Asian Economic and Financial Review
ISSN(e): 2222-6737
ISSN(p): 2305-2147
DOI: 10.18488/journal.aefr.2018.85.653.668
Vol. 8, No. 5, 653-668

URL: www.aessweb.com

RE-EXAMINING THE MEAN REVERSION OF INFLATION RATE IN ECOWAS

Check for updates

DRAMA Bedi Guy Hervé[1]

[1]*Department of Economics, University Peleforo Gon of Korhogo, France*
Email: dramsiben.upgck@gmail.com

Article History
Received: 13 April 2018
Revised: 30 April 2018
Accepted: 2 May 2018
Published: 4 May 2018

Keywords
Inflation rate
ECOWAS
Mean-reversion
PANIC
The Pooled MSB
Panel unit roots

JEL Classification:
C12, C15, C22, C23, E31

ABSTRACT

This paper investigates whether inflation series is mean-reverting in Economic Community of West African States (ECOWAS). First generation panel unit root tests (LLC, MW, Breitung, Hadri, ADF, PP and IPS) are conducted in the paper. These tests indicate that inflation do not contains a unit root. It is however well-known that these first generation unit root tests have a limit: they are based on the cross-sectional independency hypothesis. Hence, in this work, Panel Analysis of Nonstationarity in Idiosyncratic and Common Component (PANIC) is performed in order to investigate if inflation is mean reverting process even we relax the previous assumption. The main finding of this paper is that rate of inflation in ECOWAS is a stationary process.

Contribution/ Originality: This study is one of very few studies which have investigated whether inflation series is mean-reverting in Economic Community of West African States from 1985 to 2015. This study originates new formula such as first and second generation panel unit root tests to evaluate the stationary properties of the inflation rate for ECOWAS. The paper's primary contribution is finding that the rate of inflation in ECOWAS is a stationary process. This study documents the originality of this article.

1. INTRODUCTION

Since the founding article of Nelson and Plosser (1982) which studied the characteristics of integration of important macroeconomic variables of the United States, the study of the characteristics of chronological series of macroeconomic variables has become a central field of research in economy. Unfortunately, the results are ambiguous in empirical literature.

In particular, the analysis of the process of unit root in the principal macroeconomic aggregates, such as joblessness rate, the real exchange rate, the real gross national product (GNP) per capita, inflation, the energy consumption or the production, is important since they throw light on the validity of relative macroeconomic theories. For example, the stationarity of the real gross national product per inhabitant, of the joblessness rate and the real exchange rate backs up the theories of convergence of stochastic income, of the natural rate of joblessness and of parity of purchasing power, respectively. There are plenty applied studies about these theories.

In this article, we are interested in the temporal characteristics of the inflation rate- in the case of ECOWAS- that is one of the main macroeconomic variables more drawing the attention of academicians in economy. The Fisher effect, the traditional model of assets' valuation, the accelerationist hypothesis, the monetary policies of control of the growth of the money supply, the model of Phillips curves and the joblessness hysteresis are a few of research fields which have to do with inflation. Moreover, the following results lead economists to probe into the characteristics of integration of the inflation rate.

Firstly, owing to the fact that inflation largely influences the decisions in terms of expenditure and saving, the inflation rate is generally taken into consideration in the conduct of monetary policy. The central banks are based on their knowledge of temporal characteristics of inflation to lead a monetary policy and target the inflation rate because the cost of disinflation is different when inflation rate shows *I(0)* or *I(1)* behaviour. As Arize *et al.* (2005) inflation is unpopular because of the real cost it imposes on economy and society, consequently, the level of inflation is generally taken into account in the conduct of monetary policy. The non-stationary inflation rate implies the inflationist shocks have a permanent effect, and then a high cost for disinflation policies. However, the stationary inflation rate will bring about a low cost for monetary authorities in the conduct of monetary policies (Cecchetti and Debelle, 2006). Thus, knowledge about the characteristics of integration of the inflation rate belongs to the decision makers in order to control inflation.

Second, "inflation is typically regarded as a key variable in many economic models, whose validity hinges critically on whether inflation is *I(0)* or not" (Basher and Westerlund, 2007). For example, the Fisher effect is one of the most reliable concepts in finance theories and it validity depends on the existence of non-stationary inflation rate. The Fisher equation suggests that inflation rate should follow *I(1)* process and need to be integrated with the nominal interest rate in order for the real interest rate to be stationary. In addition, another main macroeconomic concept such as the expectations augmented Phillips curve model, where wages and prices share a long-run relationship, requires non-stationary inflation rate. Furthermore, the accelerationist hypothesis indicates non-stationary inflation rate. According that theory (accelerationist hypothesis), the government policy makers have to keep high level of inflation in order to maintain unemployment level below its natural rate. In addition, the rational expectation behaviour developed by Cagan (1956) stipulates that a stable money growth is followed by a stationary inflation rate unless there exist puzzles. In other words, rational expectations hypothesis suggests that stable growth of money supply implies stationary inflation rate.

Thirdly, the stationary of inflation rate is equally important in the selection of the correct economic modelling. For example, to evite wrong political decision a VAR model can be utilized in the case of stationary inflation rate to make reliable estimation. However, it is more practical to study non-stationary variables by applying a cointegration model or vector error correction (VEC) model see (Arize *et al.*, 2005). By taking into account all these above-mentioned reasons, this study aims at contributing to literature under two aspects. Firstly, we use data about the inflation rate to analyse its characteristics in certain West African countries. Secondly, we apply second generation panel unit root recently developed. The remaining part of the paper is organised as follows. The second section is a literature review about inflation. The third section comprises the panel unit root procedure. In the fourth section, we describe the data and the variables. The fifth section presents the principal results. At last, in the sixth section, we suggest few political implications followed by the concluding part.

2. LITERATURE REVIEW

As Narayan and Narayan (2010) have indicated it, "comparatively to the documentation about unit root tests in the real gross national product and the real exchange rate, literature on the hypothesis of unit root applied to inflation rate is rare". However, literature is very rich. We can classify them in seven bits.

The first step of the studies uses some unvaried conventional unit root tests to prove if the inflation rate is stationary or not. For example, Lai (1997) who used the modified Dickey-Fuller test, developed by Park and Fuller (1995) on the inflation rate of the G7 countries noticed that the inflation rates were stationary. In 2005, inflation rate stationarity of 93 inflation rates in the world have been examined by Charemza *et al.* (2005). They applied Dickey and Fuller (1979;1981) conventional increased and have compared the results to those obtained by taking into account the symmetric stable innovations. The results showed that there is significant change in favour of the non-stationary if innovations are treated as some samples of stable symmetric paretian distribution with an infinite variance. The implementation of Dickey and Fuller unit root (1979, DF below) in the analysis of the stationary of inflation rates in 40 countries, Ball *et al.* (1990) showed that the null hypothesis of non-stationary could not be rejected for 38 countries over 40. The integrated nature of inflation rates in United States has been also analysed by Cook (2005) using DF and the unit root tests based on the rank. The first test indicated the rejection of the null hypothesis of the unit root, whereas this latter was not.

