INCOME ELASTICITIES OF ELECTRIC POWER CONSUMPTION: EVIDENCE FROM AFRICAN COUNTRIES, 1971-2002

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Abstract

The paper examines the relationship between electric power consumption and real GDP per capita for 16 African countries over the period 1971-2002. Bi-directional causality is found and all tests support the existence of a long run relationship. The short run income elasticity of electric power consumption (YEEPC) is estimated to be 0.39 while the long run elasticities are 0.70 and 0.76 when employing the FMOLS and DOLS respectively. Additionally, YEEPC is found to be pro-cyclical.

Keywords: Electric power consumption, panel causality, panel cointegation, business cycles, Africa

JEL: C23, Q41

1. Introduction

Energy consumption in Africa remains a dominant concern despite its huge potential in fossil and renewable energy sources. A large proportion of the African communities still relies very much on traditional energy sources such as biomass[1] while only one third of them has accessed to electricity. Yet, most of them are subject to frequent rationing and cut-offs. Making electricity more accessible has often been evoked as the key to Africa's prosperity. Efficient YEEPC estimates can provide an indication of how consumption will respond to the ceaseless

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[1] It constitutes about 58% of total energy consumption (Kauffman, 2005).

fall in real income due to the current hike in oil and gas prices and how resilient the energy market is to exogenous shocks.

Several studies on *income elasticity of electric power consumption*, YEEPC, have been done. Branch (1993) uses the generalized least squares (GLS) and finds an income elasticity of residential electricity demand of 0.23 for the US. Holtedahl and Joutz (2004) examine the residential electricity demand for Taiwan and find a short run and long run income elasticity of 0.23 and 1.04 respectively. Liu (2004) has resort to the one-step generalized methods-of-moments (GMM) to uncover the income elasticities of electricity of OECD countries which are between 0.06 and 0.30 in the short run and 0.30 and 1.04 in the long run. The purpose of this study is to evaluate the link between electricity consumption and GDP and estimate the YEEPC for 16 African countries[2] over the period 1971-2002. The remaining of the paper is organized as follows: Section 2 presents the testing framework, section 3 provides the results and section 4 summarizes and concludes.

2. The Testing Framework

To determine YEEPC the following reduced-form equation is estimated:

$$ELEC_{it} = \beta_0 + \beta_1 LGDP_{it} + \varepsilon_{it} \qquad (1)$$

where *ELEC* is natural logarithm of per capita electric power consumption (measured in kWh) and *LGDP* is the natural logarithm of GDP (at constant 2000 US$) per capita. β_1 captures YEEPC. If $\beta_1 < 0$, $0 < \beta_1 < 1$ and $\beta_1 > 1$, electricity consumption is deemed to be an inferior, necessity and luxury good respectively. Electricity is usually considered a normal good. Higher disposable income is expected to boost consumption through greater economic activities and acquisition of electricity-using appliances. As depicted in Figure 1, there seems to be a close link between growth rate of ELEC and LGDP. ε_{it} is the error term.

[2] The selection of countries is purely one on the availability of data gathered from the World Development Indicators (2005).

A Granger-type panel causality test is constructed by using Arellano and Bond's (1991) method. A reverse relationship is likely to yield inconsistent ordinary least squares (OLS) estimators (Gramlich, 1994). Bi-directional causality is synonymous to endogenous regressors which can produce both inconsistent and biased parameters. The model is:

$$ELEC_{it} = \alpha_0 + \sum_{e=1}^{m} \alpha_e ELEC_{it\text{-}k} + \sum_{k=1}^{n} \beta_k LGDP_{it\text{-}k} + \eta_i + u_{it} \qquad (2)$$

where i = 1, ..., N; $t = m$+2, …., T; α_0, α_e, and β_k are parameters to be estimated. u_{it} is the stochastic error. To account for individual effects, the intercept is allowed to vary with each unit as represented by η_i. The test of whether *LGDP* causes *ELEC* is a Wald test of the joint hypothesis where $\beta_1 = \beta_2 = \ldots = \beta_n$ are all equal to zero. If this H_0 is accepted, then *LGDP* does not cause *ELEC*. Ghosh (2002) finds unidirectional causality from economic growth to electricity consumption in India while Shiu and Lam (2004) discover a reverse relationship for the China.

