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Testing for Hysteresis in Unemployment for African Countries Using Wavelet Unit Root Tests

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Abstract

This paper uses the wavelet unit root procedures to explore the validity of the hysteresis hypothesis in unemployment for 28 African countries covering the period 1991 through 2017. In particular, the study applied the wavelet-based unit root tests proposed by Fan and Gencay. The frequency domain procedures of DWT and MODWT involve the decomposition of the variance of the time series stochastic process into the variance in its high and low-frequency series. As a benchmark, the study implemented time domain unit root tests including DF-GLS, Phillips-Perron and KPSS. The standard unit root tests produced mixed results relative to the validity of the hysteresis hypothesis for the sample countries. However, the wavelet-based unit root tests provided more consistent results as the hysteresis hypothesis was rejected in all of the sample countries, save Rwanda. Policy implications are derived from the results.

Keywords: Hysteresis, unemployment rate, DWT, MODWT, Africa

JEL Classification Numbers: C12, C14, E24, J64

1. Introduction

For decades, most African countries have experienced high and persistent unemployment. Since after their independence, many of these countries have experienced turbulent times that have emanated either from fratricidal wars or from improper economic structures or even from the exposure to external shocks. These factors have therefore had adverse effects on their people particularly in the area of unemployment. As things settled in these countries, however, a new awareness emerged as to the depth of human suffering resulting mostly from unemployment. With the help of many international organizations like the International Monetary Fund (IMF) and the World Bank, these countries have redirected their resources to tackle this major economic problem.

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While there have been significant economic growth rates in these countries which have created opportunities for their people, high unemployment still persists and thus raises the question of these countries' unemployment dynamics. Industrialized countries are not immune from persistent unemployment problems, though. For instance, OECD countries, including the United States, experienced persistently high unemployment during the 1970s (Akay et al, 2011). The same was the case following the Global Financial Crisis of 2008 as both the U.S. and Japan experienced high unemployment rates (Chang, 2011).

The economic and social problems associated with unemployment usually compel authorities to formulate policies to ameliorate those maladies. Therefore, a clearer understanding of the theoretical dynamics of unemployment is crucial in the formulation of appropriate policies to curb unemployment problems. Two divergent theories have emerged in the literature regarding unemployment hypothesis. One theory, otherwise called the natural rate hypothesis, argues that any policy to reduce unemployment can only have a transitory effect as it will revert back to its natural rate (Friedman, 1968). As a result, any attempt to push the policy beyond that point will rather be inflationary with no positive effect on real output and employment (Phelps, 1967, 1968). The natural rate hypothesis portrays unemployment as a mean reverting I(0) process, and suggesting that shocks to unemployment only have temporary effects. It therefore means that irrespective of the shock's structure, unemployment rate eventually returns to its natural rate. The other theory, known as the hysteresis hypothesis, purports that unemployment can be shifted from one equilibrium level to another (Blanchard and Summers, 1986, 1987). The term hysteresis in economics refers to an event in the economy that persists into the future even after the factors that led to that event have been removed. According to Blanchard and Summers (1986, 1987), unemployment hysteresis implies that cyclical fluctuations have permanent effects on the level of unemployment. These effects are due to labor market rigidities introduced by insider-outsider interactions, or human-capital effects. They further suggested that unemployment data tend to be a I (1) process, thereby making them non-stationary.

Unlike the previous studies that used time domain procedures such as the ADF, Phillips-Perron and the KPSS procedures, the present study uses frequency domain unit root tests to ascertain the validity of hysteresis in unemployment for 28 African countries. The wavelet-based unit root tests have attractive features over the time domain techniques because they have the ability to assess the contributions of the variance of the process through wavelet power spectrum. These procedures also have the ability to decompose time series into wavelet components with each of the decomposed stochastic process being associated with a particular frequency band. They also provide better information relative to the trade-offs between oscillations and peaks in time series. Dewandaru, Masih and Masih, (2016), Boubaker and Raza (2017), Yang, Ce and Lian (2017), Shrivastava and Panigrahi (2014) all document that the wavelet-based unit root tests are capable of performing multitimescale analysis which decomposes any observed variable on scale-by-scale basis.

The rest of the paper is organized as follows: Section 2 discusses the relevant literature review. Section 3 presents the methodology. Section 4 discusses the empirical results. Section 5 offers the conclusions and implications of the study.

