Convergence of gender unemployment gaps in Africa: New evidence from Fourier ADF and KPSS unit root tests with break

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Abstract

This paper uses four ADF-type unit root tests and four KPSS-type stationarity tests to examine whether the gender unemployment gap would converge to zero in Africa. Among these different tests, the two most restricted models, namely the ADF test and the KPSS test, indicate no convergence in the gender unemployment gap in Africa. By contrast, the two most general models, the FADF-SB test and the FKPSS-SB test, indicate convergence in the gender unemployment gap. The discrepancy in the empirical findings could be overcome by setting up an *F*-test to determine which model specification could be considered the best testing model among the four alternatives in each case. The best model specification from both the ADF-type and KPSS-type tests offers consistent results that show the convergence of the gender unemployment gap in the line of the "Law of one unemployment rate". The findings in the paper have significant policy implications.

Keywords: Unemployment rate; gender disparity; Africa; unit roots; mean reversion
JEL Classification: A19; C12

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1. Introduction

Gender disparities concerning job opportunities have become a pressing issue for developing nations (Awolaja et al., 2021), particularly for African economies with high unemployment rates in some countries (Yaya et al., 2019). In an aggressive bid to attain poverty alleviation and Sustainable Development Goals (SDGs) by 2030, bridging the gender gaps in the labour force is necessary (United Nations, 2018). Women in Africa are destined to face worse labour market outcomes than men, ranging from increased unemployment and under-employment to poorly paid jobs. Job separatism by sex is typically associated with an African labour market which has led to job allocation deficiencies and wage gaps (World Bank, 2011). According to a UNDP estimation, gender inequality in the labour market may cost more than US$90 billion to the Sub-Saharan African countries as a whole (UNDP, 2021).

From a practical perspective, gender disparities in the labour market could be crucial for two major reasons. First, women's employment and earnings are key in combating social vices and poverty in any nation; this is not limited to women's improvement in household care alone, but also in the area of enhancing and adequately channelling household spending on important needs, especially in favour of children's health and education (UNICEF, 1999). In most African countries, a mother's employment tends to have a greater impact on children's education and well-being than that of the father (Hill and King, 1995). The second reason why understanding the magnitude of the gender gap in the labour market is essential is because of the consensus that a country tends to attain greater economic development when gender disparities in the labour market are narrowed over time (Abney and Lava, 2018). In this regard, a better understanding of the extent of gender disparities in the labour market in Africa is very important for the development of effective policies to enhance gender equality and economic development in the long-run.

From a theoretical perspective, the persistence of the gender unemployment gap could be seen as the violation of the "Law of one unemployment rate" which is a hypothesised regularity in the labour market. It assumes that there would be convergence of unemployment gaps which are differentiated by three main demographic factors, these being gender, disability and race. This hypothesis assumes that, in the absence of labour market friction and possible labour market discrimination under a competitive labour market with a perfectly flexible wage, there would be a convergence of unemployment gaps.[1] (Furuoka, 2024).

Several empirical studies have documented causal relationships between bridging the gender gaps in the labour market and advancing sustainable economic growth and development (Aguirre et al., 2012; Lemmon & Vogelstein, 2017; Kazandjian et al., 2016; Klasan & Lamanna, 2019; Thevenon et al., 2018). Most of these past empirical studies have reported the benefits of closing the gender gaps in the labour market for sustainable economic growth. However, these studies failed to capture the intricate nature of unemployment dynamics by emphasising the critical aspects and complex magnitudes of the gaps.

Against such background, the basic objective of the current study is to examine empirically the convergence of the gender unemployment gap in Africa. The novel and uniqueness of the current study is that it employs sophisticated and new unit root tests to estimate the degree of persistence in the data and the extent of gender disparities in job opportunities in African countries. In other words, previous empirical studies tend to use some conventional econometric methods which could not capture fully the complex nature of the time series of unemployment rates. By contrast, the methodological advantage of the current research is that it employed a newly proposed econometric method which could examine effectively the unemployment rate in the presence of structural break and nonlinearity. The contribution of the manuscript is twofold. On the one hand, there is a methodological contribution

[1] Each of different demographic groups, namely gender, disability and race, may have own unique factors which may contribute to widen their unemployment gaps. For example, gender unemployment gap could be derived from allocation of household production or the preferent, not labour market discrimination. Regarding the disability unemployment gap or the difference in the unemployment rate between people with disabilities and people without disabilities could be derived from the lack of appropriate labour market intervention to promote the employment for people with disabilities. With regard to the race unemployment gap could be derived mainly from the labour market discrimination.

with the Fourier ADF and KPSS unit root tests with break, and, on the other hand, an empirical contribution with the study of the gender unemployment gap in the African context.

2. Literature Review

There have been numerous research papers which have examined the difference in unemployment between men and women since the middle of the 1980s. The pioneering research on the gender unemployment gap was conducted by Nilsen (1984). He examined the impact of recessions on the different unemployment rates between men and women in the United States. He claimed that this recession had a stronger job-destruction impact on residents in rural areas, than those in urban areas. In particular, the 1981-1982 recession had particularly severe job destruction effects on men who were employed in rural areas. Furthermore, Shettle (1997) examined whether gender differences in doctoral degree holders would have any impact on their employment status in the United States. Among the science and engineering doctoral degree holders in the United States, the men's unemployment rate was 1.6 percent and women's unemployment rate was 1.3 percent in 1993. Thus, the researcher concluded that gender differences would not have an impact on the unemployment rates among doctoral degree holders. Thiessen and Nickerson (1999) examined the gender unemployment gap in Canada. They claimed that there were three distinctive phases in the history of the gender unemployment gap. In the first phase from 1953 to 1965, women's unemployment rates were lower than men's unemployment rates. On the other hand, Bruegel (2000) claims that there is an ongoing process of the substitution of men in the workplace for cheaper, more flexible and less skilled women in the United Kingdom. Alongside this feminisation of the labour market, there is a drastic decline of females in the manufacturing sector in the country. According to Lauerova and Terrell, (2007), there were different trajectories of patterns in the gender unemployment gap in two member countries of the European Union (EU), namely Hungary and Poland. In the case of Hungary, men's unemployment rates were consistently higher than women's unemployment rates in the 1990s.

INSERT TABLE 1 ABOUT HERE

Despite these pioneering contributions, these previous studies on the gender unemployment gap are descriptive. Since the late 2000s, there have been several empirical research which employed some advanced statistical methods to examine the gender unemployment gap and its convergence. Especially, the unit root test and the "reverse" unit root test or the stationarity test have become the popular method to examine the gender unemployment gap. This is because the rejection of the null hypothesis of unit root in the unemployment gap could be interpreted as consistent empirical evidence for convergence (Narayan, 2007). The summary of the major empirical findings on this topic is reported in Table 1. For example, Queneau and Sen (2008) employed the ADF test to examine the pattern of men's and women's unemployment rates in eight OECD countries between 1965 and 2003. They concluded that there is no major difference in the pattern of unemployment for men and women in these countries. Queneau and Sen (2009) analysed the persistence or convergence of the gender unemployment gap in eight OECD countries for the period of 1965-2003 by using the ADF test with a structural break. The ADF test with structural break failed to reject the null hypothesis of no convergence for all countries, except Finland and Italy. Bicakova (2010) used *t*-tests to examine whether there were significant differences between the male unemployment rate and female unemployment for the period of 1996-2007 in the eight new member countries in the European Union (EU). The author claimed that there were significant differences in the unemployment gap in five countries, namely the Czech Republic, Hungary, Slovakia, Slovenia and Poland. Sahin et al. (2010) examined the impact of the 2008 economic recession on the gender unemployment gap in the United States. They claimed that unemployment rates for men and women were around five percent before the economic crisis. However, the economic recession had a stronger negative impact on the employment status of men than on that of women.

In the middle of the 2010s, several researchers used alternative methods, such as the panel unit root tests or the Shorrocks index and fractional integration tests, to examine the gender unemployment gap (Bakas and Papapetrou, 2014; Bazen et al., 2014; Baussola et al., 2015; Koutentakis, 2015; Albanesi and Sahin, 2018). For example, Bakas and Papapetrou (2014) applied the panel unit root methods to examine the convergence of the gender unemployment gap in 15 countries in the European Union for the period of 1977-2009. The panel LM unit root test enabled the rejection of the null hypothesis of no convergence. However, the panel LM unit root test with a structural break and cross-sectional dependency failed to reject the null hypothesis. Bazen et al. (2014) used the Shorrocks index to examine the convergence of the gender unemployment gap in France for the period of 2003-2008. They concluded that there was no convergence in the country's gender unemployment gap. Baussola et al. (2015) examined the determinants of the gender unemployment gap in Italy and the United Kingdom for the period 2004-2013. In Italy, male workers with tertiary education may have had a higher possibility of losing their employment in both the pre-recession period of 2004-2008 and the recession period of 2009-2013. By contrast, in the UK, male workers with lower education and female workers with higher education may have had a higher likelihood of losing their employment in the pre-recession period of 2004-2008.

Further, Altuzarra (2015) used three different methods, namely the unit root test, the stationarity test and the fractional integration test, to examine the pattern of men's unemployment rate and women's unemployment rate in Spain for the period of 1976-2012. The researcher concluded that there is no major difference in the pattern of unemployment rate between men and women in Spain. Koutentakis (2015) examined the gender unemployment dynamics in nine countries in Europe and the United States. Among these ten developed countries, it is only Norway where the job separation rates among women are lower than men. Among these ten countries, Norway could be considered as the outlier where women have a lower likelihood of being unemployed because they have a higher job-finding rate and a lower job separation rate. Bicakova (2016) analysed the determinants of the gender unemployment gap in the European Union. She claims that there are three main determinants of the gender unemployment gap, namely the family leave system, flexible working conditions and training programs to help women obtain work. Albanesi and Sahin (2018) examined the gender unemployment gap in 12 countries in the OECD countries for the period of 1975-2005. They claimed that women's unemployment rates were constantly higher than men's before the middle of the 1980s. However, the gender unemployment gap disappeared after the middle of the 1980s, except in the period of economic recession when there was a negative gender unemployment gap or the men's unemployment rate was higher than women's unemployment rates.