Three panel unit root tests are considered (See Annex 1): Levin-Lin-Chu (2002, LLC) *t*-statistic, Im, Pesaran, and Shin (2003, IPS) The third unit root test is Hadri's (2000) Lagrange Multiplier (LM) test which is based on the KPSS (Kwiatkowski *et al*, 1992) LM-statistics.

Although OLS estimators are usually consistent in case of cointegrating relationship, biases can accrue with the size of the cross section within the panel data (Dreger and Reimers, 2005). Unbiased long run estimates can be obtained by the *fully modified* OLS (FMOLS) and *dynamic* OLS (DOLS) which account for both endogenous and serially correlated regressors. In a bi-variate FMOLS model:

$$y_{it} = \alpha_i + \beta_i x_{it} + u_{it}, \text{ where } x_{it} = x_{it-1} + \varepsilon_{it}, \quad \varpi_{it} = \left(u_{it}, \varepsilon_{it}\right)' \qquad (8a)$$

the asymptotic distribution of the OLS depends on the long run covariance matrix of the residual process ω. For the i-th panel member, the matrix is given by:

$$\Omega_i = \lim_{T\to\infty} \frac{1}{T} E\left(\sum_{t=1}^{T} \varpi_{it}\right)\left(\sum_{t=1}^{T} \varpi_{it}\right)' = \Sigma_i + \Gamma_i + \Gamma_i' = \begin{pmatrix} \varpi_{u,i} & \varpi_{u\varepsilon,i} \\ \varpi_{u\varepsilon,i} & \varpi_{\varepsilon,i} \end{pmatrix} \qquad (8b)$$

where $\sum_i = \lim_{T\to\infty} \frac{1}{T} \sum_{t=1}^{T} E\left(\varpi_{it}\varpi'_{it}\right) = \begin{pmatrix} \sigma^2_{u,i} & \sigma_{u\varepsilon,i} \\ \sigma_{u\varepsilon,i} & \sigma^2_{\varepsilon,i} \end{pmatrix}$ (8c)

and $\sum_i = \lim_{T\to\infty} \frac{1}{T} \sum_{k=1}^{T-1} \sum_{t=k+1}^{T} E\left(\varpi_{it}\varpi'_{it-k}\right) = \begin{pmatrix} \gamma_{u,i} & \gamma_{u\varepsilon,i} \\ \gamma_{u\varepsilon,i} & \gamma_{\varepsilon,i} \end{pmatrix}$ (8d)

denote the matrices of contemporaneous correlation coefficients and the autocovariances, respectively. For convenience, the matrix:

$$\theta_i = \begin{pmatrix} \theta_{u,j} & \theta_{u\varepsilon,i} \\ \theta_{\varepsilon u,j} & \theta_{\varepsilon,j} \end{pmatrix} = \Sigma_i + \Gamma_i = \sum_{j=0}^{\infty} E\left(w_{ij} w_{io}\right)' \quad (8e)$$

is defined. The endogeneity correction is achieved by the transformation:

$$y^*_{it} = y_{it} - \widehat{\varpi}_{u\varepsilon,i} \widehat{\varpi}^{-1}_{u\varepsilon,i} \Delta x_{it} \quad (8f)$$

and the fully modified estimator is:

$$\widehat{\beta}^*_i = \left(X'_i X_i\right)^{-1} \left(X'_i y^*_i - T\widehat{\theta}^i_{\varepsilon u}\right), \text{ where } \widehat{\theta}^*_{\varepsilon u} = \widehat{\theta}_{eu} - \widehat{\theta}_e \varpi^{-1}_{\varepsilon,i} \varpi_{\varepsilon u,i} \quad (8g)$$

