Inflation persistence and asymmetries: evidence for African countries

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Abstract

In this paper we aim at testing the inflation persistence hypothesis as well as modelling (using logistic smooth transition autoregressive, LSTAR, models) the long run behaviour of inflation rates in a pool of African countries. In order to do so, we rely on unit root tests applied to nonlinear models, i.e. Kapetanios et al. (2003). The results point to the non-persistence of inflation hypothesis for most of the countries. In addition, the estimated models are stable in the sense that the variable tends to remain in the regime (low inflation or high inflation) once reached and changes between regimes are only achieved after a shock.

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1 Introduction

Modelling the dynamics of inflation has become a hot topic during the last decades, in particular for industrialised countries. This is not surprising, given that price stability has become the main objective of the monetary authorities for a number of countries. Accordingly, the analysis of whether the inflation has a unit root, i.e. persistence hypothesis, or is stationary has several implications. From the theoretical point of view this analysis is important provided that stationarity is assumed in a number of theoretical models (Dornbusch, 1976; Taylor, 1979, 1980; and Calvo, 1983). In addition, it is important for practical purposes, given that monetary authorities assume that inflation is stationary, as is the growth of the monetary base -the main instrument of monetary policy, when taking policy decisions (Taylor, 1985; and McCallum, 1988). However, although the empirical literature on inflation persistence is quite vast for developed countries (see Baum et al., 1999; and Kumar and Okimoto, 2007, for a literature review), the topic has been less researched in developing economies.

Regarding the relationship between economic growth and inflation persistence, Faria and Carneiro (2001), after analysing the effects of inflation persistence on Brazil's output, find that inflation persistence may negatively affect economic growth, in particular in the short run. This finding has important implications for developing countries, given that any shock may retard the economic development of these countries. Proper assessment of the dynamics of inflation becomes, therefore, the cornerstone for monetary policy decisions, in particular when aiming at promoting economic growth.

In recent contributions, such as Arango and González (2001), Gregoriou and Kontonikas (2005) and Byers and Peel (2000) among others, nonlinear models for the inflation dynamics have gained some popularity. There are several reasons why nonlinear modelling may be superior to linear models to understand the behaviour of inflation rates. First, it might be sensible to think that the speed of adjustment towards the equilibrium after a shock is asymmetric. That is, the further the inflation rate deviates from the equilibrium or inflation target, the higher will be the efforts of the government to control it and, therefore, the speed of reversion of the variable (Gregoriou and Kontonikas, 2005). This implies the existence of a threshold for the inflation rate where the monetary authority may not apply any particular policy, not only when inflation targets are set in terms of a threshold of values, but also when the costs of applying monetary policy offset the benefits of its application (see Orphanides and Wieland's, 2000, model). Second, according to Sargent and Wallace (1973) among others, inflation may behave as a nonlinear process with multiple equilibria[1].

The above mentioned sources of nonlinearities can be captured through smooth transition autoregressive (STAR) models (Byers and Peel, 2000). In general, smooth transitions are preferred to other alternatives because, among other reasons, their flexibility captures a wide range of nonlinear behaviours; they allow for the variable to smoothly vary between regimes; there exists a well-defined modelling cycle in the literature; and standard nonlinear inference techniques can be used. Granger and Teräsvirta (1993), Teräsvirta (1994, 1998) and van Dijk et al. (2002) discuss these models at length.

Furthermore, ample evidence on the good performance of STARs reflecting asymmetric behaviour can be found in the empirical literature; see, for instance, the works on several aggregate macroeconomic variables (Teräsvirta and Anderson, 1992; Skalin and Teräsvirta, 1999, 2002; and Öcal and Osborn, 2000), exchange rates (Taylor and Peel, 2000; and Cuestas and Mourelle, 2009) or inflation with strong fluctuations (Arango and González, 2001).

Therefore, we have a two-fold objective in this paper. On the one hand, we aim at proving the inflation persistence hypothesis or the stationarity one for a group of African countries, that is, Burkina Faso, Cameroon, Egypt, Ethiopia, Gambia, Ghana, Ivory Coast, Kenya, Madagascar, Mauritius, Morocco, Niger, Nigeria, Senegal, Seychelles,

[1] Arango and Melo (2006) also justify the use of STAR models for macroeconomic variables based upon the assumption of asymmetries in business cycles.

South Africa, Sudan and Swaziland[2]. On the other hand, we look for evidence of asymmetries in the evolution of these inflation rates and, in the affirmative, we model nonlinear components by means of STAR models. As aforementioned, an assessment of the dynamic properties of inflation could be of further help when aiming at promoting economic growth. The reason for choosing African countries is two-fold. First, in the empirical literature there is not much evidence on the topic for these economies [3], in particular using nonlinear techniques; and second, the results we obtain could help policy makers on the design of the inflation policy to promote economic growth.

The paper is organised as follows. The next section summarises the unit root tests that have been applied to test the inflation persistence hypothesis. Section 3 explains the estimation procedure in order to model inflation in the selected countries. Section 4 presents the results. The main conclusions are drawn in the last section.

2 Testing for the inflation persistence hypothesis

In order to test for the persistence in inflation in our pool of African countries, we apply two types of unit root tests, i.e. Ng and Perron (2001) and Kapetanios et al. (2003).

According to Ng and Perron (2001), traditional unit root techniques based on linear models might suffer from two issues. First, they may tend to over accept the null hypothesis -have power problems- when the autoregressive parameter is near to unity and, second, when the errors of a Moving Average process are close to -1, information criteria tend to select a lag length not high enough to avoid power problems. In order to avoid these problems, Ng and Perron (2001) propose a Modified Information Criterion (MIC) that controls for the sample size. Further, Ng and perron (2001) propose a Generalised Least Squares (GLS) detrending method to overcome the power problem associated with

[2]From our pool of countries, only South Africa and Ghana have established an inflation target. The former started pursuing a 3-6% inflation target in 2000, whereas the latter only set a 0-10% in 2007.

[3]In a recent contribution, Coleman (2008b), by means of fractional integration tests, finds evidence of inflation persistence in the Franc Zone countries.

the traditional unit root tests. Thus, Ng and Perron (2001) obtain the following unit root tests: MZ_α and MZ_t that are the modified versions of the Phillips (1987) and Phillips and Perron (1988) Z_α and Z_t tests; the MSB that is related to the Bhargava (1986) R_1 test; and, finally, the MP_T test that is a modified version of the Elliot et al. (1996) Point Optimal Test.

In addition, many economic variables, and in particular inflation rates, may present asymmetric speed of mean reversion. This implies the existence of two regimes, i.e. in the inner regime the variable behaves as a unit root process, whereas in the outer regime the variable reverts to the equilibrium value. Controlling for this source of nonlinearity is interesting when dealing with the inflation rate, since policy makers may decide not to react when the inflation is within range of certain values, given that the costs of any policy decision may overwhelm the benefits. However, when the inflation rate is outside a given threshold, the monetary authority might intervene in the markets in order to return the inflation rate to a more sensible value.

Nonlinearites and the order of integration of inflation rates become, therefore, a key point to understand the degree of persistence of inflation. Thus, Henry and Shields (2004) applied the Caner and Hansen's (2001) unit root test, which takes into account the analysis of the order of integration of the variables in the threshold autoregression (TAR) framework, for the US, Japanese and UK inflation. Their results are supportive of the partial unit root hypothesis, implying that shocks have permanent effect in one regime, but have finite lives in the other one. However, the Caner and Hansen's (2001) unit root test assumes that the shifts between regimes are sudden instead of smooth.

Kapetanios et al. (2003) develop a unit root test in order to take into account non-linear adjustment of variables towards equilibrium, assuming that the transition between regimes is smooth rather than sudden. According to the authors, the reason for applying the latter is that linear unit root tests might suffer from lack of power in the presence of nonlinearities in the dynamics of the variables and, hence, may not be able to distinguish between a unit root and a nonlinear I(0) process. Accordingly, this test analyses nonstationarity under the null hypothesis against nonlinear but globally stationary exponential smooth transition autoregressive (ESTAR hereafter) processes under the alternative, i.e.

$$y_t = \beta y_{t-1} + \phi y_{t-1} F(\theta; y_{t-1}) + \epsilon_t \tag{1}$$

where $\epsilon_t \sim iid(0, \sigma^2)$ and $F(\theta; y_{t-1})$ is the transition function, which is assumed to be exponential,

$$F(\theta; y_{t-1}) = 1 - exp\{-\theta y_{t-1}^2\}, \quad \theta > 0 \tag{2}$$

In practice, it is common to reparameterise equation (1) as

$$\Delta y_t = \alpha y_{t-1} + \gamma y_{t-1}(1 - exp\{-\theta y_{t-1}^2\}) + \epsilon_t \tag{3}$$

in order to apply the test. The idea behind this technique is to test whether the variable is a unit root process in the outer regime, assuming that it is a unit root in the inner regime by imposing $\alpha = 0$. However, the issue with equation (3) is that in order to test the null hypothesis $H_0 : \theta = 0$ against $H_1 : \theta > 0$ in the outer regime[4], the coefficient γ cannot be identified under H_0. In order to overcome this problem, KSS propose a Taylor approximation of the ESTAR model, i.e.

$$\Delta y_t = \delta y_{t-1}^3 + \text{error term} \tag{4}$$

Now, it is possible to apply a standard t-statistic to test whether y_t is a I(1) process, $H_0 : \delta = 0$, or is a stationary process, $H_1 : \delta < 0$. Note that equation (4) may include lags of the dependent variables to control for autocorrelation, whose selection can be done using standard procedures.

[4]Note that the process is globally stationary provided that $-2 < \phi < 0$.

In recent contributions, Cuestas and Harrison (2008), and Gregoriou and Kontonikas (2006) find evidence of stationarity of inflation rates applying Kapetanios et al. (2003) unit root test for a number of countries, which highlights the importance of taking into account the possibility of asymmetric speed of adjustment towards the equilibrium when testing for the order of integration of inflation.

3 Modelling nonlinearities

3.1 The STAR model

Smooth transition (ST) models are a special class of state-dependent, nonlinear time series models, where the variable is assumed to vary between two extreme regimes and the smoothness of the transition is estimated from the data. The dependent variable is given by a linear combination of predetermined variables plus a random disturbance, where each coefficient is a function of a state variable. Such a parameterisation permits a variety of dynamic behaviour; at the same time, once the state is given, the model is locally linear, involving an easy interpretation of the local dynamics.

This paper focusses on the basic univariate version of ST models, the smooth transition autoregression (STAR), where all predetermined variables are lags of the dependent variable and regimes are endogenously determined. Let y_t a stationary, ergodic process. The STAR model of order p is defined as:

$$y_t = \pi_0 + \sum_{i=1}^{p} \pi_i y_{t-i} + F(y_{t-d}) \left[\theta_0 + \sum_{i=1}^{p} \theta_i y_{t-i} \right] + u_t \qquad (5)$$

where $F(y_{t-d})$ is a transition function that satisfies $0 \leq F \leq 1$, d is the transition lag and u_t is an error process, $u_t \sim Niid(0, \sigma^2)$. STARs are usually interpreted as consisting of two extreme regimes, corresponding to $F = 0$ (with π_i coefficients, $i = 1, ..., p$) and $F = 1$ (with $\pi_i + \theta_i$ coefficients, $i = 1, ..., p$), and a continuum of intermediate situations.

The transition from one regime to the other is smooth over time, meaning that parameters in (5) gradually change with the state variable. The transition variable, y_{t-d}, and the associated value of $F(y_{t-d})$ determine the regime at each t.

The features of the transition function are a key issue for understanding nonlinearities, especially the fact of having an even or odd $F(y_{t-d})$. The logistic function usually represents the odd case:

$$F(y_{t-d}) = \frac{1}{1 + exp\left[-\gamma(y_{t-d} - c)\right]} \tag{6}$$

The resulting model is the logistic STAR or LSTAR, where $F(-\infty) = 0$ and $F(\infty) = 1$. The slope parameter determines the smoothness of the transition from one extreme regime to the other: the higher it is, the more rapid the change. The location parameter c indicates the threshold between the two regimes; in the logistic case, $F(c) = 0.5$, so the regimes are associated with low and high values of y_{t-d} relative to c.

The exponential function is employed for the even case

$$F(y_{t-d}) = 1 - exp\left[-\gamma(y_{t-d} - c)^2\right] \tag{7}$$

and provides the exponential STAR or ESTAR model. This specification implies $F(c) = 0$ and $F(\pm\infty) = 1$ for some finite c, defining the inner and the outer regime, respectively.