More recently, researchers started using newly developed methods, such as the unit root test with structural break, the fractional integration test, and the Fourier ADF test, to examine the gender unemployment gap (Cheratian et al., 2021; Cuestas and Gil-Alana, 2023; Yilanci et al., 2023). For example, Cheratian et al. (2021) employed several unit root tests, namely the ADF test, the DF-GLS test, the Ng-Perron test, and the LM unit root test with the structural break, to examine the men’s and women’s unemployment in Iran between 2001 and 2020. They claimed that there is no difference in the pattern of unemployment rate between men and women in Iran. Cuestas and Gil-Alana (2023) employed the fractional integration test to examine the pattern of men's and women's unemployment in 22 EU countries between 2003 and 2019. They asserted that there are seven countries which have a mean-reversion tendency among men's unemployment rate with lower education levels. On the other hand, there are six countries which have a mean-reversion tendency among women’s unemployment rate with the same level of education. Among the higher education level, there are eleven countries which have a mean-reversion tendency among men’s unemployment rates. Yilanci et al. (2023) employed four different types of unit root tests, namely the ADF test, the Fourier ADF test, the KSS test and the Fourier KSS test, to examine the pattern of men’s and women’s unemployment rates in five countries in the Nordic region between 1983 and 2020. Despite these minor differences, these findings indicated that there is no major difference in the pattern of men's and women's unemployment rates in these Nordic countries. Furuoka (2024) employed the autoregressive neural network (ARNN) unit root test to examine the convergence of gender unemployment rates in the United States between

2008 and 2022. He claimed that there are no major differences in the pattern of unemployment rate between men and women. The findings from the ARNN test indicated that the difference between men's and women's unemployment rates would converge to zero in the United States.

3. Data and Methods

Male and female unemployment rates analysed in this study are annual time series that represent the proportion of unemployed males and females in the total labour force. The data are obtained from the World Bank Development Indicator at https://data.worldbank.org/indicator/SL.UEM.TOTL.ZS. A total of forty-nine (49) African countries were chosen, with each series covering the time from 1991 to 2022. As Table 1 indicates, there is no systematic research on the gender unemployment gap in the previous studies. To fill this important research gap, the current study uses some advanced statistical methods to examine the gender unemployment gap in Africa.

Plots of unemployment rates for six (6) sampled countries in African zones, namely Algeria, Central Africa Republic, Nigeria, Libya, Mauritius and Zimbabwe, are given in Figure 1. These six African countries were selected because gender unemployment gaps in these countries have unique patterns and demonstrate some differences in the possible path for convergence. Among them, in the case of the Central African Republic, Libya and Mauritius, there is a consistent negative gender unemployment gap which does not seem to be narrowed over the period. Interestingly, in the case of Algeria, Nigeria and Zimbabwe, the unemployment gap between male and female unemployment rates fluctuates around zero. It means that there is a higher possibility for convergence.

INSERT FIGURE 1 ABOUT HERE

Further, by way of data description, we provide in Table 1 a data summary of unemployment rates by gender. We report their 1991 and 2022 values to deduce if unemployment rates increase annually. Historic minimum and maximum values are also reported. It is observed that unemployment rates have increased for some countries, and these have shown decreases for some other countries. In terms of gender, there is no clear difference in the distributions.

Unemployment rates are notoriously problematic in low-income country contexts, given the presence of disguised unemployment (which would not be included in the numerator). In other words, careful consideration should be given to the relevance of the measurement of the unemployment gap between men and female.

INSERT TABLE 2 ABOUT HERE

Furuoka (2017) proposed the FADF-SB testing regression model,

$$\Delta y_t = \alpha + \beta t + \gamma_1 \sin\left(2\pi kt/N\right) + \gamma_2 \cos\left(2\pi kt/N\right) + \delta DU_t + \theta D\left(T_B\right)_t + \left(\rho - 1\right) y_{t-1} + \sum_{i=1}^{p} c_i \Delta y_{t-i} + \varepsilon_t \qquad (1)$$

where $\Delta = \left(1 - B\right)$, B is the backshift operator such that By_t = y_{t-1}, and $\pi = 3.1416$; α is the constant term; β and ρ are, respectively, the slope parameters for the trend term t and the lagged dependent variable y_t. Whenever $\rho = 1$, there is a unit root in the series. The parameters γ_1 and γ_2, rendered in the Fourier function as slope parameters make the model nonlinear instead of the linear ADF regression as in Dickey and Fuller (1979). The frequency number k further influences the degree of nonlinearity in the FADF model structure (see, Enders and Lee, 2012a, 2012b); N is the number of observations; T_B indicates the point of an observed structural break; δ and θ are, respectively, the slope parameters for the structural break dummy $\left(DU_t\right)$ and the one-time break dummy $\left(D\left(T_B\right)\right)$. We define $DU_t = 1$ if $t > T_B$ and $DU_t = 0$, otherwise; and $D\left(T_B\right)_t = 1$ whenever $t = T_B$ and $D\left(T_B\right)_t = 0$, otherwise. In the absence of structural break dummies in (1), the FADF-SB model reduces to the FADF model while in the absence of significant Fourier parameters γ_1 and γ_2, the FADF test further reduces to the classical ADF test. In the FADF-SB test, the insignificance of Fourier parameters leads to the ADF-SB regression model of Perron and Vogelsang (1992). Thus, unit roots are tested in the gender-disparity unemployment rates using the ADF, FADF, ADF-SB and FADF unit root tests. The t statistic for FADF-SB is then given as,

$$t = \frac{\rho - 1}{se(\rho)}, \tag{2}$$

where $se(\rho)$ is the standard error of ρ.

Recall, the ADF-like unit root tests discriminate between a unit root, i.e., $I(1)$, in a time series versus no unit roots, i.e., $I(0)$. In the case of rejection of the unit root, it is necessary to further involve a test that separates. $I(0)$ series from stationary mean reverting series, i.e., $I(< d < 0.5)$. This test is the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test of Kwiatkowski et al. (1992). The test has the null hypothesis of $I(0)$Series to be tested against the alternative of long memory and mean reverting series.

In the case of Fourier KPSS with a structural break (FKPSS-SB) of Furuoka (2017), the unit root test relies on the residual series e_t from the model,

$$y_t = \alpha + \beta t + \gamma_1 \sin\left(2\pi kt/N\right) + \gamma_2 \cos\left(2\pi kt/N\right) + \delta DU_t + \theta D\left(T_B\right)_t \quad + \left(\rho - 1\right) y_{t-1} + \sum_{i=1}^{p} c_i \Delta y_{t-i} + w_t . \tag{3}$$

The partial sum $\hat{S}_t = \sum_{t=1}^{T} \hat{w}_t$ of the residuals is then obtained. The long-run variance formula $\sigma_T^2\left(q\right)$ given by Lo (1991) is computed as $\sigma_T^2\left(q\right) = c_0 + \sum_{j=1}^{q} w_j\left(q\right) c_j$ with the conditions that c_j are the j^{th}–order sample autocovariance of y_t and $w_j\left(q\right)$ are the Bartlett window weights given by $w_j\left(q\right) = 1 - j/\left(q+1\right)$ for $q < T$. Then, the FKPSS-SB test is given as,

$$t_{FKPSS-SB} = T^{-2} \sum \hat{S}_t^2 / \hat{\sigma}_T^2\left(q\right). \tag{4}$$

Correspondingly, the FKPSS-SB regression model in (3) reduces to the FKPSS model whenever there is no significant structural break. Also, the FKPSS model becomes the KPSS model whenever the Fourier parameters are not significant. The FKPSS-SB model becomes the KPSS-SB model whenever the Fourier function is absent. Since these unit root tests have the same set-up of the null hypothesis versus the alternative hypothesis, there is the need to determine the best or fair test regression model which judge correctly the unit root decision. This also applies to the ADF-like unit root tests described earlier. In the section below, the F testing procedure for ADF-like and KPSS-like unit root tests is presented.

3.1 F testing procedure

Furuoka (2017) details an F-testing procedure for judging the performance of a unit root testing regression over its restricted variants. For instance, the ADF regression model is considered to be the restricted ADF-SB model when the series does not exhibit structural breaks. The ADF regression model becomes a restricted FADF model when the Fourier function parameters are not significant. In the FADF-SB model, the ADF regression represents a constrained FADF-SB model where there are no nonlinearity or structural breaks present. The FADF model is a constrained version of the FADF-SB model in the absence of a structural break in the series. Lastly, the ADF-SB model can be viewed as a restricted version of the FADF-SB model when there is no nonlinearity in the functional form of the model. These combinations of constrained and unconstrained models yield five pairs, which are evaluated using the F-test. These tests are $F_{(FADF,\ ADF)}$, $F_{(ADF-SB,\ ADF)}$, $F_{(FADF-SB,\ ADF)}$, $F_{(FADF-SB,\ FADF)}$ and $F_{(FADF-SB,\ ADF-SB)}$, and serve as robustness checks in judging the unit root decisions of each unrestricted model. In each case, the F test, according to Furuoka (2017) is set up as follows:

$$F = \frac{\left(SSR_0 - SSR_1\right)/k}{SSR_1/\left(T-m\right)}, \tag{5}$$

where SSR_0 and SSR_1 are the sum of squares residuals (SSR) from the restricted and unrestricted unit root testing models, respectively; k and m are the number of restrictions in the restricted model, and the number of regressors in the unrestricted model, respectively.

Similarly, in the case of KPSS-like unit root tests, the KPSS model is a restricted model to the KPSS-SB model when there are no structural breaks in the series. The KPSS is also seen as a restricted version of the FKPSS model when the Fourier function parameters are not significant. Also, for the

FKPSS-SB model, the model is restricted to the KPSS model when there is no nonlinearity or structural break present. The FKPSS-SB model also reduces to the FKPSS model in the absence of a structural break in the series. The FKPSS-SB model is also restricted to the KPSS-SB model when nonlinearity is not expected.

Critical values of the corresponding F test, as detailed in Furuoka (2017), are obtained as bootstrapped estimates.

4. Empirical findings

In the first stage of the empirical analysis, two standard tests, namely the ADF test and the KPSS test, are used to examine the convergence of gender unemployment gaps in Africa. As Table 3 indicates, the ADF test failed to reject the null hypothesis of no convergence for all 49 African countries, except Chad, Congo and Morocco. It means that the ADF test indicated that there is no convergence of the unemployment gap between males and females in Africa. These findings are confirmed by the KPSS test in Table 5. As Table 5 shows, the KPSS test rejects the null hypothesis of convergence for all 49 countries, except 11 countries namely Algeria, Angola, Chad, Congo, Ghana, Morocco, Malawi, Niger, South Sudan, Tanzania, and Uganda. It also means that the ADF test and the KPSS test offer some consistent findings to indicate the non-convergence in the gender unemployment gap in Africa. There are some minor discrepancies in the empirical findings between the ADF and the KPSS tests. The ADF test indicates the non-convergence for 9 countries, Algeria, Angola, Ghana, Morocco, Malawi, Niger, South Sudan, Tanzania, and Uganda. By contrast, the KPSS test shows convergence for these nine countries. Despite these minor discrepancies, the ADF test and the KPSS test offer some consistent findings indicating that there is no convergence in the gender unemployment gap in Africa.