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2. Literature Review

Blanchard and Summers (1987) suggest that high unemployment rates have characteristics of hysteresis. The implication is that economic shocks have permanent effects on overall future unemployment rate of the economy. There is no doubt in their understanding of this phenomenon that finding evidence of a unit root supports hysteresis hypothesis while rejecting a unit root serves as an evidence for the natural-rate hypothesis. Blanchard and Summer (1996) further stated that unemployment hysteresis can be strongly attributed to recessions. They believe that recessions can have a permanent impact if they change the attitude of those who lost their jobs as a result of the recessions. Recessions in many instances create structural changes in the economy. Firms shift manufacturing strategies, and unemployed workers must also be retrained in order for them to be gainfully employed. Also noted are the facts that when people become unemployed during recessions, they become less motivated to look for jobs especially if it is a longer recession. Firms, at times, may be reluctant to hire workers who have been unemployed for a long period of time.

Koustas and Veloce (1996) applied long-memory univariate time series models, also known as ARFIMA approach, to measure shock persistence in Canada and the U.S. Both gross domestic product and employment data exhibited higher persistence in Canada than in the United States. A disaggregated Canadian unemployment rate indicates that hysteresis showed more prevalence in adult male workers. Based on their robust findings, they concluded that the prevailing notion of unemployment hysteresis being a European rather than the U.S. or Canadian phenomenon should be seriously re-considered.

Roed (1997) study about unemployment hysteresis stated that the concept is invariably associated with dynamic models. He further stated that hysteresis denotes the idea that transitory shocks may have permanent effects on long-run unemployment rates in the economy. This concept tends to emphasize that a hysteresis model's solution cannot in general be derived by solely referencing the present state of the economy's explanatory variables. The past history of the system under review must be evaluated, and the position of any contemporary equilibrium is path dependent. In as much as monetary policy may have any short-run effects on employment, hysteresis challenges the classical dichotomy between the monetary and the real economy in the long-run. It is not appropriate for the same macroeconomic policies be applied in hysteresis situations without ascertaining whether you are dealing with inside-outside hysteresis or human-capital hysteresis.

Peel and Speight (1998) stated that most previous studies tested for unemployment hysteresis within a linear framework. However, many economic literatures have documented that nonlinearities in unemployment rates occur as a result of cyclical asymmetries or idiosyncratic factors specific to labor market. It is also well documented that the commonly used linear unit root tests such as ADF (1979) and Phillips–Perron (1988) may have lower power when the unemployment rate data display nonlinear behavior. Therefore, taking a non-linear approach in studying unit root properties may be a better option reinforcing whether or not unemployment hysteresis is a stationary or non-stationary behavior.

Chang et al (2007) reviewed unemployment hysteresis by stating that if unemployment is a I(1) process, then a shock affecting the series will be a permanent one. They tested for unemployment hysteresis among Taiwan 21regional data sets covering the period of 1993-2001.

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Their unit root tests results showed that unemployment hysteresis can be justifiably rejected. It is important to state that all the three conventional unit root tests (ADF, DF-GLS and PP) employed for individual regional data accepted that hysteresis hypothesis existed. However, a much broader panel-based unit root test rejected the existence of unemployment hysteresis. It is important to state that panel data, also known as longitudinal data or cross-sectional time series data in some special cases, is data that is derived from a usually small number of observations over time on a usually large number of cross-sectional units like individuals, households, firms, or governments. Since their study employed panel data set, the choice of policy actions to correct unemployment hysteresis is limited. The implication is that adopting any fiscal or monetary stabilization policy may not have any permanent effects on the high unemployment rates in the 21 Taiwan regions.

According to Chang, Tsangyao (2011), high unemployment rates can be as a result of I(0) or I(1) process. However, if it is a I(1) process, then a shock affecting the series will be a permanent one. In this case, policy actions are required to return the unemployment rate close to its original level. Close to the original level does not indicate exact rate prior to the shock. It will shift the equilibrium form one level to another. On the other hand, if it is a I(0) process, the shock will have a temporary affect, making the need for policy action less necessary. With the I(0) process, high unemployment rate eventually returns to the original equilibrium condition. This condition has been referred as the Natural-Rate of Unemployment hypothesis. This describes natural-rate unemployment rate dynamics as a mean reverting process. His study concluded that unemployment hysteresis is a I(1) process, it is linked to non-stationarity, and various unit root tests can be employed to analyze the phenomenon.