The type of (regime-switching) behaviour is quite different depending on the specification considered. In the logistic model the two extreme regimes correspond to y_{t-d} values far above or below c, where dynamics may be different; the exponential model suggests rather similar dynamics in the extreme regimes, related to low and high y_{t-d} absolute values, while it can be different in the transition period.

In this paper we have considered the LSTAR model the most appropriate one for reflecting the potentially nonlinear evolution of African inflation rates. The decision is justified as this specification can generate two regimes with different dynamics for the inflation rates, one for high values of the variable and another for low ones.

3.2 Modelling approach

Traditionally, the STAR modelling cycle has relied on developing the iterative methodology proposed by Teräsvirta (1994). It is based on that of Box and Jenkins (1970) and involves three stages: search for specification, estimation and evaluation of the model. There exists a well-established STAR modelling procedure in the literature (see Granger and Teräsvirta, 1993; and Teräsvirta, 1994).

The starting point consists of finding out the linear model that is characterising the behaviour of the series under study. Once this specification is obtained, its appropriateness for the relation being analyzed is tested, i.e. whether the data display the kind of behaviour generated by smooth transition autoregressions. This stage is centered on the selection of the appropriate transition lag and the form of the transition function. In the next step, the parameters of the STAR specification are estimated by nonlinear least squares.

However, most recent empirical works do not follow this strategy in such a strict manner. It is argued that it is possible to develop valid nonlinear formulations that improve the fit of the linear ones without having to do the previous tests. This is done by means of an extensive search of STAR models through a grid for the combination (γ, c, d) and by paying more attention to their evaluation; any possible inadequacy of the models is expected to be unveiled at the validation stage (see Potter, 1999; Öcal and Osborn, 2000; van Dijk et al., 2002; Skalin and Teräsvirta, 1999; and Sensier et al., 2002, among others).

After estimating the STAR model, it is necessary to evaluate its properties in order to verify if it satisfactorily explains the behaviour of the variable. Most tests commonly used in dynamic models are valid in STAR models. Besides, Eitrheim and Teräsvirta (1996) have especially derived three evaluation tests for smooth transitions.

Finally, we develop a structural analysis of the nonlinear model; it is based on computing the roots of the characteristic polynomials associated to the STAR model, which provide with information to understand its dynamic properties. Unit and explosive roots deserve special attention, as the model may be globally stationary but locally unstable (see Teräsvirta and Anderson, 1992; Skalin and Teräsvirta, 1999; and Öcal and Osborn, 2000). Specifically, in a logistic specification the model is nonstationary if it contains a positive real root with modulus equal or greater than one; the reason is that positive real roots lead to monotonous behaviour, whereas negative real and complex ones generate oscillations and the series as a whole can be stationary if the oscillations are important enough to drive the series out of the nonstationary state.

4 Empirical results

4.1 The data

The data for this empirical analysis consists of monthly CPI-based inflation rates for a number of African countries, that is, Burkina Faso, Cameroon, Egypt, Ethiopia, Gambia, Ghana, Ivory Coast, Kenya, Madagascar, Mauritius, Morocco, Niger, Nigeria, Senegal, Seychelles, South Africa, Sudan and Swaziland, from 1969:1 until 2008:2, except for Seychelles whose sample starts in 1976:6 and Gambia and Swaziland whose series ends in 2006:9 and 2007:4, respectively. The data have been obtained from the *International Financial Statistics* database of the *International Monetary Fund*.

In figures 1 - 3 and table 1 we plot the series of inflation and display preliminary descriptive statistics, respectively, for this group of countries. The first feature to highlight is that most of these countries have suffered from high inflation periods. However, these high inflation periods can be considered as moderate compared with some Latin American countries. Secondly, the path of the inflation rates of these countries is pretty volatile. This may be caused by the frequent socio-political turmoils at which most of these countries have been subject to, as well as interventions in the markets.

The sources of inflation may vary depending upon the country. For instance, the Central Bank of West African countries devaluated Burkina Faso, Ivory Coast, Niger, Senegal's currencies in 1994 against the French Franc. Likewise, the currency of Cameroon was devaluated at the end of 1993. These measures could increase quite considerably the prices of imported products, raising hence, the inflation rates in those periods. Further, Jeong et al. (2002) provide evidence that domestic inflation in a number of African countries is attributable to inflation shocks originating in foreign -African- countries. This explains the apparent high degree of correlation among the inflation rates of these countries. Furthermore, Coleman (2008a) finds certain degree of real exchange rate undervaluation, which might have pushed up the inflation rates. Finally, two recent contributions, Barnichon and Peiris (2007) and Jumah and Kunst (2007), provide evidence of the strong and positive relationship between inflation and money gap and output gap in Sub-Saharan countries, in the former, and cocoa prices in West African countries, in the latter.

All these events may generate nonlinear behaviour in the inflation rates of these countries, which should be taken into account when modelling the dynamics of the variable.

4.2 Unit root testing

Prior to the statistical analysis, we have plotted the autocorrelation functions of the inflation rates in figures 4 - 6. It is obvious to notice the high degree of persistence of the inflation series for these countries. In this case, it is difficult to conclude with only visual inspection of the autocorrelation functions, whether the series need to be differenced or not, in order to obtain stationary variables.

In table 2 we display the results of the Ng and Perron (2001) and KSS unit root tests. It is worth noticing that in most cases these two tests provide similar conclusions. However, there are a few exceptions, such those of Egypt, Seychelles and Sudan, where we cannot reject the null hypothesis with the Ng and Perron (2001) test, but we do reject with the KSS, and for Morocco, the opposite applies, i.e. we cannot reject the null hypothesis of unit root with the KSS test, but we do reject with the Ng and Perron (2001). To sum up, it is possible to reject the null hypothesis in favour of stationarity in all the cases except for Kenya and South Africa. In the latter, although an inflation target was set from 2000 onwards, the inflation rate appears to be nonstationary for the whole period.

The unit root tests results have important implications about the behaviour of inflation rates, as stated in the introduction. Accordingly, our results point to lack of inflation persistence for most of the countries.

4.3 Estimated STAR models

The first step in detecting nonlinearities in the evolution of African inflation rates is to determine the linear specifications for the eighteen countries under study. An ordinary least squares estimation is carried out, where the number of lags is selected using the Akaike information criterion (AIC); the lag order p ranges from 1 to 12[5].

Although several authors demonstrate that conclusions from linearity tests are not a tool for guiding the modelling process, it is commonplace to compute such tests; for doing so, we follow the so-called unconditional approach. This strategy assumes that the transition variable is the linear combination $\sum_{d=1}^{p} \upsilon_d y_{t-d}$, where $\upsilon' = (0...1...0)'$ is a selection vector with the only unit element corresponding to the unknown transition lag (Teräsvirta, 1998). The tests for a linear characterisation of inflation rates against a LSTAR representation have been computed for the value of p selected with AIC and d varying from 1 to p. Table 3 displays a summary of p-values of the linearity tests in their F version; the figures indicate that the hypothesis of a linear behaviour of inflation rates is rejected in all countries at a 0.05 significance level except for Morocco and Nigeria, where we can reject the null at a 0.1 significance level.

[5]To save space, these models are not reported but they are available from authors upon request.

The next step is to specify and estimate LSTARs for the eighteen inflation series. Model building is based on an extensive grid search; all the combinations of p and d are defined, trying for different values of γ and considering a value for c close to the sample mean of the transition variable. This strategy necessarily generates a great number of LSTAR specifications.

LSTAR models are estimated by nonlinear least squares. Following the recommendations of Teräsvirta (1994), the argument of the logistic transition function is scaled by dividing it by the standard deviation of the dependent variable, in order to overcome some usual problems in the estimation. In those countries where parameter convergence is attained[6], the models presenting the best statistical properties are selected for further refinement. First, nonsignificant coefficients are dropped to conserve degrees of freedom and then, we simplify this first set of estimations through cross-parameter restrictions so as to increase efficiency; the limit t-value for these coefficients is 1.6.

Tables 4 - 6 report the final selected models in full detail. All processes are I(0) except for Kenya and South Africa, so that in these two countries the variable is the inflation rate growth (inflation in first differences). Inflation rates (and their growth) display remarkable dependence on their own history in most African countries. Strictly speaking, this dependence refers to concrete and repeated periods in time. Figures 1 - 3 show that inflation rates undergo continuous oscillations, moving from situations of huge inflation to more moderate ones and vice versa. The estimated location parameter defines the two extreme regimes; as it is close to the sample means of inflation rates in most countries (where it is not, c is greater than the mean, except for Cameroon), the lower regime is given by negative or low to moderate inflation rates and the upper regime, by high inflation values (three digits in some countries).

Figures 7 - 9 display the estimated transition functions. The values of γ indicate

[6] It is not possible to obtain adequate LSTARs that describe the evolution of the inflation rates in Senegal, Sudan and Egypt; this is due to either convergence problems in the estimation or to getting unsatisfactory models.

rapid transitions between the extreme regimes in almost all countries; the change is even abrupt in some of them, so that the corresponding STAR model mimics a threshold (SETAR) model. These results are the expected ones, according to the already discussed evolution of African inflation rates. Exogenous factors may play a more important role than domestic demand in determining inflation, leading to the observed sudden changes in its values.

LSTAR models are validated by means of misspecification tests and by paying particular attention to the features of their transition functions. Regarding the former, we consider the test of no autoregressive conditional heteroskedasticity (ARCH) with one lag and the three tests proposed by Eitrheim and Teräsvirta (1996): the test of residual serial independence against processes of different orders, although just the corresponding to order 8 is shown (AUTO); the test of no remaining nonlinearity in the residuals, computed for several values of the transition lag under the alternative but only the one minimizing the p-value of the tests is displayed (NL); the test of parameter constancy that allows for monotonically changing parameters under the alternative (PC). The following diagnostic statistics are also reported: the residual standard error (s), the adjusted determination coefficient ($\bar{R}^2$) and the variance ratio of the residuals from the nonlinear model and the best linear specification (s^2/s_L^2).

The estimated models present no evidence of misspecification in general. In few countries, some tests do not offer satisfactory results, like the ARCH one or one of the Eitrheim and Teräsvirta's (1996) tests. However, the evaluation procedure as a whole points to the expected behaviour of the estimated models. As a result, LSTAR models seem adequate to describe the evolution of African inflation rates (and their growth).

Two questions are highlighted. First, according to the variance ratio, the estimated nonlinear models explain 3%-22% of the residual variance of the best linear autoregression in all fifteen countries. Second, in order to describe the behaviour of the LSTAR models more in depth, the validation stage is completed with the examination of the estimated residuals. Thus, figures 10 - 12 plot the residuals from the nonlinear and the linear models. Clearly, LSTAR models globally lessen the largest (positive or negative) residuals of the linear specifications.

The key point is that these divergences between residuals are particularly striking in outstanding phases of the African economies along the sample, i.e., the devaluation process carried out by the Central Bank of West African countries in 1994, severe droughts (Ethiopia 1984, 1991; Kenya 1992; or Ghana 1982-1983, for example), the coffee boom in 1993 in Kenya, or the drop in uranium revenues in 1981 in Niger (the last two are country-specific sources of inflation). Although for space reasons the results are not shown, the differences, in absolute values, between the residuals of the linear specifications and those of the LSTAR models have been computed: positive deviations are the prevailing ones over time. In short, we count on a sign of better behaviour of the nonlinear models, a fact that is supported by the variance ratios.

In order to better characterise the variable within each country and possibly find common facts, we study the local dynamic properties of the LSTAR models. Conditional on the regime, the models are locally linear and the dynamics can be interpreted through the roots of the characteristic polynomials. To summarise local dynamics, we consider the two extreme values of the transition function, F = 0 and F = 1, and compute the roots of the resulting polynomial. Table 7 reports the main results; to save space, only the dominant root is shown, that is, the root with the highest modulus that determines the long-run behaviour of the series within each regime.

In almost all countries the estimated LSTAR models are always stable. As long as the inflation rate (and its growth) remains within the lower or the upper regime, the variable tends to remain there. In our sample, the lower regime spans negative to moderate values of inflation, while the upper regime corresponds to high inflation rates or hyperinflation phases. An exogenous shock is needed to push the inflation from one extreme regime to the other. Cameroon, Niger, Nigeria, Kenya and South Africa are the only countries presenting locally unstable but globally stationary models.

Cameroon presents an explosive root in the lower regime, so that inflation evolves quickly towards the upper regime (rates greater than 0.44%), where it tends to remain unless an exogenous shock occurred. The opposite situation takes place in the remaining countries; stability is found in the lower regime, but inflation will not remain indefinitely in this state. For Niger and Nigeria, once the transition variable is above 30.69% and 53.96%, respectively, the model becomes locally unstable and is dominated by an explosive root that sends inflation back to moderate rate. In the cases of Kenya and South Africa, variations in inflation rates exceeding 2.73% and 0.84%, respectively, involve local instability.