INSERT TABLE 3 ABOUT HERE

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In the second stage of empirical analysis, two tests with Fourier approximation function, namely the FADF test and the FKPSS test, are employed for the analysis of gender unemployment convergence. The findings from the FADF test largely confirm those from the ADF test indicating there is no convergence in the gender unemployment gap in Africa. As Table 3 shows, the FADF test fails to reject the null hypothesis of no convergence for all 49 African countries, except Chad, Congo and Djibouti. By contrast, the FKPSS test fails to reject the null hypothesis of convergence for all 49 African countries, except 12 countries, namely Algeria, Benin, Burkina Faso, Cameroon, Comoros, Ghana, Kenya, Madagascar, Mali, Sudan and Senegal and Uganda. The FADF test also confirms that all these 12 countries' gender unemployment gaps are not convergent. In other words, as Table 3 shows, the FADF test indicates non-convergence and the FKPSS test in Table 5 indicates convergence in the gender unemployment gap in Africa. Despite large discrepancies in the findings between the FADF and the FKPSS tests, both tests confirm that there is convergence of gender unemployment gap in three African countries, namely Chad, Congo and Djibouti.

INSERT TABLE 5 ABOUT HERE

In the third stage of the empirical analysis, two tests which could incorporate structural breaks, namely the ADF-SB test and the KPSS-SB test, are used to examine gender unemployment convergence in Africa. As Table 3 shows, the ADF-SB test largely confirms the findings from the FKPSS test that there is convergence in the gender unemployment gap. The ADF-SB test rejects the null hypothesis of no convergence for all 49 countries, except 18 countries, namely Burundi, Benin, Burkina Faso, Central African Republic, Cameroon, Democratic Republic of Congo, Comoros, Eritrea, Gabon, Ghana, Guinea, Equatorial Guinea, Liberia, Libya, Lesotho, Mozambique, Sierra Leone and Zimbabwe. In other words, the ADF-SB test indicates that there is convergence of the gender unemployment gap in 31 countries. Among the 31 countries with gender unemployment convergence, the KPSS-SB test confirmed that the gender unemployment gap is convergent in only eight countries. On the other hand, as Table 5 indicates, the KPSS-SB test confirms the findings from the KPSS test that there is no convergence in the gender unemployment gap in Africa. The KPSS-SB test rejects the null hypothesis of convergence in all 49 countries, except 13 countries, namely Angola, Chad, Democratic Republic of Congo, Djibouti, Egypt, Gabon, Guinea-Bissau, Morocco, Mauritania, Rwanda, Sierra Leone, Uganda and Zambia. Among these 13 countries with gender unemployment convergence, the KPSS test also confirms that the gender unemployment gap is also convergent in eight countries.

In the fourth stage of empirical research, two advanced tests which were able to incorporate the Fourier approximation function and a structural break, namely the FADF-SB test and FKPSS-SB, were used to examine the gender unemployment gap in Africa. As Table 3 shows, the FADF-SB test basically confirms the findings from the ADF-SB test indicating there is convergence in the gender unemployment gap in Africa. The FADF-SB rejected the null hypothesis of no convergence for all 49 countries, except 11 countries namely Burkina Faso, Central African Republic, Cameroon, Democratic Republic of Congo, Comoros, Guinea, Mozambique, Malawi, Senegal, Sierra Leone and Zimbabwe. It means that the FADF-SB test indicates that the gender unemployment rate of a wide majority of countries, that is 38, would converge. Among these 38 countries, the FKPSS-SB test confirms gender unemployment convergence in 17 countries. On the other hand, as Table 5 indicates, the FKPSS-SB test was able to broadly confirm the findings from the FKPSS test that there is convergence in the gender unemployment gap in Africa. In other words, the FKPSS-SB test fails to reject the null hypothesis of convergence for all 49 countries, except 19 countries namely Angola, Burundi, Benin, Burkina Faso, Cameroon, Democratic Republic of Congo, Comoros, Ghana, Kenya, Libya, Madagascar, Mali, Malawi, Niger, Sao Tome and Principe, Eswatini, Togo, Tanzania and Uganda. Among these 19 countries with non-convergence for the gender unemployment gap, the FADF-SB test also confirms that 15 countries' gender unemployment gap would converge. It also means that the FADF-SB test and the FKPSS-SB test offer consistent findings that the gender unemployment gap is convergent in Africa.

As Table 7 of the summary table indicates, the findings from these four ADF-type tests, namely the ADF test, the FADF test, the ADF-SB test and the FADF-SB test, and these four KPSS-type tests, namely the KPSS test, the FKPSS test, the KPSS-SB test and the FKPSS-SB test, could be summarised into four interesting facts regarding the convergence of gender unemployment gaps in Africa.[2] Firstly, two standard tests with fully restricted specifications, namely the ADF test and the KPSS test, failed to offer some consistent empirical evidence for the convergence. Secondly, two advanced tests with the most general specification which could take account of nonlinearity and structural breaks, that is, the FADF-SB test and the FKPSS-SB test, could offer some consistent evidence for the convergence. Thirdly, two partially restricted tests that only take account of nonlinearity, namely the FADF test and the FKPSS test, offer some contradictory findings. The FADF test shows that the gender unemployment gap failed to offer consistent evidence for the convergence, while the FKPSS test shows that the gap would offer consistent findings for the convergence. Fourthly, the other two partially restricted tests that only take account of structural breaks, namely the ADF-SB and the KPSS-SB tests also failed to offer consistent findings. The ADF-SB test offer some consistent evidence for the convergence, while the KPSS-SB test failed to offer consistent evidence.

As described earlier in Section 3.1, an F-testing procedure is employed in the final stage of the empirical analysis to determine whether the restricted model or the unrestricted model gives better results. Based on the critical values detailed in Furuoka (2017), the *F*-test results in Table 4 indicate rejection of the null hypothesis of no nonlinearity in the ADF-type test for only eight countries. By contrast, the *F*-test was able to reject the null hypothesis of no structural break in the ADF-type test for 33 countries. Similarly, the *F*-test was able to reject the null hypothesis of neither nonlinearity nor

[2] As Table 7 indicates, there are some discrepancies using the different methods. The discrepancies in the findings could be derived from the differences in specifications of each different tests. Firstly, two most restricted tests, namely the ADF test and the KPSS test, could not take account of structural break and nonlinearity in the unemployment time-series. Secondly, the partially restricted tests, namely the FADF test and the FKPSS test, could take account of nonlinearity, but not structural break, in the time series data. Thirdly, other partially restricted tests, namely the ADF-SB test and the KPSS-SB test, could take account of structural break, but not nonlinearity. Fourthly, two most general test, the FADF-SB test and the FKPSS-SB test, could take account of structural break and nonlinearity. These unique differences in the methodological advantage and disadvantage may cause some difference in the empirical findings.

structural break in the ADF-type test for 38 countries. The *F*-test allowed us to reject the null hypothesis of no nonlinearity in the ADF-type test with a structural break for 34 countries. Similarly, the *F*-test was able to reject the null hypothesis of no structural break in the ADF-type test with a Fourier approximation function for 33 countries.

There are four steps to select the best specifications. This "Four-step" procedure would loosely follow a "general-to-specific method" (see Hendry, 2024). By considering the most general model or the FADF-SB test first, and using the *F*-test to examine the relevance of restriction, first, the most general model or the FADF-SB test could be considered as the best model if all three *F*-tests which incorporate the FADF-SB test as an unrestricted model, namely $F_{3\,(FADF-SB\ vs\ ADF)}$, $F_{4\,(FADF-SB\ vs\ FADF)}$ and $F_{5\,(FADF-SB\ vs\ ADF-SB)}$ were able to reject the null hypothesis that the restricted model is better. Second, the most specific model or the ADF test could be considered as the best model if all three *F*-tests which incorporate the ADF test as a restricted model, namely $F_{1\,(FADF\ vs\ ADF)}$, $F_{2\,(ADF-SB\ vs\ ADF)}$ and $F_{3\,(FADF-SB\ vs\ ADF)}$ failed to reject the null hypothesis. Third, the best model could not be determined if $F_{3\,(FADF-SB\ vs\ ADF)}$ was able to reject the null hypothesis, however both $F_{4\,(FADF-SB\ vs\ FADF)}$ and $F_{5\,(FADF-SB\ vs\ ADF-SB)}$ would fail to reject the null hypothesis. This is because there is no direct test for preference of restriction between the FADF test or the ADF-SB test even if these specifications were better than the FADF-SB test. Fourth, the best specification could be determined by combining systematic findings from several *F*-tests if the first three steps of the "Four-step procedure" failed to determine the best specification.

These four scenarios of F testing results (for ADF-type test results in Table 4 and the KPSS-type test results in Table 6) were used to identify the best model for unit root decisions in unemployment disparities. Furthermore, the summary findings from the ADF-type tests are reported in Table 7 and the best model specifications for the ADF-type tests and their findings are reported and Table 8. As Table 8 indicates, the findings from the *F*-test show that the ADF test could be considered the best specification of the four alternative models for seven countries. Similarly, the ADF-SB test could be considered the best specification model for seven countries. By contrast, the FADF test could be considered the best specification model for the two countries. It means that the most general model specification or the FADF-SB test could be considered as the best model specification in the majority of the countries (i.e., 27 countries). Using the findings from the best specification model of the four alternative models, the ADF-type unit root test was able to reject the null hypothesis of no convergence in the gender unemployment gap for 28 countries. In other words, the empirical findings from the ADF-type test indicated that there is convergence in the gender unemployment gap in Africa.

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On the other hand, as Table 6 also indicates, the *F*-test was able to reject the null hypothesis of no nonlinearity in the KPSS-type test for 40 countries. By contrast, the *F*-test was able to reject the null hypothesis of no structural break in the KPSS-type test for 35 countries. Interestingly, the *F*-test was able to reject the null hypothesis of neither nonlinearity nor a structural break in the KPSS-type test for all 49 countries. Similarly, the *F*-test was also able to reject the null hypothesis of no nonlinearity in the KPSS-type test with a structural break for all 49 countries. As Table 6 indicates, the *F*-test was able to reject the null hypothesis of no structural break in the KPSS-type test with a Fourier approximation function for 46 countries. Furthermore, the summary findings from the KPSS-type tests are reported in Table 7 and the best model specifications for the KPSS-type tests and their findings are reported and Table 8. The most general model specification or the FKPSS-SB test could be considered as the best model specification of the four alternatives in the KPSS-type tests in a wide majority, specifically 46 countries. In the remaining three countries, the KPSS-SB test is the best model specification. Using the findings from the best specification model among the four alternative models, the KPSS-type of stationarity test failed to reject to null hypothesis of convergence in the gender unemployment gap for 31 countries. In other words, the empirical findings from the KPSS-type test indicate that there is convergence in the gender unemployment gap in Africa.