The second step of the studies performs the panel unit root tests method. Lee and Wu (2001) for example, used a bootstrap version of the panel unit root of Im *et al.* (2003) with seemingly unrelated approach of Taylor and Sarno (1998) in the analysis of the stationarity of inflation rates in 13 countries of the Organisation for Economic Cooperation and Development (OECD). They found overwhelming proof of average reversion. Culver and Papell (1997) analysed the stationary of inflation rates in 13 countries of OECD by using unvaried unit tests and some unit root tests. The results of the ADF, KPSS (Kwiatkowski *et al.*, 1992) and sequential break tests demonstrated that in most countries covering by the study, the inflation rates followed the unit root process. However, the results of the panel data provided some reliable proof against the non-stationary. Another researcher, Osterholm (2004) showed the stationary of inflation rates in the United Stated of America by using three unit root tests, namely the IPS unit root test Im *et al.* (2003) the MADF Taylor and Sarno (1998) and the Johansen (1988) test of the likelihood report. Tsong *et al.* (2012) found reliable proof of the mean reversion of inflation rates of 19 OECD countries. For their investigation they utilise the panel unit root tests that allow a transversal dependence and the optimal test of the covariable point. In the same order, Otero (2008) using the unvaried KPSS unit root test and Hadri (2000) analysed the stationary of inflation rates in 13 OECD countries. The results of the KPSS unit root test generally showed that the inflation rates of OECD countries could be described as the $I(1)$ process, whereas the Hadri unit root test implied the stationary.

The third step of the studies takes into account the structural ruptures during the unit root process. The unvaried unit root tests that do not take into account the structural ruptures generally indicate that the inflation rates are non-stationary, whereas the unit root tests with structural ruptures generally imply that the inflation rates are stationary. Caporale and Paxton (2013) for example, studied the stationary of inflation rates for 5 Latina American countries by using the standard ADF unit root test and the test of the Bai multiple structural rupture and Bai and Perron (1998;2003) cover the period of 1980-2004. The results of the ADF unit root test revealed that the stationary was only obtained for three countries. However, when the structural ruptures have been authorized, the five countries turned towards some stationary inflation rates. Benati and Kapetanios (2002) found that the unit root could strongly be rejected for most of the series by using a unit root test newly developed allowing until m of structural breaking up to the 23 inflation series of 18 countries. Levin and Piger (2003) used some Bayesian and classical econometric framework to characterise the dynamic behaviour of the inflation rates for 12 industrialised countries by estimating an unvaried autoregressive model for each series and by considering the possibility of structural rupture. The results show that permitted rupture induced the stationary in the inflation rates.

In addition, there also exist some studies utilizing unit root tests with structural ruptures. Narayan and Narayan (2010) for example, investigated if the inflation rate of 17 OECD countries could be modelled as a stationary process using some unvaried KPSS unit root tests and of panel allowing in the maximum five structural ruptures developed by Carrion-i-Silvestre *et al.* (2005). The results unvaried tests of the KPSS showed that the inflation rates were stationary in 10 of the countries. Moreover, the test of the KPSS panel provided some reliable proof favourable to the stationary of inflation rates in the panels composed of countries that have been declared non-stationary by unvaried tests. To some comparison ends, Narayan and Narayan (2010) also applied the LM unit root test of Im *et al.* (2005) and obtained some strong proof against the non-stationary. Basher and Westerlund (2007) used a group of unit root tests on the data of Culver and Papell (1997). They noticed that the stationary of the inflation rate was independently maintained of the transversal dependence and the structural changes.

Romero-Avila and Usabiaga (2009) used three-panel unit root tests carried out by Smith *et al.* (2004); Hadri (2000) and Carrion-i-Silvestre *et al.* (2005) for 13 OECD countries. However, the outcomes of these tests were ambiguous. Hadri (2000) demontrated a non-stationary whereas (Smith *et al.*, 2004) provided evidence of unit root. However, the test of the KPSS panel shows strong proof of joint stationary. In addition, in this section, there exists a group of studies applying unvaried unit root tests and LM allowing some structural ruptures as in our study. For example, Im *et al.* (2010) made unvaried panel unit root tests and LM with two structural ruptures to test the stationary of inflation rates in 22 OECD countries. The results of the unvaried LM test indicate that 16 countries out of 22 have some stationary inflation rate. They afterwards used the LM panel unit root test and obtained some results against the non-stationary. Another study implementing the LM unit root belongs to Lee and Chang (2008). They examined the stationary of inflation rates in 11 OECD countries and in Asia and presented some results to support the stationary.

In the fourth section, we can view other studies conducted by a non-linear approach analysing the stationarity of the inflation rates. Henry and Shields (2004) for example, apply the Wald bootstrap approach developed by Caner and Hansen (2001) applied to United States inflation rates, Japan and the United Kingdom. The results imply that the inflation rates in the United Kingdom and in Japan were described as a unit root with threshold two regimes process. However, for the United States, the threshold was insignificant and the shocks on the inflation seem to be infinitely persistent. In the same order, the works of Ho (2009) depicted evidence of unit root process covering 19 OECD countries using the non-linear statistics IV that takes into account the transversal dependence. Another researcher, Zhou (2013) used the unit root test that allows the non-linearity to explore the stationarity of inflation rates in 12 European countries. The non-linearity has been observed in 8 countries over 12 and, among them, 6 countries seemed to have a non-linear stationary in their inflation rates. Arize (2011) applied some non-linear and linear unit root tests, such as the DF-GLS test developed by Elliot *et al.* (1996) the classic ADF unit root test, as well as the KSS non-linear unit root test of Kapetanios *et al.* (2003) to the inflation rates of 34 African countries. The DF-GLS, ADF and KSS tests have not rejected the null hypothesis of stationary in respectively 17, 13 and 25 cases. Gregoriou and Kontonikas (2009) used ADF (Ng and Perron, 2001) and the non-linear ADF unit root tests Kapetanios *et al.* (2003) on the inflation rates of 5 OECD countries adopting the inflation targeting. The results of the ADF unit root test showed that the null unit roots could not be rejected in all the countries. Moreover, the NP test showed that the null hypothesis of unit roots could only be rejected at the level of 5% significant in two countries. However, the results of the non-linear ADF test implied a unit root process in all cases.

The fifth section of the studies analyses the stationary of inflation rates as a necessary first step while testing Fisher hypothesis. To name a few, Malliaropulos (2000) applying the ADF unit root tests and Zivot and Andrews (1992) to the inflation rate by testing Fisher hypothesis for the United States, got some favourable results to the non-stationary. However, the ZA test indicated that the inflation rate was stationary. Moreover, Atkins and Chan (2004) noticed that the nominal interest rate and the inflation rates in Canada were stationary around a determinist tendency with two ruptures in the framework of Fisher hypothesis. In addition to that, while searching the validity of the Fisher effect in the United States, Crowder and Wohar (1999) applied the ADF unit root test and noticed that the inflation rates were not stationary. Clemente *et al.* (2004) who used a unit root test with ruptures of inflation rates of the G7 countries to test the validity of Fisher hypothesis, had proof that the inflation was represented by a stationary variable of broken tendency.

