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A PANIC Attack on Inflation and Unemployment in Africa:

Analysis of Persistence and Convergence

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Abstract:

The purpose of the study is to analyze the nature of inflation and unemployment rates -in Africa and its regions- allowing cross-sectional dependence among their countries. The paper contributes to the literature assessing the stochastic properties of unemployment and inflation using the recently developed and more powerful panel unit root tests namely PANIC -Panel Analysis of Non-stationarity in Idiosyncratic and Common Component- from Bay and Ng (2010). To check the robustness of our finding we added Pesaran (2007) and Chang (2002). In our analysis, many PANIC tests clearly show that the validation of the hysteresis hypothesis for unemployment rates in Central Africa, East Africa and North Africa; and convergence of inflation in Africa and its regions

Keywords: Panel unit root tests, PANIC, Unemployment, Inflation, African countries

JEL Classification: C12, C15, C22, C23, E31, J64

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I. Introduction

In the mainstream macroeconomics literature, unemployment characteristics can be explained by two opposite theoretical views; namely, the non-accelerating inflation rate of unemployment (NAIRU) hypothesis and the hysteresis hypothesis. The hysteresis hypothesis suggests that cyclical fluctuations in the labor market can significantly and permanently affect unemployment rate, and this can lead to a 'long-term persistence'. In other words, unemployment rates should follow a unit root process. On the basis of this view, if unemployment rates are a unit root process, the shocks that affecting the series will have permanent effects, and shocks will shift the 'unemployment equilibrium' from one level to another. In this case, the policy-point of this view can be summarized as the policy action is certainly necessary to turn back 'first equilibrium level' of the unemployment rate. On the other hand, inflation and unemployment dynamics are interrelated in the short-run through a Phillips Curve (PC). However, in the longer run these two variables are presumed to be independent of one another. This independence is well-documented in the 'classical view', whereby monetary policy has no long-run real effects, and unemployment converges towards the natural rate of unemployment (NRU) or the NAIRU. On this account, this view indicates that unemployment rates should follow a stationary process or a mean-reversion. The NAIRU hypothesis state that the equilibrium unemployment rate is independent from monetary policy variables particularly in the long-run and actual unemployment tends to converges towards its natural rate. As we can see above, it is important to assess the stochastic properties of unemployment rates and the realized inflation. As a matter of fact, it is particularly critical for policy-makers to understand the nature of unemployment and inflation not only at national level, but also at regional level. In the literature, less number of papers has investigated the stochastic properties of regional unemployment rates, when they compared with the number of papers that have examined the characteristics of national unemployment rates.

Song and Wu (1997, 1998) used PUR test by Levin et al. (2002, henceforth LLC) in 48 states of the United States (US) and they concluded that the hysteresis hypothesis was rejected. Leon-Ledesma (2002) used the data from 1985 quarter one to 1990 quarter four for 51 US states and he concluded that the rejection of the hysteresis hypothesis by Im et al. (2003, henceforth IPS) PUR test. On the contrary, Smyth (2003) both used LLC and IPS PUR tests for the states of Australia and he concluded that the hysteresis hypothesis was valid. Chang et al. (2007) used LLC, IPS and Taylor and Sarno (1998)'s PUR tests from July 1993 to September 2001 for 21 regions of Taiwan, and they concluded that the hysteresis hypothesis was rejected by all these PUR tests. Romero-Avila and Usabiaga (2008) tested the hysteresis hypothesis for the unemployment rate of Spanish regions over the period 1976-2004 by using Carrion-i-Silvestre et al. (2005)'s PUR test and they concluded that the persistent regional unemployment rates have observed in Spain. Gomes and Da Silva (2009) applied the Lee and Strazicich (2003)'s unit root test for the period from 1981 January to 2002 December for six major Brazilian metropolitan-areas and the results of unit root tests were showed that the hysteresis hypothesis was only rejected in one region. Lanzafame (2012) showed that the hysteresis hypothesis was only valid in 1 of 20 regions in Italy. Bakas and Papapetrou (2012) used the data from 1998 quarter one to 2011 quarter two for 13 regions of Greece, and they concluded that the validation of hysteresis hypothesis by using several different PUR tests.

The main objective of this paper is to test the possible presence of unemployment persistence and inflation convergence in Africa and its regions by using recently data on inflation and unemployment. The remainder of paper is organized as follows. Section 2 presents Panel unit root tests used in this paper. Section 3 describes the Data and the variable across African regions. In Section 4, we report the main results. And finally, in Section 5, we suggest some policy implications and conclude the study.

II. Panel Unit Root Tests

To investigate the mean reversion of inflation and unemployment rate across African countries, we used several panel unit root tests. We divide these tests in two groups, namely, 'first generation panel unit root tests' and 'second generation panel unit root tests. The first generation of panel unit root tests applied in this study included LLC test (Levin et al., 2002), IPS test (Im et al., 2003) and Hadri test (Hadri, 2000). The second generation tests are the two PANIC tests (Bai and Ng, 2004 and 2010), Pesaran test (Pesaran, 2007) and Chang test (Chang, 2002). The main difference between two generations of tests lies in the cross-sectional independence assumption.