5. Conclusions

The current study uses four versions of ADF-type unit root tests namely the ADF test, the Fourier ADF test, the ADF with structural break (ADF-SB) test, and the Fourier ADF with a structural break (FADF-SB) test, and four corresponding versions for the KPSS-type stationarity tests against long memory mean reversions in time series, namely the KPSS test, the Fourier KPSS (FKPSS) test, the KPSS with structural break (KPSS-SB) test, and the Fourier KPSS with a structural break (FKPSS-SB) test, to examine whether the gender unemployment gap is likely to converge in 49 countries in Africa. The empirical findings could be summarised in three interesting aspects of the gender unemployment gap in the African continent. First, the most restricted version of the ADF-type test or the ADF test failed to reject the null hypothesis of a unit root in the gender unemployment gap, implying no convergence in the gender unemployment gap. The most restricted version of the KPSS-type test, that is the KPSS test rejected the null of stationary I(0) series of the gender unemployment gap against long memory/mean reversion in the unemployment gap. Thus, this test further confirmed that there is no convergence in the gender unemployment gap. In other words, the most restricted version of the tests tended to indicate non-convergence of difference between men's and women's unemployment rates in Africa.

Second, the most general version of the ADF-type test or the FADF-SB test was able to reject the null hypothesis of the unit root in the gender unemployment gap. Similarly, the most general version of the KPSS-type test or the FKPSS-SB test was also able to reject their null hypotheses, with both ADF-type tests and KPSS-type tests, implying convergence in the gender unemployment gap in Africa. In other words, the most general tests tend to indicate the convergence of differences between the male and female unemployment gap.

Third, the findings from the most restricted tests and the most general tests failed to offer consistent findings on the gender unemployment gap. To overcome these discrepancies in the empirical findings, an *F*-test was set up to determine which one was the best test among four different versions of tests. The best model specification among the four different ADF-type tests was able to reject the null hypothesis of no convergence in the gender unemployment gap. The best model specification of the four different KPSS-type tests was also able to reject its null hypothesis for convergence in the unemployment gap. In other words, the findings from the best model specification of both the ADF-type tests and the KPSS-type tests offer consistent findings to indicate the convergence of the gender unemployment gap. Therefore, the current study may conclude that empirical findings offer additional empirical evidence to validate the "Law of one unemployment rate".

As Table 1 indicated, there is no previous research which examined the gender unemployment gap in the context of African countries. In other words, the current study is the first to select 49 countries in Africa to examine whether the unemployment gap between men and women would converge to zero. Despite geographic differences, previous studies tend to conclude that there is no convergence, except for Furuoka (2024). The discrepancies in the empirical findings could be derived from the methodological difference. Previous research does not seem to incorporate systematic structural breaks and nonlinearity. By contrast, the current study employed a new unit root test and the stationarity test which could take account of the structural break and nonlinearity in the time-series data on the unemployment rate.

Based on the findings in Table 8, over the time period tested there was convergence according to the best specification ADF-type test in 28 countries in Africa. Furthermore, according to the best specification KPSS-type test, there was convergence in 31 countries in the continent. Based on this, we can expect further convergence if the governments in these countries would continue taking approach measures to ensure gender equality in the labour market. By contrast, according to the ADF-type test, there is no convergence in 15 countries. Furthermore, according to the KPSS-type test, there is no convergence in 18 countries. Based on this, we can expect a stronger convergence if the governments in these countries make serious efforts to reduce gender inequality in the labour market.

Also, the current study may suggest that policymakers in Africa may need to be aware of this interesting pattern of the gender unemployment gap. Empirical findings may suggest that the difference between men's and women’s unemployment rates is unlikely to exacerbate over the tested time without any policy intervention in the labour market. This also signals to women that their participation in the labour market is being felt, even though the employment of females in African countries is conditioned on social, economic, cultural, and political criteria. Both women and men should work together and continue in their efforts to achieve gender equality in the labour market. In this context, some African countries could learn from the best practices in other countries to enhance women’s labour force participation. For example, South Africa appointed a Minister of Women, Youth and Persons with a disability who is dedicated to ensuring gender equality in the labour market (Wakibi, & Oleche, 2024).

There are two main limitations of the study. The first limitation is the external relevance of the current study. In the analytical process of the convergence hypothesis, the stationary process of the unemployment gap could be seen as consistent evidence for the convergence of the unemployment gap (Narayan, 2007). This proposition could be relevant for the empirical analysis of the convergence hypothesis. However, this proposition could be irrelevant if the convergence could be tested by alternative methods, such as the cointegration test. The second limitation is the measurement problem of unemployment rates. As mentioned in the “methodology” section of this paper, the unemployment rate in developing countries is not reliable and problematic in terms of measurement.

Future studies may use similar empirical methods to examine the gender unemployment gap in other regions and continents, such as the Middle East and North Africa (MENA), Asia, North America, or South America. These findings may offer a comprehensive understanding of gender differences in the pattern of unemployment rates around the world. Furthermore, researchers who are interested in the gender gap may consider using different measurements to assess gender equality in the labour market. In the current study, the difference in the unemployment rates between men and women is used to measure gender equality. In future empirical analysis, the labour force participant rate could be used as an alternative measurement.

More importantly, female labour force participation is largely determined by the allocation of domestic products within the family (Agovino et al. 2019). It means that the unemployment rate for women may fall if many women would leave the labour market by undertaking solely unpaid domestic productions. In other words, failure of appropriate allocation of domestic product apparently would contribute to and cause a positive outcome to reduce the gender unemployment gap. In this sense, future research may need to consider as female labour force participation as an important research agenda by conducting more nuanced research which could incorporate domestic production in this framework.

References

Abney, F. and Lava, G. (2018). Narrowing the gender gap: Implications for economies in transition. Journal of Economic Growth, 23(3), 295-322.

Agovino, M., Garofalo, A., & Cerciello, M. (2019). Do local institutions affect labour market participation? The Italian case. The BE Journal of Economic Analysis & Policy, 19(2), 20180077.

Aguirre, D., Hoteit, L., Rupp, C. and Sabbagh, K. (2012). Empowering the female workforce: The economic impact. Journal of Economic Perspectives, 26(1), 113-132.

Albanesi, S. and Sahin, A. (2018). The gender unemployment gap, Review of Economic Dynamics, 30, 47-67.

Altuzarra, A. (2015). Measuring Unemployment Persistence by Age and Gender. Romanian Journal of Economic Forecasting, 18(4), 110-133.

Awolaja, O. G., Yaya, O. S., Vo, X. V., Ogbonna, A. E. and Joseph, S. O. (2021). Unemployment Hysteresis in Middle East and North Africa Countries: Panel SUR-based Unit root test with a Fourier function. Middle East Development Journal, 13 (2), 318-334.

Bakas, D. and Papapetrou, E. (2014). Unemployment by gender: Evidence from EU countries. International Advances in Economic Research, 20, 103-111.

Bazen, S., Joutard, X. and Niang, M. M. (2014). The measurement of unemployment using completed durations: evidence on the gender gap in unemployment in France. Journal of Economic Inequality, 12, 517-534.

Baussola, M., Mussida, C., Jenkins, J., and Penfold, M. (2015). Determinants of the gender unemployment gap in Italy and the United Kingdom: A comparative investigation. International Labour Review, 154(4), 537-562.

Bicakova, A. (2010). Gender unemployment gaps: Evidence from the new EU member states. CERGE-EI Working Paper Series, 20(2), 41-97.

Bicakova, A. (2016). Gender unemployment gaps in the EU: blame the family. IZA Journal of European Labor Studies, 5, 1-31.

Bruegel, I. (2000). No more jobs for the boys? Gender and class in the restructuring of the British economy. Capital & Class, 24(2), 79-102.

Cheratian, I., Goltabar, S., and Gil-Alana, L. A. (2021). The dynamics of unemployment by territory, gender, and age groups in Iran. SN Business & Economics, 3, https://doi.org/10.1007/s43546-023-00424-5.

Cuestas, J. C., and Gil-Alana, L. (2023). Unemployment hysteresis by sex and education attainment in the EU. Journal of the Knowledge Economy, 1-27.

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, 366, 427-431.

Enders, W. and J. Lee (2012a), A Unit Root Test Using a Fourier Series to Approximate Smooth Break, Oxford Bulletin of Economics and Statistics 74, 4, 574-599.

Enders, W. and J. Lee (2012b), The flexible Fourier form and Dickey-Fuller-type unit root tests. Economic Letters, 117: 196-199.

Furuoka, F. (2017). A new approach to testing unemployment hysteresis. Empirical Economics, 53(3): 1253-1280.

Furuoka, F. (2024). *Disability and Employment: Towards a Humanistic Economy*, Singapore: Springer.

Hendry, D. F. (2024). A Brief History of General-to-Specific Modelling. Oxford Bulletin of Economics and Statistics, 86(1), 1-20.

Hill, M. A. and King, E. M. (1995). Women's education and economic well-being. Feminist Economics, 1(2), 21-46.

Kazandjian, R., Kolovich, L., Kochhar, K. and Newiak, M. (2016). Gender inequality and economic diversification. International Monetary Fund Working Paper, 2016/210, 1-24.

Klasen, S. and Lamanna, F. (2019). The impact of gender inequality in education and employment on economic growth. World Development, 47, 339-349.

Koutentakis, F. (2015). Gender Unemployment Dynamics: Evidence from Ten Advanced Economies. Labour, 29(1), 15-31.

Kwiatkowski, D., Phillips, P. C. B., Schmidt, P. and Shin, Y. (1992). Testing the null hypothesis of stationarity against the alternative of a unit root. Journal of Econometrics, vol. 54, pp. 159-178.

Lauerova, J. S., and Terrell, K. (2007). What drives gender differences in unemployment? Comparative Economic Studies, 49, 128-155.

Lemmon, G. T., and Vogelstein, R. (2017). Advancing women's economic participation. Foreign Affairs, 96(1), 160-169.

Lo, A.W. (1991), Long-Term Memory in Stock Market Prices, Econometrica 59, 5, 1279-1313.

Narayan, P. K. (2007). Testing convergence of Fiji’s tourism markets. Pacific Economic Review, 12(5), 651-663.