The sixth section of the studies uses the fractional integration analysis to assess the stationarity of inflation rates. Use a fractionated analysis of integration to the inflation rates of 50 developing countries, Arize *et al.* (2005) for example, determined that the inflation rate was non-stationary in most the concerned countries. Bos *et al.* (1999) used a fractional integration test to the inflation rates of the G7 and got some results to the support of the long memory or the unit root process. In another article, Bos *et al.* (2001) using a fractionnaly integrated moving average model, found that the after war American inflation had a long memory, with integration order around 0,3. Gadea *et al.* (2004) used DF, PP, NP, and the KPSS unit root tests for the persistence of inflation rates by fractionated integration. The results of the DF, PP and NP unit root tests published the null hypothesis of unit root in all the countries.

At last, the last section consists in some studies analysing the inflation or the convergence of price levels between a group of countries by examining the stationarity of inflation differentials or by testing the relations of co-integration between the inflation rates. The convergence holds if the inflation rates are stationary. Holmes (2002) for example, using the monthly data over the period 1972-1999 studied the strong and weak convergence between the principal economies of EU. The univaried ADF unit root test demonstrated the null hypothesis of unit root has been rejected for only a few cases, whereas the t bar test suggested by Im *et al.* (2003) implied the stationary in its ensemble. Drine and Rault (2006) who tested the inflation convergence between the Euro area and central and oriental Europe, found some strong proof of convergence thanks to the unit root tests of the LM panel. Das and Bhattacharya (2004) tried to examine the convergence of prices in the Indian regions by using the panel unit root tests taking into account the transversal dependence. The results laid bare the convergence of the levels of the relative prices between the different regions of India.

3. PANEL UNIT ROOTS

To study the average reversion of the inflation rate in the African countries, we used several unit root tests. We divide these tests in two groups, namely the first generation of unit root tests and the second-generation unit root tests. The first generation of unit root tests applied in this study comprised the LLC test (Levin *et al.*, 2002) the IPS Im *et al.* (2003) and the Hadri (2000). The second-generation tests are the two PANIC tests (Bai and Ng, 2010) and Pesaran (2007). The main difference between two generations of tests is in the hypothesis of cross independence. First generation methods suppose that all cross-sections are independent and second-generation methods relax this assumption. And the positive side of the PANIC method compared to the others second generation methods is that PANIC test main objective is to exploit the factor structure of panel data to fragment panel unit root tests, and also univariate counterparts, with advantage size and power characteristics. More precisely, its exploits the contemporaneous correlation between cross-section units to split the process in two parts: a common and idiosyncratic component.

First Generation: Cross-Sectional Independence

The basic model underlying these tests is:

$$\Delta y_{i,t} = \alpha_i + \rho_i y_{i,t-1} + \sum_{k=1}^{p_i} \beta_{i,k} \Delta y_{i,t-k} + \zeta_t \quad (1)$$

For $i = 1,\ldots,N$ and $t = 1,\ldots,T$.

For all these tests (excepted the LLC test), the null hypothesis is defined as $H_0 : \rho_i = 0$ for $i = 1,\ldots,N$ and the alternative hypothesis is $H_1 : \rho_i < 0$ for all $i = 1,\ldots,N_1$ and $\rho_i = 0$ for $i = N_1,\ldots,N$ with $0 < N_1 \le N$.

The alternative hypothesis allows the unit roots (but not all) of the countries. In the particular case of the LCC, we simplify the model (1) with additional hypotheses: $\alpha_i = 0$ and $\rho_i = \rho$ for all $i = 1,\ldots,N$. The null hypothesis is then defined as $H_0 : \rho = 0$ for all $i = 1,\ldots,N$ and the alternative is $H_1 : \rho < 0$ for all $i = 1,\ldots,N_1$

The first test included in the first generation of unit root tests is the LLC test of Levin *et al.* (2002). This test uses the following adjusted t statistics:

$$t_{\partial}^{*} = \frac{t_{\alpha} - (NT)\hat{S}_N \sigma_{\tilde{\varepsilon}}^{-2} \sigma_{\tilde{\alpha}} \mu_T^{*}}{\sigma_T^{*}} \tag{2}$$

where $\hat{S}_N$ is the average of individual ratios in the long-run to short-run variance for the country *i*, $\sigma_{\tilde{\varepsilon}}$ is the standard deviation of the error term, $\sigma_{\tilde{\alpha}}$ is the standard deviation of the slope coefficients, σ_T^{*} is the standard deviation adjustment, μ_T^{*} is the mean adjustment. Another test that we keep in the category of the first generation is the IPS test f (Im *et al.*, 2003) that uses the statistics t_ standardized bar based on the movement of the distribution of Dickey-Fuller:

$$Z_{t\_bar} = \frac{\sqrt{N}\left\{t\_bar - N^{-1}\sum_{i=1}^{N} E(t_{iT})\right\}}{\sqrt{N^{-1}\sum_{i=1}^{N} Var(t_{iT})}} \tag{3}$$

Where $E(t_{iT})$ is the expected mean of t_{iT} and $Var(t_{iT})$ is its variance.

Contrary to the precedent tests of the first generation, the test proposed by Hadri (2000) lays on the stationary null hypothesis. It is an extension of the test of stationary developed by Kwiatkowski *et al.* (1992) in the context of chronological series. Hadri proposes a multiplying test of Lagrange based on the residue for the null hypothesis than the individual series $y_{i,t}$ (for $i = 1,\ldots,N$) are stationary around a determinist level or around a deterministic trend, with regard to the alternative of a unit root in the panel data. Hadri (2000) considers the two following models:

$$y_{i,t} = r_{i,t} + \varepsilon_{i,t} \tag{4}$$

And

$$y_{i,t} = r_{i,t} + \phi_i t + \varepsilon_{i,t} \tag{5}$$

Where $r_{i,t}$ is a random walk: $r_{i,t} = r_{i,t-1} + u_{i,t}$, $u_{i,t}$ is $i.i.d.(0,\sigma_u^2)$, $u_{i,t}$ and $\varepsilon_{i,t}$ being independent. Model (4) can also be written:

$$y_{i,t} = r_{i,0} + e_{i,t} \tag{6}$$

And model (5)

$$y_{i,t} = r_{i,0} + \phi_i t + e_{i,t} \tag{7}$$

With $e_{i,t}=\sum_{j=1}^{t}u_{i,j}+\varepsilon_{i,t}$, $r_{i,0}$ being initial values that play the role of heterogeneous intercepts.

