our results can be summarized as follows: If no breaks are taken into account most of the estimated orders of integration for Price level of consumption and GDP are around 1 and estimates much higher than 1 are obtained in all the Population series except for Togo. In the case of GDP per capita the results support the unit root in all except two cases: Benin, with an order of integration smaller than 1, and Togo, with the order of integration much higher than 1. The results of the cointegration analysis indicate some evidence of fractional cointegration between GDP and prices for Benin and Burkina Faso. Finally, when structural breaks are allowed and focusing on GDP, a single break is detected in five of the countries, namely, Benin, Burkina Faso, Côte d'Ivoire, Guinea-Bissau and Togo, and we notice a reduction in the

order of integration after the break in the majority of the countries, especially in the case of Côte d'Ivoire.

2. A bit of history

The West African Economic and Monetary Union (WAEMU or UEMOA from its name in French, Union Économique et Monétaire Ouest-Africaine) is an organization of eight West African states. It was established to promote economic integration between countries that share the CFA franc as a common currency. Currently the countries that belong to the union are Benin, Burkina Faso, Côte d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal and Togo.

The CFA franc was created at the end of 1945 due to the weakness of the French franc immediately after World War II. When France ratified the Bretton Woods Agreement in December 1945 the French franc was devalued in order to set a fixed exchange rate with the US dollar. New currencies were created in the French colonies to protect them from the severe devaluation and to encourage exports to France. Between 1945 and 1958, the CFA stood for "Colonies françaises d'Afrique" (French colonies of Africa). Between 1958 (establishment of the French Fifth Republic) and the independence of these African countries at the beginning of the 1960s the CFA responded to "Communauté française d'Afrique" (French Community of Africa). Since their independence, the CFA used in the western former colonies has stood for "Communauté Financière Africaine" (African Financial Community).

After their independence some colonies began to establish bilateral agreements with France on monetary and economic collaborations. The former colonies were thus allowed to continue belonging to the so called Franc zone thereby maintaining a stable cooperation with France. In 1960 Guinea decided to leave the currency zone, and in 1962

some West African countries that belonged to this zone decided to create a monetary union. This was known as the Monetary Union of the West African Countries (Union Monétaire des États de l’Afrique de l’Ouest). Formed at that time by Côte d’Ivoire, Dahomey (now Benin), Upper Volta (now Burkina Faso), Mauritania, Niger and Senegal, this union was the origin of what is today the WAEMU (West African Economic and Monetary Union) or in French the UEMOA (Union Économique et Monétaire Ouest-Africaine). Mali decided to stay temporarily outside this union and had its own currency for some years until it rejoined in 1984.

At the beginning of the 70s several agreements were reached between France and its former African colonies belonging to the Franc zone. The central African states belonging to this zone decided to constitute their own currency union known as the Economic and Monetary Community of Central Africa. Thus this union formed by Cameroon, the Central African Republic, Chad, the Republic of Congo and Gabon was formally established. Equatorial Guinea joined in 1985. The member countries continued having the same CFA that was being used in other countries of the franc zone. However the CFA used in these central African countries responds to “Coopération financière en Afrique centrale” (Financial Cooperation in Central Africa). It has the same value as its brother currency the CFA used in the west, and both currencies can be equally used in both zones, yet they have different central banks and institutions.

The WAEMU was finally created by a Treaty signed in Dakar, Senegal, on the 10th January 1994 by the heads of state and governments of Benin, Burkina Faso, Côte d’Ivoire, Mali, Niger, Senegal, and Togo. In 1997, Guinea-Bissau, a former Portuguese colony, became the organization’s eighth and only non-Francophone member state. The main objectives of the union are to promote the harmonization of fiscal policies among the country members and the promotion of a common market. It tries to achieve

convergence of macro-economic policies and indicators and to create greater economic competitiveness through open markets.

In this paper we analyze the eight countries that belong to the WAEMU and in particular we focus on three variables (GDP, Price level of consumption and Population), this being the only available data that we could work with. Additionally we exploit the data information by looking at the GDP per capita, along with the analysis of a bivariate relationship between GDP and prices. We use fractional integration techniques because they are useful to determine the statistical properties of the data from a very general perspective, and this allows us to determine the degree of persistence of the series across time.

The outline of the paper is as follows: Section 3 briefly describes the literature review, focusing on fractional integration techniques on macro data in Africa. Section 4 is devoted to the methodology; Section 5 presents the data and the main empirical results; Section 6 deals with the potential presence of breaks in the GDP data, while Section 7 concludes the paper.

3. Literature review

Several papers have been conducted on macroeconomic issues in African countries using long memory fractional integration. For instance, focusing on the exchange rates, some results show that except for South Africa none of the SADC (Southern African Development Community) real exchange rates are fractionally integrated (Mokoena, Gupta and Van Eyden, 2009). Fractional integration has also been used to analyze the stock market structure (Anouro and Gil-Alana, 2010; Rambaccussing, 2010), inflation (Gil-Alana and Barros, 2013), and housing prices (Gil-Alana, Goodness and Gupta, 2012) in African countries.

When it comes to African monetary unions, most of the literature is related to the current aim of building up a new currency known as the ECO. This currency union of Anglophone West African countries could eventually exist soon under the name of West African Monetary Zone (WAMZ). By using fractional integration it has been established that some significant differences exist between these countries. It has been shown, for instance, that shocks to inflation in Sierra Leone are not mean-reverting, while the results for Gambia, Ghana and Guinea suggest some inflation persistence (Alagidede, Coleman and Cuestas, 2010). Balogun (2007) proved that independent monetary and exchange rate policies have been relatively ineffective in influencing domestic activities (especially GDP and inflation) and therefore a currency union could benefit the region. There are also papers investigating how efficient the West African Economic and Monetary Union (WAEMU) has been since its origins and about the problems it has faced (Léon, 2012; Hefeker, 2010; Sy 2006).

On the other hand, the cointegrating relationship between GDP and inflation has been examined in various papers. For instance, Mallik and Chowdhury (2001) proved that there exists evidence of a long-run positive relationship between GDP growth rate and inflation for four South Asian countries (Bangladesh, India, Pakistan and Sri Lanka), obtaining significant feedbacks between inflation and economic growth. Cointegration techniques were also employed to determine which European Union countries would form a successful Economic and Monetary Union (EMU), based on long-run behavior of the nominal convergence criteria laid down in the Maastricht treaty. The results in Haug, MacKinnon and Michelis (1999) suggested that not all of the twelve original countries of the European Union could possibly form a successful EMU over time, unless several countries made significant adjustments. Focusing on Africa, Agboluaje and Olaleye (2013) propose an error correction model of GDP and inflation based on a long-run

equilibrium relationship for the Nigerian economy. They conclude that nominal GDP is positively correlated with both GDP per capita and inflation rates.

Nevertheless, none of these studies have conducted a long memory and fractional integration analysis including structural breaks in Africa. As earlier mentioned, in this study we employ a long memory I(d) model to analyze the degree of dependence in three variables of the eight countries that belong to the WAEMU.