Nilsen, S. R. (1984). Recessionary impacts on the unemployment of men and women. Monthly Labour Review, 107, 21-23.

Perron, P. and T.J. Vogelsang (1992). The flexible Fourier form and Dickey-Fuller-type unit root tests. Economic Letters, 117: 196-199.

Queneau, H. and Sen, A. (2008). Evidence on the dynamics of unemployment by gender. Applied Economics, 40(16), 2099-2108.

Queneau, H., and Sen, A. (2009). On the persistence of the gender unemployment gap: evidence from eight OECD countries. Applied Economics Letters, 17(2), 141-145.

Shettle, C. (1997). Who is Unemployed? Factors Affecting Unemployment Among Individuals with Doctoral Degrees in Science and Engineering. National Science Foundation, SRS Special Report, NSF 97-336.

Sahin, A., Song, J., and Hobijn, B. (2010). The unemployment gender gap during the 2007 recession. Current Issues in Economics and Finance, 16(2), 1-7.

Thevenon, O., Ali, N. A., Adema, W. and Salvi del Pero, A. (2018). Female labour force participation and economic growth: Evidence from developed countries. Labour Economics, 25, 24-34.

Thiessen, V., and Nickerson, C. (1999). Canadian gender trends in education and work. Applied Research Branch, Human Resources Development Canada. Applied Research Branch Paper No. T-00-4E.

United Nations Children's Fund (UNICEF). (1999). The impact of mothers' employment on family dynamics. UNICEF Social Policy Report, 12(4), 3-24.

United Nations Development Programme (UNDP). (2021). Economic costs of gender gaps in Africa. UNDP Africa Human Development Report, 2021(1), 99-120.

United Nations. (2018). Bridging gender disparities in developing nations. Report on Sustainable Development Goals.

Wakibi, S., & Oleche, M. (2024). A Study on Women in the Labour Force in Kenya. Women's Economic Empowerment Hub (WEE-Hub), University of Nairobi. ISBN: 978-9914-42-977-0.

World Bank. (2011). Gender disparities in African labour markets. World Bank Policy Research Report, 2011(2), 45-68.

Yaya, O. S., Ogbonna, A. E. and Mudida, R. (2019). Hysteresis of Unemployment rate in Africa: New Findings from Fourier ADF test. Quality and Quantity International Journal of Methodology, 53(6): 2781-2795.

Yilanci, V., Kırca, M., Canbay, Ş., and Sağlam, M. S. (2023). Unraveling unemployment hysteresis in Nordic countries: a multifaceted analysis of age, gender and frequency differentials. International Journal of Manpower. Doi: 10.1108/IJM-03-2023-0147

Table 1: Summary of empirical findings on the gender unemployment gap

Name (year)	Country	Data	Source of data	Methods	Findings
Queneau and Sen (2008)	8 OECD countries (Australia, Canada, Finland, France, Germany, Italy, Japan and United States)	Annual data 1965-2002	OECD Quarterly Labour Force Statistics	ADF test	No difference: Unit root process, except Finland and Germany (Men) and Finland (Female)
Queneau and Sen (2009)	8 OECD countries (Australia, Canada, Finland, France, Germany, Italy, Japan and United States)	Annual data 1965-2002	OECD Quarterly Labour Force Statistics	ADF test with structural break	No convergence, except Finland and Italy
Bicakova (2010)	8 EU countries (Czech, Hungary, Slovakia, Poland, Estonia, Latvia and Lithuania, Slovenia)	Annual data 1996-2007	EU Labor Force Survey Dataset	*t*-test	Significant differences, except Estonia, Latvia, Lithuania
Bazen et al. (2014)	France	Annual data 2003-2008	French Labour Force Survey	Shorrocks index	No convergence
Bakas and Papapetrou (2014)	15 EU countries (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, UK).	Annual data 1977-2009	Annual Labor Force Statistics database, OECD	Panel unit root test	No convergence
Altuzarra (2015)	Spain	Quarterly data 1976Q1-2012Q4	Economically Active Population Survey, Spain	Unit root test, stationarity test, fractional integration test	No difference
Cheratian et al. (2021)	Iran	Quarterly data 2001Q2-2020Q1	Labour Force Survey, Iran	Unit root test	No difference
Cuestas and Gil-Alana (2023)	22 EU countries (Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden)	Quarterly data 2003Q2-2019Q4	Eurostat	Fractional integration test	No difference
Yilanci et al. (2023)	5 countries in Nordic region (Denmark, Finland, Iceland, Norway, Sweden)	Monthly data 1983M1-2020M5	Eurostat	Unit root tests	No difference
Furuoka (2024)	USA	Monthly data 2008M6-2022M6	US Bureau for Labour Statistics	Neural network unit root test	Convergence

