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Convergence in Per Capita Energy Consumption among African Countries: Evidence from Sequential Panel Selection Method

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ABSTRACT: This paper applies a battery of panel unit root procedures to test for convergence in per capita energy consumption among 22 African countries. Specifically, the study implements both the conventional panel unit root testing procedures and the Sequential Panel Selection Method (SPSM). The results from the standard panel unit root tests provide evidence of convergence in per capita energy consumption for the 22 countries as a group. However, these procedures lack the ability to separate the series in the panel into stationary and nonstationary groups. The results from the SPSM procedure provide support for per capita energy consumption convergence for Angola, Mozambique, Libya, Tanzania, Zambia, Ethiopia, Algeria, Senegal, Congo Republic, South Africa, Benin, Cameron, and Nigeria. For Tunisia, Cote d'Ivoire, Sudan, Gabon, Zimbabwe, Morocco and Togo, the results from the SPSM procedures suggest that their per capita energy consumption series have not converged with the other panel members.

Keywords: Per capita energy consumption; SPSM; convergence; panel KSS unit root test
JEL Classifications: C22; C23; Q41

1. Introduction

Economists in the area of economic development and growth have long been concerned with the notion of convergence because of its implication for income inequality between nations. Quite a while ago, Baumol looked for convergence over an extended period of time for a large group of countries around the world using Maddison's historical income data (Baumol, 1986). The central idea of convergence is that convergence in the standard of living between countries occurs if poorer countries grow faster than richer countries. Poorer countries may be able to do this, that is, to grow faster than richer countries, and, as a consequence, to catch up to richer counties, for a number of reasons. For instance, poor countries may be are able to borrow advanced existing technology from the rich countries.

On the other hand, divergence may occur because poorer countries grow slower than the rich countries. One important reason that this may occur is a combination of instability and unreliability in energy supply in poor countries. As energy availability is crucial for the running of any modern economy, countries experiencing inconstant energy supply are almost certain to have much lower growth rates than countries that do not.

Two measures of country welfare that are commonly used in convergence studies are GDP per capita and energy consumption per capita. This study employs energy consumption per capita. The use of energy consumption per capita allows the researcher to test both for convergence (divergence) in countries, and, at the same time, if and when there is evidence for divergence, to consider instability in energy supply as a potential source for divergence.

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Regardless of whether GDP per capita or energy use per capita is employed as a measure of social well-being, when researchers find evidence for convergence in a set of countries, it does not necessarily mean that convergence exists for all, for each and every one, of the countries within the group. Assuming that it does for each country and using empirical results based on that assumption, is likely to lead to poor policy decisions. For example, suppose policy makers in a hypothetical region consisting of 10 countries look at convergence research in the area, based on the assumption, and it shows convergence in the 10 countries in the region. In this case, policy makers may be very happy to maintain their present policies in the region believing them to be a resounding success. However, it may be that there are actually four out of the ten countries that are not converging, so that, given more detailed information, policy could be improved by addressing the lack of convergence in the non-converging countries and by addressing potential energy supply instability and other issues these countries may be facing.

Unlike the traditional approach for looking at convergence, the present study in its analysis of convergence, not only utilizes the traditional approach, but also supplements the traditional approach by using the Sequential Panel Selection Method (SPSM). The sequential panel selection approach allows the researcher to identify the countries in a group of countries that are converging and the countries in the group that are not, and, hopefully, as a result, to conduct better policy.

African region presents an excellent avenue to investigate the issue of per capita energy consumption. Despite the fact that Africa countries are endowed with abundant natural resources, they however continue to experience difficulties in attaining high rates of economic growth compared to the rest of the world. To be specific, we will undertake convergence analysis for 22 African countries. They are Angola, Benin, Cote d'Ivoire, Cameroon, Congo (Republic), Algeria, Ethiopia, Gabon, Ghana, Libya, Morocco, Mozambique, Nigeria, Sudan, Senegal, Togo, Tunisia, Tanzania, South Africa, Congo (Democratic Republic), Zambia, and Zimbabwe.