First generation tests assume that all cross-sections are independent and second-generation tests relax this assumption. And the positive side of the PANIC method compared to the others Second Generation tests is that: The main idea of PANIC is to exploit the factor structure of panel data to devise panel unit root tests, and also univariate counterparts, with favorable size and power properties. More precisely, its exploits the contemporaneous correlation between cross-section units to split the process into two parts: a common and idiosyncratic component.

First Generation: Cross-sectional independence

The basic model underlying these tests is

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

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

For all these tests (with the exception of the LCC test), the null hypothesis is defined as $H_0 : \rho_i = 0$ for all $i = 1,\ldots,N$ 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 $0 < N_1 \leq N$. The alternative hypothesis allows unit roots for some (but not all) of the countries. In the particular case of the LCC test, we simplify the model (1) with the additional assumptions: $\alpha_i = 0$ 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 hypothesis 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, Lin and Chu (2002). This test employs the following adjusted *t*-statistic:

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

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 retain in the first generation category is the IPS test of Im *et al*. (2003), which employs a standardized *t*_bar statistic based on the movement of the Dickey-Fuller distribution:

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

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

Contrary to the previous first generation tests, the test proposed by Hadri (2000) is based on the null hypothesis of stationarity. It is an extension of the stationarity test developed by Kwiatkowski et al. (1992) in the time series context. Hadri proposes a residual-based Lagrange multiplier test for the null hypothesis that the individual series $y_{i,t}$ (for $i = 1,\ldots,N$) are stationary around a deterministic level or around a deterministic trend, against the alternative of a unit root in 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 $i.i.d.\left(0,\sigma_u^2\right)$, $u_{i,t}$ 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 $S_{i,t}$ denotes the partial sum of the residuals: $S_{i,t} = \sum_{j=1}^{t} \hat{e}_{i,j}$ and $\hat{\sigma}_{\varepsilon}^2$ is a consistent estimator of σ_{ε}^2. Under the null of level stationarity (model (4)), the test statistic:

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

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).

PANIC Pooled Tests

In their paper published in (2004), Bai and Ng showed that under $X_{it} = D_{it} + \lambda_i' F_t + e_{it}$ testing can still proceed even when both components are unobserved and without knowing a priori whether e_{it} is nonstationary. The strategy is to obtain consistent estimates of the space spanned by F_t (denoted by $\hat{F}_t$) and the idiosyncratic error (denoted by $\hat{e}_{it}$). In a nutshell, they apply the method of principal components to the first differenced data and then form $\hat{F}_t$ and $\hat{e}_{it}$ by recumulating the estimated factor components.

Bai and Ng (2004) provide asymptotically valid procedures for (a) determining the number of stochastic trends 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 the p values of the individual tests. If π_i is the p-value of the ADF test for the ith cross-section unit, the pooled test is

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

The test is asymptotically standard normal. For a two-tailed 5% test, the null hypothesis is rejected when $P_{\hat{e}}$ exceeds 1.96 in absolute value. Note that $P_{\hat{e}}$ does not require a pooled ordinary least squares (OLS) estimate of the AR(1) coefficient in the idiosyncratic errors. Pooling p values has the advantage that more heterogeneity in the units is permitted. However, a test based on a pooled estimate of ρ can be easily constructed by estimating a panel autoregression in the (cumulated) idiosyncratic errors estimated by PANIC, i.e., $\hat{e}_{it}$.

The test statistics depend on the specification of the deterministic component D_{it}. For p = −1 and 0,

$$P_a = \frac{\sqrt{N}T\left(\rho^{+} - 1\right)}{\sqrt{2\hat{\phi}_{\varepsilon}^{4} / \hat{\omega}_{\varepsilon}^{4}}} \quad (11a)$$

$$P_b = \sqrt{N}T\left(\rho^+ - 1\right)\sqrt{\frac{1}{NT^2}tr\left(\hat{e}'_{-1}\hat{e}_{-1}\right)\frac{\hat{\omega}_\varepsilon^2}{\hat{\phi}_\varepsilon^4}} \tag{11b}$$

For p=1,

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

$$P_b = \sqrt{N}T\left(\rho^+ - 1\right)\sqrt{\frac{1}{NT^2}tr\left(\hat{e}'_{-1}\hat{e}_{-1}\right)\frac{5}{6}\frac{\hat{\omega}_\varepsilon^2}{\hat{\phi}_\varepsilon^4\hat{\sigma}_\varepsilon^4}} \tag{12b}$$

See Bai and Ng 2010, for details.

Jang and Shin (2005) studied the properties of $P_{a,b}$ for p = 0 by simulations. But Bai and Ng (2010) proposed a Theorem that provides the limiting theory for both p = 0 and p = 1. It shows that the t tests of the pooled autoregressive coefficient in the idiosyncratic errors are asymptotically normal. The convergence holds for N and T tending to infinity jointly with $N/T \rightarrow 0$. It is thus a joint limit in the sense of Phillips and Moon (1999). The P_a and P_b are the analogs of t_a and t_b of Moon and Perron (2004), except that (a) the tests are based on PANIC residuals and (b) the method of "defactoring" of the data is different from the method of Moon and Perron (2004).