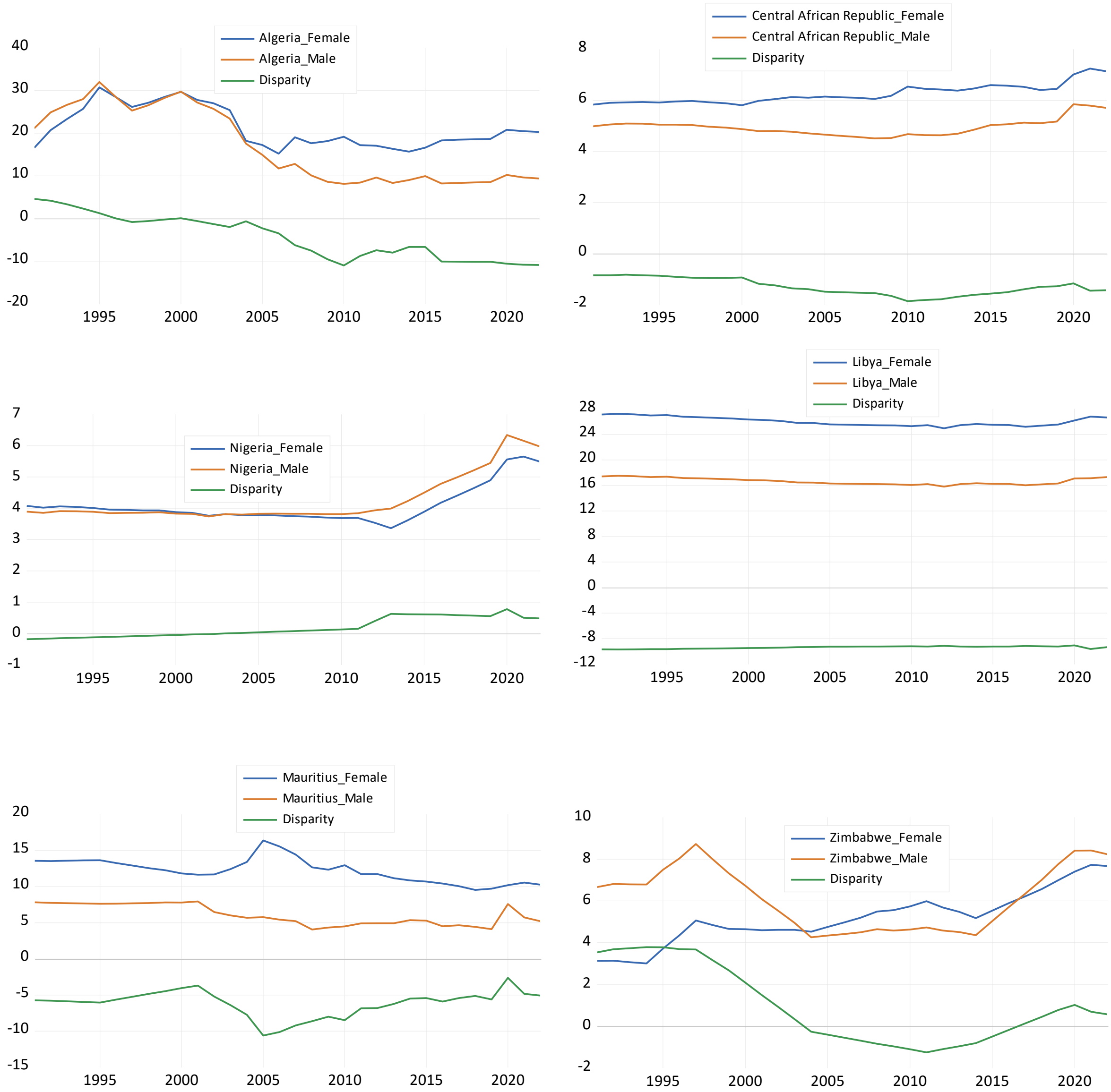

Figure 1: Plots of Male and Female Unemployment rates in Africa

Table 2: Data summary

Countries	Male				Female				Gap	Gap
	1991	**2022**	**Min.**	**Max.**	**1991**	**2022**	**Min.**	**Max.**	**1991**	**2002**
Algeria	21.16	9.39	8.14	32.00	16.58	20.30	15.22	30.75	4.58	-10.91
Angola	5.15	10.46	4.71	10.80	3.83	9.96	2.85	10.90	1.32	0.5
Burundi	3.03	1.03	0.89	4.07	2.24	1.02	0.86	2.40	0.79	0.01
Benin	2.11	1.39	0.91	2.43	0.58	1.97	0.43	2.88	1.53	-0.58
Burkina Faso	2.39	5.18	2.30	5.24	2.72	5.17	2.58	5.23	-0.33	0.01
Botswana	11.54	18.82	11.54	21.56	16.97	22.76	16.97	26.50	-5.43	-3.94
C.A.R	4.99	5.71	4.51	5.85	5.84	7.15	5.81	7.25	-0.85	-1.44
Cameroon	8.82	3.48	2.65	9.49	6.40	4.58	3.50	6.70	2.42	-1.1
Chad	0.98	1.67	0.98	1.98	0.29	1.04	0.28	1.16	0.69	0.63
Congo, DR	3.49	5.64	3.46	5.90	2.60	4.30	2.20	4.41	0.89	1.34
Congo	19.11	20.43	18.53	21.41	21.56	23.17	21.07	23.64	-2.45	-2.74
Comoros	4.97	7.37	4.35	7.72	5.64	11.20	4.88	11.36	-0.67	-3.83
Djibouti	27.75	23.78	22.11	27.75	38.16	37.88	35.86	38.20	-10.41	-14.1
Egypt	5.72	4.99	4.74	9.78	21.01	15.93	15.93	26.40	-15.29	-10.94
Eritrea	4.92	5.93	4.83	6.70	5.77	7.40	5.77	7.94	-0.85	-1.47
Ethiopia	2.99	2.91	1.66	3.13	3.32	5.28	2.95	5.28	-0.33	-2.37
Gabon	18.87	16.19	12.90	19.08	16.13	29.41	15.99	29.70	2.74	-13.22
Ghana	3.46	3.70	1.98	10.19	3.52	4.05	2.38	10.76	-0.06	-0.35
Guinea	5.33	5.69	4.94	5.99	3.80	5.84	3.51	5.91	1.53	-0.15
Guinea-Bissau	3.02	3.96	3.02	4.08	2.88	3.13	2.70	3.22	0.14	0.83
Equatorial Guinea	6.98	7.92	6.98	8.70	7.98	9.74	7.98	10.15	-1	-1.82
Kenya	3.01	5.21	2.58	5.45	3.56	5.80	2.95	5.94	-0.55	-0.59
Liberia	2.24	4.25	2.02	4.60	2.49	2.96	1.79	3.02	-0.25	1.29
Libya	17.43	17.32	15.83	17.52	27.14	26.67	24.98	27.25	-9.71	-9.35
Lesotho	15.55	16.09	15.07	16.71	18.64	20.38	18.64	20.64	-3.09	-4.29
Morocco	12.57	9.92	8.45	14.15	13.23	12.35	9.29	13.50	-0.66	-2.43
Madagascar	4.96	2.08	0.57	5.73	5.31	2.21	0.63	6.25	-0.35	-0.13
Mali	1.15	2.74	1.15	3.52	1.30	2.80	1.27	3.54	-0.15	-0.06
Mozambique	3.97	3.56	3.16	4.13	1.73	4.23	1.54	4.25	2.24	-0.67
Mauritania	9.28	10.44	8.56	10.61	12.51	12.44	11.54	12.62	-3.23	-2
Mauritius	7.85	5.21	4.07	7.96	13.58	10.29	9.55	16.39	-5.73	-5.08
Malawi	4.05	4.71	4.00	4.90	5.50	6.56	5.48	6.61	-1.45	-1.85
Namibia	19.59	21.98	14.68	23.24	18.61	19.70	18.60	25.88	0.98	2.28
Niger	1.67	0.64	0.40	3.40	1.09	0.39	0.22	3.19	0.58	0.25
Nigeria	3.89	5.97	3.74	6.34	4.08	5.49	3.37	5.65	-0.19	0.48
Rwanda	11.34	11.90	11.11	12.13	12.87	14.31	12.60	14.69	-1.53	-2.41
Sudan	14.37	13.73	8.96	14.50	19.95	30.17	19.53	30.45	-5.58	-16.44
Senegal	4.74	3.28	2.74	8.24	7.43	3.68	3.04	13.95	-2.69	-0.4
Sierra Leone	4.27	4.63	4.15	5.52	2.66	2.57	2.13	3.84	1.61	2.06
Somalia	17.83	17.37	16.31	17.97	23.40	25.89	23.40	25.89	-5.57	-8.52
South Sudan	11.08	11.85	11.03	12.82	12.99	14.04	12.99	14.63	-1.91	-2.19
Sao tome/Principe	12.93	11.69	9.97	12.93	17.71	21.91	17.71	26.54	-4.78	-10.22
Eswatini	20.70	22.67	19.83	25.52	23.46	26.31	23.20	31.27	-2.76	-3.64
Togo	3.73	4.92	2.29	5.04	3.91	3.16	1.64	4.20	-0.18	1.76
Tunisia	15.16	13.01	10.88	15.49	17.77	23.59	15.13	27.34	-2.61	-10.58
Tanzania	2.84	1.99	1.57	3.03	4.36	3.57	2.69	4.46	-1.52	-1.58
Uganda	2.64	3.71	1.39	4.05	4.10	4.86	2.11	4.99	-1.46	-1.15
Zambia	16.11	6.04	4.98	18.91	22.13	6.25	5.09	22.13	-6.02	-0.21
Zimbabwe	6.66	8.23	4.25	8.73	3.13	7.67	3.00	7.73	3.53	0.56

Table 3: ADF, ADF-SB, FADF and FADF-SB Unit root tests with lag length fixed to 1

Countries	ADF	FADF	ADF-SB	FADF-SB
Algeria	-2.622	-2.9489 [2]	**-4.1146 [2006, 0.50]**	**-4.4248 [2010, 0.63, 2]**
Angola	-2.899	-3.9091 [2]	**-10.3705 [2010, 0.63]**	**-9.5407 [2009, 0.59, 1]**
Burundi	-1.850	-3.8102 [1]	-2.9906 [1998, 0.25]	**-6.2538 [2006, 0.50, 1]**
Benin	0.193	-2.405 [1]	-1.6642 [2014, 0.75]	**-6.5269 [2010, 0.63, 1]**
Burkina Faso	-1.364	-1.1441 [1]	-2.4725 [1999, 0.28]	-3.1646 [2003, 0.41, 1]
Botswana	-2.276	-4.0690 [1]	**-4.0916 [2016, 0.81]**	**-8.5947 [2000, 0.31, 2]**
C.A.R	-1.001	-2.1740 [1]	-2.7498 [2014, 0.75]	-4.0059 [2020, 0.94, 1]
Cameroon	-1.602	-1.8721 [1]	-2.9790 [2001, 0.34]	-3.1247 [1995, 0.16, 1]
Chad	**-3.726**	**-5.5701 [1]**	**-9.1511 [2019, 0.91]**	**-10.9459 [2019, 0.91, 1]**
Congo, DR	-0.143	-2.8242 [1]	-3.6238 [2021, 0.97]	-3.6706 [2009, 0.59, 1]
Congo	**-4.092**	**-7.6563 [1]**	**-5.1658 [2000, 0.31]**	**-11.4793 [2019, 0.91, 1]**
Comoros	-2.274	-3.6749 [2]	-2.9584 [2007, 0.53]	-3.9024 [1994, 0.13, 2]
Djibouti	-2.859	**-4.5970 [1]**	**-9.4294 [2019, 0.91]**	**-9.2657 [2019, 0.91, 2]**
Egypt	-2.833	-3.4418 [1]	**-4.3268[1999, 0.28]**	**-5.4007 [2006, 0.50, 1]**
Eritrea	-1.108	-2.1947 [1]	-2.8888 [2013, 0.72]	**-4.1858 [2020, 0.94, 1]**
Ethiopia	-3.437	-3.6979 [1]	**-4.6333 [1994, 0.13]**	**-4.6986 [1997, 0.22, 1]**
Gabon	-1.766	-3.4210 [1]	-2.6455 [2010, 0.63]	**-5.3521 [2007, 0.53, 1]**
Ghana	-2.048	-2.0475 [2]	-3.3389 [1999, 0.28]	**-4.7632 [2015, 0.78, 2]**
Guinea	-2.470	-1.8754 [1]	-3.2752 [1997, 0.22]	-3.5765 [2005, 0.47, 1]
Guinea-Bissau	-2.989	**-5.6313 [1]**	**-4.3693 [2013, 0.72]**	**-7.3055 [1999, 0.28, 1]**
Equatorial Guinea	-1.301	-1.8916 [1]	-3.0207 [2013, 0.72]	-3.9306 [2000, 0.31, 2]
Kenya	1.181	-1.4818 [1]	**-7.7289 [2021, 0.97]**	**-7.5616 [2021, 0.97, 1]**
Liberia	-1.737	-2.0236 [1]	**-5.4448 [2014, 0.75]**	**-5.2014 [2014, 0.75, 2]**
Libya	1.068	-2.3664 [1]	-1.3277 [2021, 0.97]	**-4.5016 [2020, 0.94, 1]**
Lesotho	-1.047	**-7.1437 [1]**	-2.6084 [2017, 0.84]	**-8.2074 [2019, 0.91, 1]**
Morocco	**-3.494**	-3.6789 [1]	**-3.9133 [2005, 0.47]**	**-6.1978 [2010, 0.63, 2]**
Madagascar	-2.156	-3.2815 [1]	**-5.3630 [2001, 0.34]**	**-5.2510 [2010, 0.63, 1]**
Mali	-0.004	-1.2929 [1]	**-10.2507 [2019, 0.91]**	**-13.2894 [2019, 0.91, 1]**
Mozambique	-1.476	-2.1944 [1]	-3.5857 [2017, 0.84]	-3.1867 [2018, 0.88, 2]
Mauritania	-1.705	-2.2599 [1]	**-5.1123 [2012, 0.69]**	**-4.3887 [2013, 0.72, 2]**
Mauritius	-1.587	-1.2784 [2]	**-4.5915 [2003, 0.41]**	**-4.8711 [2004, 0.44, 1]**
Malawi	-2.452	-2.1558 [1]	**-4.4224 [2016, 0.81]**	-3.9902 [2016, 0.81, 2]
Namibia	-1.845	-4.3913 [1]	**-5.8100 [2016, 0.81]**	**-8.0665 [2016, 0.81, 2]**
Niger	-2.910	**-4.3188 [2]**	**-8.7839 [2012, 0.69]**	**-13.5292 [2012, 0.69, 1]**
Nigeria	-2.030	-2.7583 [2]	**-5.6141 [2011, 0.66]**	**-6.2761 [2012, 0.69, 1]**
Rwanda	-2.634	-4.2098 [1]	**-40.1271 [2019, 0.91]**	**-42.1936 [2019, 0.91, 1]**
Sudan	-2.082	-3.4993 [2]	**-13.8689 [2008, 0.56]**	**-15.3785 [2008, 0.56, 1]**
Senegal	-1.168	-0.5426 [2]	**-4.1925 [2012, 0.69]**	-3.0438 [2012, 0.69, 2]
Sierra Leone	-1.622	-3.8597 [2]	-3.0004 [2007, 0.53]	**-4.4614 [1994, 0.13, 2]**
Somalia	-1.939	**-5.8119 [1]**	**-3.8973 [1997, 0.22]**	**-6.6721 [2018, 0.88, 1]**
South Sudan	-2.821	**-5.5905 [1]**	**-4.1200 [2014, 0.75]**	**-6.4786 [2008, 0.56, 1]**
Sao Tome and Principe	-1.390	-2.5682 [1]	**-11.0086 [2000, 0.31]**	**-20.9979 [2000, 0.31, 1]**
Eswatini	-2.420	-4.3251 [1]	**-7.8983 [1995, 0.16]**	**-11.5021 [1995, 0.16, 2]**
Togo	-1.949	-3.1580 [1]	**-4.5480 [2015, 0.78]**	**-6.1724 [2016, 0.81, 1]**
Tunisia	-1.884	-3.4300 [2]	**-4.8951 [2008, 0.56]**	**-5.179 [2010, 0.63, 2]**
Tanzania	-3.392	-4.0291 [2]	**-4.1041 [2003, 0.41]**	**-4.5108 [2003, 0.41, 1]**
Uganda	-3.428	-3.5659 [2]	**-6.9359 [2003, 0.41]**	**-8.0606 [2003, 0.41, 1]**
Zambia	-2.975	-3.8904 [2]	**-4.2798 [1997, 0.22]**	**-5.8475 [1997, 0.22, 2]**
Zimbabwe	-2.088	-2.0126 [1]	-3.4499 [1997, 0.22]	-3.9792 [1997, 0.22, 2]

Note: * denote 5% level of significance. Note, critical values for tests are detailed in Furuoka (2017).