These results stress the following fact: both extreme regimes are very well defined in the vast majority of the countries, in the sense that they contain a large number of observations; in other words, these countries can be in a low as well as in a high inflation phase, where they remain for a given period of time. However, in those countries with few observations in one of the extreme regimes, e.g. Cameroon, Niger, Nigeria and South Africa (in the first case there is almost no lower regime strictly speaking), the model shows local instability and inflation would take low to moderate values.

Therefore, we appreciate how African countries coexist, in an intermittent way, with low and large inflation stages, passing abruptly from one to the other. Our results also suggest that countries where extreme values for inflation are seldom observed do not stay in this phase for long and go back to more reasonable rates. The underlying explanation to this behaviour may be that African inflation is especially affected by exogenous shocks, which cause a sudden impact on it, as the ability of the internal forces of the economy to control prices is quite limited (Jeong et al., 2002). Economic agents do not react in the dynamic manner typical of industrialised countries, so that the tendency to remain in a given state subsequent to a shock is unlikely.

More specifically, in the literature demand pressures (output gap) and monetary and fiscal policies have been suggested as major factors in determining inflation in African countries (see Barnichon and Peiris, 2007; and Jumah and Kunst, 2007), but we suggest the role that supply shocks (movements in exchange rates, variations in oil prices in international markets, social and political conflicts, droughts, etcetera) and inertia play in the evolution of domestic prices, as a differential fact from what is usual in developed countries.

Exchange rate variations of African currencies come out as a relevant source of inflation. The oscillating evolution of the exchange rate in these countries, even containing structural changes, will steadily push up or down domestic prices. Domestic inflation in Africa is also influenced by innovations coming from other countries or international events (for instance, the oil crisis in the seventies, see figures 1 - 3), but geographical proximity does not seem to be a deciding transmission factor of inflation. The case of Ivory Coast is an exception for being one of the leader inflation producers in Africa; its effects are clearly observed in neighboring countries like Ghana, Cameroon or Senegal (see figures 1 - 3).

Finally, expectations are usually not well-anchored in these countries, so price shocks are likely to last a meaningful period of time; the results we have obtained confirm this point. This inertia is mainly due to poor credibility on central banks and politics. It is worth mentioning that price stability has become the main objective for some African central banks, like those of South Africa and Ghana, which have recently adopted an inflation-targeting framework.

5 Conclusions

Inflation is still a source of severe problems in many developing countries and high levels of inflation disrupt steady growth and lead to missallocation of resources through distortions in relative prices. Aimed at contributing to the empirical literature on inflation persistence in developing economies, this paper analyses the evolution of inflation in a group of African countries, by means of nonlinear (regime-dependent) models.

The persistence analysis points to lack of persistence patterns in most of the countries under study, implying that shocks tend to dissipate their effects along time, i.e. shocks only have temporary effects. In addition, the inflation rate tends to remain in its current regime (low or high inflation) as long as no exogenous shocks occurred. This conclusion has important insights; monetary policy decisions to reduce inflation might have the desired effect if they are applied with the correct magnitude and as the variable is globally stationary, the effects should last until another shock pushes inflation to the upper (high inflation) regime.

As further research, we propose to include exogenous variables that might explain the nonlinearities in the inflation rate, such as exchange rates, external deficit, GDP, etc., on account of not being within the scope of the present paper to apply multivariate analysis.

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Table 1: Descriptive statistics summary

Country	Mean	Std Error	Minimum	Maximum
Burkina Faso	5.3047	8.8108	-16.7286	60.7784
Cameroon	6.8509	7.6892	-6.0610	47.2634
Egypt	10.4272	6.8040	-2.8777	35.1111
Ethiopia	7.5412	10.1341	-18.1011	44.9963
Gambia	10.1221	10.9113	-4.6140	75.6420
Ghana	33.8949	32.8353	-0.9211	174.1440
Ivory Coast	6.9873	7.3978	-4.3309	38.8820
Kenya	12.2783	9.5667	-3.6624	61.5421
Madagascar	13.6493	11.6092	-8.4464	64.2909
Mauritius	8.9575	8.1637	-2.2351	49.3506
Morocco	5.5208	4.3109	-1.6677	20.7753
Niger	5.4362	10.0028	-13.6979	46.4400
Nigeria	20.1188	17.8216	-4.9297	89.5666
Senegal	5.9841	8.6094	-7.7693	43.4657
Seychelles	6.5888	8.6583	-16.4468	44.5993
South Africa	9.9368	4.4740	0.1644	20.9424
Sudan	35.9656	38.1489	-3.8861	164.7320
Swaziland	10.5731	6.5438	-5.2731	31.1003

Table 2: Ng-Perron and KSS unit root test results

Country	MZ_a	MZ_t	MSB	MP_T	$\hat{t}_{NL}$	$\hat{t}_{NLD}$
Burkina Faso	-37.6768**	-4.34028**	0.11520**	0.65038**	-2.89679*	-2.83387*
Cameroon	-8.10112**	-1.99369**	0.24610**	3.09837**	-2.46385*	-2.40880
Egypt	-3.70277	-1.29645	0.35013	6.65062	-2.14086*	-3.00063**
Ethiopia	-9.66018**	-2.03173**	0.21032**	3.18293**	-3.33837**	-3.50028**
Gambia	-9.56014**	-2.16786**	0.22676**	2.63713**	-2.43822*	-2.75373*
Ghana	-6.31252*	-1.77621*	0.28138	3.88248*	-4.07465**	-5.06459**
Ivory Coast	-14.9918**	-2.70834**	0.18066**	1.74900**	-1.96605*	-1.99264
Kenya	-3.85244	-1.26919	0.32945	6.46202	-1.99522*	-1.86977
Madagascar	-6.93430*	-1.85832*	0.26799*	3.54691*	-1.99754*	-1.91247
Mauritius	-7.81919*	-1.95802*	0.25041*	3.20795*	-3.54197**	-3.94045**
Morocco	-7.36445*	-1.91737*	0.26035*	3.33267*	-1.61313	-2.15850
Niger	-18.9213**	-3.06796**	0.16214**	1.32388**	-2.82085**	-2.99555**
Nigeria	-8.59416*	-2.07291*	0.24120*	2.85088*	-2.05404*	-2.40386
Senegal	-20.6729**	-3.21503**	0.15552**	1.18513**	-2.60929**	-2.72865*
Seychelles	-4.02173	-1.02293	0.25435	6.52005	-3.87539**	-4.09288**
South Africa	-1.16415	-0.67769	0.58213	18.0789	-1.22845	-1.63503
Sudan	-4.01824	-1.41541	0.35225	6.09973	-2.75137**	-3.55871 **
Swaziland	-11.7627**	-2.41301**	0.20514**	2.13181**	-3.62084**	-5.86949**

Note: The order of lag to compute the tests has been chosen using the modified AIC (MAIC) suggested by Ng and Perron (2001). The Ng-Perron tests include an intercept, whereas the KSS test has been applied to the raw data, $\hat{t}_{NL}$ say, and to the demeaned data, $\hat{t}_{NLD}$ say. The symbols * and ** mean rejection of the null hypothesis of unit root at the 10% and 5% respectively. The critical values for the Ng-Perron tests have been taken from Ng and Perron (2001), whereas those for the KSS have been obtained by Monte Carlo simulations with 50,000 replications:

	MZ_a	MZ_t	MSB	MP_T	$\hat{t}_{NL}$	$\hat{t}_{NLD}$
5%	-8.100	-1.980	0.233	3.170	-2.210	-2.921
10%	-5.700	-1.620	0.275	4.450	-1.917	-2.648

Table 3: Linearity tests against logistic smooth transition autoregressions

Country	**p-value**
Burkina Faso	0.00000
Cameroon	0.00000
Egypt	0.00000
Ethiopia	0.01995
Gambia	0.00000
Ghana	0.00000
Ivory Coast	0.00000
Kenya	0.00000
Madagascar	0.00000
Mauritius	0.00000
Morocco	0.06982
Niger	0.00015
Nigeria	0.05386
Senegal	0.00000
Seychelles	0.00000
South Africa	0.00005
Sudan	0.00000
Swaziland	0.02094

Table 4: Estimated LSTAR models for inflation rates

BURKINA FASO

$$y_t = \underset{(0.29)}{0.63} + \underset{(0.05)}{0.92}y_{t-1} + \underset{(0.05)}{0.10}y_{t-2} - \underset{(0.05)}{0.08}y_{t-4} + \underset{(0.05)}{0.23}y_{t-5} - \underset{(0.09)}{0.32}y_{t-6} - \underset{(0.08)}{0.11}y_{t-7} + \underset{(0.06)}{0.26}y_{t-9} - \underset{(0.03)}{0.18}y_{t-10} + \left(\underset{(1.00)}{1.88} - \underset{(0.06)}{0.31}y_{t-1} + \underset{(0.10)}{0.29}y_{t-6} + \underset{(0.08)}{0.11}y_{t-7} - \underset{(0.06)}{0.26}y_{t-9}\right) \times \left[1 + exp\left\{-\underset{(24.14)}{17.36} \times 0.11\left(y_{t-6} - \underset{(0.74)}{7.63}\right)\right\}\right]^{-1} + u_t$$

s=4.33; $\bar{R}^2 = 0.76$; $s^2/s_L^2 = 0.92$; ARCH=64.88 (0.00); AUTO=1.59 (0.13); NL=1.59 (0.08); PC=0.74 (0.80)

CAMEROON

$$y_t = -\underset{(3.13)}{3.39} + \underset{(0.21)}{1.50}y_{t-1} - \underset{(0.38)}{0.85}y_{t-2} + \underset{(0.39)}{0.62}y_{t-3} - \underset{(0.33)}{0.54}y_{t-4} + \underset{(0.28)}{0.62}y_{t-5} - \underset{(0.04)}{0.05}y_{t-7} - \underset{(0.32)}{0.54}y_{t-9} + \underset{(0.43)}{0.66}y_{t-10} - \underset{(0.77)}{1.64}y_{t-11} + \left(\underset{(3.78)}{7.31} - \underset{(0.22)}{0.67}y_{t-1} + \underset{(0.38)}{0.85}y_{t-2} - \underset{(0.39)}{0.62}y_{t-3} + \underset{(0.33)}{0.54}y_{t-4} - \underset{(0.28)}{0.62}y_{t-5} + \underset{(0.34)}{0.70}y_{t-9} - \underset{(0.46)}{0.79}y_{t-10} + \underset{(0.77)}{1.53}y_{t-11}\right) \times \left[1 + exp\left\{-\underset{(0.70)}{2.43} \times 0.13\left(y_{t-11} - \underset{(2.38)}{0.44}\right)\right\}\right]^{-1} + u_t$$

s=2.11; $\bar{R}^2 = 0.92$; $s^2/s_L^2 = 0.81$; ARCH=27.50 (0.00); AUTO=1.03 (0.41); NL=1.19 (0.28); PC=1.17 (0.26)

ETHIOPIA

$$y_t = \underset{(0.21)}{0.89} + \underset{(0.03)}{0.95}y_{t-1} + \underset{(0.05)}{0.10}y_{t-4} - \underset{(0.05)}{0.07}y_{t-5} - \underset{(0.05)}{0.12}y_{t-8} + \underset{(0.07)}{0.25}y_{t-9} - \underset{(0.07)}{0.13}y_{t-10} - \underset{(0.05)}{0.12}y_{t-11} + \left(\underset{(1.60)}{1.94} - \underset{(0.09)}{0.11}y_{t-1} + \underset{(0.13)}{0.36}y_{t-3} - \underset{(0.18)}{0.76}y_{t-4} + \underset{(0.18)}{0.24}y_{t-5} - \underset{(0.17)}{0.20}y_{t-6} + \underset{(0.14)}{0.33}y_{t-7} - \underset{(0.07)}{0.25}y_{t-9} + \underset{(0.07)}{0.13}y_{t-10} + \underset{(0.05)}{0.12}y_{t-11}\right) \times \left[1 + exp\left\{-\underset{(96.41)}{30.15} \times 0.10\left(y_{t-10} - \underset{(0.49)}{22.09}\right)\right\}\right]^{-1} + u_t$$

s=3.15; $\bar{R}^2 = 0.90$; $s^2/s_L^2 = 0.91$; ARCH=6.21 (0.01); AUTO=2.06 (0.04); NL=1.18 (0.28); PC=0.73 (0.82)