4. Methodology

One characteristic of many economic and financial time series is their nonstationary nature. There exists a variety of models to describe such nonstationarity. Until the 1980s a standard approach was to impose a deterministic (linear or quadratic) function of time, thus assuming that the residuals from the regression model were stationary I(0). Later on, and especially after the seminal work of Nelson and Plosser (1982), there was a general agreement that the nonstationary component of most series was stochastic, and unit roots (or first differences, I(1)) were commonly adopted. However, the I(1) case is merely one particular model to describe such behavior. In fact, the number of differences required to get I(0) may not necessarily be an integer value but any point in the real line. In such a case, the process is said to be fractionally integrated or I(d). The I(d) models belong to a wider type of processes called long memory.

Long memory is a feature of the data which tells us that observations that are far distant apart in time are highly correlated. We can provide two definitions of long memory, one in the time domain and the other one in the frequency domain. Starting with the time domain definition, given a covariance stationary process $\{x_t, t = 0, \pm 1, \dots\}$, with autocovariance function $E(x_t - Ex_t)(x_{t-j} - Ex_t) = \gamma_j$, according to McLeod and Hipel (1978), x_t is said to be long memory if

$$\lim_{T \rightarrow \infty} \sum_{j=-T}^{j=T} |\gamma_j| \quad (1)$$

is infinite. An alternative definition, based on the frequency domain, is the following. Suppose that x_t has an absolutely continuous spectral distribution function, implying that it has a spectral density function, denoted by $f(\lambda)$, and defined as

$$f(\lambda) = \frac{1}{2\pi} \sum_{j=-\infty}^{j=\infty} \gamma_j \cos \lambda j, \quad -\pi < \lambda \leq \pi. \quad (2)$$

Then, x_t displays the property of long memory if the spectral density function has a pole at some frequency λ in the interval $[0, \pi)$, i.e.,

$$f(\lambda) \rightarrow \infty, \quad \text{as } \lambda \rightarrow \lambda^*, \quad \lambda^* \in [0, \pi). \quad (3)$$

The empirical literature has mainly focused on the case where the singularity or pole in the spectrum occurs at the 0 frequency, i.e., ($\lambda^* = 0$). This is the standard case of I(d) models of the form:

$$(1 - L)^d x_t = u_t, \quad t = 0, \pm 1, \dots, \quad (4)$$

where d can be any real value, L is the lag-operator ($Lx_t = x_{t-1}$) and u_t is I(0), defined for our purposes as a covariance stationary process with a spectral density function that is positive and finite at the zero frequency. The polynomial $(1-L)^d$ in equation (4) can be expressed in terms of its binomial expansion, such that, for all real d ,

$$(1-L)^d = \sum_{j=0}^{\infty} \psi_j L^j = \sum_{j=0}^{\infty} \binom{d}{j} (-1)^j L^j = 1 - dL + \frac{d(d-1)}{2} L^2 - \dots,$$

and thus

$$(1-L)^d x_t = x_t - dx_{t-1} + \frac{d(d-1)}{2} x_{t-2} - \dots,$$

implying that equation (4) can be expressed as

$$x_t = dx_{t-1} - \frac{d(d-1)}{2} x_{t-2} + \dots + u_t,$$

In this context, d plays a crucial role since it indicates the degree of dependence of the time series: the higher the value of d is, the higher the level of association will be between the observations (Barros et al. 2011). The above process also admits an infinite Moving Average (MA) representation such that

$$x_t = \sum_{k=0}^{\infty} a_k u_{t-k},$$

where

$$a_k = \frac{\Gamma(k+d)}{\Gamma(k+1)\Gamma(d)},$$

and $\Gamma(x)$ represents the Gamma function.

Given the parameterization in (4) we can distinguish several cases depending on the value of d . Thus, if $d = 0$, $x_t = u_t$, x_t is said to be “short memory” or $I(0)$, and if the observations are autocorrelated (i.e. AR), then they are of a “weakly” form, in the sense that the values in the autocorrelations are decaying exponentially fast; if $d > 0$, x_t is said to be “long memory”, so named because of the strong association between observations far distant in time. Here, if d belongs to the interval $(0, 0.5)$ x_t is still covariance stationary, while $d \geq 0.5$ implies nonstationarity. Finally, if $d < 1$, the series is mean reverting in the sense that the effect of the shocks disappears in the long run, contrary to what happens if $d \geq 1$ with shocks persisting forever.

There exist several methods for estimating and testing the fractional differencing parameter d . Some of them are parametric while others are semiparametric and can be specified in the time or in the frequency domain. In this paper, we use a Whittle estimate of d in the frequency domain (Dahlhaus, 1989) along with a parametric testing procedure, which is based on the Lagrange Multiplier (LM) principle and that also uses the Whittle function in the frequency domain. It tests the null hypothesis:

$$H_0: d = d_0, \quad (5)$$

for any real value d_0 , in a model given by the equation (4), where x_t can be the errors in a regression model of the form:

$$y_t = \beta^T z_t + x_t, \quad t = 1, 2, \dots, \quad (6)$$

where y_t is the observed time series, β is a $(k \times 1)$ vector of unknown coefficients and z_t is a set of deterministic terms that might include an intercept (i.e., $z_t = 1$), an intercept with a linear time trend ($z_t = (1, t)^T$), or any other type of deterministic processes. Robinson (1994) showed that, under certain very mild regularity conditions, its LM-based statistic (\hat{r}):

$$\hat{r} \rightarrow_d N(0, 1) \quad \text{as} \quad T \rightarrow \infty, \quad (7)$$

where “ \rightarrow_d ” stands for convergence in distribution, and this limit behavior holds independently of the regressors z_t used in (6) and the specific model for the $I(0)$ disturbances u_t in (4).

As in other standard large-sample testing situations, Wald and LR test statistics against fractional alternatives have the same null and limit theory as the LM test of Robinson (1994). Lobato and Velasco (2007) essentially employed such a Wald testing procedure, though it requires a consistent estimate of d ; therefore the LM test of Robinson (1994) seems computationally more attractive. Semiparametric Whittle approaches (Robinson, 1995; Abadir et al., 2007) will also be implemented in the paper.

5. Data and empirical results

We use data of Price level of Consumption, GDP and Population, covering the period 1960 - 2010 for each of the eight countries belonging to the WAEMU, obtained from the

Penn World Tables. Additionally, we use another series corresponding to the exchange rate of the CFA.¹

[Insert Figure 1 and Table 1 about here]

Figure 1 displays the time series plots for the three variables in the eight countries. Descriptive statistics are displayed in Table 1. We observe that there is no clear relation between the mean values of GDP and Price level of Consumption, which is the PPP over Consumption divided by the exchange rate, and we can appreciate huge values for the variance in the population series.