For the DOLS, the long run regression is augmented by lead and lagged difference of the dependent and explanatory variables in order to control for serial correlation (Stock and Watson, 1993) and endogenous feedback effects (Saikkonen, 1991). The equation is:

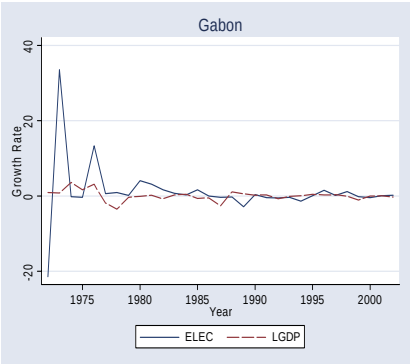
$$y_{it} = \alpha_i + \beta_i x_{it} + \sum_{j=-p_1}^{p_2} \delta_j \Delta y_{it-j} + \sum_{j=-q_1}^{q_2} \lambda_j \Delta x_{it-j} + u_{it} \quad (9)$$

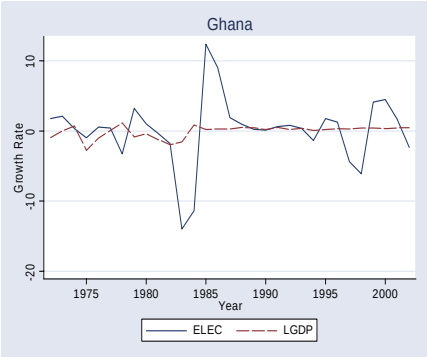
is run for the *i*-th panel member. Kao and Chiang (2000) reveal that the DOLS outperforms the FMOLS estimators in term of mean biases.

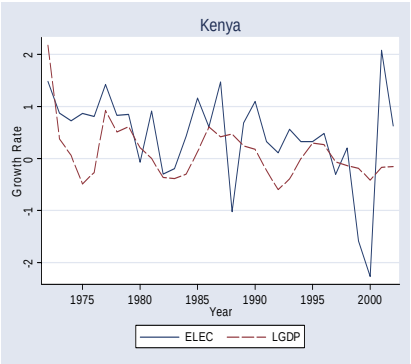
3. Data and Results

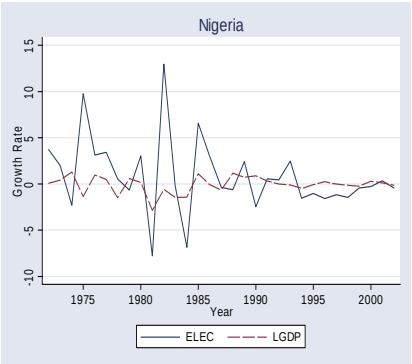
ELEC is natural logarithm of per capita electric power consumption (measured in kWh) and *LGDP* is the natural logarithm of GDP (at constant 2000 US$) per capita. The evolution of these variables in 16 African countries for the period 1971-2002 are presented in the following graphs.

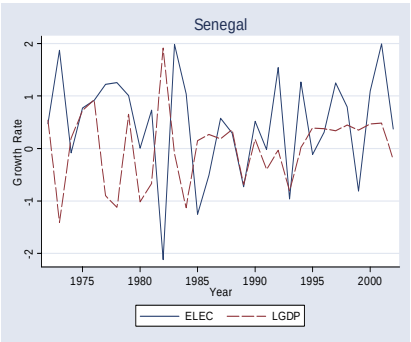
Figure 1: *ELEC* and *LGDP* for Individual Countries, 1972-2002