When p = 1, the adjustment parameters used in $P_{a,b}$ are also different from $t_{a,b}$ of Moon and Perron (2004). In this case, the PANIC residuals $\hat{e}_{it}$ have the property that T $^{-1/2}\hat{e}_{it}$ converges to a Brownian bridge, and a Brownian bridge takes on the value of zero at the boundary. In consequence, the Brownian motion component in the numerator of the autoregressive estimate vanishes. The usual bias correction made to recenter the numerator of the estimator to zero is no longer appropriate. This is because the deviation of the numerator from its mean, multiplied by $\sqrt{N}$, is still degenerate. However, we can do bias correction to the estimator directly because $T\left(\hat{\rho}-1\right)$ converges to a constant

The Pooled MSB

An important feature that distinguishes stationary from nonstationary processes is that their sample moments require different rates of normalization to be bounded asymptotically. In the univariate context, a simple test based on this idea is the test of Sargan and Bhargava (1983). Stock (1990) developed the modified Sargan–Bhargava test (MSB test) to allow $\varepsilon_{it}=\Delta e_{it}$ to be serially correlated with short- and long-run variance $\sigma_{\varepsilon i}^{2}$ and $\omega_{\varepsilon i}^{2}$, respectively. In particular, if $\hat{\omega}_{\varepsilon i}^{2}$ is an estimate of $\omega_{\varepsilon i}^{2}$ that is consistent under the null hypothesis and is bounded under the alternative, $MSB=Z_i/\hat{\omega}_{\varepsilon i}^{2}\Rightarrow\int_0^1 W_i^2\left(r\right)dr$ (see, Bai & Ng, 2010 for details) under the null and degenerates to zero under the alternative. Thus the null is rejected when the statistic is too small. As shown in Perron and Ng (1996) and Ng and Perron (2001), the MSB has power similar to the ADF test of Said and

Dickey (1984) and the Phillips–Perron test developed in Phillips and Perron (1988) for the same method of detrending. An unique feature of the MSB is that it does not require estimation of ρ, which allows us to subsequently assess whether power differences across tests are due to the estimate of ρ. This motivates the following simple panel nonstationarity test for the idiosyncratic errors, denoted the panel PMSB test. Let $\hat{e}$ be obtained from PANIC. For p = −1,0, the test statistic is defined as:

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

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 & Ng, 2010 for details)

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

The MP Tests

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

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

(14)

In this paper, we used two models to consider: a base case model (A) that assumes $D_{it} = a_i$ and an incidental trend model (B) that has $D_{it} = a_i + b_i t$. Note that we use $p = -1, 0, 1$ to represent the data generating process (DGP, hereafter) and use Models A–B to represent how the trends are estimated. Based on the first step estimator $\hat{\rho}$ one computes the residuals $\hat{u}$, from which a factor model is estimated to obtain $\hat{\Lambda}$ (see, Bai and Ng 2010, for details).

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

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

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

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).

Other Second Generation Tests

Regarding second generation tests, Pesaran (2007) proposes a test where the augmented Dickey-Fuller (ADF) regressions are augmented with the cross-sectional average of the lagged levels and the first-differences of the individual time series. This way, the common factor is proxied by the cross-section mean of $y_{i,t}$ and its lagged 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 slope coefficients estimated from the ADF test for the country *i*, $\bar{y}_{t-1}$ is the mean of lagged levels, $\Delta \bar{y}_i$ is the mean of first-differences, $\xi_{i,t}$ are the error terms. In fact, Pesaran (2007) advances a modified IPS statistics based on the average of the individual CADF, which is denoted as a cross-sectional augmented IPS (CIPS):

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

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).

The next test integrated in the second generation of unit root tests is that of Chang (2002). Indeed, the second approach to model cross-sectional dependencies consists in imposing few or none restrictions on the covariance matrix of residuals (O'Connell, 1998; Taylor and Sarno, 1998; Chang, 2002 and 2004). In this framework, Chang (2002) derives a nonlinear IV estimator of the autoregressive parameter in simple ADF model. She proves that the corresponding t-ratio (denoted Z_i) asymptotically converges to a standard normal distribution. Moreover, it can be shown that the asymptotic distributions of individual Z_i statistics are independent across cross-sectional units. Chang proposes an average IV t-ratio statistic, denoted S_N and defined as:

$$S_N = \frac{1}{\sqrt{N}} \sum_{i=1}^{N} Z_i \qquad (18)$$

In a balanced panel, this statistic has a limit standard normal distribution. The instruments are generated by an Instrument Generating Function (IGF) which corresponds to a nonlinear function $F\left(y_{i,t-1}\right)$ of the lagged values $y_{i,t-1}$. It must be a regularly integrable function which satisfies $\int_{-\infty}^{\infty} xF\left(x\right)dx \neq 0$. This assumption can be interpreted as the fact that the nonlinear instrument $F\left(\bullet\right)$ must be correlated with the regressor $y_{i,t-1}$. Chang provides several examples of regularly integrable IGFs.

III. Data and Variable

In this study we use yearly consumer price index, as proxy of inflation[1], for 47 African countries grouped in 05 regions (see Table 1 for more

[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.

details) over the period 1985-2014. The inflation rate is calculated as the logarithmic first difference of consumer price index.

Unemployment rate used is calculated as the logarithmic of Total Unemployment (% of total labor force). The data come from the World Development Indicators as published by the World Bank (2016). The countries under study and time span are dictated by data availability.