More specifically, Hadri (2000) tests the null $\lambda=0$ against the alternative $\lambda>0$ where $\lambda=\sigma_u^2/\sigma_\varepsilon^2$. Let $\hat{e}_{i,t}$ be the estimated residuals from (6) or (7), the LM statistic is given by:

$$LM=\frac{1}{\hat{\sigma}_\varepsilon^2}\frac{1}{NT^2}\left(\sum_{i=1}^{N}\sum_{t=1}^{T}S_{i,t}^2\right) \tag{8}$$

Where $S_{i,t}$ illustrates the partial residuals sum: $S_{i,t}=\sum_{j=1}^{t}\hat{e}_{i,j}$ and $\hat{\sigma}_\varepsilon^2$ is a consistent estimator of σ_ε^2. Under the null hypothesis of stationary at level (model (4)), the test statistic:

$$Z_\mu=\frac{\sqrt{N}\left\{LM-E\left[\int_0^1 V(r)^2\,dr\right]\right\}}{\sqrt{V\left[\int_0^1 V(r)^2\,dr\right]}} \tag{9}$$

Follows a standard normal law, where $V(r)$ is a standard Brownian bridge, for $T\to\infty$ followed by $N\to\infty$ (see Hadri (2000) for details).

Second Generation: PANIC Pooled Tests

In their article published in 2004, Bai and Ng showed that test $X_{it}=D_{it}+\lambda_i'F_t+e_{it}$ could always be done even when the two components are not observed and without knowing a priori e_{it} is non-stationary. The strategy consists in obtaining some coherent estimation of the space covered by F_t (denoted by $\hat{F}_t$) and the idiosyncratic error (denoted by $\hat{e}_{it}$). Briefly, they apply the method of main components to the differentiated first data, then form $\hat{F}_t$ and $\hat{e}_{it}$ by pooling the estimated factorial components.

Bai and Ng (2004) provide asymptotically valid procedures for; (a) determining the stochastic trends number in $\hat{F}_t$, (b) testing if $\hat{e}_{it}$ are individually *I(1)* using augmented Dickey–Fuller (ADF) regressions, and (c) testing if the panel is *I(1)* by pooling individual' the p values test. If π_i is the *p*-value of the ADF test for the *i*th cross-section unit, the pooled test is:

$$P_{\hat{e}} = \frac{-2\sum_{i=1}^{N} \log \pi_i - 2N}{\sqrt{4N}} \tag{10}$$

The test is asymptotically normal standard. For a bilateral test to 5% the nil hypothesis is rejected $P_{\hat{e}}$ when it is beyond 1,96 absolute value. Note that $P_{\hat{e}}$ does not necessitate the ordinary least squares (OLS) of the AR coefficient (1) in the idiosyncratic errors. The putting in common of the p values has the advantage to allow more heterogeneity in the units. However, a test based on a grouped estimation of p can easily be constructed by estimating an auto regression in panel of idiosyncratic errors (cumulated) estimated by PANIC, i.e., $\hat{e}_{it}$. The test statistics depend on the specification of the determinist component. D_{it}. For $p=-1$ and 0,

$$P_a = \frac{\sqrt{NT}\left(\rho^{+}-1\right)}{\sqrt{2\hat{\phi}_{\varepsilon}^{4}/\hat{\omega}_{\varepsilon}^{4}}}$$

(11a)

$$P_b = \sqrt{NT}\left(\rho^{+}-1\right)\sqrt{\frac{1}{NT^2}tr\left(\hat{e}'_{-1}\hat{e}_{-1}\right)\frac{\hat{\omega}_{\varepsilon}^{2}}{\hat{\phi}_{\varepsilon}^{4}}}$$

(11b)

For p=1, $$P_a = \frac{\sqrt{NT}\left(\rho^{+}-1\right)}{\sqrt{(36/5)\hat{\phi}_{\varepsilon}^{4}\hat{\sigma}_{\varepsilon}^{4}/\hat{\omega}_{\varepsilon}^{4}}} \tag{12a}$$

$$P_b = \sqrt{NT}\left(\rho^{+}-1\right)\sqrt{\frac{1}{NT^2}tr\left(\hat{e}'_{-1}\hat{e}_{-1}\right)\frac{5}{6}\frac{\hat{\omega}_{\varepsilon}^{2}}{\hat{\phi}_{\varepsilon}^{4}\hat{\sigma}_{\varepsilon}^{4}}} \tag{12b}$$

See Bai and Ng (2010) for details.

Jang and Shin (2005) studied the characteristics of $P_{a,b}$ for p = 0 by some simulations. But Bai and Ng (2010) proposed a theorem that provides the limitative theory for $p=-1$ and $p=0$. They show that the t tests of the autoregressive coefficient put in common in the idiosyncratic errors are asymptotically normal. The convergence is for N and T tending to the infinite conjunctly with N / T → 0. It is therefore about a common limit according to Phillips and Moon (1999). The Pa and Pb are the analogous of t_a and t_b of Moon and Perron (2004) except that; (a) the tests are focus on some PANIC residuals and (b) the method of data's "de factorization" is different from the method of Moon and Perron (2004). When $p=-1$, the parameters of adjustment used in $P_{a,b}$ are equally different from $t_{a,b}$ of Moon and Perron (2004). In this case, the PANIC residues $\hat{e}_{it}$ have the characteristic that T -1/2 converges towards a Brownian bridge, and a Brownian bridge has the zero value to the limit. Consequently, the component of the Brownian moving in the numerator of the auto regressive estimation disappears. The usual biased correction made to centre again the numerator of the estimator on zero is no more appropriate. It is because the deviation of the numerator from its average, multiplied by $\sqrt{N}$, is again degenerated. However, we can do a biased correction directly of the estimator because $T\left(\hat{\rho}-1\right)$ converges towards a constant.

3.1. The Pooled MSB

An important characteristic that distinguishes the stationary processes from the non-stationary processes is that their sampling moments require some different normalisation rates to be asymptotically limited. In the unvaried context, a simple test focused on this idea is the test of Sargan and Bhargava (1983). Stock (1990) issued the modified test of Saran and Bhargava (MSB test) to allow $\varepsilon_{it}=\Delta e_{it}$ a serial correlation with the short and long term $\sigma_{\varepsilon i}^2$ and $\omega_{\varepsilon i}^2$ respectively. In particular, if $\omega_{\varepsilon i}^2$ is an estimation of $\hat{\omega}_{\varepsilon i}^2$ this one is coherent under the null hypothesis and is limited by the alternative, $MSB = Z_i/\hat{\omega}_{\varepsilon i}^2 \Rightarrow \int_0^1 W_i^2\left(r\right)dr$ (see, Bai and Ng (2010) for details) under the null hypothesis and generated at zero under the alternative. Thus, the null value is rejected when the statistics is too small. As Perron and Ng (1996) show it and Ng and Perron (2001) the MSB has a similar power to the ADF test of Said and Dickey (1984) and the Phillips-Perron test developed by Phillips and Perron (1988) for the same method of tendency. A unique characteristic of the MSB is that it doesn't necessitate an estimation of ρ, which allows us to afterward assess the differences of power between the tests are due to the estimation of ρ. This motivates the test of non-stationary of simple panel following the idiosyncratic errors called panel PMSB test. Let us consider that $\hat{e}$ got from the PANIC test. For $p=0;1$ the statistics of the test is defined as follows:

$$PMSB=\frac{\sqrt{N}\left(tr\left(NT^{-2}\hat{e}'\hat{e}\right)-\hat{\omega}_{\varepsilon}/2\right)}{\sqrt{\hat{\phi}_{\varepsilon}^4/3}} \tag{13 a}$$