The remainder of the paper is structured as follows: Section 2 provides a brief literature review on energy convergence. Section 3 details the econometric techniques of the study. Section 4 discusses the data and the descriptive statistics. Section 5 presents the empirical results. Section 6 provides the summary and implications of the results.

2. Literature Review

The direction of causation between economic growth and development is almost certain to depend on the level of economic development. In energy dependent developing countries, such as those on the continent of Africa, causation is likely to go from energy growth to economic growth and development, as energy bottlenecks and supply disruptions are likely to be a major factor impairing the ability to produce at this level of development.

Although the studies, when looking at assorted countries from around the world at various levels of development, testing for a causal relationship moving from energy use to economic growth are mixed, a relatively recent study by Akinlo finds, for the African country of Nigeria, support for the existence of a causal relationship between electricity consumption and economic growth (Akinlo, 2009). Lee, looking at a panel of eighteen developing countries and using cointegration techniques, also discovers support for causation going from energy consumption to economic growth (Lee, 2005).

The issue of per capita energy consumption convergence has been examined by different studies in the literature. Jaunky, using data from 1971 through 2002 and a battery time series and panel unit root procedures, examined the existence of per capita electricity power consumption among a group of 22 African countries (Jaunky, 2008). He failed to find evidence in support of per capita electricity convergence. He did, however, find evidence, consistent with earlier studies, of convergence in per capita energy consumption. Robinson, using β-convergence and a cointegration analysis, explored the extent to which electricity prices for nine European countries converged during the period 1978 through 2003 (Robinson, 2007). He found evidence supporting convergence in electricity prices for most of the sample countries. Meng and his coauthors, utilizing the standard Lagrangian Multiplier (LM) and the 'residual augmented least squares' (RALS)-LM unit root procedures, explored the convergence of per capita energy usage for 25 OECD countries for the time period running from 1960 to 2010 (Meng, et al., 2013). They find that per capita energy usage among the 25 sample countries has converged.

Liu applying the Sequential Panel Selection Method (SPSM) examined the time series properties of energy consumption for the 50 states of the United States from 1963 through 2009 (Liu, 2013). He finds, after accounting for nonlinearity and structural breaks in the data generating process, that energy consumption for the 50 states are stationary. From his results, he concludes that shocks to energy consumption in the United States are temporary. Narayan and Smyth examined the stationarity of per capita energy consumption for 182 countries using panel unit root testing procedures (Narayan and Smyth, 2009). They find evidence of panel stationarity in per capita energy consumption for the sample countries.

Aslan applying both linear and nonlinear unit root procedures tested the time series properties of natural gas consumption for the 50 U. S. states (Aslan, 2011). He finds evidence of nonlinear stationarity in the natural gas consumption series for 27 out of the 50 states under study. Ozturk and Aslan examined the time series properties of per capita energy consumption by sector in Turkey (Ozturk and Aslan, 2011). They find that per capita energy consumption is stationary. Barros and company apply the fractional integration procedure probe for the existence of long memory in U.S. renewable energy consumption (Barros et al., 2012). They find that renewable energy consumption for the U.S. is nonstationary. Kula et al. explored the time series properties of per capita electricity consumption for 23 high income OCED countries covering the time period 1960 through 2005 (Kula et al., 2012). They find that per capita electricity consumption for most of the sample countries is stationary. They conclude that shocks to per capita energy consumption for the sample countries are temporary, and, hence, that future movements in per capita energy consumption can be predicated using their past observations. Shahbaz et al.,using the Lagrange Multiplier (LM) unit root procedures developed by Lee and Strazicich (Lee and Strazicich, 2003; Lee and Stazicich 2004), examined the time series properties of electricity consumption per capita for 67 developed and developing countries for the time period running 1971–2010 (Shahbz et al., 2013). They find evidence of stationarity in electricity consumption per capita for 65 out of the 67 countries under study. They therefore concluded that past values of electricity consumption per capita are informational in predicting its future movements.