Table 1: Grouping of African Countries by region

Number of countries	Regions	Countries
11	Austral	Botswana, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, South Africa, Swaziland, Zambia, Zimbabwe
07	Central	Cameroon, Central Africa Rep, Chad, Congo Dem., Congo Rep, Equatorial Guinea, Gabon
08	East	Burundi, Eritrea, Ethiopia, Kenya, Rwanda, Somalia, Tanzania, Uganda
06	North	Algeria, Egypt, Libya, Morocco, Sudan, Tunisia
15	West	Benin, Burkina Faso, Cote d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Togo

Figure 1 and figure 2 respectively plot the evolution of inflation rate and unemployment rate (in mean) by region and the corresponding table 2, its descriptive statistics. As we see:

Inflation rate is very high in Central Africa (17%), follow by Austral Africa (14%), North (10%) and East (6.5%) region respectively reached in third and fourth position and West Africa close with smallest rate (3%); the Central and West Africa both reach their maximum level of inflation rate in 94'. Indeed, this date corresponds to the year Franc devaluation in Africa. This devaluation affected 13 African countries. The countries concerned were, on the one hand, Benin, Burkina Faso, Ivory Coast, Mali, Niger, Senegal and Togo and, on the other hand, Cameroon, Central African Republic, Congo, Gabon, Equatorial Guinea and Chad; The dispersion of inflation rate in Africa is very high in Central region (61%); The average level of inflation rate in Africa is 11% (with a standard deviation of 29).

Table 2: Descriptive Statistics

Sample	Full	Central	East	West	Austral	North
			Inflation			
Mean	11.37	17.22	6.52	2.92	14.45	10.17
Standard. Dev.	28.74	61.02	9.50	3.65	15.70	15.15
Minimum	-21.25	-19.41	-8.12	-4.08	-21.25	-10.31
Maximum	547.53	547.53	54.72	20.52	104.14	84.51
			Unemployment			
Mean	10.34	15.82	8.77	5.34	15.02	7.15
Standard Dev	7.86	9.01	4.82	2.88	4.69	7.06
Minimum	0.60	2.60	4.10	0.60	8.10	0.70
Maximum	39.30	39.30	21.60	10.20	29.80	32.50

IV. Results and Discussions

Tables 3 report results of first generation panel unit root tests applied on: 47 African countries (full) and its 05 regions. In the application of these tests the dependence between the series has not been taken into account.

In table 3a, we present the results of first generation tests apply on inflation rate. In model 1: The LLC test provides evidence to reject the null hypothesis of panel unit root in the case of Africa (full sample), Central Africa, East Africa, West Africa at (1% level) and North Africa (at 5% significance level). So according to the LLC test, inflation rate contains a unit root only in the case of Austral African countries. However, LLC unit root test is criticized for its assumption of common unit root process across countries, i.e. all the cross sections have a unit root property. The IPS unit root test goes a step further and relaxes this assumption by assuming individual unit root process. As LLC test, results of IPS unit root test provide evidence to reject the null hypothesis of unit root for entire panel of 47 countries, Central Africa, East Africa and West Africa except North Africa and Austral Africa. Finally, by using Hadri[2] unit root test we find that the null hypothesis of stationarity is rejected for the entire panel and its corresponding subsamples. In model 2: The second specification, with intercept and linear trend (Model 2), we get the same results as above except in the case of Austral Africa. Indeed, in this case, inflation rate -in Austral Africa- contains a unit root.

Table 3a: First Generation Tests on Inflation

Sample	Full Sample	Central Africa	East Africa	West Africa	Austral Africa	North Africa

[2] Note: High autocorrelation leads to severe size distortion in Hadri test leading to over-rejection of the null.

Test	Stat	Prob	Stat	Prob	Stat	Prob	Stat	Prob	Stat	Prob	Stat	Prob
						Model 1: With only Intercept						
LLC	-13.5	0.00	-8.83	0.00	-4.94	0.00	-3.56	0.00	-1.10	0.14	-1.75	0.04
IPS	-13.5	0.00	-8.43	0.00	-5.80	0.00	-5.55	0.00	0.04	0.52	-1.23	0.11
Hadri	7.28	0.00	2.89	0.00	2.88	0.00	6.37	0.00	7.37	0.00	2.58	0.00
						Model 2: With Intercept and Linear Trend						
LLC	-12.5	0.00	-8.77	0.00	-4.52	0.00	-6.76	0.00	-5.61	0.00	-0.60	0.27
IPS	-11.1	0.00	-7.51	0.00	-4.35	0.00	-5.79	0.00	-4.57	0.00	0.52	0.70
Hadri	4.47	0.00	1.88	0.03	2.84	0.00	2.37	0.01	3.85	0.00	1.90	0.03

The null hypothesis of the LLC and IPS tests assumes that the series has a unit root while Hadri Test assumes that the series is stationary.

In table 3b, we have the same tests on unemployment rates. Firstly, we focus on Model 1 i.e. the specification with only intercept. The LLC and IPS test both clearly reject the null hypothesis only in Africa (full), in West Africa and Austral Africa region. In the second specification, with intercept and linear trend (Model 2), we get the same results as above except in the case of Austral Africa.