Table 4: F tests for ADF-type tests

Countries	F_{FADF_ADF}	$F_{ADF\text{-}SB\_ADF}$	$F_{FADF\text{-}SB\_ADF}$	$F_{FADF\text{-}SB\_FADF}$	$F_{FADF\text{-}SB\_ADF\text{-}SB}$
Algeria	2.2821	**5.2138**	5.2927	**7.2127**	**10.0979**
Angola	3.8770	**697.0014**	**20.1685**	**28.3142**	**40.2814**
Burundi	6.9640	2.7772	**15.4168**	**15.8921**	**28.0794**
Benin	5.6768	**5.4673**	**15.6664**	**18.1618**	**16.2539**
Burkina Faso	6.2103	2.9046	**8.6162**	**7.7820**	1.8828
Botswana	6.6068	**5.5589**	**20.0837**	**22.5888**	**39.9951**
C.A.R	6.4169	4.6607	**14.1996**	**15.0481**	**11.8080**
Cameroon	9.5017	3.3618	**7.9430**	4.1107	**7.4807**
Chad	7.2625	**26.0685**	**23.7269**	**26.1444**	**46.3753**
Congo, DR	6.3777	**16.9368**	5.0030	2.7633	-2.4439
Congo	**19.0559**	4.1090	**25.1515**	**13.2665**	5.4662
Comoros	6.9909	1.9787	4.9271	2.2117	0.1092
Djibouti	5.7163	**53.0349**	**26.3201**	**32.8977**	**13.1439**
Egypt	2.0944	4.9254	5.8132	**8.3481**	**8.7485**
Eritrea	6.1517	**6.6910**	**11.6574**	**11.9714**	**12.3571**
Ethiopia	3.9149	4.0971	4.7444	4.5153	**9.0794**
Gabon	**11.5086**	**9.6509**	**12.4304**	**7.5520**	**17.8582**
Ghana	1.9840	4.1291	**9.2366**	**14.4383**	**16.2013**
Guinea	9.2924	2.7157	**9.4485**	6.0178	5.5346
Guinea-Bissau	**14.3418**	4.5143	**12.6406**	5.7258	-1.3694
Equatorial Guinea	5.1408	**6.6253**	5.5093	4.4956	2.6627
Kenya	4.4778	**101.7239**	**49.9394**	**71.2153**	0.6776
Liberia	3.3419	**13.3728**	**8.5993**	**11.2276**	**7.2183**
Libya	4.5465	**44.3179**	**50.1197**	**71.1568**	**13.4565**
Lesotho	**31.4909**	3.6764	**21.9242**	4.3186	-2.0095
Morocco	0.9169	1.6429	5.5830	**9.6398**	**10.4015**
Madagascar	4.1755	**11.8874**	**7.4292**	**8.3290**	**14.5466**
Mali	5.7759	**141.9931**	**119.3173**	**161.5341**	**142.7775**
Mozambique	**11.2088**	**8.9625**	3.2142	-2.1040	0.5720
Mauritania	3.3689	**16.7804**	**10.0927**	**13.5612**	5.3910
Mauritius	3.1357	**10.7355**	**7.1861**	**9.2472**	**9.5256**
Malawi	1.4144	**6.6777**	3.3012	4.7771	**9.3139**
Namibia	8.2352	**15.4070**	**17.1085**	**16.2936**	**32.7437**
Niger	5.1124	**184.0805**	**288.0819**	**410.1488**	**558.0940**
Nigeria	3.3874	**14.5383**	**17.4594**	**25.2203**	**11.5606**
Rwanda	5.2240	**1064.7777**	**604.7968**	**859.4165**	**341.8774**
Sudan	6.5940	**102.4093**	**107.5324**	**138.6501**	**211.8238**
Senegal	9.0308	**15.2301**	**10.5199**	**7.4962**	**20.4652**
Sierra Leone	**14.9941**	4.7833	**10.5442**	3.3657	**16.1217**
Somalia	**16.3159**	**5.6375**	**11.5509**	3.5657	1.1248
South Sudan	**14.8868**	4.2725	**10.4445**	3.3319	-7.4655
Sao Tome and Principe	4.4316	**66.8656**	**198.0389**	**292.3335**	**395.6357**
Eswatini	8.6855	**26.3050**	**29.5534**	**30.6271**	**50.5210**
Togo	5.9426	**8.1580**	**20.6720**	**24.6091**	**27.4796**
Tunisia	6.6246	**11.2176**	**8.1928**	**6.8035**	**16.0580**
Tanzania	3.1839	2.8962	2.5179	1.6843	3.0201
Uganda	1.3505	**16.2813**	**13.0746**	**22.5591**	**23.6078**
Zambia	3.4463	**5.1495**	**6.6537**	**8.0042**	**9.2453**
Zimbabwe	8.0183	**6.1663**	4.7570	1.3065	1.4459

Note: In bold indicates significance at 5% level. For critical values, see Furuoka (2017).

Table 5: KPSS, KPSS-SB, FKPSS and FKPSS-SB Unit root tests with lag length fixed to 1

Countries	KPSS	KPSS-SB	FKPSS	FKPSS-SB
Algeria	0.124	0.122*	0.124*	0.058
Angola	0.090	0.037	0.098*	0.067*
Burundi	0.389*	0.048	0.140*	0.064*
Benin	0.370*	0.084*	0.117*	0.052
Burkina Faso	0.368*	0.096*	0.159*	0.077*
Botswana	0.227*	0.036	0.118*	0.039
C.A.R	0.335*	0.053	0.105*	0.044
Cameroon	0.322*	0.106*	0.132*	0.069*
Chad	0.145	0.028	0.071	0.043
Congo, DR	0.323*	0.067	0.077	0.089*
Congo	0.068	0.041	0.335*	0.051
Comoros	0.263*	0.084*	0.118*	0.067*
Djibouti	0.190*	0.045	0.048	0.049
Egypt	0.198*	0.045	0.042	0.031
Eritrea	0.340*	0.058	0.101	0.044
Ethiopia	0.192*	0.069	0.238*	0.046
Gabon	0.405*	0.057	0.159*	0.055
Ghana	0.102	0.143*	0.065	0.105*
Guinea	0.379*	0.072	0.129*	0.043
Guinea-Bissau	0.104	0.048	0.259*	0.037
Equatorial Guinea	0.338*	0.056	0.096	0.044
Kenya	0.245*	0.074*	0.162*	0.067*
Liberia	0.348*	0.069	0.114*	0.050
Libya	0.326*	0.040	0.312*	0.065*
Lesotho	0.220*	0.048	0.324*	0.048
Morocco	0.146	0.055	0.057	0.033
Madagascar	0.287*	0.083*	0.149*	0.053
Mali	0.209*	0.088*	0.135*	0.066*
Mozambique	0.193*	0.064	0.221*	0.036
Mauritania	0.350*	0.069	0.091	0.045
Mauritius	0.244*	0.078	0.117*	0.046
Malawi	0.131	0.047	0.204*	0.083*
Namibia	0.358*	0.054	0.202*	0.044
Niger	0.121	0.044	0.178*	0.053
Nigeria	0.188*	0.075	0.171*	0.034
Rwanda	0.233*	0.076	0.042	0.052
Sudan	0.169*	0.144*	0.227*	0.039
Senegal	0.338*	0.086*	0.140*	0.059
Sierra Leone	0.229*	0.077	0.085	0.051
Somalia	0.243*	0.045	0.314*	0.048
South Sudan	0.111	0.050	0.326*	0.048
Sao Tome and Principe	0.310*	0.072	0.184*	0.065*
Eswatini	0.339*	0.045	0.155*	0.073*
Togo	0.364*	0.047	0.201*	0.090*
Tunisia	0.205*	0.061	0.113*	0.062*
Tanzania	0.097	0.057	0.157*	0.034
Uganda	0.084	0.079*	0.070	0.146*
Zambia	0.315*	0.073	0.106	0.039
Zimbabwe	0.378*	0.075	0.183*	0.043