Mohammadi and Ram using cross-country data for the period 1971 through 2007 looked for possible convergence for both per capita energy and electricity consumption (Mohammadi and Ram, 2012). They find evidence for weak convergence in per capita energy usage. Apergis and Tsoumas, applying the fractional integration technique which allows for structural breaks, explore the long term memory properties of fossil fuel, coal, and electric consumption in the United States by sector (Apergis and Tsoumas, 2012). They find that fossil fuel, coal, and electric consumption are fractionally integrated and therefore conclude that shocks to the three time series are temporary. Bolat, et al., using the Lagrangian Multiplier (LM) unit root procedure that allows for structural breaks in the data generating process, investigated whether energy consumption for 15 MENA countries exhibit unit root behavior (Bolat et al., 2013). They find that per capita energy consumption for 8 out of the 15 countries under study is stationary. Based on their finding they conclude that future movements in per capita consumption the 8 countries can be predicated using their past observations. Hsu et al., using panel unit root test (SURADF), explored the existence of convergence in energy consumption for five regions consisting of 84 countries (Hsu et al., 2008). They find that energy consumption for the sample countries has a unit root, implying that shocks to the series are permanent.

Most of the preceding studies concentrated on the issue of per capita energy consumption in the context of developed countries and OCED countries in particular. It is therefore apparent that little or no attention has been devoted on this issue relative to Africa. The convergence of per capita energy consumption observed by the previous researchers cannot be generalized to Africa. After all, policies governing the consumption of energy are quite different from those of developing countries of Africa. In addition, most of the earlier studies implemented linear unit root tests, which have been shown in the literature to have low statistical power in the presence of nonlinearity.

This paper makes two contributions to the literature. First, the study extends the discussion on convergence in per energy consumption to a panel of 22 African countries. Second, the present study applies the Sequential Panel Selection Method (SPSM) with KSS unit root test and Fourier function to test for per capita energy consumption for the sample countries. The attractive feature of the SPSM includes its ability to account for both structural breaks and nonlinearity in the data generating process.

3. Methodology

To test for convergence in per capita energy consumption for the 22 African countries in the panel, the study applies the first generation panel unit root tests including the LLC test (Levin, Lin and Chu, 2002), the IPS test (Im, Pesaran, and Shin, 2003) and the MW test (Maddala and Wu, 1999). The study also applies the second generation panel unit root tests (Bai and Ng, 2004; Moon and Perron, 2004) and Pesaran's CD test (Pesaran, 2007). The first generation panel unit root tests presume that all cross-sections are independent. However, the second generation panel unit root tests assume that all cross-sections are not independent. The details about the first and second generation panel unit root tests will not discussed in this paper, given that they have been extensively applied in the extant literature.

This study further implements the SPSM to ascertain whether per capita energy consumption for the sample countries has converged or diverged. Kapetanios et al. developed the exponential star model [ESTAR] nonlinear unit root test known as the KSS procedure (Kapetanios et al., 2003). The KSS nonlinear unit root test has the ability to capture the presence of nonstationarity against a nonlinear behavior in the data generating process. They suggest the following ESTAR model for the data generating process (DGP), x_t:

$$\Delta x_t = \varphi x_{t-1} + \gamma x_{t-1}[(1-\exp(-\theta x^2_{t-d}))] + \varepsilon_t \tag{1}$$

In equation (1), θ represents the parameter that determines the degree of mean reversion. The error term given by ε_t is assumed to be normally distributed, with a zero mean and a constant variance. The null hypothesis in equation (1) is that x_t is a unit root process which involves testing that θ=0. However the alternative hypothesis is that x_t is nonlinear but globally stationary (i.e. θ > 0). Given that γ is not identified, Kapetanios et al (2003) use a first-order Taylor approximation to modify equation (1) which yields:

$$\Delta x_t = \delta x^3_{t-1} + \sum_{i=1}^{j} \rho_i \Delta x_{t-i} + error_t \tag{2}$$

In equation (2) serial correlation is controlled by including the lagged values of the series (i.e. x). The null hypothesis is that δ =0 (nonstationary) while the alternate hypothesis is that δ <0 (nonlinear ESTAR stationary).