Table 3b: First Generation Tests on Unemployment

Sample	Full Sample		Central Africa		East Africa		West Africa		Austral Africa		North Africa	
Test	Stat	Prob	Stat	Prob	Stat	Prob	Stat	Prob	Stat	Prob	Stat	Prob
						Model 1: With only Intercept						
LLC	-3.17	0.00	-0.45	0.33	-0.79	0.22	-2.92	0.00	-3.08	0.00	0.78	0.78
IPS	-2.82	0.00	-0.63	0.26	0.10	0.54	-2.63	0.00	-2.72	0.00	0.66	0.75
Hadri	13.41	0.00	6.48	0.00	4.70	0.00	6.86	0.00	3.40	0.00	6.29	0.00
						Model 2: With Intercept and Linear Trend						
LLC	-1.91	0.03	0.50	0.69	-2.31	0.01	-2.43	0.01	0.04	0.52	0.94	0.83
IPS	-2.59	0.00	-1.29	0.10	-1.04	0.15	-2.36	0.01	-0.86	0.20	0.22	0.59
Hadri	8.80	0.00	3.32	0.00	3.55	0.00	5.91	0.00	1.64	0.05	3.80	0.00

The null hypothesis of the LLC and IPS tests assumes that the series has a unit root while Hadri Test assumes that the series is stationary.

Tables 4 present the results of PANIC (2010 and 2004) unit root tests proposed by (Bai and Ng) on inflation and unemployment.

Table 4a presents the PANIC attack on inflation unit root tests. For the common approach, we used two factors. An example of these two factors, in the case of inflation rate -of durable goods-, may consist of a component that is common to all prices (factor 1), and a component that is specific to durable goods (factor 2). As we see, common approach test rejects unit root test at 1% level in all case, except East Africa which is 5% level. For the Pooled approach, we used three cases: Pool demeaned test, Pool Idiosyncratic test and Pool Cointegration of residuals test. As we see, the demeaned case rejects the null hypothesis in Africa and its subsamples; the idiosyncratic case rejects the null hypothesis only in Africa and West Africa; in the cointegration case we cannot reject the null hypothesis only in Austral and North Africa.

The first and second MP test provide evidence to reject the null hypothesis of panel unit root in Africa and its subsamples namely Austral Africa, Central Africa, East Africa, North Africa and West Africa at 5% level. Thus, according to the first and second Moon Perron test, inflation rate is a mean reverting process in Africa. However, Pool MSB and Pool ADF tests reject the null hypothesis (at 10% level) of panel unit roots only in the case of full sample. The second specification, with intercept and linear trend (Model 2), we get the same results as above except in the Pool LM case which reject the null hypothesis in case of Africa, Central, East and West Africa. Thus, we can conclude that, according to the PANIC unit root tests, inflation rate –as first generation tests- is mean reverting in Africa.

Table 4a: PANIC Tests on Inflation

PANIC 2004												
Region	Full		Central		East		West		Austral		North	
Test	Lag 1	Lag 2	Lag 1	Lag 2	Lag 1	Lag 2	Lag 1	Lag 2	Lag 1	Lag 2	Lag 1	Lag 2
						Common factor						
Factor 1	-2.84 ^{a}	-3.39 ^{a}	-2.86 ^{a}	-3.44 ^{a}	-3.66 ^{a}	-2.90 ^{a}	-3.51 ^{a}	-3.06 ^{a}	-4.56 ^{a}	-2.38 ^{a}	-1.45	-1.46
Factor 2	-4.63 ^{a}	-2.96 ^{a}	-4.80 ^{a}	-4.25 ^{a}	-3.56 ^{a}	-2.06 ^{b}	-3.87 ^{a}	-2.66 ^{a}	-2.02 ^{b}	-2.59 ^{a}	-2.04 ^{b}	-1.52
						Pooled						
Demeaned	26.1 ^{a}	15.2 ^{a}	16.4 ^{a}	10.1 ^{a}	8.66 ^{a}	3.89 ^{a}	18.8 ^{a}	9.46 ^{a}	10.2 ^{a}	7.36 ^{a}	1.99 ^{b}	2.22 ^{b}
Idiosync	9.52 ^{a}	3.17 ^{a}	2.63 ^{a}	-0.29	1.76 ^{b}	-0.01	5.85 ^{a}	2.69 ^{a}	1.17	-0.01	1.65 ^{b}	1.28
Cointeg	21.3 ^{a}	6.91 ^{a}	20.2 ^{a}	7.32 ^{a}	1.58 ^{b}	-1.66 ^{b}	17.1 ^{a}	4.25 ^{a}	3.58 ^{a}	-0.15	1.05	2.80 ^{a}

PANIC 2010												
Region	Full		Central		East		West		Austral		North	
Test	A	B	A	B	A	B	A	B	A	B	A	B
First MP	-3.65 ^{a}	-8.21 ^{a}	-18.1 ^{a}	-15.8 ^{a}	-2.76 ^{a}	-3.70 ^{a}	-5.52 ^{a}	-6.05 ^{a}	-3.15 ^{a}	-7.87 ^{a}	-3.24 ^{a}	-3.94 ^{a}
2nd MP	-2.37 ^{a}	-6.83 ^{a}	-9.33 ^{a}	-13.74 ^{a}	-1.87 ^{b}	-3.32 ^{a}	-2.93 ^{a}	-4.77 ^{a}	-2.47 ^{a}	-6.63 ^{a}	-1.87 ^{b}	-3.49 ^{a}
PMSB	-1.55 ^{c}	-1.59 ^{c}	-0.31	-0.42	0.71	0.46	0.05	-0.37	-0.41	-1.06	-0.91	-0.77
Pool	2.59 ^{a}	3.47 ^{a}	0.05	3.56 ^{a}	0.21	1.49 ^{c}	1.53 ^{c}	5.41 ^{a}	-0.21	0.64	1.04	-0.26