Mednik et al. (2012), tested 13 Latin American countries for unemployment hysteresis covering the period of 1980-2005. Their results found that for most Latin American countries, their aggregate unemployment can be summed up as hysteric dynamics by nature. The extent of the hysteric feature of the labor markets is as a result of labor market inflexibilities, pro-cyclical monetary and fiscal policies, or decreasing capital stock trend. They also emphasized how difficult it is to critically analyze Latin America's economic growth and the region's unemployment structures and dynamics. This statement is expressed as a result of the countries higher policy volatilities, greater frequencies of crisis, and short periods of booms compared to other regions of the world.

Dritsaki and Dritsaki (2013) investigated hysteresis in unemployment in the three European Union countries namely- Greece, Ireland and Portugal for the period of 1984-2010. Using various unit root tests, they did not reject unit roots in unemployment rates of these countries. The implication is that hysteresis resulting from recessions tends to increase cyclical unemployment. This in turn creates increases in structural unemployment, and consequently increasing the future natural-rate of unemployment.

Marjanovic, et al. (2014) looked into the unemployment hysteresis evidenced from two groups of data namely OECD countries and Central and Eastern European countries. Hysteresis was rejected in the OECD countries, implying that natural-rate of unemployment hypothesis existed. Economic shocks posed temporary effects in these countries. On the other hand, unemployment hysteresis could not be rejected in the Central and Eastern European countries. However, when structural breaks were introduced into the models, it became obvious that

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unemployment movements in those countries in transitions (Central and Eastern European countries) can be explained with hysteresis hypothesis while OECD countries can be explained with the natural-rate hypothesis.

Munir and Ching (2015) re-examined the hypothesis of hysteresis in unemployment using panel data for 11 Asian countries covering the period of 1980-2009. Contrary to the findings from past studies, their study provided robust empirical evidence against unemployment hysteresis hypothesis in the 11 Asian countries. High unemployment rates have mean reverting tendencies, and wider choice of fiscal and monetary policies should be adopted. Their findings further suggested that short-run policies to deal with high unemployment rates are less worthy of implementation. Rather, these Asian countries should concentrate on implementing long-run policies that will help in strengthening the fundamentals of their labor markets.

3. Methodology

This study applies the Discrete Wavelet Transform (DWT) with Haar and Daubechies wavelet filters as suggested by Fan and Gencay (2010). To complement the results from the DWT, the study implemented the Maximum Overlap DWT (MODWT) with Haar and Daubechies wavelet filters. Fan and Gencay (2010) define $\{y\}_{t=1}^{T}$ as a univariate time series generated by:

$$y_t = \rho y_{t-1} + \mu_t \tag{1}$$

where μ_t stands for a weakly stationary zero mean error term with strictly positive long-run variance given by:

$$\emptyset^2 = \propto_0 + 2\sum_{j=1}^{\infty} \propto_j \tag{2}$$

$$\propto_j = E(\mu_t \mu_{t-j}) \tag{3}$$

Fan and Gencay develop two wavelet-based unit root tests for nonzero mean and the second is for the case of linear trend. Assume that the process {yt} is given by:

$$y_t = \beta t + y_t^s \tag{4}$$

Where y_t^s is derived from equation (1). If the null hypothesis (H0): $= 0$, then y_t^s ia a unit root process. If on the other hand, H0: $|\rho| < 1$, then y_t^s is a zero mean stationary process. If β =0, then the demeaned series $\{y_t - \bar{y}\}$ Where $\bar{y} = \frac{1}{T}\sum_{t=1}^{T} y_t$ is the sample mean of $\{y_t\}$. If $\beta \neq 0$, then we work with the detrended series $\{\bar{y}_t - \bar{\bar{y}}\}$ where $\bar{y} = \sum_{j=1}^{T}(\Delta y_j - \Delta\bar{y})$, $\bar{\bar{y}}$ is the sample mean of $\{\tilde{y}_t\}$ in which Δyt = yt –yt-1 and $\Delta\bar{y}$ represents the mean of {Δyt}. Based on the unit scale DWT wavelet, Fan and Gencay (2010) developed two test statistics $\bar{S}_{T,1}^{LM}$ and $\bar{S}_{T,1}^{Ld}$, for the demeaned and the detrended series, respectively. The two test statistics are given by the following expressions:

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$$\bar{S}_{T,1}^{LM} = \frac{\sum_{t=1}^{T/2}\left(V_{T,1}^{M}\right)^2}{\sum_{t=1}^{T}(y_t-\bar{y})^2} \quad (5)$$

and

$$\bar{S}_{T,1}^{Ld} = \frac{\sum_{t=1}^{T/2}\left(V_{T,1}^{d}\right)^2}{\sum_{t=1}^{T}(y_t-\bar{y})^2} \quad (6)$$

where $\left(V_{T,1}^{M}\right)$ and $\left(V_{T,1}^{d}\right)$, respectively represent the scaling coefficients of the demeaned and the detrended series. The two test statistics are used to test H0: $\rho = 0$ against H0: $|\rho| < 1$ in equation (1). Under the alternative hypothesis, {yt} is a zero mean stationary process with the long run variance $\emptyset^2/(1-\rho)^2$ where $\emptyset^2$ is estimated by taking the OLS residuals from a regression of yt on a linear trend and yt-1. Next, a nonparametric kernel estimator with the Bartlett kernel is applied to the residuals. Tiwari and Kyophilavong (2014) pointed out that when the testing procedure is based on the Haar wavelet filter, the test statistic reduces to:

$$\bar{S}_{T,1}^{LM} = 1 - \frac{\sum_{t=1}^{T/2}(y_{2t}-y_{2t-1})^2/2}{\sum_{t=1}^{T}(y_t-\bar{y})^2} \quad (7)$$

4. Data and Descriptive Statistics

This study employs annual data on unemployment rates (% of total labor force) based on International Labor Organization (ILO) estimates. The data were obtained from International Labor Organization, ILOSTAT database (retrieved in November 2017). Unemployment denotes the share of the labor force that is without work but available for and seeking employment. The data span the time period 1991 through 2017. The sample consists of 28 African countries namely — Benin, Botswana, Burkina Faso, Cameroon, Congo, Republic, Ethiopia, Gabon, Ghana, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritius, Morocco, Namibia, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, South Africa, Swaziland, Tanzania, Uganda, Zambia, and Zimbabwe. The selection of countries was based on the availability of consistent data.

The summary statistics for unemployment rates are presented in Table 1. Benin recorded the lowest mean value of 0.99%. While Lesotho exhibited the highest mean value. The standard deviations varied from a high of 5.91% for Lesotho to a low of 0.17% for Benin. The minimum and maximum statistics reveal for the unemployment series have fluctuated over the years. For instance, unemployment rate for Zambia varied from a minimum of 19.70% to a maximum of 7.40% for the time period under study. The kurtosis statistics for Benin, Ethiopia, Mauritius, Namibia, Niger, Senegal and South Africa are greater than 3 suggesting that the unemployment series for these countries are not normally distributed. Similarly, the Jarque-Bera statistics indicate that the null hypothesis that the unemployment series are normally distributed should be rejected at least, at the 10% significance level, for these same 7 countries.

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Table 1: Descriptive Statistics

Country	*Mean*	*Max*	*Min*	*Std. Dev.*	*Kurt.*	*J-B*	*Prob.*
Benin	0.99	1.50	0.70	0.17	4.66	5.49*	0.06
Botswana	18.42	23.80	12.90	2.60	2.61	0.17	0.92
Burkina Faso	2.94	4.00	2.30	0.44	2.23	0.76	0.68
Cameroon	5.15	8.10	2.90	1.51	2.48	2.32	0.31
Congo, Rep.	12.17	16.10	10.00	1.85	2.78	2.78	0.25
Ethiopia	5.63	8.20	5.00	0.77	6.33	30.27***	0.00
Gabon	18.38	21.60	16.60	1.54	1.80	2.58	0.28
Ghana	6.46	10.40	3.60	1.98	2.06	2.10	0.35
Kenya	10.69	12.20	8.10	1.10	2.66	1.21	0.55
Lesotho	28.97	39.30	16.10	5.91	2.55	0.67	0.71
Liberia	4.29	5.60	3.60	0.57	2.50	2.58	0.28
Madagascar	3.29	5.80	1.30	1.49	1.80	2.04	0.36
Malawi	6.88	7.80	6.40	0.45	2.22	3.37	0.19
Mali	8.53	12.20	3.30	2.15	2.90	0.35	0.84
Mauritius	7.45	10.00	3.30	1.61	3.79	4.62*	0.10
Morocco	12.84	22.90	8.90	3.97	2.75	3.96	0.14
Namibia	20.25	24.00	18.40	1.36	4.11	8.76***	0.01
Niger	2.81	5.10	1.50	0.79	5.80	19.32***	0.00
Nigeria	6.37	7.60	4.30	0.93	2.47	3.24	0.20
Rwanda	2.20	3.40	0.30	1.04	1.69	2.63	0.27
Senegal	9.24	10.40	5.60	1.12	4.93	10.73***	0.00
Sierra Leone	2.99	3.40	2.50	0.20	3.23	0.10	0.95
South Africa	24.21	27.30	16.90	2.36	4.67	9.73***	0.01
Swaziland	24.69	28.20	21.70	2.27	1.48	2.81	0.25
Tanzania	3.24	5.10	2.00	0.72	2.98	0.14	0.93
Uganda	2.39	3.50	0.90	0.65	2.38	0.51	0.77
Zambia	12.83	19.70	7.40	4.02	1.88	1.44	0.49
Zimbabwe	5.48	6.90	4.20	0.61	3.00	0.20	0.90