Ucar and Omay (2009) developed a nonlinear heterogeneous panel unit root test by combining the Kapetanios et al. (Kapetanios et al., 2003) nonlinear time series procedure with the panel unit root framework of Im et al. (Im et al., 2003). Ucar and Omay (2009) modify equation (1) for nonlinear panel unit root testing purposes as follows:

$$\Delta x_{i,t} = \varphi x_{i,t-1} + \gamma x_{i,t-1}[(1-\exp(-\theta x^2_{i,t-d}))] + \varepsilon_{i,t} \tag{3}$$

Ucar and Omay (2009) applied a first-order Taylor series approximation to the panel ESTAR of equation (3) around θ=0 for all i resulting in the following auxiliary regression:

$$\Delta x_{i,t} = \delta x^3_{i,t-1} + \sum_{i=1}^{j} \rho_{i,i} \Delta x_{t-i} + error_{i,t} \tag{4}$$

In equation (4), the hypotheses are as follows:

H_0: δ_i =0, for all i, (linear nonstationarity)

H_A: δ_i <0, for some i, (nonlinear stationarity)

The study implements the following system of KSS equations with a Fourier function:

$$\Delta x_{i,t} = \alpha_i + \delta x^3_{i,t-1} + \sum_{i=1}^{j} \rho_{i,i} \Delta x_{t-i} + \lambda_{i,t} \sin(2\pi kt/T) + \lambda_{2i,t} \cos(2\pi kt/T) + \upsilon_{i,t} \tag{5}$$

In equation (5), k is the number of frequencies, while $\lambda_1 \sin 2\pi kt/T + \lambda_2 \cos 2\pi kt/T$ is the Fourier function that captures the number of smooth breaks by minimizing the residual sum of squares. T is the sample size while t represents the time trend and π takes the value of 3.1416. The sine and cosine terms are added to equation (5) given that the Fourier function can accurately approximate integrable functions. Among the attractive features of equation (5) is that it reduces to a standard linear expression by setting $\lambda_1 = \lambda_2 = 0$. In addition, the presence of at least one frequency indicates the existence of structural break in the data-generating process. Rejection of the hypothesis that $\lambda_1 = \lambda_2 = 0$ indicates that the series of interest (in our case, x_t) is nonlinear.

Given the inability of the conventional panel unit root procedures to identify stationary and nonstationary series in a panel, Chortareas and Kapetanios proposed the application of the Sequential Panel Selection Method (SPSM) (Chortareas and Kapetanios, 2009). The SPSM classifies panel members into stationary groups and nonstationary groups. The SPSM consists of three steps. In the first step, the panel KSS test is applied to all the series in a panel. If the null hypothesis of a panel unit-root is accepted, the procedure is halted, and all of the series in the panel are presumed to be non-stationary. However, if the null hypothesis of a unit root is rejected, then the process goes to the second step. In the second step, the series with the minimum KSS statistic is removed from the panel given it has been identified as a stationary process. In the third step, the process returns to step one for the remaining series in the panel, or terminate the test if all of the series in the panel are removed. The final result of the SPSM involves the separation of the whole panel into a set of stationary and nonstationary series.

Table 1. Descriptive Statistics for Per Capita Energy Consumption (kwh)

Country	Mean	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	J-B	Prob.
Angola	581.56	684.33	521.83	46.27	0.75	2.37	4.56*	0.10
Benin	346.46	384.56	285.30	26.86	-0.51	2.27	2.71	0.26
Cote Voire	431.28	579.30	355.11	66.82	0.85	2.59	5.22*	0.07
Cameron	392.56	429.41	317.62	27.39	-1.21	4.04	11.90***	0.00
Congo Dem. Rep.	337.84	383.17	307.65	22.86	0.74	2.19	4.86*	0.09
Congo, Rep.	326.29	392.64	230.21	41.84	-0.60	2.39	3.09	0.21
Algeria	755.43	1122.03	229.46	243.56	-0.78	2.67	4.30	0.12
Ethiopia	396.44	414.00	379.42	13.99	-0.05	1.07	6.40**	0.04
Gabon	1553.74	2474.94	1176.04	377.82	0.79	2.29	5.16*	0.08
Ghana	378.23	425.04	308.64	27.21	-0.37	2.83	1.00	0.61
Libya	2502.91	3577.55	727.09	733.52	-0.91	2.78	5.70*	0.06
Morocco	312.06	539.08	149.40	100.12	0.54	2.48	2.49	0.29
Mozambique	474.85	713.47	381.43	95.68	1.07	2.92	7.82**	0.02
Nigeria	718.85	763.04	627.82	35.12	-1.22	3.60	10.73***	0.00
Sudan	411.49	491.37	355.08	35.00	0.57	2.80	2.25	0.32
Senegal	250.79	285.55	207.76	23.64	-0.10	1.89	2.16	0.34
Togo	364.00	446.16	303.18	49.23	0.43	1.43	5.50*	0.06
Tunisia	627.53	917.03	317.90	176.78	0.07	1.91	2.06	0.36
Tanzania	421.80	539.46	356.69	45.77	0.72	3.06	3.59	0.17
South Africa	2553.92	3007.98	1997.50	259.67	-0.56	2.46	2.66	0.26
Zambia	700.21	860.54	609.34	77.98	0.54	2.09	3.43	0.18
Zimbabwe	844.45	1017.19	678.62	90.99	0.02	2.40	0.61	0.74