The superscript a, b and c respectively indicate significance at 1%, 5% and 10%. MP is Moon Perron, PMSB is Pool Modified Sargan–Bhargava. A and B respectively means "model with only intercept" and "model with intercept and trend". Critical value at 1% = - 2,326; Critical value at 5% = - 1,645; Critical value at 10% = - 1.281

Table 4b presents PANIC attack on unemployment. As we see, the two factors, the demeaned and the idiosyncratic unit root tests clearly reject the null hypothesis of unit roots in Africa and its regions. The first and second MP tests provide evidence to reject the null hypothesis of panel unit root in only in West and Austral Africa at 5% level when we consider a model with only intercept. And in model with intercept and trend, the MP test does not reject the null hypothesis only in Central and North Africa. Hence, the PANIC attack on unemployment reveals a mean reverting process in Africa.

Table 4b: PANIC Tests on Unemployment

PANIC 2004												
Region	Full		Central		East		West		Austral		North	
Test	Lag 1	Lag 2	Lag 1	Lag 2	Lag 1	Lag 2	Lag 1	Lag 2	Lag 1	Lag 2	Lag 1	Lag 2
	Common factor											
Factor 1	-2.01 [b]	-2.01 [b]	-2.28 [b]	-2.26 [b]	-2.38 [a]	-1.9 [b] 3	-2.02 [c]	-1.96 [b]	-2.78 [a]	-3.86 [a]	-2.80 [a]	-3.34 [a]
Factor 2	-3.37 [a]	-2.01 [b]	-2.02 [b]	-2.20 [b]	-3.25 [a]	-3.94 [a]	-3.75 [a]	-3.43 [a]	-3.84 [a]	-3.37 [a]	-2.12 [b]	-2.65 [a]
	Pooled											
Demeaned	15.05 [a]	13.79 [a]	6.44 [a]	5.21 [a]	4.16 [a]	3.73 [a]	12.36 [a]	8.33 [a]	6.25 [a]	7.87 [a]	2.14 [b]	4.57 [a]
Idiosync	6.31 [a]	4.16 [a]	6.3 [a]	2.4 [a]	0.28	-0.29	6.27 [a]	5.19 [a]	3.56 [a]	3.12 [a]	0.91	1.71 [b]
Cointeg	2.82 [a]	0.38	3.40 [a]	3.72 [a]	3.28 [a]	0.33	3.2 [a]	0.94	0.12	1.43	-0.43	0.82
PANIC 2010												
Region	Full		Central		East		West		Austral		North	
Test	A	B	A	B	A	B	A	B	A	B	A	B
First MP	-0.55	-5.83 [a]	-0.44	1.28	0.14	-1.98 [b]	-2.78 [a]	-6.08 [a]	-2.35 [b]	-2.55 [a]	0.34	0.34
2^{nd} MP	-0.40	-5.73 [a]	-0.37	1.24	0.12	-1.96 [b]	-1.82 [b]	-5.71 [a]	-1.56 [c]	-2.34 [b]	0.22	0.30
PMSB	-2.41 [a]	-1.98 [b]	-0.54	0.47	-0.78	-0.59	-1.48 [c]	-1.50 [c]	-1.36 [c]	-1.56 [c]	-1.17	-0.89
Pool	4.92 [a]	4.83 [a]	3.37 [a]	5.92 [a]	0.30	-0.58	6.64 [a]	4.04 [a]	3.61 [a]	3.49 [a]	0.82	0.14

The superscript a, b and c respectively indicate significance at 1%, 5% and 10%. MP is Moon Perron, PMSB is Pool Modified Sargan–Bhargava. A and B respectively means “model with only intercept” and “model with intercept and trend”. Critical value at 1% = - 2,326; Critical value at 5% = - 1,645; Critical value at 10% = - 1.281

For the robustness of our results, we added some second generation tests namely Pesaran test and Chang test (see appendix II). And we see they support the convergence of inflation rate and hysteresis of unemployment in Africa. Our findings are similar with recent studies such as that examined by Filiztekin (2009) Gozgor (2012 and 2013) and Yilmazkuday, H. (2013).

Conclusion

The empirical testing of unit root properties of Inflation and unemployment rate is necessary to know the behavior of business cycles. Furthermore, it would also help to understand the long run and short run impact of macroeconomic policies on consumption of durable goods and economic activity. In doing so, we have used battery of Panel Analysis of Non-stationarity in Idiosyncratic and Common Component unit root tests to check stationarity properties of inflation and unemployment in African countries.

In our analysis, many PANIC tests clearly show that the validation of the hysteresis hypothesis for unemployment rates and convergence of inflation in Africa. Our findings may have some practical implications for econometric modeling as well as for policy makers in formulating inflation policy to sustain economic growth in sampled countries.