In terms of growth, Price level of Consumption has experienced a negative increase in all countries except Mali, whereas for GDP the increase has been positive yet very small in all the countries except for Niger where it has been negative. The population has notably increased in all countries. We can also appreciate a clear relation between the Price level of Consumption and the exchange rate of the CFA. It is worth noting that the price level decreased in all countries after the devaluation of the CFA in an attempt to favor the export of agricultural goods in 1994.

[Insert Appendix A here]

The first thing we do in the paper is to conduct standard unit root procedures. In particular, we use the ADF (Dickey and Fuller, 1979) and Phillips and Perron (PP, 1988) approaches. These are some of the most commonly employed tests in the literature. The p-values of all the series of the three variables reveal that we cannot reject the null hypothesis of a unit root. Therefore we would need to difference the series in order to make them $I(0)$ stationary. Nevertheless, we should take into account that these unit root tests might have very low power when directed against specific alternatives such as trend-stationary models (DeJong et al., 1992), structural breaks (Campbell and Perron, 1991), regime-switching (Nelson et al., 2001), or fractionally integration (Diebold and

¹ All computations were carried out using log-transformations.

Rudebusch, 1991; Hassler and Wolters, 1994; Lee and Schmidt, 1996). In this paper we focus on the latter type of alternatives, noting that fractional integration includes the classic unit root models as particular cases of interest.

Based on the I(d) approaches, we estimate the following model,

$$y_t = \beta_0 + \beta_1 t + x_t, \quad (1 - L)^d x_t = u_t, \quad t = 1, 2, \dots, \quad (8)$$

where y_t is the observed time series; β_0 and β_1 are the coefficients corresponding to the intercept and the linear time trend respectively, and u_t is I(0) described for the purpose of the present work as a simple white noise disturbance term.²

Table 2 displays the Whittle estimates of d along with the 95% confidence interval of the non-rejection values of d using the Robinson (1994) parametric approach. We present the estimates of d for the three standard cases of no regressors in the undifferenced regression (i.e., $\beta_0 = \beta_1 = 0$ in (8)), an intercept (β_0 unknown and $\beta_1 = 0$), and an intercept with a linear time trend (β_0 and β_1 unknown).

[Insert Table 2 about here]

The first thing we observe in this table is that the results are very consistent for the three cases of no regressors, an intercept and an intercept with a linear time trend. Nevertheless, we marked in bold the cases corresponding to significant deterministic terms, noting that Robinson's (1994) approach is based on the null differenced model, which is I(0) by construction and thus, it maintains the validity of the t-values in the differenced regression model.³

Starting with the Price level of Consumption we observe that the linear trend is only required for Guinea- Bissau. Most of the estimates are below 1 but the unit root null

² AR-type errors were also considered leading to very similar results to those reported here. A semiparametric approach where no functional form is adopted for the error term will also be conducted in the paper .

³ In other words, under the null hypothesis (5), equation (8) becomes $\tilde{y}_t = \beta_0 \tilde{1}_t + \beta_1 \tilde{t}_t + u_t$, where $\tilde{1}_t = (1-L)^d 1_t$, and $\tilde{t}_t = (1-L)^d t_t$, and given that u_t is I(0) standard t-tests apply.

hypothesis cannot be rejected in any single case with the exception of Senegal. For this country the estimated value of d is 0.795 and the unit root null is rejected in favor of mean reversion, i.e., $d < 1$. Focusing now on the GDP series, four out of the eight series display linear trends (Benin, Burkina Faso, Mali and Niger) while for the remaining four an intercept is sufficient to describe the deterministic part. Only two series (Côte d'Ivoire and Togo) display estimates above 1 but the unit root is rejected in favor of $d > 1$ only for the case of Togo, and mean reversion is found in the cases of Benin, Burkina Faso and Senegal. Finally, for the population series, the trend is required in the majority of the cases and d is found to be statistically above 1 in all except one single case (Togo)

[Insert Table 3 about here]

Table 3 displays the estimates of d using the Robinson's semiparametric method (1995). This is a local 'Whittle estimator' in the frequency domain, which uses a band of frequencies that degenerates to zero. The estimator is implicitly defined by:

$$\hat{d} = \arg \min_d \left(\log \overline{C(d)} - 2d \frac{1}{m} \sum_{s=1}^m \log \lambda_s \right), \quad (9)$$

$$\overline{C(d)} = \frac{1}{m} \sum_{s=1}^m I(\lambda_s) \lambda_s^{2d}, \quad \lambda_s = \frac{2\pi s}{T}, \quad \frac{m}{T} \rightarrow 0,$$

where m is a bandwidth number, and $I(\lambda_s)$ is the periodogram of the raw time series, x_t , given by:

$$I(\lambda_s) = \frac{1}{2\pi T} \left| \sum_{t=1}^T x_t e^{i\lambda_s t} \right|^2,$$

and $d \in (-0.5, 0.5)$. Under finiteness of the fourth moment and other mild conditions, Robinson (1995) proved that:

$$\sqrt{m} (\hat{d} - d_o) \rightarrow_d N(0, 1/4) \quad \text{as } T \rightarrow \infty,$$

where d_0 is the true value of d . This estimator is robust to a certain degree of conditional heteroscedasticity and is more efficient than other more recent semiparametric competitors. Consistently with the parametric results of Table 2, most of the estimated values of d for Price level of Consumption and GDP are around 1 and estimates much higher than 1 are obtained in all the population series except for Togo.

[Insert Tables 4 and 5 here]

Tables 4 and 5 focus on the GDP per capita series and display the estimated values of d for each country using respectively the parametric and the semiparametric methods described above. Using the Whittle parametric approach of Robinson (1994) (in Table 4) we see that the time trend is required in all cases. Estimates of d above 1 are only obtained in the case of Togo, and mean reversion ($d < 1$) takes place in the case of Benin. For all the other countries, the unit root null hypothesis ($d = 1$) cannot be rejected. Very similar results are obtained with the “local” semiparametric approach in Table 5.

The results presented above indicate that GDP and prices might be both $I(1)$ in the majority of the cases. Based on that, we also examine if the two variables might be cointegrated. For this purpose we conduct OLS regressions of one variable against the other, and test if the estimated residuals are $I(d)$ with $d < 1$ in which case the two variables would be cointegrated.⁴

[Insert Table 6 about here]

We observe in Table 6 that only for Benin and Burkina Faso do we have evidence of mean reversion, and thus, a long run equilibrium relationship between the two variables. Nevertheless, the fact that the estimated d 's are relatively high ($d > 0.5$) in the two cases suggests that the process of convergence takes a very long time to be achieved.

⁴ A similar approach was conducted in Gil-Alana (2003) testing fractional cointegration for a group of macroeconomic variables.