Note: * denote 5% level of significance

Table 6: F tests for KPSS-type tests

Countries	F_{FKPSS_KPSS}	$F_{KPSS-SB\_KPSS}$	$F_{FKPSS-SB\_KPSS}$	$F_{FKPSS-SB\_FKPSS}$	$F_{FKPSS-SB\_KPSS-SB}$
Algeria	7.961*	4.516*	13.575*	12.595*	17.358*
Angola	2.527	152.434*	90.263*	150.935*	3.279
Burundi	119.275*	2.961	159.937*	21.967*	261.768*
Benin	122.723*	0.899	221.386*	33.670*	415.266*
Burkina Faso	78.882*	13.315*	115.835*	23.879*	112.401*
Botswana	2.298	9.594*	18.430*	29.829*	16.585*
C.A.R	80.495*	1.255	95.743*	17.296*	174.657*
Cameroon	89.815*	0.656	102.439*	16.382*	195.127*
Chad	0.074	46.450*	26.301*	52.261*	2.193
Congo, DR	47.811*	6.781*	38.055*	7.183*	47.033*
Congo	1.905	166.649*	835.165*	1468.695*	117.456*
Comoros	81.251*	0.415	104.581*	19.653*	202.772*
Djibouti	8.969*	50.789*	29.275*	30.611*	2.461
Egypt	5.330*	1.615	6.155*	5.332*	9.693*
Eritrea	80.096*	4.062*	101.155*	19.035*	153.892*
Ethiopia	42.013*	13.200*	88.161*	34.319*	84.445*
Gabon	1022.668*	1.069	721.735*	6.669*	1340.169*
Ghana	4.960*	1.382	7.506*	7.684*	12.494*
Guinea	417.158*	1.032	421.23*	14.777*	783.734*
Guinea-Bissau	2.875	46.158*	54.938*	88.944*	15.596*
Equatorial Guinea	75.106*	1.060	96.461*	19.353*	178.433*
Kenya	14.244*	60.388*	66.304*	59.174*	14.404*
Liberia	48.087*	115.401*	85.764*	28.609*	6.964*
Libya	22.114*	33.613*	77.108*	51.823*	36.168*
Lesotho	6.871*	116.601*	329.884*	438.285*	59.118*
Morocco	4.002*	0.268	16.615*	22.954*	32.361*
Madagascar	20.106*	38.883*	40.850*	25.872*	12.070*
Mali	20.901*	278.805*	272.221*	210.610*	13.653*
Mozambique	139.744*	1.025	110.463*	8.301*	204.972*
Mauritania	58.928*	113.044*	96.309*	26.473*	9.659*
Mauritius	14.443*	37.575*	33.604*	26.480*	8.772*
Malawi	2.808	13.574*	32.045*	51.212*	26.140*
Namibia	51.997*	57.102*	78.126*	22.904*	20.326*
Niger	7.029*	37.568*	40.248*	49.244*	12.383*
Nigeria	9.829*	45.958*	41.184*	43.032*	9.268*
Rwanda	3.704*	1084.544*	535.171*	843.695*	0.806
Sudan	15.328*	285.359*	272.671*	253.527*	13.112*
Senegal	44.388*	64.056*	65.290*	21.427*	12.752*
Sierra Leone	12.965*	4.944*	44.620*	40.081*	62.559*
Somalia	6.361*	37.745*	130.975*	176.057*	61.390*
South Sudan	2.641	47.500*	459.597*	771.254*	199.208*
Sao Tome and Principe	24.248*	182.286*	324.286*	229.159*	34.186*
Eswatini	117.311*	174.532*	488.072*	92.460*	60.452*
Togo	65.269*	50.393*	131.228*	35.649*	46.888*
Tunisia	34.448*	21.317*	49.322*	19.262*	31.257*
Tanzania	2.793	9.425*	10.586*	15.487*	7.423*
Uganda	3.494*	19.543*	22.951*	34.137*	11.584*
Zambia	91.167*	0.757	92.243*	13.290*	174.351*
Zimbabwe	328.797*	2.426	292.290*	11.405*	496.334*

Note: * denote 5% level of significance

Table 7: Summary of findings

Countries	**ADF**	**FADF**	**ADF-SB**	**FADF-SB**	KPSS	KPSS-SB	FKPSS	FKPSS-SB
Algeria	*No*	*No*	*Yes*	*Yes*	*Yes*	*No*	*No*	*Yes*
Angola	*No*	*No*	*Yes*	*Yes*	*Yes*	*Yes*	*No*	*No*
Burundi	*No*	*No*	*No*	*Yes*	*No*	*Yes*	*No*	*No*
Benin	*No*	*No*	*No*	*Yes*	*No*	*No*	*No*	*Yes*
Burkina Faso	*No*	*No*	*No*	*No*	*No*	*No*	*No*	*No*
Botswana	*No*	*No*	*Yes*	*Yes*	*No*	*Yes*	*No*	*Yes*
C.A.R	*No*	*No*	*No*	*No*	*No*	*Yes*	*No*	*Yes*
Cameroon	*No*	*No*	*No*	*No*	*No*	*No*	*No*	*No*
Chad	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Congo, DR	*No*	*No*	*No*	*No*	*No*	*Yes*	*Yes*	*No*
Congo	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*No*	*Yes*
Comoros	*No*	*No*	*No*	*No*	*No*	*No*	*No*	*No*
Djibouti	*No*	*Yes*	*Yes*	*Yes*	*No*	*Yes*	*Yes*	*Yes*
Egypt	*No*	*No*	*Yes*	*Yes*	*No*	*Yes*	*Yes*	*Yes*
Eritrea	*No*	*No*	*No*	*Yes*	*No*	*Yes*	*Yes*	*Yes*
Ethiopia	*No*	*No*	*Yes*	*Yes*	*No*	*Yes*	*No*	*Yes*
Gabon	*No*	*No*	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*
Ghana	*No*	*No*	*No*	*Yes*	*Yes*	*No*	*Yes*	*No*
Guinea	*No*	*No*	*No*	*No*	*No*	*Yes*	*No*	*Yes*
Guinea-Bissau	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*No*	*Yes*
Equatorial Guinea	*No*	*No*	*No*	*No*	*No*	*Yes*	*Yes*	*Yes*
Kenya	*No*	*No*	*Yes*	*Yes*	*No*	*No*	*No*	*No*
Liberia	*No*	*No*	*Yes*	*Yes*	*No*	*Yes*	*No*	*Yes*
Libya	*No*	*No*	*No*	*Yes*	*No*	*Yes*	*No*	*No*
Lesotho	*Yes*	*Yes*	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*
Morocco	*Yes*	*No*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Madagascar	*No*	*No*	*Yes*	*Yes*	*No*	*No*	*No*	*Yes*
Mali	*No*	*No*	*Yes*	*Yes*	*No*	*No*	*No*	*No*
Mozambique	*No*	*No*	*No*	*No*	*No*	*Yes*	*No*	*Yes*
Mauritania	*No*	*No*	*Yes*	*Yes*	*No*	*Yes*	*Yes*	*Yes*
Mauritius	*No*	*No*	*Yes*	*Yes*	*No*	*Yes*	*No*	*Yes*
Malawi	*No*	*No*	*Yes*	*No*	*Yes*	*Yes*	*No*	*No*
Namibia	*No*	*No*	*Yes*	*Yes*	*No*	*Yes*	*No*	*Yes*
Niger	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*No*	*Yes*
Nigeria	*No*	*No*	*Yes*	*Yes*	*No*	*Yes*	*No*	*Yes*
Rwanda	*No*	*No*	*Yes*	*Yes*	*No*	*Yes*	*Yes*	*Yes*
Sudan	*No*	*No*	*Yes*	*Yes*	*No*	*No*	*No*	*Yes*
Senegal	*No*	*No*	*Yes*	*Yes*	*No*	*No*	*No*	*Yes*
Sierra Leone	*No*	*No*	*No*	*Yes*	*No*	*Yes*	*Yes*	*Yes*
Somalia	*No*	*Yes*	*Yes*	*Yes*	*No*	*Yes*	*No*	*Yes*
South Sudan	*No*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*No*	*Yes*
Sao Tome and Principe	*No*	*No*	*Yes*	*Yes*	*No*	*Yes*	*No*	*No*
Eswatini	*No*	*No*	*Yes*	*Yes*	*No*	*Yes*	*No*	*No*
Togo	*No*	*No*	*Yes*	*Yes*	*No*	*Yes*	*No*	*No*
Tunisia	*No*	*No*	*Yes*	*Yes*	*No*	*Yes*	*No*	*No*
Tanzania	*No*	*No*	*Yes*	*Yes*	*Yes*	*Yes*	*No*	*Yes*
Uganda	*No*	*No*	*Yes*	*Yes*	*Yes*	*No*	*Yes*	*No*
Zambia	*No*	*No*	*Yes*	*Yes*	*No*	*Yes*	*Yes*	*Yes*
Zimbabwe	*No*	*No*	*No*	*No*	*No*	*Yes*	*No*	*Yes*

Note: *Yes* denote the convergence and *No* denotes no convergence.

Table 8: The best specification models and their results

	The ADF-type tests		The KPSS-type tests	
Countries	The best specification model	Convergence	The best specification model	Convergence
Algeria	ADF	No	FKPSS-SB	Yes
Angola	FADF-SB	Yes	KPSS-SB	Yes
Burundi	FADF-SB	Yes	FKPSS-SB	No
Benin	FADF-SB	Yes	FKPSS-SB	No
Burkina Faso	ADF-SB	No	FKPSS-SB	No
Botswana	FADF-SB	Yes	FKPSS-SB	Yes
C.A.R	FADF-SB	No	FKPSS-SB	Yes
Cameroon	FADF	No	FKPSS-SB	No
Chad	FADF-SB	Yes	KPSS-SB	Yes
Congo, DR	ADF-SB	No	FKPSS-SB	No
Congo	ADF-SB	Yes	FKPSS-SB	Yes
Comoros	ADF	No	FKPSS-SB	No
Djibouti	FADF-SB	Yes	FKPSS-SB	Yes
Egypt	ADF	No	FKPSS-SB	Yes
Eritrea	FADF-SB	Yes	FKPSS-SB	Yes
Ethiopia	ADF	No	FKPSS-SB	Yes
Gabon	FADF-SB	Yes	FKPSS-SB	Yes
Ghana	FADF-SB	Yes	FKPSS-SB	No
Guinea	Indecisive	Indecisive	FKPSS-SB	Yes
Guinea-Bissau	Indecisive	Indecisive	FKPSS-SB	Yes
Equatorial Guinea	ADF-SB	No	FKPSS-SB	Yes
Kenya	ADF-SB	Yes	FKPSS-SB	No
Liberia	FADF-SB	Yes	FKPSS-SB	Yes
Libya	FADF-SB	Yes	FKPSS-SB	No
Lesotho	Indecisive	Indecisive	FKPSS-SB	Yes
Morocco	ADF	No	FKPSS-SB	Yes
Madagascar	FADF-SB	Yes	FKPSS-SB	No
Mali	FADF-SB	Yes	FKPSS-SB	No
Mozambique	Indecisive	Indecisive	FKPSS-SB	Yes
Mauritania	ADF-SB	Yes	FKPSS-SB	Yes
Mauritius	FADF-SB	Yes	FKPSS-SB	Yes
Malawi	ADF	No	FKPSS-SB	No
Namibia	FADF-SB	Yes	FKPSS-SB	Yes
Niger	FADF-SB	Yes	FKPSS-SB	No
Nigeria	FADF-SB	Yes	FKPSS-SB	Yes
Rwanda	FADF-SB	Yes	KPSS-SB	Yes
Sudan	FADF-SB	Yes	FKPSS-SB	Yes
Senegal	FADF-SB	No	FKPSS-SB	Yes
Sierra Leone	FADF	No	FKPSS-SB	Yes
Somalia	Indecisive	Indecisive	FKPSS-SB	Yes
South Sudan	Indecisive	Indecisive	FKPSS-SB	Yes
Sao Tome and Principe	FADF-SB	Yes	FKPSS-SB	No
Eswatini	FADF-SB	Yes	FKPSS-SB	No
Togo	FADF-SB	Yes	FKPSS-SB	No
Tunisia	FADF-SB	Yes	FKPSS-SB	No
Tanzania	ADF	No	FKPSS-SB	Yes
Uganda	FADF-SB	Yes	FKPSS-SB	No
Zambia	FADF-SB	Yes	FKPSS-SB	Yes
Zimbabwe	ADF-SB	No	FKPSS-SB	Yes