Temporary shocks into the African unemployment rates will have permanent effects. Thus, the demand-side policies will be substantially effective in reducing the unemployment rates in the long-run. However, temporary shocks into the inflation rates will have transitory effects. This indicates: (i) a possible trade-off between inflation and unemployment for African regions as the New Keynesian Phillips Curve suggests; (ii) fluctuations in inflation rate have transitory effect; (iii) Shocks to inflation have no long lasting effects on the inflation rates of African countries. Therefore, monetary authorities of these countries would less costly implement disinflationary policies than those of the countries with nonstationary inflation rates; (4i) Furthermore, trend stationarity of inflation rate indicates that inflation rate will return to its trend path over time and it might be possible to forecast future movements in the inflation rate based on its past behavior.

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Appendix I:

Figure 1: Inflation evolution in African Regions

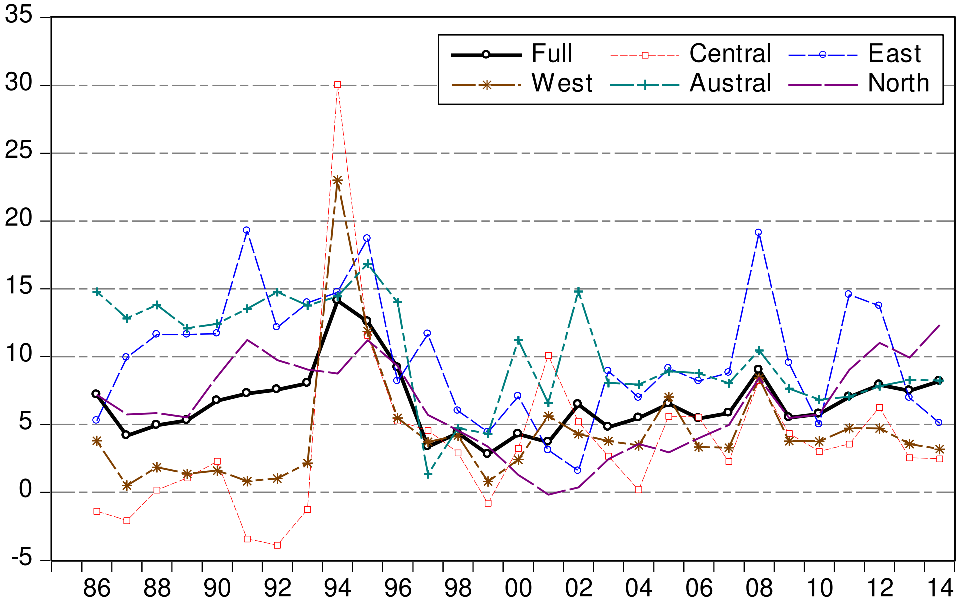
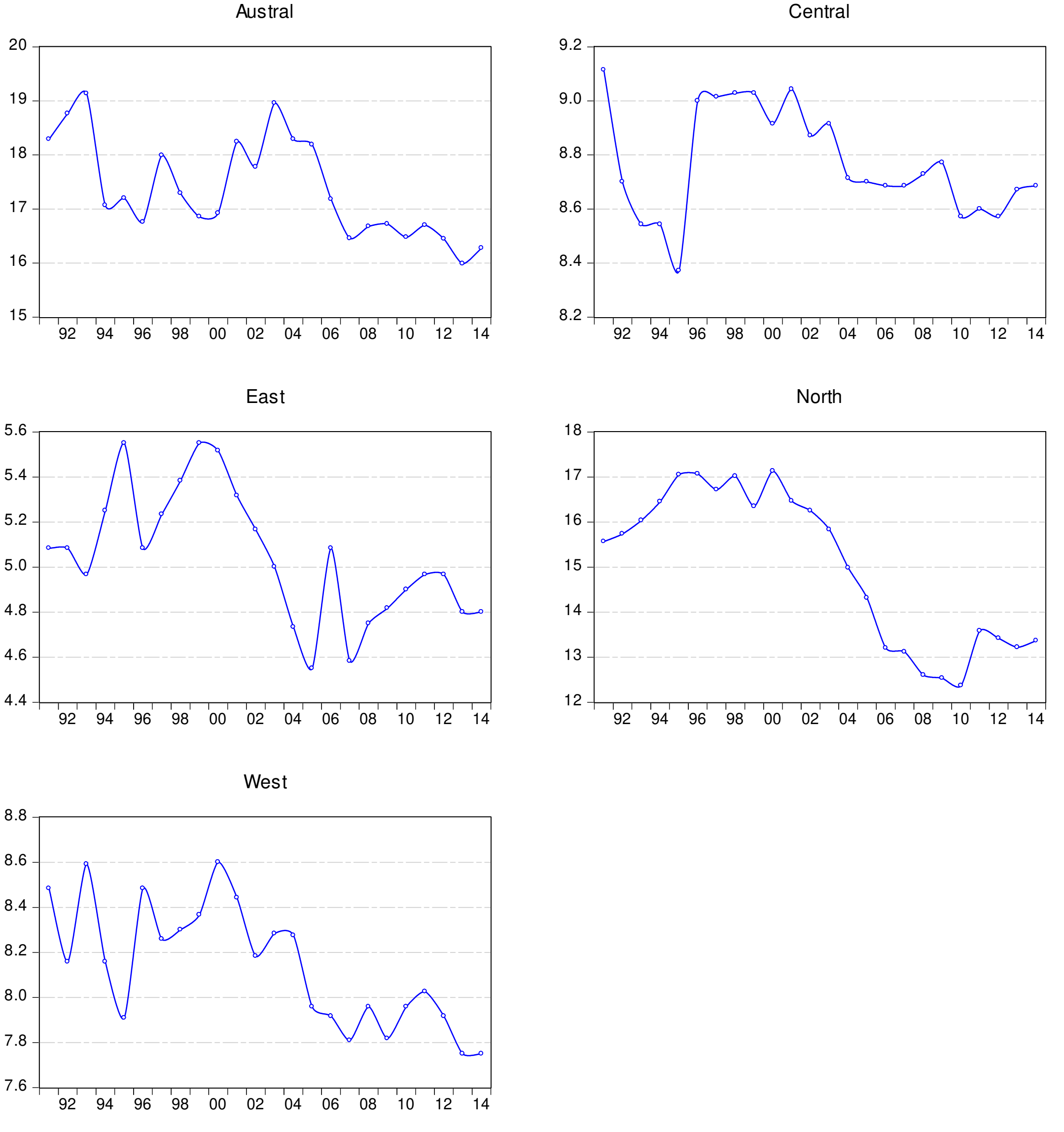