***, ** and * rejection of normality assumption at the 1%, 5% and 10%, levels of significance, respectively.

Table 2: Conventional Unit Tests

	Constant Only			*Constant and Trend*		
Country	DF_GLS (k)	PP(k)	KPSS(k)	DF_GLS (k)	PP(k)	KPSS(k)
Benin	-1.48(4)	-3.77***(1)	0.144(2)	-1.59(4)	-3.69**(1)	0.140*(1)
Botswana	-2.13(0)	-2.77*(1)	0.178(2)	-2.60(0)	-3.02(0)	0.095(2)
Burkina Faso	-0.94(2)	-3.94***(2)	0.554**(3)	-1.71(2)	-5.95***(1)	0.088(0)
Cameroon	-1.80(0)	-1.78(0)	0.453*(3)	-2.43(0)	-2.38(1)	0.100(3)
Congo, Rep	-3.00***(0)	-2.95*(0)	0.132(2)	-3.03*(0)	-2.90(0)	0.129*(2)
Ethiopia	-2.0**(1)	-3.11**(2)	0.269(3)	-2.34(1)	-3.31*(1)	0.118(2)
Gabon	-2.09**(0)	-2.93*(2)	0.199(3)	-2.64(0)	-3.25*(2)	0.162**(3)
Ghana	-1.80*(1)	-2.96*(2)	0.287(3)	-2.24(1)	-3.28(2)	0.107(3)
Kenya	-1.61*(0)	-1.58(0)	0.513**(3)	-2.35(0)	-2.44(1)	0.124*(2)
Lesotho	-1.81*(3)	-2.58(1)	0.141(3)	-2.21(3)	-2.43(2)	0.142*(3)
Liberia	-1.93*(1)	-2.42(2)	0.242(3)	-2.33(1)	-2.65(2)	0.105(3)
Madagascar	-2.01*(0)	-2.21(1)	0.163(3)	-2.10(0)	-2.04(0)	0.137*(3)
Malawi	-1.61*(0)	-1.64(2)	0.266(3)	-1.82(0)	-1.64(2)	0.137*(3)
Mali	-3.27***(0)	-3.34**(1)	0.093(1)	-3.35**(0)	-3.30*(0)	0.053(1)
Mauritius	-1.58(6)	-4.31***(2)	0.356*(1)	-1.34(6)	-5.09***(2)	0.111(1)
Morocco	-0.56(6)	-1.32(5)	0.616**(3)	-0.87(6)	-1.87(2)	0.134*(3)
Namibia	-0.95(6)	-3.25**(0)	0.404*(2)	-2.68(1)	-3.75**(1)	0.096(1)

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Table 2: Cont.