GAMBIA

$$y_t = \underset{(0.29)}{0.45} + \underset{(0.05)}{0.89}y_{t-1} + \underset{(0.06)}{0.13}y_{t-3} - \underset{(0.14)}{0.22}y_{t-5} + \underset{(0.10)}{0.10}y_{t-6} + \left(\underset{(0.90)}{1.57} + \underset{(0.09)}{0.33}y_{t-1} - \underset{(0.10)}{0.22}y_{t-2} - \underset{(0.09)}{0.37}y_{t-4} + \underset{(0.18)}{0.75}y_{t-5} - \underset{(0.13)}{0.48}y_{t-6}\right) \times \left[1 + exp\left\{-\underset{(2.11)}{3.62} \times 0.09\left(y_{t-5} - \underset{(2.16)}{12.95}\right)\right\}\right]^{-1} + u_t$$

s=2.60; $\bar{R}^2 = 0.94$; $s^2/s_L^2 = 0.94$; ARCH=9.74 (0.00); AUTO=1.04 (0.40); NL=2.38 (0.02); PC=1.07 (0.38)

GHANA

$$y_t = \underset{(0.69)}{2.04} + \underset{(0.11)}{0.51}y_{t-1} + \underset{(0.10)}{0.25}y_{t-2} + \underset{(0.07)}{0.14}y_{t-4} + \underset{(0.05)}{0.11}y_{t-5} - \underset{(0.03)}{0.08}y_{t-10} + \left(-\underset{(0.94)}{0.28} + \underset{(0.13)}{1.01}y_{t-1} - \underset{(0.14)}{0.62}y_{t-2} - \underset{(0.09)}{0.15}y_{t-3} - \underset{(0.09)}{0.26}y_{t-4} + \underset{(0.02)}{0.05}y_{t-12}\right) \times \left[1 + exp\left\{-\underset{(171.22)}{103.98} \times 0.03\left(y_{t-11} - \underset{(0.44)}{14.87}\right)\right\}\right]^{-1} + u_t$$

s=5.63; $\bar{R}^2 = 0.97$; $s^2/s_L^2 = 0.78$; ARCH=41.26 (0.00); AUTO=0.55 (0.82); NL=1.58 (0.06); PC=1.52 (0.05)

Notes: y_t denotes the inflation rate. Values under regression coefficients are standard errors of the estimates; s is the residual standard error; $\bar{R}^2$ is the adjusted determination coefficient; s^2/s_L^2 is the variance ratio of the residuals from the nonlinear model and the best linear AR selected with AIC; ARCH is the statistic of no ARCH based on one lag; AUTO is the test for residual autocorrelation of order 8; NL is the test for no remaining nonlinearity; PC is a parameter constancy test. Numbers in parentheses after values of ARCH, AUTO, NL and PC are p-values.

Table 5: Estimated LSTAR models for inflation rates (continued)

IVORY COAST

$$y_t = \underset{(0.27)}{0.34} + \underset{(0.05)}{0.90}y_{t-1} - \underset{(0.11)}{0.20}y_{t-2} + \underset{(0.12)}{0.24}y_{t-3} - \underset{(0.10)}{0.25}y_{t-4} + \underset{(0.09)}{0.09}y_{t-6} + \underset{(0.07)}{0.12}y_{t-8} + \left(\underset{(0.47)}{0.39} + \underset{(0.11)}{0.28}y_{t-2} - \underset{(0.12)}{0.24}y_{t-3} + \underset{(0.11)}{0.25}y_{t-4} - \underset{(0.09)}{0.09}y_{t-6} - \underset{(0.08)}{0.19}y_{t-8}\right) \times \left[1 + exp\left\{-\underset{(153.08)}{58.38} \times 0.13\left(y_{t-1} - \underset{(0.45)}{4.74}\right)\right\}\right]^{-1} + u_t$$

s=2.66; $\bar{R}^2 = 0.87$; $s^2/s_L^2 = 0.97$; ARCH=4.86 (0.03); AUTO=1.35 (0.22); NL=1.62 (0.10); PC=1.21 (0.25)

KENYA

$$\Delta y_t = \underset{(0.10)}{0.13} + \underset{(0.04)}{0.05}\Delta y_{t-1} + \underset{(0.04)}{0.19}\Delta y_{t-2} - \underset{(0.04)}{0.13}\Delta y_{t-4} + \underset{(0.04)}{0.11}\Delta y_{t-6} + \underset{(0.05)}{0.10}\Delta y_{t-8} + \underset{(0.04)}{0.07}\Delta y_{t-10} + \underset{(0.04)}{0.10}\Delta y_{t-11} - \underset{(0.04)}{0.51}\Delta y_{t-12} - \left(-\underset{(1.14)}{2.95} + \underset{(0.15)}{0.37}\Delta y_{t-1} + \underset{(0.13)}{0.33}\Delta y_{t-3} + \underset{(0.04)}{0.13}\Delta y_{t-4} - \underset{(0.13)}{0.38}\Delta y_{t-5} - \underset{(0.04)}{0.11}\Delta y_{t-6} + \underset{(0.19)}{0.51}\Delta y_{t-8} - \underset{(0.14)}{0.20}\Delta y_{t-9} - \underset{(0.18)}{0.48}\Delta y_{t-10}\right) \times \left[1 + exp\left\{-\underset{(8.18)}{9.74} \times 0.43\left(\Delta y_{t-8} - \underset{(0.26)}{2.73}\right)\right\}\right]^{-1} + u_t$$

s=1.84; $\bar{R}^2 = 0.38$; $s^2/s_L^2 = 0.86$; ARCH=0.15 (0.70); AUTO=0.31 (0.96); NL=1.63 (0.06); PC=1.57 (0.04)

MADAGASCAR

$$y_t = \underset{(0.24)}{1.03} + \underset{(0.05)}{1.27}y_{t-1} - \underset{(0.07)}{0.39}y_{t-2} + \underset{(0.06)}{0.14}y_{t-3} - \underset{(0.04)}{0.06}y_{t-5} - \underset{(0.02)}{0.04}y_{t-10} + \left(-\underset{(2.96)}{1.01} - \underset{(0.09)}{0.42}y_{t-1} + \underset{(0.10)}{0.37}y_{t-3} + \underset{(0.08)}{0.13}y_{t-6} + \underset{(0.08)}{0.12}y_{t-8} + \underset{(0.11)}{0.22}y_{t-10} - \underset{(0.09)}{0.43}y_{t-11}\right) \times \left[1 + exp\left\{-\underset{(73.14)}{63.40} \times 0.09\left(y_{t-9} - \underset{(0.24)}{35.81}\right)\right\}\right]^{-1} + u_t$$

s=2.63; $\bar{R}^2 = 0.95$; $s^2/s_L^2 = 0.92$; ARCH=5.97 (0.01); AUTO=1.17 (0.32); NL=1.17 (0.28); PC=1.45 (0.08)

MAURITIUS

$$y_t = \underset{(0.19)}{0.37} + \underset{(0.05)}{1.31}y_{t-1} - \underset{(0.05)}{0.27}y_{t-2} - \underset{(0.02)}{0.09}y_{t-8} + \left(\underset{(1.70)}{3.21} - \underset{(0.05)}{0.25}y_{t-1} + \underset{(0.09)}{0.21}y_{t-4} - \underset{(0.10)}{0.17}y_{t-5} + \underset{(0.08)}{0.17}y_{t-7} - \underset{(0.02)}{0.09}y_{t-8}\right) \times \left[1 + exp\left\{-\underset{(1.86)}{2.63} \times 0.12\left(y_{t-7} - \underset{(3.16)}{19.41}\right)\right\}\right]^{-1} + u_t$$

s=1.81; $\bar{R}^2 = 0.95$; $s^2/s_L^2 = 0.97$; ARCH=3.76 (0.05); AUTO=2.76 (0.00); NL=1.55 (0.09); PC=1.62 (0.05)

MOROCCO

$$y_t = \underset{(0.12)}{0.26} + \underset{(0.05)}{1.24}y_{t-1} - \underset{(0.07)}{0.49}y_{t-2} + \underset{(0.09)}{0.24}y_{t-3} - \underset{(0.10)}{0.20}y_{t-4} + \underset{(0.10)}{0.17}y_{t-5} - \underset{(0.07)}{0.08}y_{t-6} + \underset{(0.03)}{0.04}y_{t-9} + \left(\underset{(0.41)}{1.47} + \underset{(0.06)}{0.09}y_{t-1} - \underset{(0.12)}{0.40}y_{t-3} + \underset{(0.17)}{0.63}y_{t-4} - \underset{(0.16)}{0.53}y_{t-5} + \underset{(0.11)}{0.30}y_{t-6} - \underset{(0.05)}{0.19}y_{t-9}\right) \times \left[1 + exp\left\{-\underset{(9.91)}{11.78} \times 0.23\left(y_{t-3} - \underset{(0.36)}{7.01}\right)\right\}\right]^{-1} + u_t$$

s=1.00; $\bar{R}^2 = 0.95$; $s^2/s_L^2 = 0.95$; ARCH=0.06 (0.80); AUTO=0.91 (0.50); NL=0.84 (0.59); PC=1.63 (0.04)

Notes: See Table 4

Table 6: Estimated LSTAR models for inflation rates

NIGER

$$y_t = \underset{(0.19)}{0.41} + \underset{(0.05)}{0.97}y_{t-1} - \underset{(0.06)}{0.10}y_{t-2} + \underset{(0.05)}{0.16}y_{t-4} - \underset{(0.06)}{0.11}y_{t-5} + \underset{(0.05)}{0.09}y_{t-6} - \underset{(0.05)}{0.09}y_{t-8} + \underset{(0.06)}{0.14}y_{t-9} - \underset{(0.04)}{0.14}y_{t-10} - \left(\underset{(10.81)}{22.43} - \underset{(0.18)}{1.02}y_{t-1} + \underset{(0.47)}{1.06}y_{t-2} - \underset{(0.24)}{0.85}y_{t-3} + \underset{(0.14)}{0.45}y_{t-5} - \underset{(0.22)}{0.43}y_{t-7} + \underset{(0.21)}{0.46}y_{t-8} - \underset{(0.12)}{0.83}y_{t-11}\right) \times \left[1 + exp\left\{-\underset{(7.60)}{8.28} \times 0.10\left(y_{t-2} - \underset{(1.20)}{30.69}\right)\right\}\right]^{-1} + u_t$$

s=3.42; $\bar{R}^2 = 0.88$; $s^2/s_L^2 = 0.87$; ARCH=23.46 (0.00); AUTO=1.37 (0.20); NL=1.46 (0.12); PC=2.75 (0.00)

NIGERIA

$$y_t = \underset{(0.31)}{1.16} + \underset{(0.02)}{1.05}y_{t-1} + \underset{(0.05)}{0.06}y_{t-5} - \underset{(0.07)}{0.20}y_{t-6} + \underset{(0.06)}{0.08}y_{t-7} - \underset{(0.02)}{0.05}y_{t-11} + \left(\underset{(5.28)}{4.21} + \underset{(0.15)}{0.40}y_{t-1} - \underset{(0.20)}{0.62}y_{t-3} + \underset{(0.31)}{0.65}y_{t-6} - \underset{(0.41)}{0.78}y_{t-7} + \underset{(0.31)}{0.33}y_{t-8} + \underset{(0.30)}{0.41}y_{t-9} - \underset{(0.40)}{0.97}y_{t-10} + \underset{(0.25)}{0.56}y_{t-11}\right) \times \left[1 + exp\left\{-\underset{(3.81)}{5.59} \times 0.06\left(y_{t-9} - \underset{(3.26)}{53.96}\right)\right\}\right]^{-1} + u_t$$

s=3.29; $\bar{R}^2 = 0.97$; $s^2/s_L^2 = 0.92$; ARCH=4.62 (0.03); AUTO=1.44 (0.18); NL=1.23 (0.23); PC=1.39 (0.11)

SEYCHELLES

$$y_t = \underset{(0.22)}{0.41} + \underset{(0.08)}{1.00}y_{t-1} - \underset{(0.10)}{0.10}y_{t-2} + \underset{(0.10)}{0.15}y_{t-4} - \underset{(0.09)}{0.10}y_{t-5} - \underset{(0.03)}{0.09}y_{t-9} + \left(\underset{(1.29)}{3.51} - \underset{(0.10)}{0.41}y_{t-1} + \underset{(0.12)}{0.29}y_{t-2} + \underset{(0.07)}{0.18}y_{t-3} - \underset{(0.12)}{0.37}y_{t-4} + \underset{(0.12)}{0.18}y_{t-5} + \underset{(0.07)}{0.09}y_{t-6} - \underset{(0.07)}{0.07}y_{t-7}\right) \times \left[1 + exp\left\{-\underset{(12.55)}{11.26} \times 0.11\left(y_{t-7} - \underset{(1.00)}{10.09}\right)\right\}\right]^{-1} + u_t$$

s=3.38; $\bar{R}^2 = 0.85$; $s^2/s_L^2 = 0.96$; ARCH=2.98 (0.08); AUTO=1.77 (0.08); NL=0.87 (0.58); PC=0.76 (0.76)