Figure 2: Unemployment Evolution in African Regions



Appendix II:

Table 5a: Other Second Generation unit Root Tests on Inflation

Sample	Full Sample		Central Africa		East Africa		West Africa		Austral Africa		North Africa	
	Model 1: With only Intercept											
Type of Test	Stat	Prob	Stat	Prob	Stat	Prob	Stat	Prob	Stat	Prob	Stat	Prob
Pesaran 0	-9.36	0.00	-3.05	0.00	-4.71	0.00	-9.80	0.00	-4.89	0.00	-4.46	0.00
Pesaran 1	-5.95	0.00	-4.95	0.00	-3.03	0.00	-4.50	0.00	-4.75	0.00	-2.45	0.01
Pesaran 2	1.35	0.91	-0.30	0.38	-0.93	0.18	-0.91	0.18	-3.62	0.00	-0.34	0.37
Chang 1	-5.72	0.00	-1.98	0.02	-2.02	0.02	-2.27	0.01	-2.14	0.02	-4.69	0.00
Chang 2	-5.51	0.00	-1.77	0.04	-2.02	0.02	-1.95	0.03	-2.23	0.01	-4.71	0.00
	Model 2: With Intercept and Linear Trend											
Pesaran 0	-7.98	0.00	-3.06	0.00	-3.71	0.00	-11.67	0.00	-3.50	0.00	-3.45	0.00
Pesaran 1	-5.37	0.00	-5.78	0.00	-1.92	0.03	-7.15	0.00	-3.27	0.00	-1.51	0.07
Pesaran 2	2.61	1.00	-1.98	0.02	0.49	0.69	-2.47	0.01	-1.25	0.11	0.20	0.58
Chang 1	-4.56	0.00	-3.88	0.00	-1.41	0.08	-1.06	0.14	-0.51	0.30	-3.85	0.00
Chang 2	-4.14	0.00	-3.62	0.00	-1.41	0.08	-0.55	0.29	-0.52	0.30	-3.75	0.00

The number in front of Pesaran and Chang tests indicate the order of the lag.

Table 5b: Other Second Generation unit Root Tests on Unemployment

Sample	Full Sample		Central Africa		East Africa		West Africa		Austral Africa		North Africa	
	Model 1: With only Intercept											
Type of Test	Stat	Prob	Stat	Prob	Stat	Prob	Stat	Prob	Stat	Prob	Stat	Prob
Pesaran 0	-5.25	0.00	0.78	0.78	0.45	0.67	-3.33	0.00	-1.21	0.11	-3.25	0.00
Pesaran 1	-3.12	0.00	1.83	0.97	0.97	0.83	-2.79	0.00	-1.39	0.08	-0.93	0.18
Pesaran 2	-1.93	0.03	2.49	0.99	1.99	0.98	-1.74	0.04	-1.04	0.15	-1.23	0.11
Chang 1	-6.11	0.00	-3.29	0.00	-1.40	0.08	-2.91	0.00	-5.08	0.00	-0.38	0.35
Chang 2	-5.58	0.00	-2.06	0.02	-1.40	0.08	-2.57	0.01	-5.17	0.00	-0.59	0.28
	Model 2: With Intercept and Linear Trend											
Pesaran 0	-3.76	0.00	-0.64	0.26	-1.25	0.11	-1.37	0.09	-0.79	0.22	-3.30	0.00
Pesaran 1	-1.31	0.10	1.28	0.90	0.00	0.50	-0.79	0.22	-0.34	0.37	-0.93	0.18
Pesaran 2	-0.48	0.32	2.36	0.99	0.89	0.81	-0.62	0.27	-0.29	0.39	-0.92	0.18
Chang 1	-8.82	0.00	-4.88	0.00	-3.26	0.00	-5.18	0.00	-4.87	0.00	-0.97	0.17

Chang 2	-8.30	0.00	-3.93	0.00	-3.26	0.00	-4.37	0.00	-4.99	0.00	-1.61	0.05

The number in front of Pesaran and Chang tests indicate the order of the lag.