Where $\hat{\omega}_{\varepsilon}/2$ estimates the asymptotic mean of $NT^{-2}tr\left(\hat{e}'\hat{e}\right)$ and the denominator estimates its standard deviation. For $p = 1$, the test statistic is defined as (see Bai and Ng (2010) for details).

$$PMSB=\frac{\sqrt{N}\left(tr\left(NT^{-2}\hat{e}'\hat{e}\right)-\hat{\omega}_{\varepsilon}/6\right)}{\sqrt{\hat{\phi}_{\varepsilon}^4/45}} \tag{13b}$$

3.2. The MP Tests

The autoregressive coefficient ρ can also be estimated from data in levels as follow:

$$X_{it}=\left(1-\rho L\right)D_{it}+\rho X_{it-1}+u_{it} \tag{14}$$

In this article, we have used two models to be considered: a model of base (A) that supposes $D_{it}=a_i$ and model of accessory tendency (B) that is $D_{it}=a_i+b_i t$. Remark that we use $p=-1,0,1$ to represent the data generating process (DGP) and utilize the A-B models to represent how the tendencies are estimated. On the basis of the $\hat{\rho}$

estimator of first step, we calculate the $\hat{u}$ residues, from which a factorial model is estimated to get $\hat{\Lambda}$ (see, Bai and Ng (2010) for more details).

The MP tests, denoted t_a and t_b, have the identic form as P_a and P_b defined in (11) and (12), with some minor differences. That is,

$$t_a = \frac{\sqrt{N}T\left(\hat{\rho}^{+}-1\right)}{\sqrt{K_a\hat{\phi}_{\varepsilon}^{4}/\hat{\omega}_{\varepsilon}^{4}}} \tag{15a}$$

$$t_b = \sqrt{N}T\left(\hat{\rho}^{+}-1\right)\sqrt{\frac{1}{NT^2}tr\left(X_{-1}'M_zX_{-1}\right)K_b\frac{\hat{\omega}_{\varepsilon}^{2}}{\hat{\phi}_{\varepsilon}^{4}}} \tag{15b}$$

Where M_z and the parameters K_a and K_b are defined as follows. When the data are demeaned (Model A), then $M_z = M_0$, $K_a = 3$, and $K_b = 2$. When the data are demeaned and detrended (Model B), $M_z = M_1$ and $K_a = 15/4$, and $K_b = 4$ (see Bai and Ng (2010) for more details).

3.3. Another Second Generation Tests: Pesaran (2007)

As far second generation test, Pesaran (2007) proposes a test where augmented regressions of Dickey-Fuller (ADF) are augmented with the average transversal of delayed levels and the first differences of individual temporal series. In this way, the common factor is represented by the cross-sectional average $y_{i,t}$ and the shifted values. The Pesaran test uses the Cross-sectional ADF statistics (CADF), which are given below:

$$\Delta y_{i,t} = \alpha_i + \theta_i y_{i,t-1} + \pi_i \bar{y}_{t-1} + \varphi_i \Delta\bar{y}_i + \xi_{i,t} \tag{16}$$

Where $\alpha_i, \theta_i, \pi_i$ and φ_i are the $\alpha_i, \theta_i, \pi_i$ and φ_i coefficient of slope estimated from the ADF test for the country i, $\bar{y}_{t-1}$ is the average of the delayed levels, $\Delta\bar{y}_i$ is the average of the first differences $\xi_{i,t}$ are the terms of errors $\xi_{i,t}$.

In fact, Pesaran (2007) puts forwards a modified IPS statistics based on the average of the individual CADF that is called (CIPS) (cross-sectional augmented IPS statistics):

$$CIPS = \frac{1}{N}\sum_{i=1}^{N} t_i\left(N,T\right) \tag{17}$$

Where $t_i\left(N,T\right)$ is the *t*-statistic of the OLS estimate for the equation $y_{it} = \alpha_i + y_{it}^{0}$ (see Moon and Perron (2004)).

4. DATA AND VARIABLES

We use the annual index of prices to consumption (base =2010) for 15 African countries namely : Benin, Burkina Faso, Cabo Verde, Côte D'Ivoire, Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo over the period 1985-2015. The inflation rate is calculated as the first logarithmic difference of the index of prices to consumption[1]. The data stem from the indicators of development in the world published by the World Bank (2016). The analyzed countries and the duration are provided by the data availability.

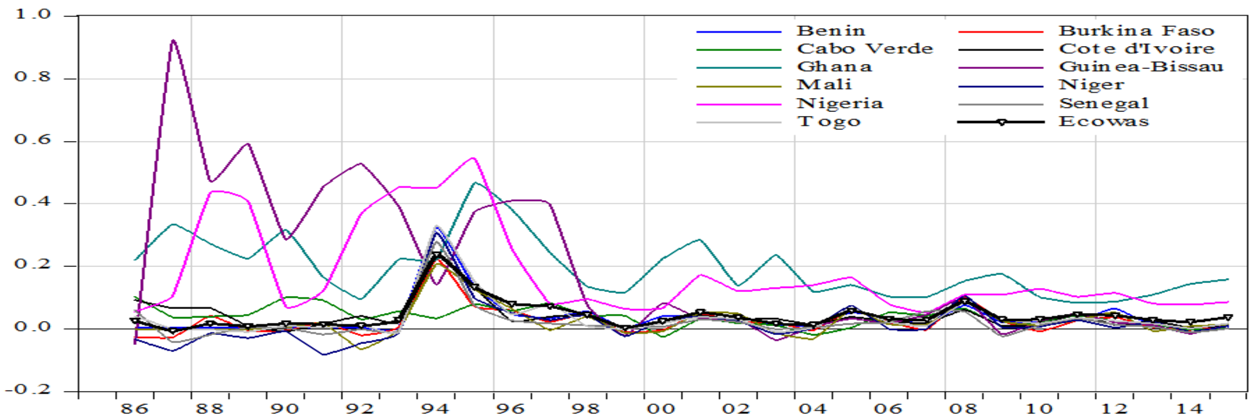

Figure-1. Inflation rate evolution in ECOWAS

Source: Own computation

Figure 1 shows the evolution of the inflation rate for ECOWAS and its countries and the tables 1a and 1b corresponding respectively show the descriptive statistics and the unidirectional tabulation. As we see it: (i) the evolution of inflation rates in most of the ECOWAS countries is similar except in Guinea Bissau, Nigeria and in Ghana; (2i). Most of these countries had several times 50% inflation (see the table in a unique sense). (3i) many countries reach their maximum inflation level in 94. Indeed, this date corresponds of the devaluation year in Africa. This devaluation reached 07 West African countries. The concerned countries were Benin, Burkina Faso, Côte d'Ivoire, Mali, Niger, Senegal and Togo; (4i). Our results of Jarque-Bera's test indicate that the ensembles of data are not normal in ECOWAS; since the corresponding p value is inferior to 5%.