6. Structural breaks and other implicit dynamics

In this section we focus on the (logged) GDP series, and examine the possibility of structural breaks in the data. This is a relevant issue, noting that structural breaks and fractional integration are intimately related (Diebold and Inoue, 2001; Granger and Hyung, 2004). In this paper we employ a procedure that determines endogenously the number of breaks and the break dates in the series. This method, of Gil-Alana (2008), is based on minimizing the residual sum of the squares at different break dates and different (possibly fractional) differencing parameters. The general model can be described as follows:

$$y_t = \beta_i^T z_t + x_t; \quad (1-L)^{d_i} x_t = u_t, \quad t=1, \dots, T_b^i, \quad i=1, \dots, nb, \quad (10)$$

where nb is the number of breaks, y_t is the observed time series, the β_i 's are the coefficients on the deterministic terms, the d_i 's are the orders of integration for each sub-sample, u_t is $I(0)$ and the T_b^i 's correspond to the unknown break dates. Given the difficulties in distinguishing between models with fractional orders of integration and those with broken deterministic trends, it is important to consider estimation procedures for fractional unit roots in the presence of broken deterministic terms.

[Insert Table 7 about here]

The results based on Gil-Alana's (2008) approach are displayed in Table 7. The first thing that we observe in this table is that only five of the series display significant evidence of a structural break and in the five series a single break is detected. These series correspond to Benin, Burkina Faso, Côte d'Ivoire, Guinea-Bissau and Togo, and the break dates take place at 1972 for Benin, when an army led by Commander Mathieu Kérékou overthrew the government, suspended the constitution and dissolved both the

National Assembly and the Presidential Council; 1983 for Burnika Faso, when a coup brought the leader Thomas Sankara to power; 1991 for Togo, when its civil war began; 1998 for Guinea Bissau, also at the beginning of its civil war and 2001 for Côte d'Ivoire, which was the year when the first Ivorian civil war took place. We also observe in this table that the time trend is unrequired in the first subsamples in the cases of Benin, Côte d'Ivoire and Togo, and also in the second subsample for Guinea Bissau. For the rest of the cases, the time trend seems to be significant. If we focus now on the fractional differencing parameters, the first thing that we notice is that the confidence intervals are very wide in some cases, clearly due to the short sample sizes in some of the subsamples. Nevertheless, we notice that the unit root null hypothesis cannot be rejected in most of the cases. This hypothesis seems to be rejected in the case of Côte d'Ivoire in both subsamples; in the first subsample it is rejected in favor of higher degrees of integration, while in the second subsample it is rejected in favor of mean reversion. Mean reversion is also obtained for Togo during the first subsample. Looking at the confidence intervals, the only significant evidence in favor of different degrees of integration is found in the case of Côte d'Ivoire, where a substantial decrease in the degree of integration is found. An explanation for this may be the dramatic change that the Ivorian society has undergone in the last two decades since the death of Houphouët-Boigny, with a terrible conflict that has divided the country in two parts and has severely hindered the prosperity of the country.

7. Conclusions

In this paper we have conducted a long memory and fractional integration modeling framework in the analysis of three time series (Price level of Consumption, GDP and Population) for a group of African countries that form the West African Economic and

Monetary Union (WAEMU). These countries are Benin, Burkina Faso, Côte d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal and Togo. The aim of the paper was to discover up to what extent the eight West African countries belonging to the same monetary union follow the same economic stability patterns. For this purpose we have estimated fractional integration or I(d) models, first without breaks and then allowing for structural breaks at unknown dates. Testing for mean reversion we only found strong evidence of it in the case of Senegal for the Price level of Consumption, and in the cases of Benin, Burkina Faso and Senegal for GDP.

The case of Benin can be explained by its economic ties to its wealthier neighboring country Nigeria. Thus its remarkable economic improvement since its transition to a democratic government in 1991 can be largely understood by the fact that its exports were highly demanded in Nigeria. This dependence on its more prosperous neighbor can explain Benin GDP mean reversion. Burkina Faso is one of the poorest countries in the world, however it has recently been involved in an economic growth acceleration program and has set an inflationary target below the WAEMU convergence level. These may be arguments for its GDP mean reversion. Senegal presents mean reversion whereas the rest of the countries which have suffered important conflicts (wars, coups, rebellions, etc) do not present mean reversion in their economic variables. Benin also displays mean reversion in the GDP per capita series, and some evidence of fractional cointegration between GDP and prices is found in the cases of Benin and Burkina Faso.

If we focus on structural breaks in the GDP series, a single break is found in five countries, Benin (in 1972), Burkina Faso (1983), Côte d'Ivoire (2001), Guinea Bissau (1998) and Togo (1991), and in general, we notice a reduction in the order of integration after the break. This is especially remarkable in the case of Côte d'Ivoire, where the order

of integration is found to be significantly above 1 prior to the break, and $I(0)$ after the break in 2001.

We can argue that the main reason for the heterogeneity among the member countries of the WAEMU is the internal political instability in some of them, and also a considerable lack of fiscal unity in the region. This divergence among the country members of this union arises despite the fact that the union has existed for a very long time, the CFA being the currency of the region for decades. It is therefore clear that what keeps this union still in existence is not the necessity of its members to form a stronger group, but it is rather due to the historical and traditional influence that French authority has had in the region. During its years of colonization, France promoted a feeling of unity among western French speaking countries, this being one of the main pillars of the existence of the WAEMU.

This paper could be extended in several directions. Focusing on GDP (or GDP per capita) we could investigate the comovements or cointegrating relations between the different countries that belong to the WAEMU in order to determine if there exists a leading country that is moving the economy of the whole region. Other more technical approaches based for example on non-linearities in the context of fractional integration could also have been conducted in the paper. Work in these directions is now in progress.

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Figure 1a: Original time series: PRICE LEVEL OF CONSUMPTION