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

4. Data and Descriptive Statistics

The annual data on per capita energy consumption were retrieved from the World Development Indicators published by the World Bank[2]. The sample consists of 22 African countries including Angola, Benin, Cote d'Ivoire, Cameroon, Congo, Republic, Algeria, Ethiopia, Gabon, Ghana, Libya, Morocco, Mozambique, Nigeria, Sudan, Senegal, Togo, Tunisia, Tanzania, South Africa, Congo, Democratic Republic, Zambia and Zimbabwe. The sample period covers the time

[2] http://data.worldbank.org/indicator/EG.USE.PCAP.KG.OE/countries?display=default)

period running from 1971 through 2011. For each country i, the natural logarithm of the ratio of per capita energy consumption (EC) relative to the average of all the 22 African countries in the sample given by the expressions:

$$y_{it} = \ln (EC_{it}/\text{average } EC_t) \quad (6)$$

Table 1 displays the descriptive statistics for per capita energy consumption measured in kilowatt hours (kwh). The mean values ranged from a high of 2555.92 (kwh) for South Africa to a low of 337.84 (kwh) for Congo Republic. Libya (733.52) posted the highest standard deviation while Ethiopia (13.99) displayed the lowest. The maximum and minimum values indicate the degrees to which per capita energy consumption for the sample countries have fluctuated over the study period. The skewness of per capita energy consumption for most of the countries is positive indicating that the upper deviations from the mean are larger than the lower deviations. This result suggests that there is a greater probability of large increases than decreases in per capita energy consumption for these countries.

The Kurtosis coefficients for most of the sample countries is less than 3 indicating that the normality assumption with regard to the distribution of per capita energy consumption should not be rejected. Similarly, the Jarque-Bera test statistics are not statistically significant at the conventional levels suggesting that per capita energy consumption for most of the sample countries are normally.

5. Empirical Results

The empirical results from the study are discussed in this section. The empirical analysis of the study begins with the application of the first generation panel unit root tests including the LLC (Levin et at., 2002), IPS (Im et al., 2003) and Maddala and Wu (Maddala and Wu, 1999). Table 2 displays the test results from the first generation panel unit root tests. The results indicate that the null hypothesis of a panel unit root should be rejected at the 1 percent level of significance. For example, the computed test statistic for the LLC procedure is -6.12 with p-value of 0.00. Similar result is provided by the other procedures. A major drawback of the first generation panel unit root tests is their inability to account for cross-sectional dependencies among the panel members. O'Connell among others, point out that failure to account for contemporaneous correlations among panel members could lead to the rejection of the joint unit root hypothesis (O'Connell, 1998).