SOUTH AFRICA

$$\Delta y_t = \underset{(0.08)}{0.09} + \underset{(0.04)}{0.06}\Delta y_{t-2} + \underset{(0.04)}{0.08}\Delta y_{t-3} - \underset{(0.06)}{0.07}\Delta y_{t-4} + \underset{(0.06)}{0.07}\Delta y_{t-5} - \underset{(0.06)}{0.06}\Delta y_{t-6} + \underset{(0.04)}{0.11}\Delta y_{t-9} - \underset{(0.04)}{0.49}\Delta y_{t-12} + \left(-\underset{(0.48)}{0.72} + \underset{(0.15)}{0.23}\Delta y_{t-1} + \underset{(0.17)}{0.26}\Delta y_{t-4} - \underset{(0.21)}{0.28}\Delta y_{t-5} + \underset{(0.20)}{0.28}\Delta y_{t-6} + \underset{(0.15)}{0.17}\Delta y_{t-7} + \underset{(0.25)}{0.41}\Delta y_{t-8} + \underset{(0.16)}{0.16}\Delta y_{t-11}\right) \times \left[1 + exp\left\{-\underset{(1.39)}{2.03} \times 1.22\left(\Delta y_{t-8} - \underset{(0.49)}{0.84}\right)\right\}\right]^{-1} + u_t$$

s=0.73; $\bar{R}^2 = 0.23$; $s^2/s_L^2 = 0.96$; ARCH=22.82 (0.00); AUTO=0.76 (0.64); NL=1.31 (0.18); PC=1.12 (0.31)

SWAZILAND

$$y_t = \underset{(0.44)}{1.12} + \underset{(0.06)}{0.55}y_{t-1} + \underset{(0.08)}{0.17}y_{t-2} + \underset{(0.05)}{0.18}y_{t-3} + \left(\underset{(1.43)}{2.70} + \underset{(0.10)}{0.35}y_{t-1} - \underset{(0.11)}{0.30}y_{t-2} - \underset{(0.09)}{0.27}y_{t-4} + \underset{(0.08)}{0.24}y_{t-5} - \underset{(0.08)}{0.14}y_{t-9} + \underset{(0.10)}{0.22}y_{t-10} - \underset{(0.08)}{0.29}y_{t-11}\right) \times \left[1 + exp\left\{-\underset{(30.64)}{22.00} \times 0.15\left(y_{t-2} - \underset{(0.49)}{12.72}\right)\right\}\right]^{-1} + u_t$$

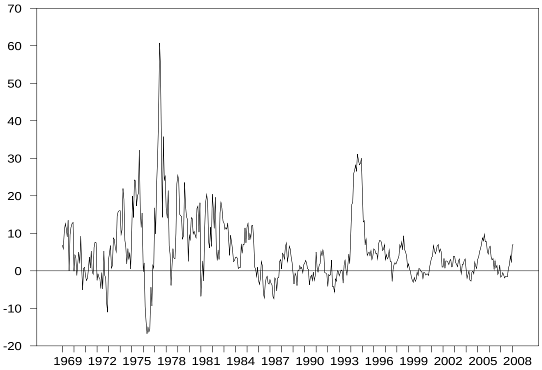
s=3.18; $\bar{R}^2 = 0.76$; $s^2/s_L^2 = 0.97$; ARCH=4.41 (0.04); AUTO=0.37 (0.94); NL=1.54 (0.07); PC=1.38 (0.11)

Notes: See Table 4

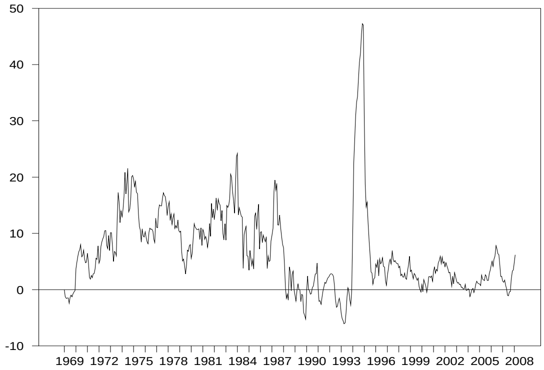
Table 7: Local dynamics: dominant roots in each regime

Country	Regime (value of F)	Root	Modulus
Burkina Faso	Lower (F=0)	$0.9441 \pm 0.2040i$	0.96
	Upper (F=1)	$0.9281 \pm 0.1682i$	0.94
Cameroon	Lower (F=0)	$1.1827 \pm 0.2103i$	1.20
	Upper (F=1)	$0.9294 \pm 0.1926i$	0.95
Ethiopia	Lower (F=0)	$0.9677 \pm 0.1356i$	0.98
	Upper (F=1)	$-0.6810 \pm 0.5355i$	0.87
Gambia	Lower (F=0)	0.8900	0.89
	Upper (F=1)	$0.9323 \pm 0.1664i$	0.95
Ghana	Lower (F=0)	0.9423	0.94
	Upper (F=1)	$0.8938 \pm 0.2027i$	0.92
Ivory Coast	Lower (F=0)	0.9568	0.96
	Upper (F=1)	$0.8779 \pm 0.1051i$	0.88
Kenya	Lower (F=0)	$-0.6931 \pm 0.6894i$	0.98
	Upper (F=1)	$1.0154 \pm 0.2187i$	1.04
Madagascar	Lower (F=0)	$0.9276 \pm 0.1331i$	0.94
	Upper (F=1)	$0.9734 \pm 0.0819i$	0.98
Mauritius	Lower (F=0)	$0.9618 \pm 0.1212i$	0.97
	Upper (F=1)	$0.8695 \pm 0.1739i$	0.89
Morocco	Lower (F=0)	0.9251	0.92
	Upper (F=1)	$0.9320 \pm 0.1890i$	0.95
Niger	Lower (F=0)	$0.9064 \pm 0.0689i$	0.91
	Upper (F=1)	-1.3449	1.34
Nigeria	Lower (F=0)	$0.9496 \pm 0.1096i$	0.95
	Upper (F=1)	$0.9942 \pm 0.2285i$	1.02
Seychelles	Lower (F=0)	$0.9230 \pm 0.1596i$	0.94
	Upper (F=1)	$0.8741 \pm 0.1747i$	0.89
South Africa	Lower (F=0)	$-0.6729 \pm 0.6711i$	0.95
	Upper (F=1)	$0.7311 \pm 0.6871i$	1.00
Swaziland	Lower (F=0)	0.9361	0.94
	Upper (F=1)	$0.9621 \pm 0.1811i$	0.98

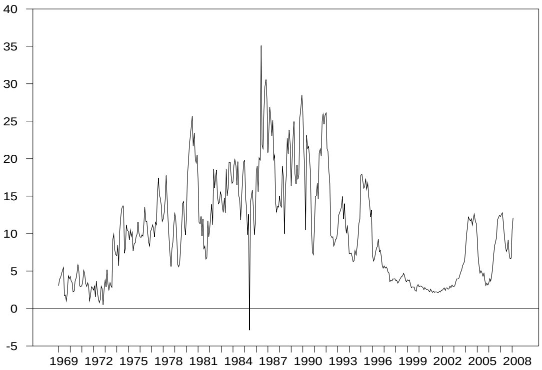
Figure 1: Inflation rates



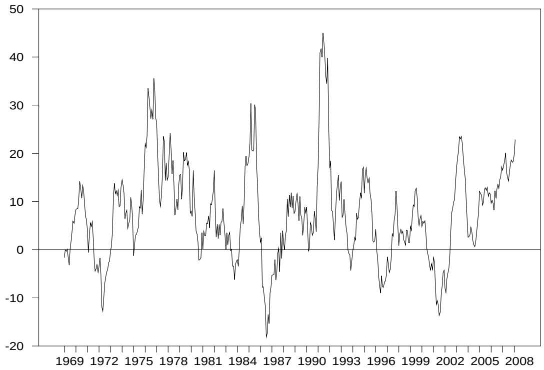
(a) Burkina Faso



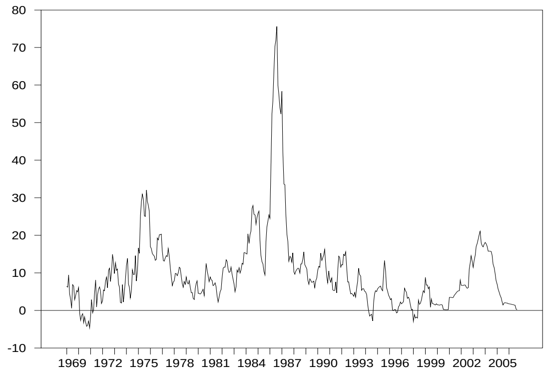
(b) Cameroon



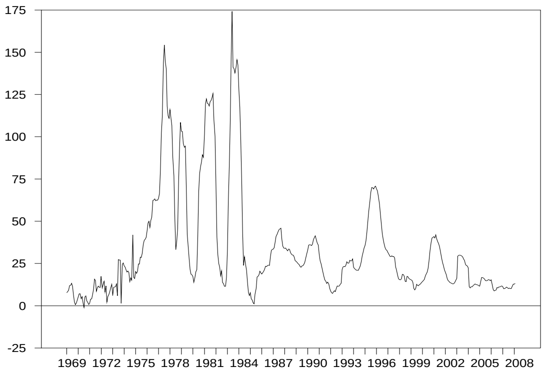
(c) Egypt



(d) Ethiopia

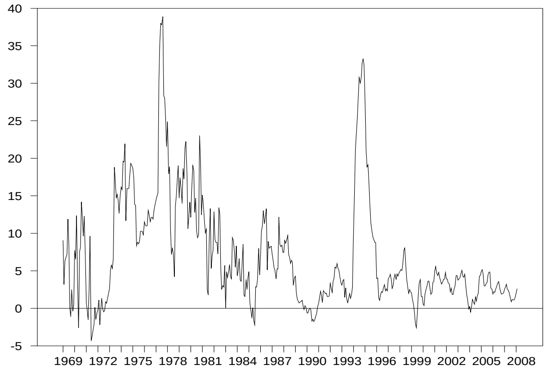


(e) Gambia

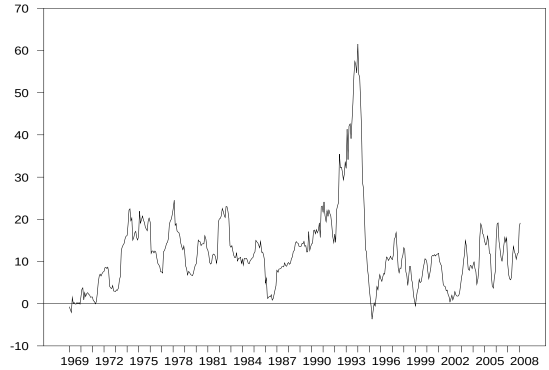


(f) Ghana

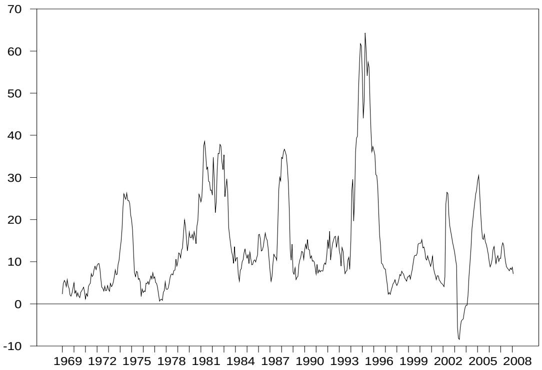
Figure 2: Inflation rates (cont.)