Table-1a. Summary Statistics of Data set

	Inflation	CPI in log	Cons. Price Index
Mean	0.072	3.938	68.77
Median	0.030	4.319	75.11
Maximum	0.923	5.189	179.21
Minimum	-0.081	-0.751	-0.244
Standard Deviation	0.121	1.090	32.90
Skewness	2.810	-2.551	-0.281
Kurtosis	13.41	9.273	2.887
Jarque-Bera	1923	928.8	4.680
Probability	0.000	0.000	0.096
Sum	23.642	1342.8	23450
Observations	330	330	330

Source: Own computation.

Table-1b. One-way tabulation of Inflation

Value	Count	Percent	Cum. Count	Cum. Percent
[-0.5, 0[	57	17.27	57	17.27
[0, 0.5 [	269	81.52	326	98.79
[0.5, 1 [	4	1.21	330	100
Total	330	100	330	100

Source: Own computation

[1] The consumer price index reflects changes in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals, such as yearly.

5. RESULTS AND DISCUSSIONS

The first generation panel unit roots tests results applied to ECOWAS are illustrated in table 2 bellow. In applying these tests, the dependence between series has not been taken into account. The LLC and Breitung tests provide proofs to reject the null hypothesis of the base unit roots to 1% level. However, they (the LLC and Breitung unit roots tests) are criticized for their process hypothesis of common unit roots in the namely countries, the entire cross section have a characteristic of unit root. The IPS unit root goes further and softens this hypothesis by supposing an individual unit roots process. As we see it, the IPS unit tests (Fisher-ADF and Fisher-PP) provide proofs to reject the null hypothesis of unit roots for the ECOWAS countries. Contrary to the precedent tests, the Hadri unit root test rejects the null hypothesis of stationary; it is important to note that the autocorrelation leads to a severe height distortion in the Hadri test leading to an excessive rejection of the null hypothesis. Thus, based to the first generation tests, inflation rate in the Economic Community of West African States is stationary.

Table-2. First Generation Tests

	Intercept Only		**Intercept and Linear Trend**	
Method	Statistic	P-value	Statistic	P-value
Levin, Lin & Chu	-6.245 [a]	0.00	-6.390 [a]	0.00
Breitung	-	-	-7.979 [a]	0.00
Hadri	8.174 [a]	0.00	5.122 [a]	0.00
Heteroscedastic Hadri	2.688 [a]	0.00	2.638 [a]	0.00
Im, Pesaran and Shin	-6.271 [a]	0.00	-5.326 [a]	0.00
ADF - Fisher	81.06 [a]	0.00	66.52 [a]	0.00
PP - Fisher	106.3 [a]	0.00	98.62 [a]	0.00
Maddala & Wu	92.74 [a]	0.00	78.01 [a]	0.00
The null hypothesis of the LLC and IPS, ADF, PP and MW tests assumes that the series has a unit root while Hadri Test assumes that the series is stationary. LLC, Hadri and Breitung used the common unit root process approach while IPS, Fisher and MW consider individual unit root process. The superscript ‘a’ indicates significance at 5%.				

Source: Own computation

The table 3 gives the results of the Moon and Perron tests with the A, B and C models as well as the nonstationarity in idiosyncratic and common components (PANIC) (Bai and Ng, 2010) and panel pooled tests. A does not suppose any deterministic component. B supposes a constant and allows a fixed effect model. C allows a constant and a trend. Since both (First and Second MP t-stat) reject the null hypothesis, we conclude the stationary of the inflation. Thus, according to the first and the second of Moon and Perron tests, the inflation rate is a mean reversion process in ECOWAS.

Table-3. PANIC Test

	Moon Perron Test		
	Model A	**Model B**	**Model C**
First MP t-stat.	-3.10 [a]	-13.09 [a]	-14.05 [a]
Second MP t-stat.	-1.84 [a]	-6.17 [a]	-11.24 [a]
	Pooled Autoregressive Coefficient Test		
	PMSB	Rho	Pool ADF
Value	-0.971	0.598	8.079 [a]
A assumes no deterministic component. B assumes a constant and allows for a fixed effect model. C allows a constant and trend. Critical value at 5% = - 1,645; The superscript ‘a’ indicates significance at 5%. MP is Moon Perron, PMSB is Pool Modified Sargan–Bhargava, ADF is Augmented Dickey Fuller			

Source: Own computation

To make our results more robust, we completed our investigation with another second generation test depicted in table 4 bellow. In addition, as we see, Pesaran (at lag 0, 1 and 2) test in model 1 and model 2, support the mean reversion of inflation rate in the Economic Community of West African States (since they reject the null hypothesis of unit root at 5%).

Table-4. CIPS Test on Inflation

	Intercept Only		Intercept and Linear Trend	
Lag order	Z_t-bar	P-value	Z_t-bar	P-value
0	-12.98 [a]	0.00	-13.17 [a]	0.00
1	-5.249 [a]	0.00	-5.09 [a]	0.00
2	-1.791 [a]	0.04	-2.22 [a]	0.01
Null hypothesis for Pesaran CIPS tests: series is *I(1)*. CIPS test assumes cross-section dependence is in form of a single unobserved common factor.				

Source: Own computation

6. CONCLUDING REMARKS

The empirical test of the unit root characteristics of the inflation rate is necessary to know the behaviour of economic cycles. Moreover, this would equally allow understanding the long and short-term impact of macroeconomic policies on the consumption of lasting goods. For this, we used a group of unit root tests to evaluate the characteristics of the stationary of the inflation rate for ECOWAS. We applied the first and second-generation tests over the 1985-2014 periods.

Our analysis indicates that the null hypothesis of the unit root problem in the series of inflation rate is rejected by the LLC, Breitung, Fisher and IPS unit root tests, (first generation tests). For the 2010 PANIC tests and the Pesaran unit root test, the inflation rate as second-generation tests is a mean reversion process.