	Constant Only			*Constant and Trend*		
Country	DF_GLS (k)	PP(k)	KPSS(k)	DF_GLS (k)	PP(k)	KPSS(k)
Niger	-2.58***(4)	-4.15***(1)	0.591**(2)	-2.46(4)	-5.73***(0)	0.138*(2)
Nigeria	-2.05**(0)	-2.06(0)	0.139(3)	-2.08(0)	-1.96(0)	0.139*(3)
Rwanda	-3.06***(0)	-3.78**(1)	0.643**(2)	-4.80***(0)	-4.79***(4)	0.103(5)
Senegal	-1.69*(2)	-3.37**(0)	0.379*(2)	-1.92(2)	-4.20***(1)	0.126*(1)
Sierra Leone	-1.93*(0)	-1.96(1)	0.164(3)	-2.02(0)	-1.96(1)	0.159**(3)
South Africa	-2.91*(0)	-2.20(0)	0.198(3)	-2.65(0)	-2.64(0)	0.068(2)
Swaziland	-0.98(0)	-1.17(2)	0.543**(3)	-1.62(0)	-1.95(2)	0.095(3)
Tanzania	-2.23**(0)	-2.14(1)	0.590**(3)	-3.66**(0)	-3.63**(0)	0.069(1)
Uganda	-1.03(3)	-5.19***(1)	0.140(2)	-1.37(3)	-5.19***(2)	0.152**(3)
Zambia	-0.94(0)	-1.35(1)	0.667**(3)	-2.67(0)	-2.56(0)	0.064(2)
Zimbabwe	-2.29***(0)	-2.95(1)	0.264(2)	-3.22**(0)	-3.15(1)	0.070(2)

***, **, * indicate rejection of null hypothesis at the 1%, 5% and 10% levels, respectively. The 1%, 5%, 10%, critical values for the DF-GLS tests with a constant only are -2.65, -1.95 and -1.61, respectively. The 1%, 5%, 10%, critical values for the DF-GLS tests with a constant and a linear trend are -3.77, -3.19 and -2.89, respectively. The lag lengths for the DF-GLS tests were determined via MAIC. The 1%, 5%, 10%, critical values for the PP tests with a constant only are -3.71, -2.98 and -2.63, respectively. The 1%, 5%, 10%, critical values for the PP tests with a constant and a linear trend are -4.36, -3.60 and -3.23, respectively. For KPSS tests, the 1%, 5% and 10% critical values are 0.739, 0.463 and 0.347, respectively for with a constant only. For the KPSS tests with a constant and a time trend, the 1%, 5%, and 10% critical values are 0.216, 0.146, and 0.119, respectively. The bandwidths for both the KPSS and PP tests were selected by means of the Bartlett Kernel proposed by Newey and West (1987).

5. Empirical Results

As a benchmark, this study first applies a number of the conventional unit root tests including the modified DF_GLS, PP and the KPSS to the unemployment rates for the sample countries. Table 2 provides the results from the univariate unit root results. The results are presented for with a constant term only and for with a constant and linear time trend. The time domain unit root tests of DF-GLS, PP and KPSS produced mixed results. For example, the null hypothesis of hysteresis in unemployment is rejected when the DF-GLS test without a linear trend is applied for 18 out of the 28 countries under study including Congo Republic, Ethiopia, Gabon, Ghana, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Namibia, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, South Africa, Tanzania, and Zimbabwe. However, when the DG-GLS with a linear trend is applied, the null hypothesis of hysteresis is rejected in only 5 out of the 28 sample countries namely Cameroon, Mali, Rwanda, Tanzania and Zimbabwe. Similarly, the PP testing procedures produced mixed results. When the PP test without a linear trend is used, the results reject the hysteresis hypothesis for 14 out of the 28 countries under study. However, When the PP test with a linear trend is applied, the results reject the hysteresis hypothesis for 11 out of the 28 countries under study. Turning next to the KPSS testing procedure whose null hypothesis is stationarity, the hysteresis hypothesis could not be rejected for 12 countries (Burkina Faso, Cameroon, Kenya, Mauritius, Morocco, Namibia, Niger, Rwanda, Senegal, Swaziland, Tanzania and Zambia) when the test is conducted without a time trend. However, when the KPSS procedure with a linear trend is implemented, the results fail to reject the hysteresis hypothesis for 13 of the 28 countries under consideration including Benin, Congo Republic, Gabon, Kenya, Lesotho, Madagascar, Malawi, Morocco, Niger, Nigeria, Senegal, Sierra Leone, and Uganda.

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As pointed out by Shiller and Perron (1985), the results from the univariate unit root tests should be taken with caution, as they tend to suffer from low power especially when the time span is short. In the present study, there are only 26 annual observations. Similarly, Maddala and Kim (1998) suggest that the univariate unit root procedures suffer from limited power against near unit root alternatives. To mitigate these limitations, this study applies the frequency based unit root tests implied in Discrete Wavelet Transform (DWT) with Haar and Daubechies filters as suggested by Fan and Gencay (2010). To complement the results from the DWT, the study also implemented the Maximum Overlap DWT (MODWT) with Haar and Daubechies wavelet filters. The wavelet-based unit root tests are attractive because they account for both time and frequency domains of the time series (unemployment rates, in our case).