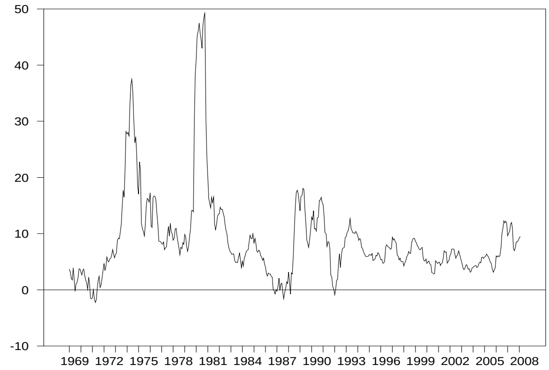
(a) Ivory Coast



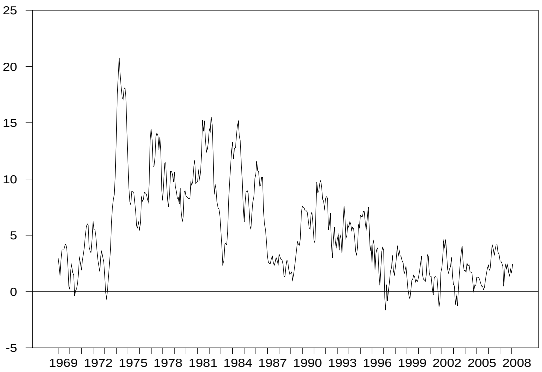
(b) Kenya



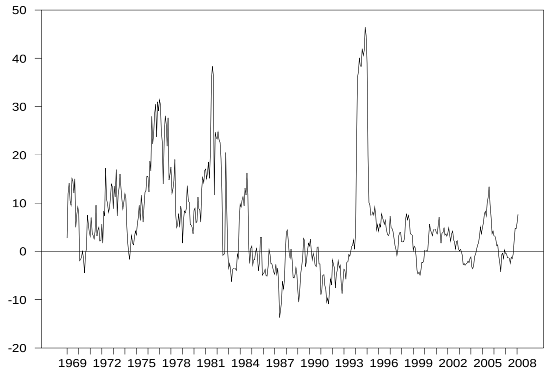
(c) Madagascar



(d) Mauritius

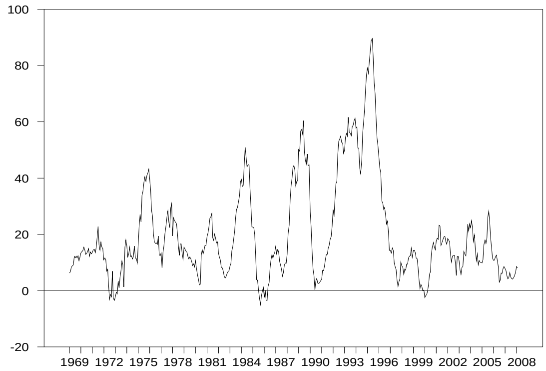


(e) Morocco

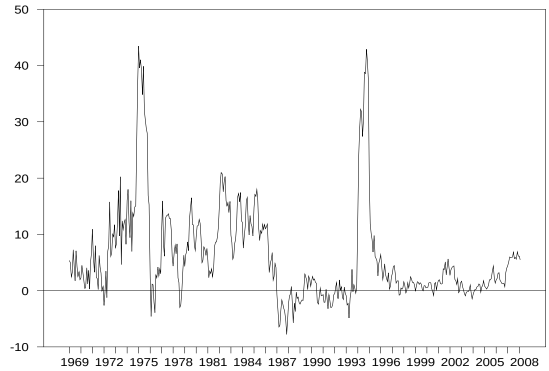


(f) Niger

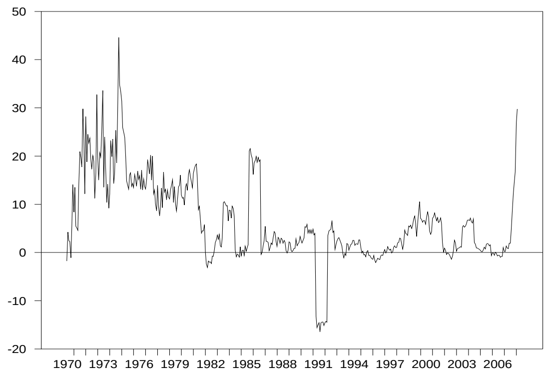
Figure 3: Inflation rates (cont.)



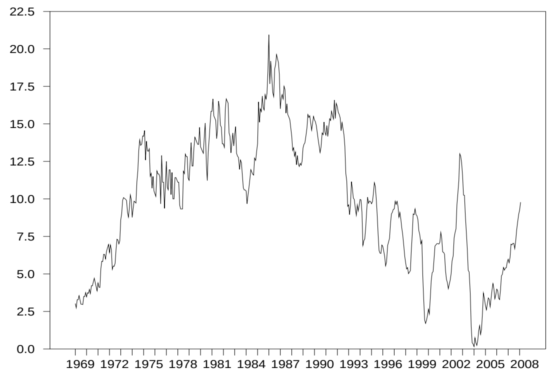
(a) Nigeria



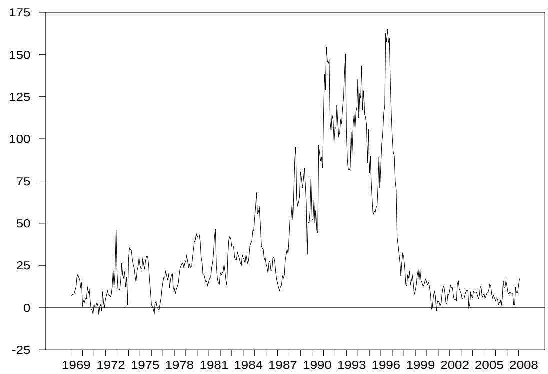
(b) Senegal



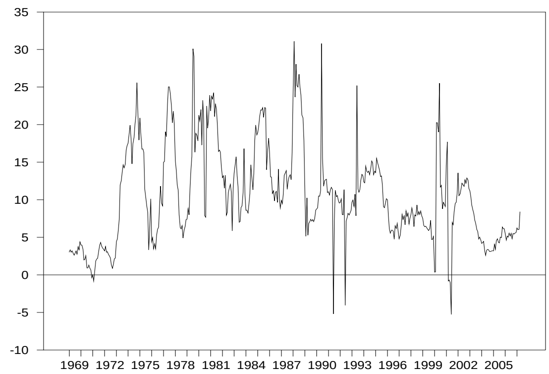
(c) Seychelles



(d) South Africa

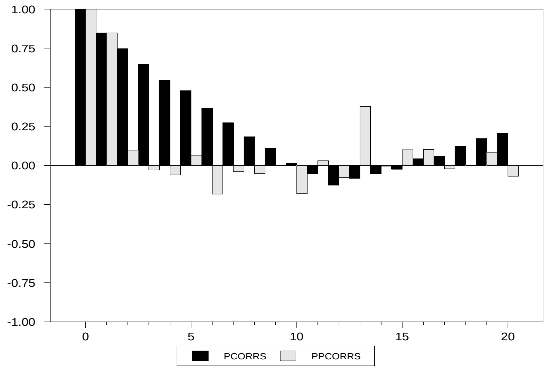


(e) Sudan

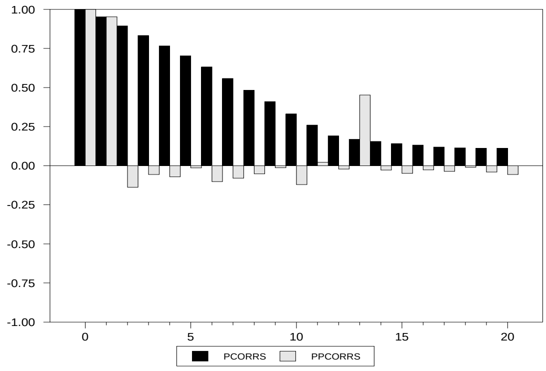


(f) Swaziland

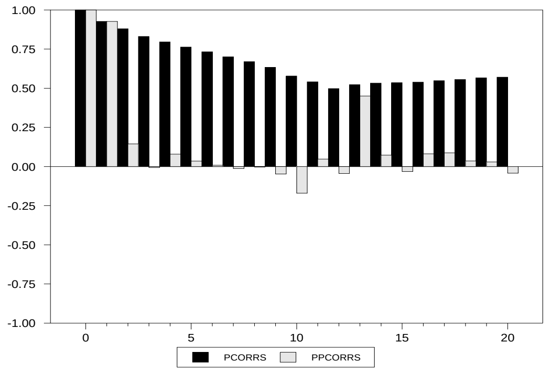
Figure 4: Autocorrelation functions



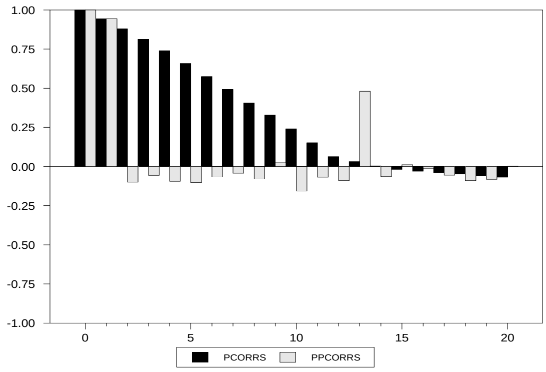
(a) Burkina Faso



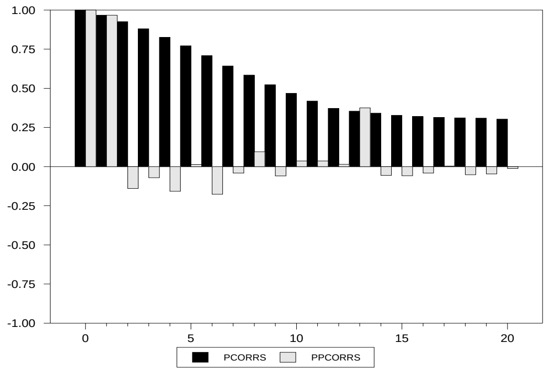
(b) Cameroon



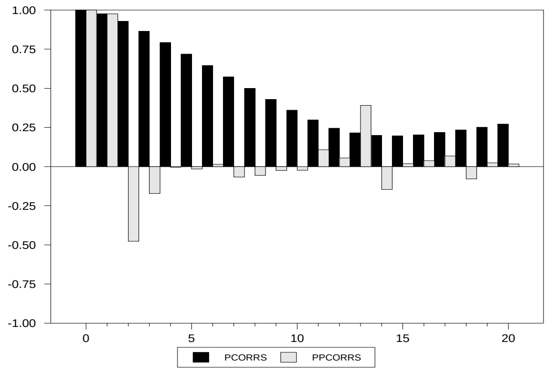
(c) Egypt



(d) Ethiopia

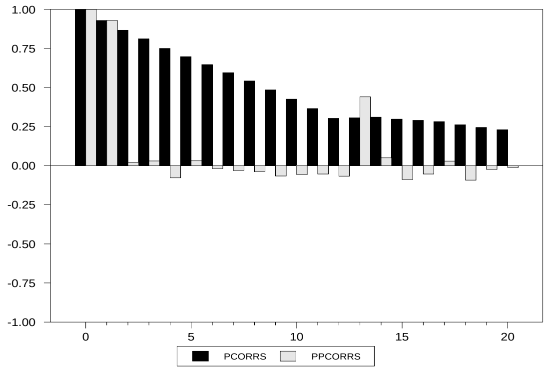


(e) Gambia

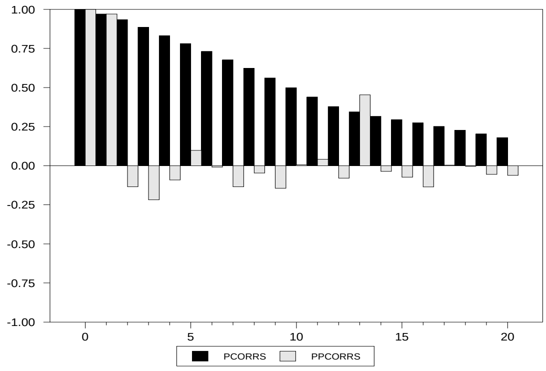


(f) Ghana

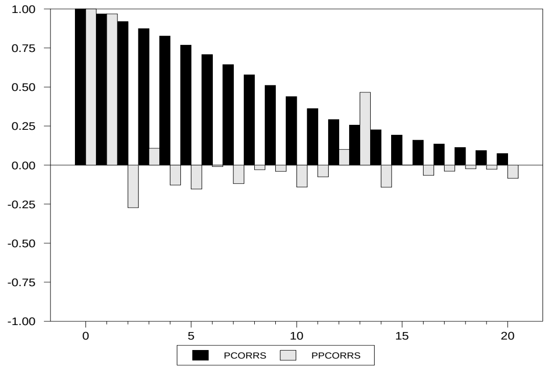
Figure 5: Auntocorrelation functions (cont.)