Our results can have practical implications for econometric modelling as well as for the political decision makers in the formulation the inflation policy to back up the economic growth in certain West African Countries. Our analysis in the major part shows that the inflation rate is stationary around a deterministic trend in ECOWAS. This implies that: (i) the fluctuations of the inflation rate have a transitory effect. (ii) The inflationist shocks do not have lasting effects on ECOWAS inflation rates. Consequently, the monetary authorities of these countries would implement some disinflation policies cheaper than those of countries having non-stationary inflation rates. Moreover, the tendentious stationary of the inflation rate indicates that the inflation rate will find again its trend in time and it could be possible to foresee the future movements of the inflation rate according to its past behaviour. (iii) Since the inflation rates are stationary around a trend, only the important shocks as the governmental policies aiming at modifying the fundamentals will have lasting effects on the inflation trajectory, but the shocks only provoke some short-term deviations around a deterministic trend. In this case, the global demand policies cannot be overestimated (Lee and Wu, 2001) and the administrative policy of a government should not be to adopt some excessive interfering targets.

Funding: This study received no specific financial support.
Competing Interests: The author declares that there are no conflicts of interests regarding the publication of this paper.

REFERENCES

Arize, A.C., 2011. Are inflation rates really nonstationary? New evidence from non-linear star framework and African Data. International Journal of Economics and Finance, 3(3): 97-108. *View at Google Scholar | View at Publisher*

Arize, A.C., J. Malindretos and K. Nam, 2005. Inflation and structural change in 50 developing countries. Atlantic Economic Journal, 33(4): 461–471. *View at Google Scholar | View at Publisher*

Atkins, F. and M. Chan, 2004. Trend breaks and the fisher hypothesis in Canada and the United States. Applied Economics, 36(17): 1907–1913. *View at Google Scholar | View at Publisher*

Bai, J. and S. Ng, 2004. A panic attack on unit roots and cointegration. Econometrica, 72(4): 1127–1177. *View at Google Scholar | View at Publisher*

Bai, J. and S. Ng, 2010. Instrumental variables estimation in a data rich environment. Econometric Theory, 26(6): 1577–1606. View at Google Scholar | View at Publisher

Bai, J. and P. Perron, 1998. Estimating and testing linear models with multiple structural changes. Econometrica, 66(1): 47–68. View at Google Scholar | View at Publisher

Bai, J. and P. Perron, 2003. Computation and analysis of multiple structural change models. Journal of Applied Econometrics, 18(1): 1–22. View at Google Scholar | View at Publisher

Ball, L., S.G. Cecchetti and R.J. Gordon, 1990. Inflation and uncertainty at short and long horizons. Brookings Papers on Economic Activity, 21(1): 215-254. View at Google Scholar | View at Publisher

Basher, S.A. and J. Westerlund, 2007. Is there really a unit root in the inflation rate? More evidence from panel data models. Applied Economics Letters, 15(3): 161-164.

Benati, L. and G. Kapetanios, 2002. Structural breaks in inflation dynamics. Manuscript, Bank of England. Queen Mary University of London.

Bos, C.S., P.H. Franses and M. Ooms, 1999. Long memory and level shifts: Re-analyzing inflation rates. Empirical Economics, 24(3): 427–449. View at Google Scholar | View at Publisher

Bos, C.S., P.H. Franses and M. Ooms, 2001. Inflation, forecast intervals and long memory regression models. Tinbergen Institute Discussion Paper No. TI-01-029/4.

Cagan, P., 1956. The monetary dynamics of hyperinflation. In M. Friedman (Ed), Studies in the quantity theory of money. Chicago: University of Chicago Press. pp: 25-117.

Caner, M. and B. Hansen, 2001. Threshold autoregression with a unit root. Econometrica, 69(6): 1555–1596. View at Google Scholar | View at Publisher

Caporale, T. and J. Paxton, 2013. Inflation stationarity during Latin American inflation: Insights from unit root and structural break analysis. Applied Economics, 45(15): 2001-2010. View at Google Scholar | View at Publisher

Carrion-i-Silvestre, J.L., T.D. Barrio-Castro and E. Lopez-Bazo, 2005. Breaking the panels: An application to the GDP per capita. Econometrics Journal, 8(2): 159-175. View at Google Scholar

Cecchetti, S.G. and G. Debelle, 2006. Has the inflation process changed? Economic Policy, 21(46): 312–352. View at Google Scholar

Charemza, W.W., D. Hristova and P. Burridge, 2005. Is inflation stationary? Applied Economics, 37(8): 901-903. View at Google Scholar

Clemente, J., A. Montanes and M. Reyes, 2004. Structural breaks, inflation and interest rates: Evidence for the G7 countries. Econometrics 0401005, EconWPA.

Cook, S., 2005. Rank-based unit root testing in the presence of structural change under the null: Simulation results and an application to US inflation. Applied Economics, 37(6): 607-617. View at Google Scholar | View at Publisher

Crowder, W.J. and M.E. Wohar, 1999. Are tax effects important in the long-run fisher relationship? Evidence from the municipal bond market. Journal of Finance, 54(1): 307-317. View at Google Scholar | View at Publisher

Culver, S.E. and D.H. Papell, 1997. Is there a unit root in the inflation rate? Evidence from sequential break and panel data models. Journal of Applied Econometrics, 12(4): 435–444. View at Google Scholar | View at Publisher

Das, S. and K. Bhattacharya, 2004. Price convergence across Regions in India. Bonn Econ Discussion Papers.

Dickey, D.A. and W.A. Fuller, 1979. Distribution of the estimators for autoregressive time series with a unit root. Journal of the American Statistical Association, 74(366a): 427–431. View at Google Scholar | View at Publisher

Dickey, D.A. and W.A. Fuller, 1981. Likelihood ratio statistics for autoregressive time series with a unit root. Econometrica, 49(4): 1057-1072. View at Google Scholar | View at Publisher

Drine, I. and C. Rault, 2006. Testing for inflation convergence between the Euro Zone and its CEE partners. Applied Economics Letters, 13(4): 235-240. View at Google Scholar | View at Publisher

Elliot, G., T.J. Rothenberg and S.J. H., 1996. Efficient tests for an autoregressive unit root. Econometrica, 64(4): 813–836. View at Google Scholar | View at Publisher

Gadea, M.D., M. Sabate and J.M. Serrano, 2004. Structural breaks and their trace in the memory inflation rate series in the long-run. International Financial Markets, Institution and Money, 14(2): 117–134. View at Google Scholar

Gregoriou, A. and A. Kontonikas, 2009. Modeling the behavior of inflation deviations from the target. Economic Modelling, 26(1): 90–95. View at Google Scholar | View at Publisher

Hadri, K., 2000. Testing for stationarity in heterogeneous panel data. Econometrics Journal, 3(2): 148–161. View at Google Scholar | View at Publisher

Henry, O.T. and K. Shields, 2004. Is there a unit root in inflation? Journal of Macroeconomics, 26(3): 481–500. View at Google Scholar

Ho, T., 2009. The inflation rates may accelerate after all: Panel evidence from 19 OECD economies. Empirical Economics, 36(1): 55-64. View at Google Scholar | View at Publisher

Holmes, M.J., 2002. Panel data evidence on inflation convergence in the European Union. Applied Economics Letters, 9(3): 155-158. View at Google Scholar | View at Publisher

Im, K.S., J. Lee and M. Tieslau, 2005. Panel LM unit root tests with level shifts. Oxford Bulletin of Economics and Statistics, 67(3): 393–419. View at Google Scholar | View at Publisher

Im, K.S., J. Lee and M. Tieslau, 2010. Panel LM unit-root tests with trend shifts. FDIC Center for Financial Research Working Paper No. 2010-1.