Table 2. First Generation Panel Unit Test Results

Method	Statistic	P-value	Cross-sect	Obs
Panel A				
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-6.12***	0.00	22	869
Panel B				
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-3.17***	0.00	22	869
ADF - Fisher Chi-square	82.39***	0.00	22	869
PP - Fisher Chi-square	103.53***	0.00	22	880
Panel C				
Maddala and Wu (1999)	84.73***	0.00	22	660

*** indicates rejection of the null hypothesis at the 1% level of significance.

To address the issue of cross-sectional dependencies among panel members, the study applies the second generation panel unit root tests including the Bai and Ng (Bai and Ng, 2004), Moon and Perron (Moon and Perron, 2004), and Pesaran's CD test. Table 3 presents the results for the second generation panel unit root tests. The results reveal that the null hypothesis of a unit root should be rejected at least at the 5 percent level based on the test statistics and their associated p-values. For example, the test statistics (i.e. -8.12 and -8.69) from the Moon and Perron (2004) panel unit root procedures are statistically significant at the 1 percent level of significance as indicated by the p-values. Taken together, the results from both the first and second generation panel unit root tests indicate that per capita energy consumption among the 22 African countries under study has converged.

The first and second generation panel unit root procedures, however, have some shortcomings. They fail to indicate which panel members or how many panel members are responsible for the rejection of the null hypothesis of a unit root. The second generation panel unit root tests are not fault free as they do not account for nonlinearity and structural breaks. They also lack the ability to classify panel members into stationary and nonstationary groups. In short, these procedures are basically designed to jointly test the null hypothesis of a unit root for all of the members of a panel.

Table 3. Second Generation Panel Unit Test Results

	Statistic	*p*-value	MQ_f	MQ_c
Panel A: Bai and Ng (2004)	-2.18**	0.02	-16.05***	-16.26***
Panel B: Moon and Perron (2004)	Statistic	*p*-value	Statistic	*p*-value
	-8.12***	0.00	-8.69	0.00
Panel C: Pesaran's CD Test	CD	*p*-value	LM	*p*-value
	9.46***	0.00	21.31***	0.00

*** and * indicate level of significance at the 1 and 10 percent, respectively.

To mitigate the problems associated with the conventional panel unit root tests, this study applies the SPSM which enables the researcher to identify which and how many panel members belong to the stationary and to the nonstationary group. Panel KSS unit test with a Fourier function is adopted. Under the panel KSS procedure a grid-search is conducted to determine the optimal frequency, given that there is a priori knowledge relative to the shape of the breaks in the data. Equation (6) is estimated for each integer k = 1, 2, ….5 as suggested by Enders and Lee (Enders and Lee, 2012) and asymptotic p-values are computed by means of bootstrap simulations using 10,000 replications. Based on the residual sum of squares (RSS) statistic, the optimal k was determined to be 2 in all of the cases.

Table 4 furnishes the results from the panel KSS test with a Fourier function. The results indicate that the null hypothesis of a unit root in per capita energy consumption should be rejected when the panel KSS unit root test was applied to the entire panel. The test statistic of -2.33 (p-value =0.00) indicates that the null hypothesis of a panel unit root should be rejected at 1 percent level. The result from the SPSM procedure indicates that per capita energy consumption for Angola is stationary with the minimum KSS value of -5.28 among the panel. Based on this result, Angola was removed from the panel and the test was applied to the remaining set of countries in the panel.

The panel KSS unit root was again applied to the remaining panel members. This time, per capita energy consumption for Mozambique was found to be stationary with the minimum KSS value of -4.80. Then Mozambique was removed from the panel and the panel KSS unit root test conducted again. This process is repeated until the null hypothesis of a unit root could not be rejected at the 10 percent significance level. Taken together, the results indicate that per capita energy consumption for Angola, Mozambique, Libya, Tanzania, Ghana, Zambia, Ethiopia, Algeria, Senegal, Congo Republic, South Africa, Benin, Cameron, Congo Democratic Republic, and Nigeria have converged as the series are stationary processes. However, divergence in per capita energy is indicated for Tunisia, Cote d'Ivoire, Sudan, Gabon, Zimbabwe, Morocco and Togo, as the series were found to be unit rot processes. To check the robustness of the result from the panel KSS unit root procedure, the process is continued until the last sequence. The finding of this study is consistent with Meng, et al. who found evidence of per capita energy consumption convergence among 23 OECD countries (Meng et al., 2013). The finding is however inconsistent with Jaunky who failed to find evidence supportive of stochastic convergence in capita energy consumption among 22 African countries (Jaunky, 2008). The inconsistencies in the results reported by both studies could be attributed to the differences in methodologies each study applied and the sample period they covered.