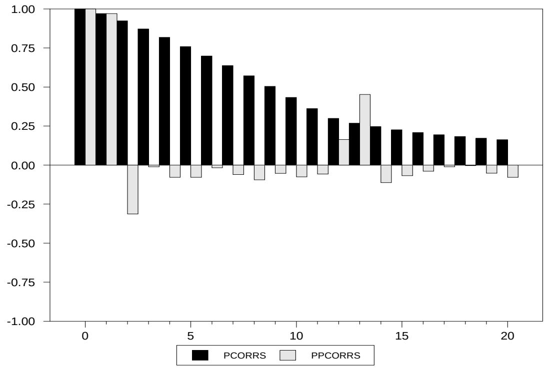
(a) Ivory Coast



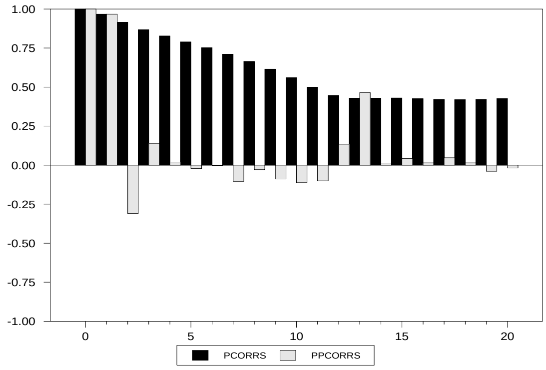
(b) Kenya



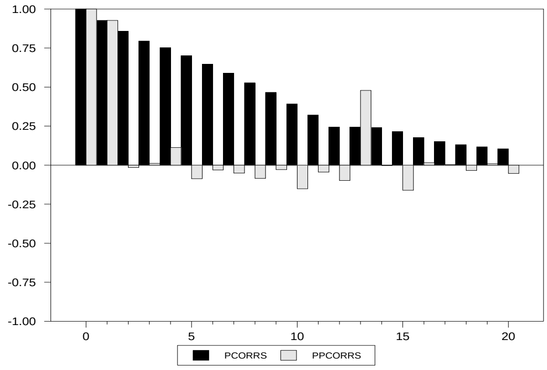
(c) Madagascar



(d) Mauritius

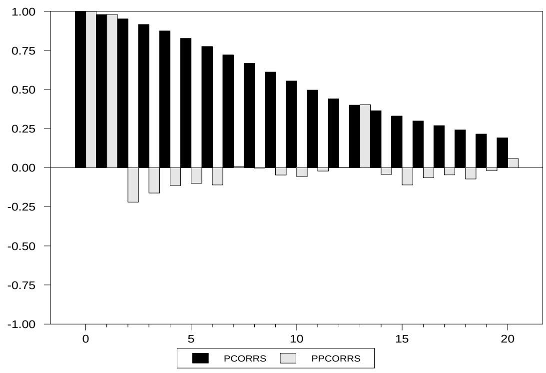


(e) Morocco

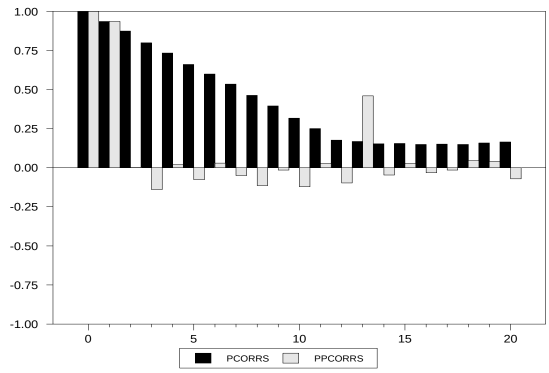


(f) Niger

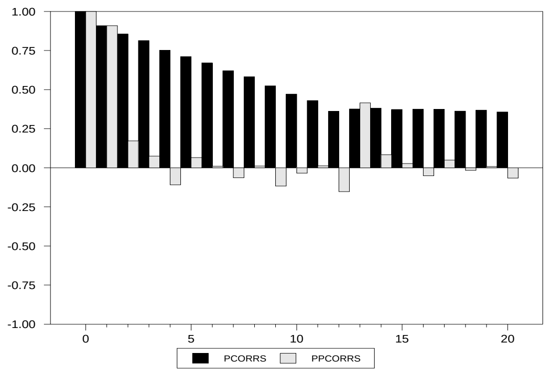
Figure 6: Autocorrelation functions (cont.)



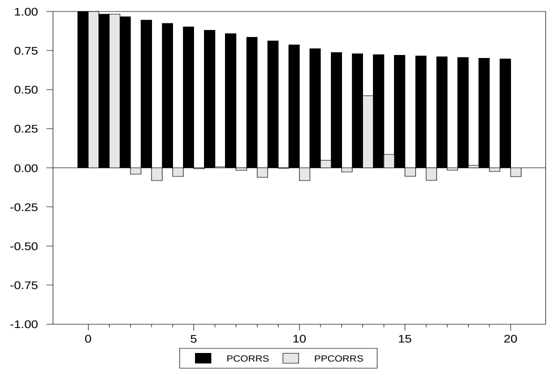
(a) Nigeria



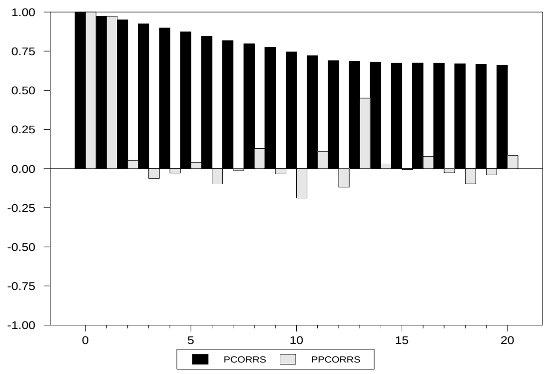
(b) Senegal



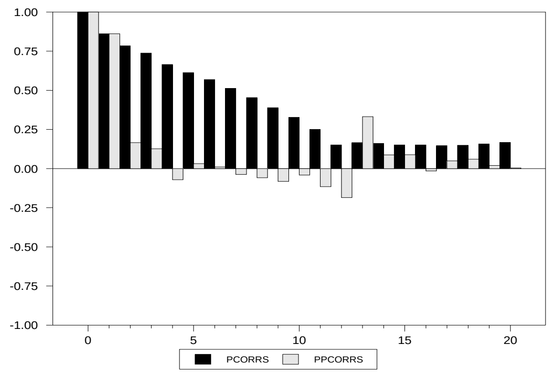
(c) Seychelles



(d) South Africa

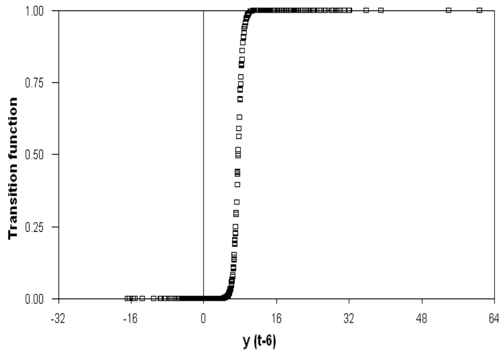


(e) Sudan

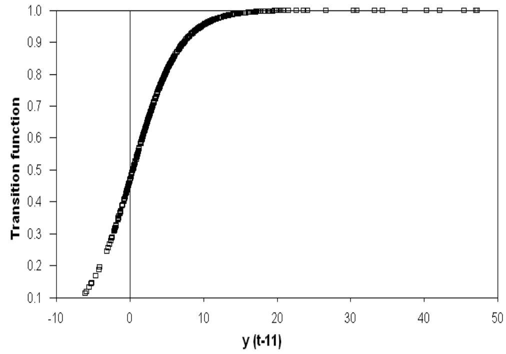


(f) Swaziland

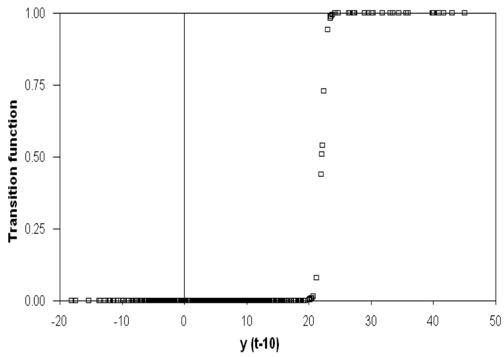
Figure 7: Estimated LSTAR functions



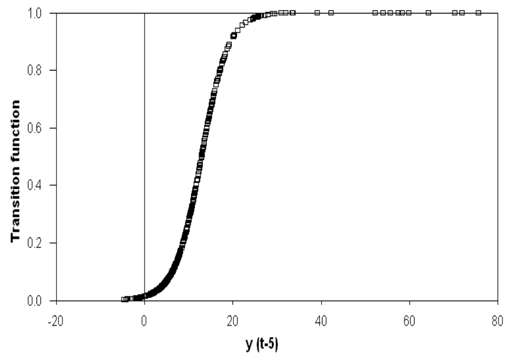
(a) Burkina Faso



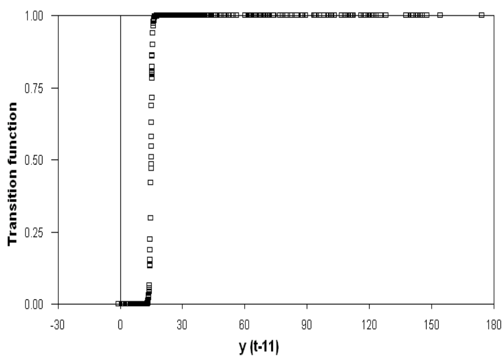
(b) Cameroon



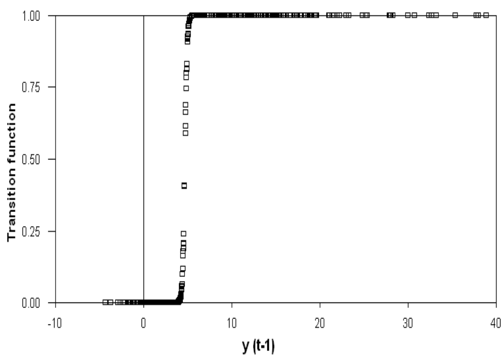
(c) Ethiopia



(d) Gambia

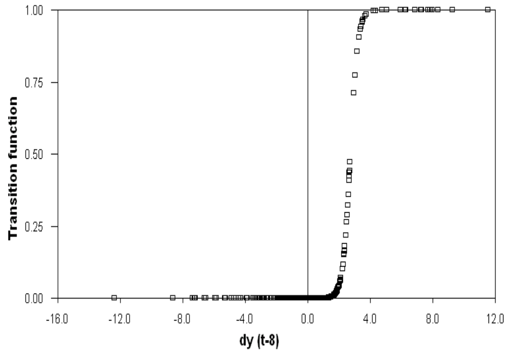


(e) Ghana

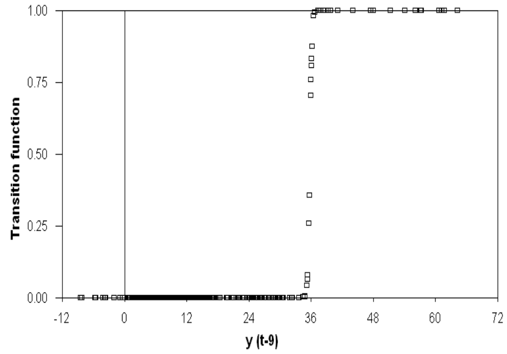


(f) Ivory Coast

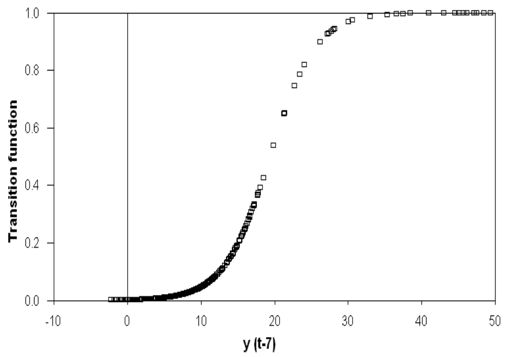
Figure 8: Estimated LSTAR functions (cont.)