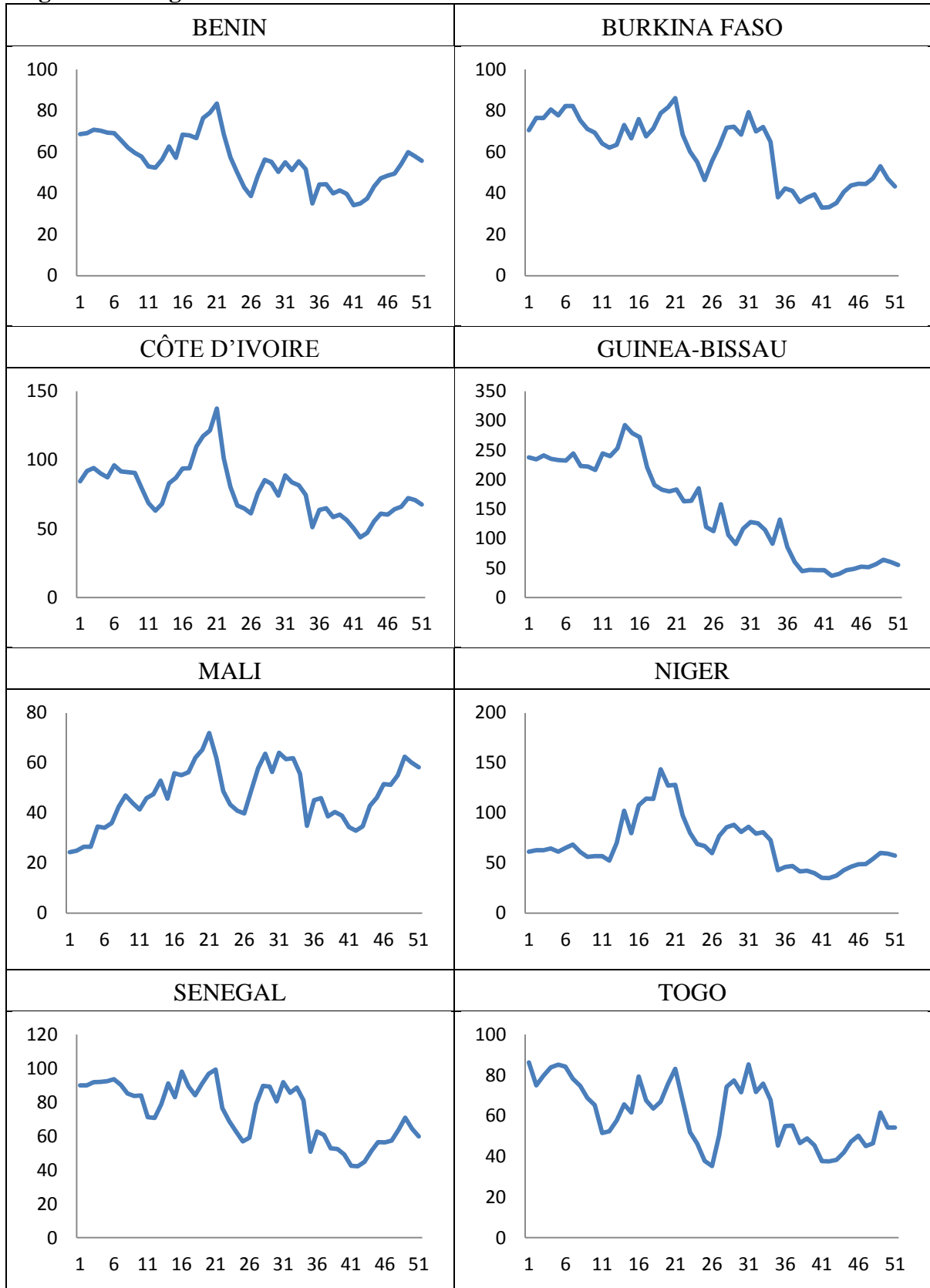


Figure 1b: Original time series: GROSS DOMESTIC PRODUCT

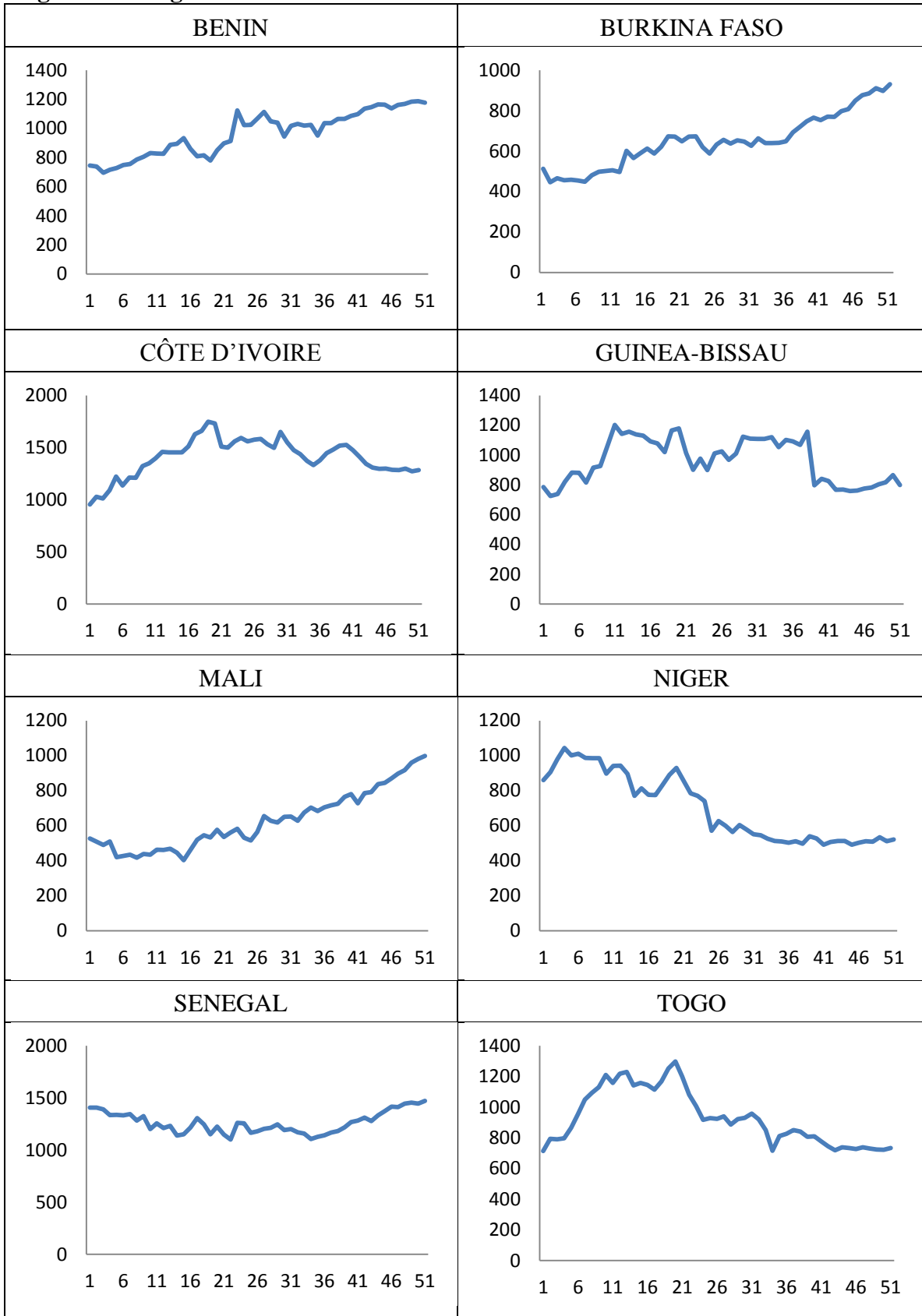


Figure 1c: Original time series: POPULATION

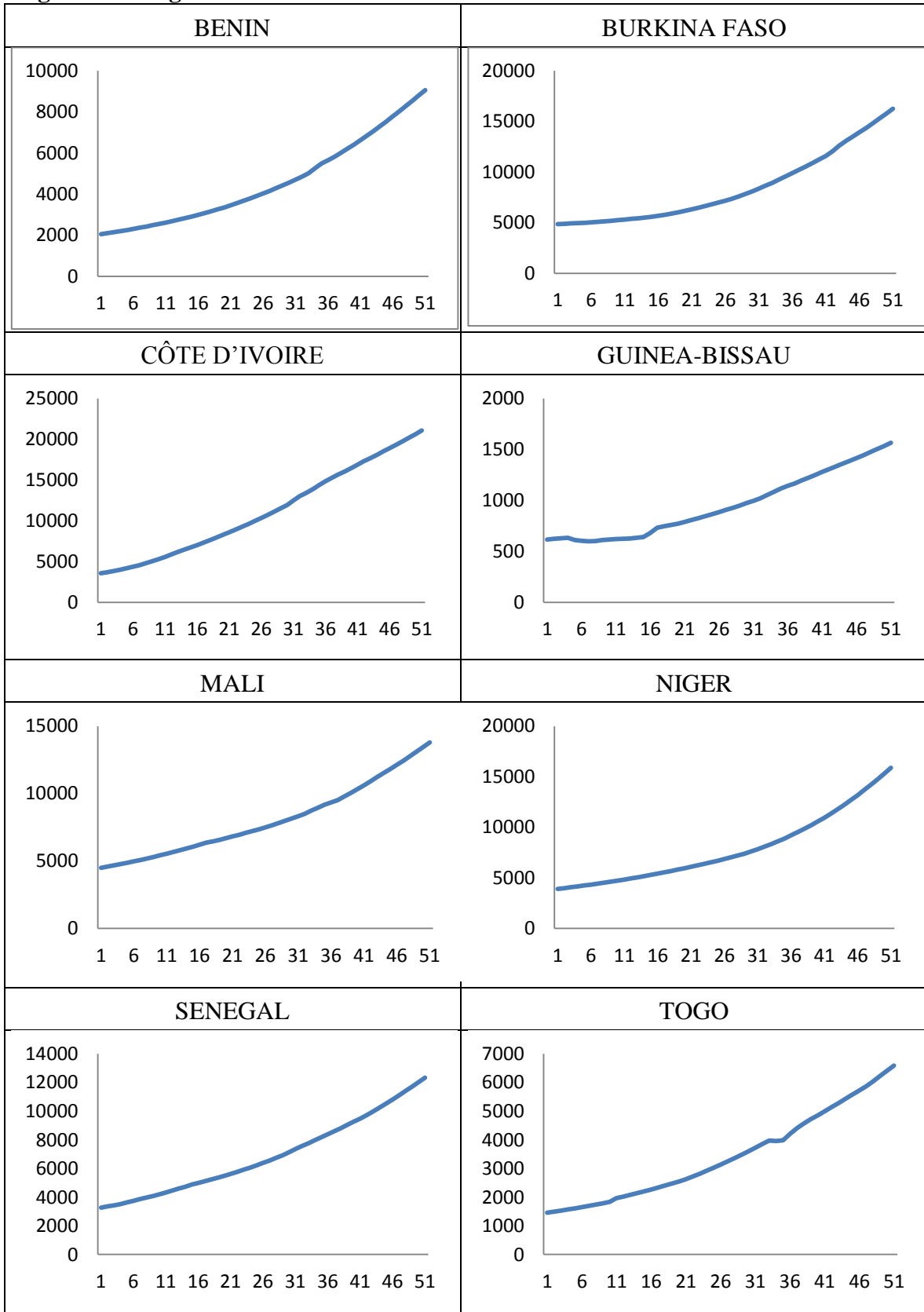


Figure 1d: Original time series: CFA exchange rate with respect to the US dollar

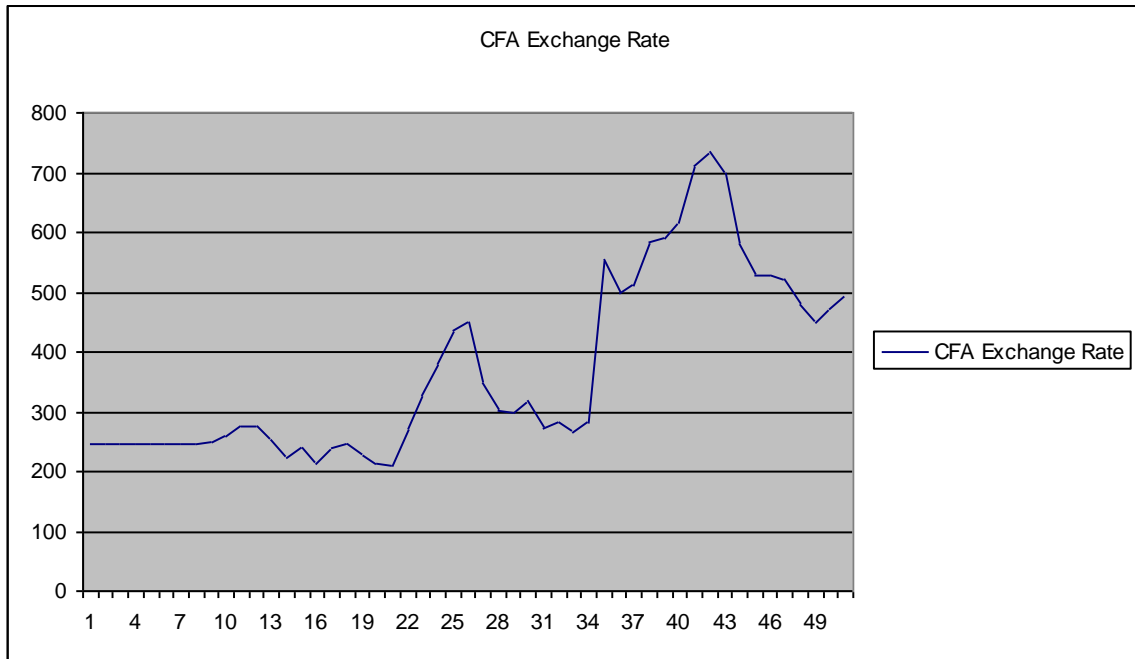


Table 1: Descriptive statistics

MEAN	Benin	Burkina Faso	Côte d'Ivoire	Guinea-Bissau	Mali	Niger	Senegal	Togo
C. Prices	55,541	60,764	77,914	147,181	47,431	69,164	74,349	61,348
GDP	966,016	648,847	1404,693	961,466	626,990	701,116	1261,94	930,45
Pop.	4581,406	4890,69	11140,53	952,643	8074,627	7884,374	6891,22	3433,79
VARIANCE	Benin	Burkina Faso	Côte d'Ivoire	Guinea-Bissau	Mali	Niger	Senegal	Togo
C. Prices	142,64	253,72	367,18	6375,68	127,23	650,51	279,17	228,16
GDP	22870,65	16864,85	31042,0007	21599,55	27363,55	36477,83	9889,83	31534,3
Pop.	4159559,2	11619606,5	28694388,8	94768,79	6878698,57	11302262	6781024	2291436
GROWTH RATE	Benin	Burkina Faso	Côte d'Ivoire	Guinea-Bissau	Mali	Niger	Senegal	Togo
C. Prices	-0,1877	-0,3867	-0,1994	-1	1,3955	-0,0647	-0,336	-0,371
GDP	0,5789	1,8145	0,3462	0,0183	0,8934	-0,3936	0,0454	0,027
Pop.	3,40664	2,33795	4,88879	1,53799	2,06944	3,05817	2,76879	3,52451