Im, K.S., M.H. Pesaran and Y. Shin, 2003. Testing for unit roots in heterogeneous panels. Journal of Econometrics, 115(1): 53-74. View at Google Scholar | View at Publisher

Jang, S.-W. and J.-S. Shin, 2005. Creating first-mover advantages: The case of samsung electronics. Unpublished Manuscript, Department of Economics, National University of Singapore.

Johansen, S., 1988. Statistical analysis of co integrated vectors. Journal of Economic Dynamics and Control, 12(2-3): 231-254. View at Google Scholar

Kapetanios, G., Y. Shin and A. Snell, 2003. Testing for a unit root in the nonlinear STAR framework. Journal of Econometrics, 112(2): 359–379. View at Google Scholar | View at Publisher

Kwiatkowski, D., P.C.B. Phillips, P. Schmidt and Y. Shin, 1992. Testing the null hypothesis of stationarity against the alternative of a unit root. Journal of Econometrics, 54(1-3): 159–178. View at Google Scholar | View at Publisher

Lai, K.S., 1997. On the disparate evidence on trend stationarity in inflation rates: A reappraisal. Applied Economics Letters, 4(5): 305-309. View at Google Scholar | View at Publisher

Lee, C.C. and C.P. Chang, 2008. Trend stationary of inflation rates: Evidence from LM unit root testing with a long span of historical data. Applied Economics, 40(19): 2523-2536. View at Google Scholar | View at Publisher

Lee, H.Y. and J.L. Wu, 2001. Mean reversion of inflation rates: Evidence from 13 OECD countries. Journal of Macroeconomics, 23(3): 477–487. View at Google Scholar | View at Publisher

Levin, A., C.F. Lin and C.S.J. Chu, 2002. Unit root test in panel data: Asymptotic and finite sample properties. Journal of Econometrics, 108(1): 1-24. View at Google Scholar | View at Publisher

Levin, A.T. and J.M. Piger, 2003. Is inflation persistence intrinsic in industrial economies? Working Paper No. 2002-023E, The Federal Reserve Bank of St. Louis.

Malliaropulos, D., 2000. A note on nonstationarity, structural breaks and the fisher effect. Journal of Banking and Finance, 24(5): 695-707. View at Google Scholar | View at Publisher

Moon, H.R. and B. Perron, 2004. Testing for a unit root in panels with dynamic factors. Journal of Econometrics, 122(1): 81-126. View at Google Scholar | View at Publisher

Narayan, P.K. and S. Narayan, 2010. Is there a unit root in the inflation rate? New evidence from panel data models with multiple structural breaks. Applied Economics, 42(13): 1661-1670. View at Google Scholar | View at Publisher

Nelson, C. and C. Plosser, 1982. Trend and random walks in macroeconomic time series: Some evidence and implications. Journal of Monetary Economics, 10(2): 139–162. View at Google Scholar

Ng, S. and P. Perron, 2001. Lag selection and the construction of unit root tests with good size and power. Econometrica, 69(6): 1519–1554. *View at Google Scholar* | *View at Publisher*

Osterholm, P., 2004. Killing four unit root birds in the US economy with three panel unit root test stones. Applied Economics Letters, 11(4): 213-216. *View at Google Scholar* | *View at Publisher*

Otero, J., 2008. Testing for stationarity in inflation rates: A re-examination of the evidence from 13 OECD countries. Oxford Business & Economics Conference Program.

Park, H. and W. Fuller, 1995. Alternative estimators and unit root tests for the autoregressive process. Journal of Time Series Analysis, 16(4): 415-429. *View at Google Scholar* | *View at Publisher*

Perron, P. and S. Ng, 1996. Useful modifications to unit root tests with dependent errors and their local asymptotic properties. Review of Economic Studies, 63(3): 435–465. *View at Google Scholar* | *View at Publisher*

Pesaran, M.H., 2007. A simple panel unit root test in the presence of cross section dependence. Journal of Applied Econometrics, 22(2): 265-312. *View at Google Scholar* | *View at Publisher*

Phillips, P.C.B. and R. Moon, 1999. Linear regression limit theory for nonstationary panel data. Econometrica, 67(5): 1057–1111. *View at Google Scholar* | *View at Publisher*

Phillips, P.C.B. and P. Perron, 1988. Testing for a unit root in time series regression. Biometrika, 75(2): 335–346. *View at Google Scholar* | *View at Publisher*

Romero-Avila, D. and C. Usabiaga, 2009. The hypothesis of a unit root in OECD inflation revisited. Journal of Economics and Business, 61(2): 153–161. *View at Google Scholar* | *View at Publisher*

Said, S.E. and D.A. Dickey, 1984. Testing for unit roots in autoregressive-moving average models of unknown order. Biometrika, 71(3): 599-607. *View at Google Scholar* | *View at Publisher*

Sargan, J.D. and A. Bhargava, 1983. Testing for residuals from least squares regression being generated by Gaussian random walk. Econometrica, 51(1): 153–174. *View at Google Scholar* | *View at Publisher*

Smith, L.V., S. Leybourne, T. Kim and P. Newbold, 2004. More powerful panel data unit root tests with an application to the mean reversion in real exchange rates. Journal of Applied Econometrics, 19(2): 147–170. *View at Google Scholar* | *View at Publisher*

Stock, J.H., 1990. A class of tests for integration and cointegration. Mimeo: Department of Economics, Harvard University.

Taylor, M.P. and L. Sarno, 1998. The behavior of real exchange rates during the post-Bretton Woods period. Journal of international Economics, 46(2): 281–312. *View at Google Scholar* | *View at Publisher*

Tsong, C.C., C.F. Lee and C.C. Lee, 2012. A revisit to the stationarity of OECD inflation: Evidence from panel unit-root tests and the covariate point optimal test. Japanese Economic Review, 63(3): 380-396. *View at Google Scholar* | *View at Publisher*

World Bank, 2016. World bank development indicators 2016. Retrieved from http://wdi.worldbank.org/tables.

Zhou, S., 2013. Nonlinearity and stationarity of inflation rates: Evidence from the euro-zone countries. Applied Economics, 45(7): 849-856. *View at Google Scholar* | *View at Publisher*

Zivot, E. and D.W.K. Andrews, 1992. Further evidence on the great crash, the oil price shock and the unit root hypothesis. Journal of Business and Economic Statistics, 10(3): 251–270. *View at Publisher*