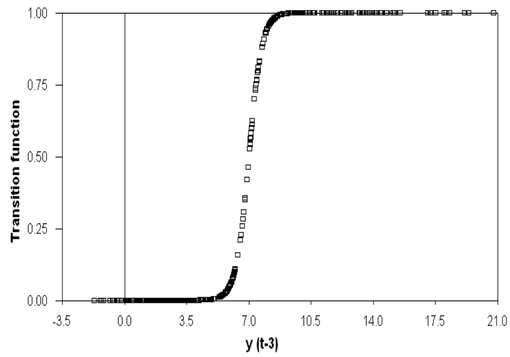
(a) Kenya



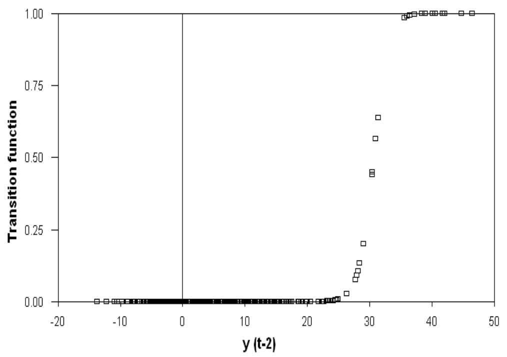
(b) Madagascar



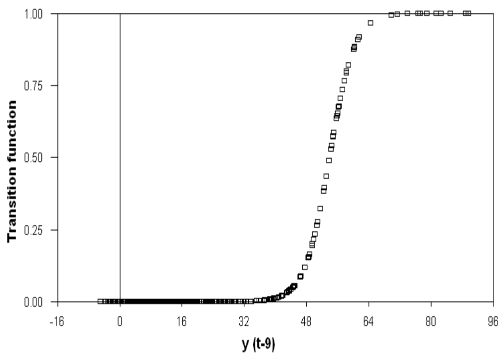
(c) Mauritius



(d) Morocco

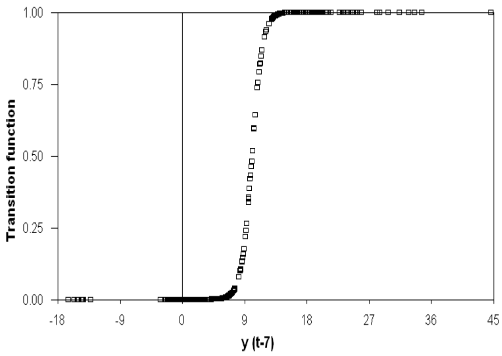


(e) Niger

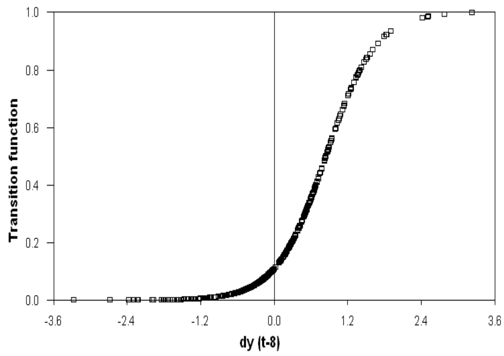


(f) Nigeria

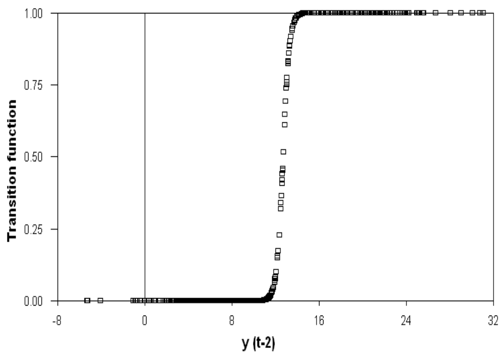
Figure 9: Estimated LSTAR functions (cont.)



(a) Seychelles

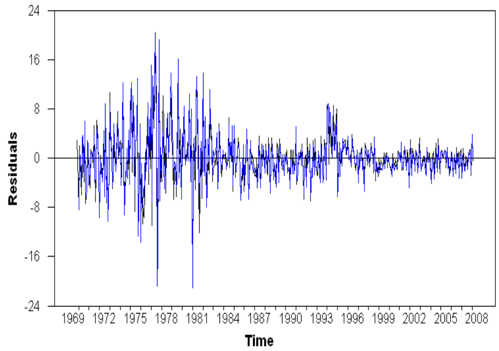


(b) South Africa

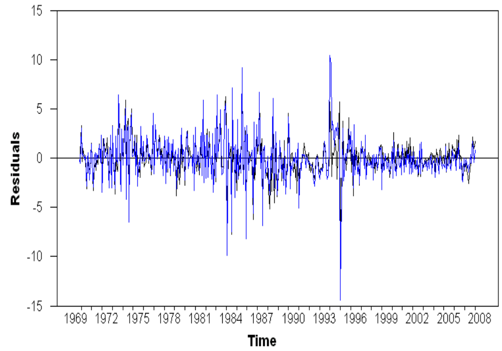


(c) Swaziland

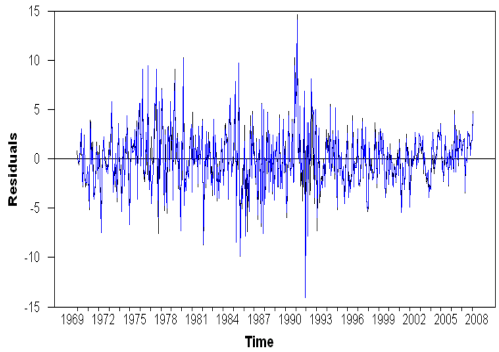
Figure 10: Residuals nonlinear estimation (black line) vs. linear estimation (blue line)



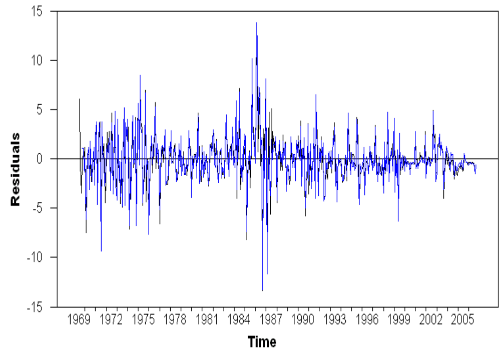
(a) Burkina Faso



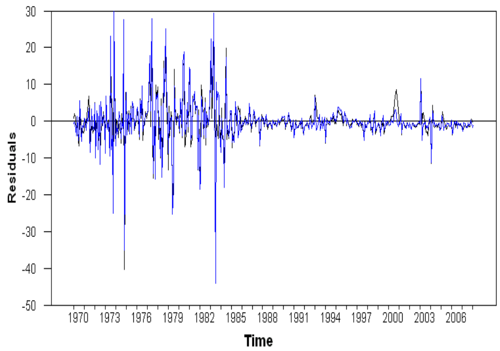
(b) Cameroon



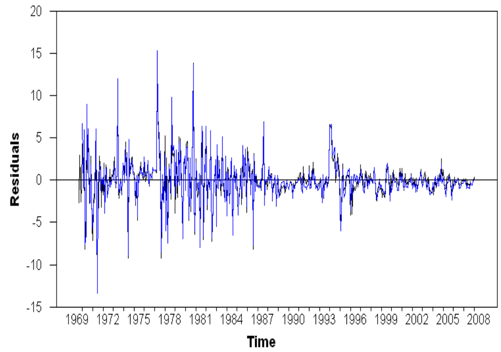
(c) Ethiopia



(d) Gambia

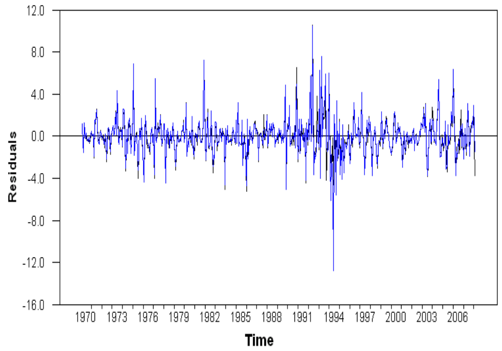


(e) Ghana

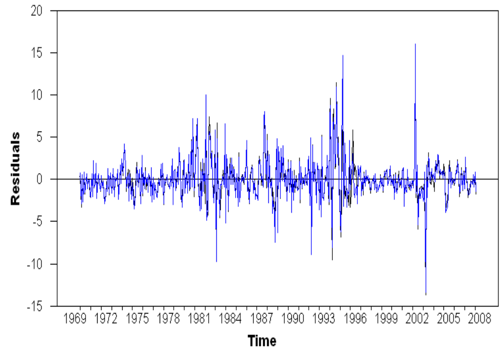


(f) Ivory Coast

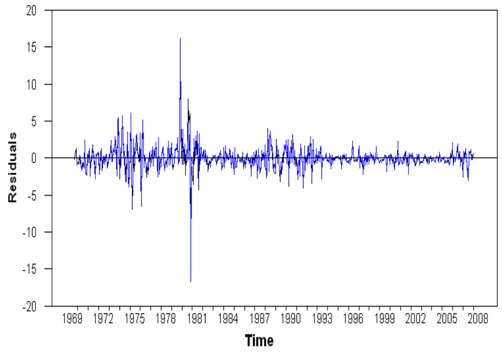
Figure 11: Residuals nonlinear estimation (black line) vs. linear estimation (blue line)



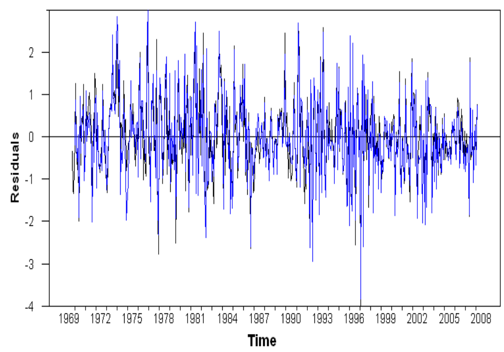
(a) Kenya



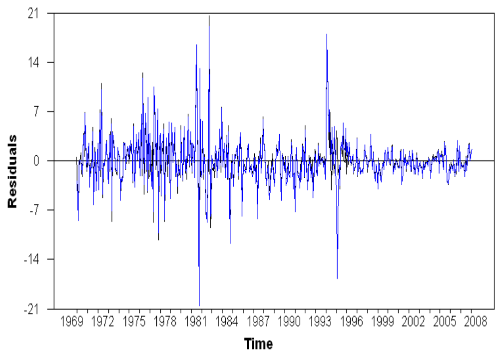
(b) Madagascar



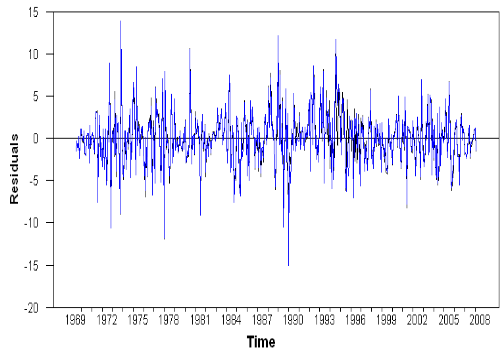
(c) Mauritius



(d) Morocco

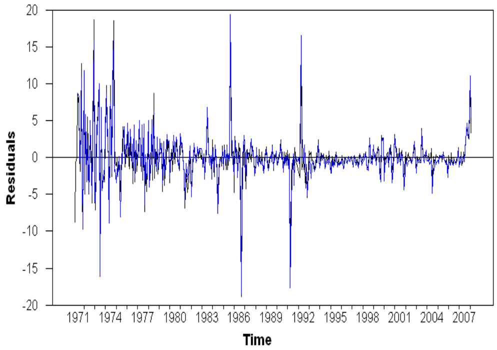


(e) Niger

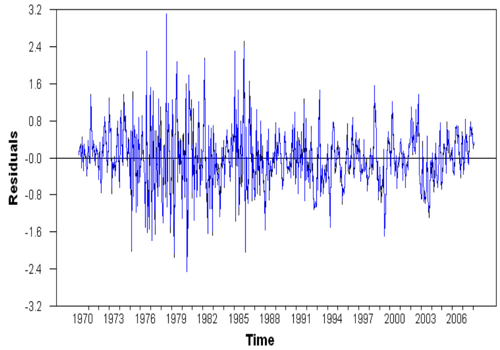


(f) Nigeria

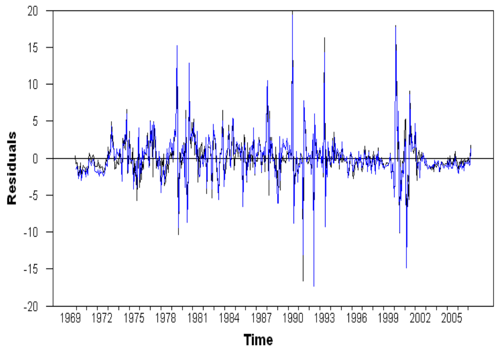
Figure 12: Residuals nonlinear estimation (black line) vs. linear estimation (blue line) (cont.)



(a) Seychelles



(b) South Africa



(c) Swaziland