Table 2: Estimates of d based on Robinson (1994)

<u>C. Prices</u>	No regressors	An intercept	A linear time trend
BENIN	0.939 (0.774, 1.184)	0.933 (0.778, 1.184)	0.933 (0.706, 1.251)
BK. FASO	0.941 (0.778, 1.184)	0.901 (0.705, 1.195)	0.896 (0.668, 1.195)
C.D'IVOIRE	0.951 (0.783, 1.201)	1.017 (0.752, 1.391)	1.017 (0.737, 1.392)
GUINEA B.	0.944 (0.789, 1.175)	0.853 (0.734, 1.074)	0.824 (0.645, 1.976)
MALI	0.955 (0.799, 1.181)	0.951 (0.736, 1.218)	0.957 (0.784, 1.210)
NIGER	0.952 (0.791, 1.190)	1.013 (0.841, 1.258)	1.013 (0.839, 1.258)
SENEGAL	0.928 (0.754, 1.182)	0.795 (0.675, 0.970)*	0.792 (0.672, 0.970)
TOGO	0.922 (0.754, 1.165)	0.888 (0.598, 1.291)	0.889 (0.579, 1.290)
<u>GDP</u>	No regressors	An intercept	A linear time trend
BENIN	0.919 (0.745, 1.173)	0.724 (0.606, 0.965)	0.648 (0.417, 0.956)*
BK. FASO	0.911 (0.737, 1.160)	0.789 (0.682, 0.976)	0.683 (0.501, 0.952)*
C.D'IVOIRE	0.941 (0.768, 1.192)	1.064 (0.911, 1.293)	1.061 (0.924, 1.269)
GUINEA B.	0.922 (0.757, 1.161)	0.839 (0.698, 1.047)	0.840 (0.699, 1.047)
MALI	0.913 (0.734, 1.172)	0.853 (0.747, 1.039)	0.788 (0.594, 1.040)
NIGER	0.951 (0.783, 1.199)	0.915 (0.786, 1.130)	0.893 (0.706, 1.131)
SENEGAL	0.928 (0.754, 1.182)	0.795 (0.675, 0.970)	0.792 (0.672, 0.970)
TOGO	0.953 (0.785, 1.202)	1.189 (1.022, 1.460)*	1.185 (1.022, 1.429)
<u>Population</u>	No regressors	An intercept	A linear time trend
BENIN	0.925 (0.747, 1.181)	1.885 (1.608, 2.292)	1.535 (1.397, 1.860)
BK. FASO	0.924 (0.747, 1.180)	2.039 (1.749, 2.548)	2.048 (1.826, 2.533)
C.D'IVOIRE	0.924 (0.746, 1.181)	2.210 (2.029, 2.528)	1.909 (1.759, 2.182)
GUINEA B.	0.921 (0.741, 1.181)	1.429 (1.234, 1.812)	1.481 (1.297, 1.825)
MALI	0.928 (0.752, 1.182)	1.942 (1.737, 2.241)	1.562 (1.426, 1.795)
NIGER	0.925 (0.752, 1.183)	2.364 (2.051, 2.921)	2.312 (2.121, 2.659)
SENEGAL	0.927 (0.766, 1.181)	2.157 (1.975, 2.444)	1.692 (1.411, 2.033)
TOGO	0.924 (0.746, 1.180)	1.065 (0.945, 1.674)	1.016 (0.732, 1.447)

In bold the selected models according to the deterministic terms. “ * “ indicates evidence of mean reversion at the 5% level.

Table 3: Estimates of d based on the semiparametric method (Robinson, 1995)

C. Prices	3	5	7	8	10	12
BENIN	0.500	0.555	0.781	0.867	0.897	0.974
B. FASO	0.502	0.606	0.831	0.793	0.907	1.020
C. D'IVOIRE	0.500	0.501	0.707	0.626*	0.812	0.965
GUINEA B.	0.763	0.948	1.153	1.270	1.212	0.843
MALI	0.937	0.890	1.027	1.035	1.096	1.084
NIGER	0.668	0.888	1.260	1.119	1.194	1.327
SENEGAL	1.498	1.306	1.136	1.115	0.941	0.946
TOGO	0.500	0.500	0.500*	0.500*	0.568	0.734
Lower I(1) CI	0.525	0.632	0.689	0.709	0.739	0.762
Upper I(1) CI	1.474	1.367	1.310	1.290	1.260	1.237
GDP	3	5	7	8	10	12
BENIN	0.500	0.500	0.500*	0.584*	0.766	0.723
B. FASO	1.290	0.719	1.045	1.017	1.083	0.938
C. D'IVOIRE	1.449	1.222	1.062	1.054	1.166	1.289
GUINEA B.	0.894	1.369	1.191	1.239	0.956	0.924
MALI	0.845	0.868	0.856	1.000	0.833	0.853
NIGER	1.171	1.063	1.061	1.182	1.232	1.236
SENEGAL	1.500	1.306	1.136	1.115	0.941	0.946
TOGO	1.500	1.185	1.287	1.211	1.147	1.187
Lower I(1) CI	0.525	0.632	0.689	0.709	0.739	0.762
Upper I(1) CI	1.474	1.367	1.310	1.290	1.260	1.237
Population	3	5	7	8	10	12
BENIN	1.711	1.543	1.515	1.500	1.500	1.500
B. FASO	1.876	1.939	1.812	1.783	1.819	1.826
C. D'IVOIRE	2.055	2.386	2.277	2.123	1.971	1.879
GUINEA B.	1.805	1.896	1.500	1.500	1.500	1.500
MALI	1.694	1.661	1.631	1.504	1.523	1.511
NIGER	2.500	2.500	2.326	2.209	2.144	2.188
SENEGAL	1.711	1.778	1.500	1.523	1.658	1.733
TOGO	1.029	0.801	0.847	0.767	0.791	0.825
Lower I(2) CI	1.525	1.632	1.689	1.709	1.739	1.762
Upper I(2) CI	2.474	2.367	2.310	2.290	2.260	2.237

In bold the models that correspond approximately at $m = (T)^{0.5}$; “* “ indicates evidence of mean reversion at the 5% level.