The results from the DWT and MODWT with Haar and Daubechies filters are presented in Table 3. The demeaned and de-trended test statistics from the DWT overwhelmingly reject the hysteresis hypothesis with the exceptions of Mauritius, Rwanda and Uganda. The unemployment rates for Benin, Botswana, Burkina Faso, Cameroon, Congo, Republic, Ethiopia, Gabon, Ghana, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Morocco, Namibia, Niger, Nigeria, Senegal, Sierra Leone, South Africa, Swaziland, Tanzania, Zambia, and Zimbabwe are stationary, at least, at the 10 percent level of significance. The finding of stationarity implies that shocks to the unemployment series in these countries are temporary or transitory. In which case, policy actions are not needed. As the series will revert to their natural rates over the time. The existence of stationarity is referred to in the literature as the natural rate of unemployment hypothesis (NAIRU). However, for Mauritius, Rwanda and Uganda where the unemployment series are nonstationary which validates the hysteresis hypothesis. In which case, shocks to the unemployment series in these countries are permanent. Policy actions are required to return the unemployment series to their natural rates. The demeaned and de-trended test statistics from the MODWT corroborate those from the DWT unit root tests. The unemployment rates for Benin, Botswana, Burkina Faso, Cameroon, Congo, Republic, Ethiopia, Gabon, Ghana, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Morocco, Mauritius, Namibia, Niger, Nigeria, Senegal, Sierra Leone, South Africa, Swaziland, Tanzania, Uganda Zambia, and Zimbabwe are stationary, at least, at the 10 percent level of significance. The results from the MODWT unit root procedures failed to reject the hysteresis hypothesis only Rwanda. Taken together, the test results from the frequency domains of DWT and MODWT with Haar and Daubechies filters provide evidence against the hysteresis hypothesis for 27 out of the 28 sample countries, with Rwanda being the only exception.

Table 3: Wavelet-based Unit Root Tests

	DWT				*MODWT*			
	$\hat{S}_{T,1}^{LM}$		$\hat{S}_{T,1}^{Ld}$		$\hat{S}_{T,1}^{LM}$		$\hat{S}_{T,1}^{Ld}$	
Country	Haar	DB4	Haar	DB4	Haar	DB4	Haar	DB4
Benin	-46.73**	-43.14***	-45.69**	-80.84***	-93.46***	-86.27***	-87.87***	-80.84***
Botswana	-57.55***	-53.12***	-40.19**	-71.10***	-115.10***	-106.25***	-77.28***	-71.10***
Burkina Faso	-37.69**	-34.79**	-43.91**	-77.68***	-75.38***	-69.57***	-84.45***	-77.70***
Cameroon	-21.36	-19.72	-27.56	-48.77***	-42.75***	-39.45**	-53.01***	-48.77**
Congo, Rep	-47.17***	-43.54***	-47.31**	-83.70***	-94.35***	-87.09***	-90.97***	-83.70***
Ethiopia	-55.74***	-51.45***	-57.34***	-101.43***	-111.48***	-102.90***	-110.26***	-103.44***
Gabon	-147.28***	-135.95***	-94.39***	-166.99***	-294.56***	-271.91***	-181.51***	-166.99***
Ghana	-17.75	-16.39	-18.39	-32.53*	-35.50**	-32.77**	-35.36*	-32.53*
Kenya	-80.44***	-74.25***	-96.95***	-171.53***	-160.88***	-148.50***	-186.45***	-171.53***
Lesotho	-24.32*	-22.44*	-20.82	-36.83**	-48.63**	-44.90***	-40.03**	-36.83**

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Table 3: Contd.