Table 4. Panel KSS Unit Root Test Results

Sequence	OU Stat	*p*-value	Min. KSS	Fourier(k)	Series
1	-2.33***	0.00	-5.28	2	Angola
2	-2.35***	0.00	-4.80	2	Mozambique
3	-2.19***	0.00	-4.44	2	Libya
4	-2.09***	0.00	-4.39	2	Tanzania
5	-1.96***	0.01	-4.25	2	Ghana
6	-1.95***	0.01	-4.11	2	Zambia
7	-1.82***	0.01	-4.03	2	Ethiopia
8	-1.79**	0.02	-3.99	2	Algeria
9	-1.77**	0.04	-3.52	2	Senegal
10	-1.70**	0.05	-3.48	2	Congo, Rep.
11	-1.69*	0.06	-3.35	2	South Africa
12	-1.66*	0.07	-3.34	2	Benin
13	-1.59*	0.09	-3.29	2	Cameroon
14	-1.78**	0.05	-3.23	2	Congo, Dem. Rep.
15	-1.66*	0.08	-3.15	2	Nigeria
16	-1.56	0.11	-2.84	2	Tunisia
17	-1.49	0.20	-2.76	2	Cote d'Ivoire
18	-1.47	0.18	-2.42	2	Sudan
19	-1.27	0.31	-2.02	2	Gabon
20	-1.05	0.47	-1.11	2	Zimbabwe
21	-0.81	0.64	-0.28	2	Morocco
22	-0.95	0.82	1.19	2	Togo

***, ** and * indicate levels of significance at the 1%, 5%, and 10%, respectively. The critical values were obtained by 10,000 bootstrapping replications in the spirit of Enders and Lee (2009).

6. Summary and Implications

This study has examined the issue of per capita energy consumption among 22 African countries; namely, Angola, Benin, Cote d'Ivoire, Cameroon, Congo (Republic), Algeria, Ethiopia, Gabon, Ghana, Libya, Morocco, Mozambique, Nigeria, Sudan, Senegal, Togo, Tunisia, Tanzania, South Africa, Congo (Democratic Republic), Zambia, and Zimbabwe. The study adopted the SPSM procedure that has the ability to detect both nonlinearity and structural breaks in the data generating process.

The results from the use of the traditional procedures namely the first and second generation panel unit root tests reveal that the per capita energy consumption series have converged as a group. However, these procedures lack the ability to identify stationary and nonstationary groups in a panel setting. The results from the SPSM procedure suggest that per capita energy consumption for Angola, Mozambique, Libya, Tanzania, Ghana, Zambia, Ethiopia, Algeria, Senegal, Congo Republic, South Africa, Benin, Cameron, Congo Democratic Republic, and Nigeria have converged to the average of the group. This finding indicates that shocks to the per capita energy consumption for these are temporary and hence mean-reverting. However, for Tunisia, Cote d'Ivoire, Sudan, Gabon, Zimbabwe, Morocco and Togo the results indicate that per capita energy consumption have diverged from the group average, implying that shocks to the series are permanent.

With regard to implications, generally, the more detailed the information, the better is the information. Distorted or incomplete information 'can often lead to bad policy choices. This paper provides a greater detailed understanding of the process of convergence for twenty two African countries by using, not just the traditional techniques in analyzing convergence, but also by using the technique of sequential panel selection method.

Just as we suspected, convergence for the entire set of countries does not necessarily imply convergence for all the individual countries in the group. Although we find evidence of convergence for the group as a whole using traditional methods, only a subset of these countries actually do converge. The use of the technique of panel selection method enabled us to identify which of the African countries converged and which diverged.

The predictability and stability of the supply of energy is critical for the expansion and growth of developing countries. The countries we have identified as less stable in energy supply in this study (the seven countries that diverged in energy supply) need to pursue policies to make their energy supply more stable. By so doing, they will make energy supply less of an obstacle, less of a bottleneck, for economic growth. In so doing, these countries may also move from being non-converging to converging, thereby reducing the inequality in living standards between the countries in Africa.

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