Table 4: Estimates of d based on Robinson (1994) for the GDP per capita series

<u>GDP cap</u>	No regressors	An intercept	A linear time trend
BENIN	0.941 (0.743, 1.204)	0.799 (0.707, 0.984)	0.732 (0.556, 0.982)*
B. FASO	0.959 (0.776, 1.228)	0.868 (0.766, 1.049)	0.862 (0.731, 1.051)
C. D'IVOIRE	0.827 (0.616, 1.111)	0.991 (0.890, 1.194)	0.958 (0.773, 1.222)
GUINEA B.	0.952 (0.851, 1.102)	0.956 (0.846, 1.134)	0.951 (0.811, 1.143)
MALI	0.959 (0.796, 1.207)	0.579 (0.373, 1.033)	0.772 (0.564, 1.033)
NIGER	0.772 (0.524, 1.084)	0.939 (0.856, 1.105)	0.859 (0.642, 1.117)
SENEGAL	0.893 (0.633, 1.154)	0.779 (0.694, 1.006)	0.823 (0.705, 1.001)
TOGO	0.849 (0.726, 1.087)	1.158 (1.029, 1.391)	1.177 (1.024, 1.401)*

Table 5: Estimates of d based on the semiparametric method (Robinson, 1995) for the GDP per capita series

<u>GDP cap</u>	3	5	7	8	10	12
BENIN	0.500	0.515	0.642*	0.708*	0.866	0.805
B. FASO	1.500	1.232	1.289	1.236	1.237	1.097
C. D'IVOIRE	1.500	0.985	0.905	0.910	1.027	1.169
GUINEA B.	1.180	1.434	1.415	1.172	1.088	1.041
MALI	0.991	0.884	0.857	0.992	0.835	0.854
NIGER	1.071	0.982	0.979	1.103	1.166	1,178
SENEGAL	1.500	1.351	1.192	1.155	0.980	0.980
TOGO	1.500	1.226	1.352	1.314	1.200	1.229
Lower I(1) CI	0.525	0.632	0.689	0.709	0.739	0.762
Upper I(1) CI	1.474	1.367	1.310	1.290	1.260	1.237

Table 6: Estimates of d in the fractional cointegration framework

Country	Estimates of d
BENIN	0.669 (0.530, 0.986)
BURKINA FASO	0.789 (0.678, 0.972)
COTE D'IVOIRE	1.098 (0.935, 1.351)
GUINEA BISSAU	0.861 (0.688, 1.091)
MALI	0.863 (0.759, 1.942)
NIGER	0.941 (0.783, 1.210)
SENEGAL	0.929 (0.755, 1.180)
TOGO	1.207 (1.027, 1.508)

In bold, evidence of fractional cointegration at the 5% level

Table 7: Estimated parameters in the model with a presence of a single structural break

Country	Break date	1 st sub-sample			2 nd sub-sample		
		d	Intercept	Linear trend	d	Intercept	Linear trend
Benin	1972	0.979 (0.771, 1.233)	6.6139 (254.025)	---	0.733 (-0.561, 1.533)	6.7740 (139.70)	0.0071 (2.603)
Burkina Faso	1983	0.806 (0.617, 1.132)	6.0797 (169.361)	0.0190 (7.583)	0.483 (-0.017, 1.188)	6.3960 (222.25)	0.0153 (6.154)
Côte D'Ivoire	2001	1.359 (1.134, 1.738)	6.8633 (139.84)	---	0.085 (-0.544, 0.670)	7.2491 (96.028)	-0.0097 (-2.677)
Guinea Bissau	1998	1.014 (0.663, 1.590)	6.6527 (96.028)	0.0101 (1.732)	0.601 (0.288, 1.023)	6.6848 (258.43)	----
Togo	1991	0.269 (-0.176, 0.936)	6.5378 (133.98)	---	0.693 (0.477, 1.009)	6.7211 (287.53)	-0.0079 (-3.975)

Appendix A: P-values of the three variables for the eight countries.

Price level of Consumption

ADF	Benin	Burkina Faso	Côte d'Ivoire	Guinea Bissau	Mali	Niger	Senegal	Togo
No regressors	0.4084	0.3273	0.4259	0.1245	0.7415	0.4520	0.6942	0.2568
Intercept	0.3344	0.5534	0.3619	0.7708	0.1551	0.4561	0.4800	0.1172
Time trend	0.5934	0.2401	0.1646	0.2424	0.4248	0.6279	0.7069	0.1823

PP	Benin	Burkina Faso	Côte d'Ivoire	Guinea Bissau	Mali	Niger	Senegal	Togo
No regressors	0.4074	0.3280	0.4259	0.1149	0.7338	0.4297	0.7225	0.2568
Intercept	0.2526	0.4796	0.2473	0.7890	0.1342	0.3344	0.4800	0.0956
Time trend	0.3906	0.1421	0.2407	0.2404	0.3743	0.5044	0.8656	0.1219

GDP

ADF	Benin	Burkina Faso	Côte d'Ivoire	Guinea Bissau	Mali	Niger	Senegal	Togo
No regressors	0.9188	0.9901	0.7935	0.5817	0.9921	0.2051	0.6942	0.6230
Intercept	0.6721	0.9808	0.1003	0.2655	0.9959	0.8147	0.4800	0.6962
Time trend	0.0552	0.3852	0.5079	0.4214	0.2040	0.3697	0.7069	0.2213

PP	Benin	Burkina Faso	Côte d'Ivoire	Guinea Bissau	Mali	Niger	Senegal	Togo
No regressors	0.9605	0.9951	0.7837	0.5817	0.9984	0.1998	0.7225	0.6056
Intercept	0.7276	0.9892	0.1012	0.3101	0.9998	0.8173	0.4800	0.5726
Time trend	0.0481	0.3291	0.5189	0.4688	0.2728	0.2301	0.8656	0.1498

Population

ADF	Benin	Burkina Faso	Côte d'Ivoire	Guinea Bissau	Mali	Niger	Senegal	Togo
No regressors	0.9956	0.9826	0.4288	0.9994	0.9968	0.9691	0.9987	1.0000
Intercept	1.0000	0.9897	0.9796	0.9999	1.0000	0.9999	1.0000	1.0000
Time trend	1.0000	1.0000	0.5974	0.0361	1.0000	0.9971	1.0000	0.9951

PP	Benin	Burkina Faso	Côte d'Ivoire	Guinea Bissau	Mali	Niger	Senegal	Togo
No regressors	0.9999	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	1.0000
Intercept	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Time trend	1.0000	1.0000	0.0118	0.0606	1.0000	1.0000	1.0000	0.9996

Appendix B: Specific events in the selected countries

Country	Years	Events
Benin	1960 to 1972	Frequent military coups and changes of government.
	26 October 1972	Government ousted by Military Coup. Military government based on Marxist-Leninist ideology introduced by president Mathieu Kérékou
Burkina Faso	1983	Blaise Compaore played a key role in a coup that brought Thomas Sankara (1949-1987) to power
Côte d'Ivoire	1970-1980	Fall in world cocoa prices
	1993	Death of Houphouët-Boigny leading to general instability
	2001	First Ivorian Civil War
	2007	Second Ivorian Civil War
Guinea-Bissau	1980	A military coup led by Joao Bernardo Viera deposing President Luis Cabral
	1998	Bissau-Guinean Civil War
Niger	1967-1970	Civil War
	1990-1995	Touareg rebellion
Senegal	Beginning of 90s	Casamance conflict
Togo	1963	Coup d'état occurred on 13 January 1963 when military officers assassinated the first President of Togo
	1991-1992	Civil War