	DWT				*MODWT*			
	$\hat{S}_{T,1}^{LM}$		$\hat{S}_{T,1}^{Ld}$		$\hat{S}_{T,1}^{LM}$		$\hat{S}_{T,1}^{Ld}$	
Liberia	-63.73***	-58.83***	-68.45***	-121.10***	-127.46***	-117.66***	-131.64***	-121.10***
Madagascar	-11.10	-10.25	-10.79	-19.08	-22.20*	-20.49	-20.74	-19.08
Malawi	-226.64***	-209.20***	-248.40***	-439.48***	-453.27***	-418.41***	-477.69***	-439.48***
Mali	-22.86*	-21.10	-22.30	-49.46**	-45.71***	-42.20***	-42.89**	-39.46**
Mauritius	-18.38	-16.97	-11.87	-21.00	-36.77**	-33.94**	-22.83	-21.00
Morocco	-25.63*	-23.64*	-61.15***	-108.18***	-51.27***	-47.32***	-117.59***	-108.18***
Namibia	-194.87***	-179.88***	-222.83***	-394.23***	-389.74***	-359.76***	-428.52***	-394.23***
Niger	-28.07**	-25.91*	-30.29*	-53.59***	-56.13***	-51.82***	-58.28***	-53.59***
Nigeria	-52.32***	-48.30***	-52.46***	-92.81***	-104.67***	-96.60***	-100.88***	-92.81***
Rwanda	-4.12	-3.81	-6.57	-11.63	-8.25	-7.61	-12.64	-11.63
Senegal	-65.37***	-60.34***	-52.77***	-93.36***	-130.74***	-120.69***	-101.47***	-93.36***
Sierra Leone	-218.44***	-201.64***	-225.42***	-398.83***	-436.88***	-403.31***	-433.51***	-398.83***
South Africa	-88.46***	-81.64***	-104.27***	-184.49***	-176.92***	-163.92***	-200.53***	-184.49***
Swaziland	-96.22***	-88.81***	-141.98***	-251.20***	-192.43***	-177.63***	-273.04***	-251.20***
Tanzania	-33.65**	-31.06**	-55.58***	-98.34***	-67.31***	-62.13***	-106.89***	-98.34***
Uganda	-19.52	-18.01	-14.26	-25.22	-39.04	-36.03**	-27.42	-25.23
Zambia	-25.79*	-23.81*	-106.51***	-188.44***	-51.58***	-47.61***	-204.83***	-188.44***
Zimbabwe	-93.34***	-86.16***	-105.72***	-187.05**	-186.68***	-172.32***	-203.31***	-187.05***

***, **, * indicate rejection of nonlinearity hypothesis at the 1%, 5% and 10% levels, respectively. The critical values for demeaned tests are -40.38, -27.38, and -21.75, respectively at the 1%, 5%, and 10% levels. The critical values for detrended tests are -50.77, -36.54, and -30.23, respectively at the 1%, 5%, and 10% levels. DWT and MODWT represent discrete wavelet transform and maximum overlap discrete wavelet transform, respectively. Bartlett bandwidth in the calculation of the long-run variance is equal to 5. DB4 = Daubechies4 function and Haar = Haar function.

6. Conclusions and Policy Implications

This paper has examined the issue of unemployment hysteresis for twenty-eight African countries using the Wavelet-based unit root tests developed by Fan and Gencay (2010). The results from the time domain procedures of DF-GLS, Phillips-Perron and KPSS produced mixed results regarding the existence of hysteresis in unemployment for the sample countries. The inconsistent results from the conventional unit root tests can be attributed to the fact that these procedures tend to lose power especially when the number of observations is small. However, the results from the Wavelet-based tests of DWT and MODWT provided more accurate information regarding hysteresis in unemployment for the sample countries. Indeed, the results from the Wavelet-based unit roots reject the hysteresis hypothesis for all of the sample countries with the exception of Rwanda. Unemployment rates for Benin, Botswana, Burkina Faso, Cameroon, Congo, Republic, Ethiopia, Gabon, Ghana, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritius, Morocco, Namibia, Niger, Nigeria, Senegal, Sierra Leone, South Africa, Swaziland, Tanzania, Uganda, Zambia, and Zimbabwe have the tendency to revert to their natural rates following cyclical fluctuations; given that they are stationary. For Rwanda, the results failed to reject the hysteresis hypothesis, as its unemployment rate is a unit root process.

From policy perspectives, the results from this study imply that the governments of Benin, Botswana, Burkina Faso, Cameroon, Congo, Republic, Ethiopia, Gabon, Ghana, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritius, Morocco, Namibia, Niger, Nigeria, Senegal, Sierra Leone, South Africa, Swaziland, Tanzania, Uganda, Zambia, and Zimbabwe should not invoke stabilization fiscal policies to combat unemployment problems in their respective countries; as the series will revert to their natural rates following cyclical fluctuations in their respective economies.

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In other words, shocks to unemployment rates in these countries are transitory. However, for Rwanda, the finding of hysteresis in unemployment rate suggests that shocks to its unemployment rate are permanent which requires the government to apply fiscal stabilization policies to curtail the unemployment problem in the country.

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