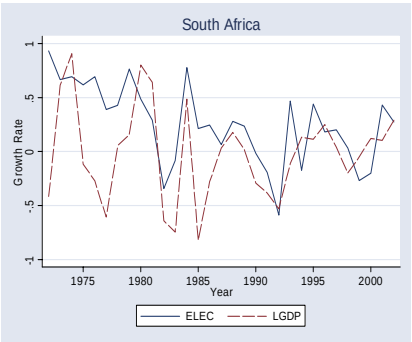

Gabon
Growth Rate
40
20
0
-20
1975
1980
1985
1990
1995
2000
Year
ELEC
LGDP

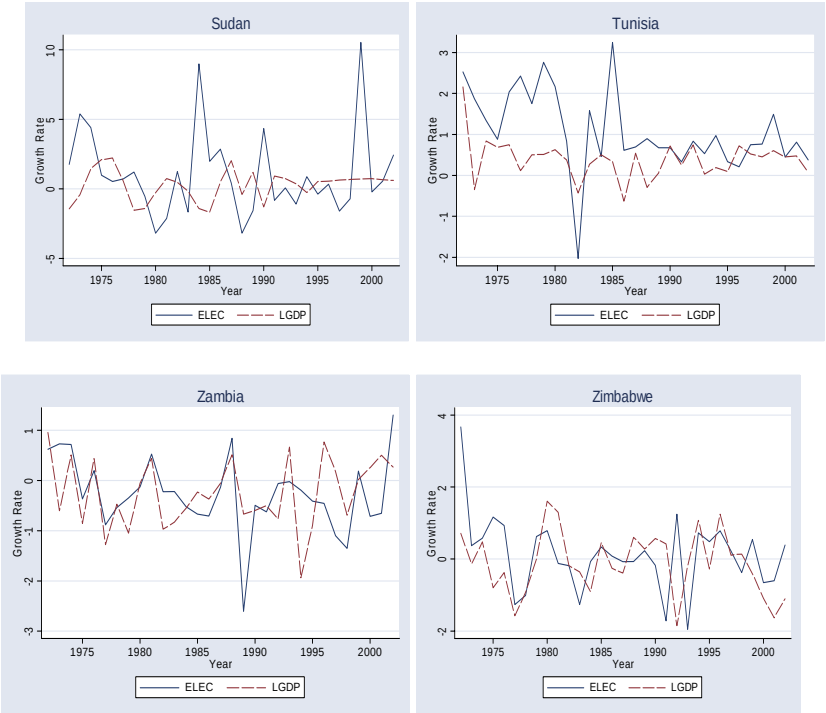

Ghana
Growth Rate
10
0
-10
-20
1975
1980
1985
1990
1995
2000
Year
ELEC
LGDP


Kenya
Growth Rate
2
1
0
-1
-2
1975
1980
1985
1990
1995
2000
Year
ELEC
LGDP


Nigeria
Growth Rate
15
10
5
0
-5
-10
1975
1980
1985
1990
1995
2000
Year
ELEC
LGDP


Senegal
Growth Rate
2
1
0
-1
-2
1975
1980
1985
1990
1995
2000
Year
ELEC
LGDP


South Africa
Growth Rate
1
.5
0
-.5
-1
1975
1980
1985
1990
1995
2000
Year
ELEC
LGDP



Source: Computed. Year on Year of Growth Rates.

For the causality test, the maximum lag length is set to be 10. In line with Holtz-Eakin *et al* (1988), the lag length is assumed to be less than $T/3$, or else the covariance matrix will not be correctly estimate due to over identification problem. As illustrated in Table 1, when the lag length is equal to two the pre-requite conditions for causality are fulfilled. The relatively short lag length indicates an immediate impact of *LGDP* on *ELEC*. On the other hand, it seems that the impact of *ELEC* on *LGDP* might not be instantaneously exerted. Causality conditions are only achieved when the lag length is equal to nine which points towards a possible long-run induced effect of electric power consumption on income. It might be because of low consumption levels of technology to assist national production. However, due to multicollinearity problems among the lagged variables, the panel causality test cannot distinguish

whether *LGDP* has a positive or negative effect on long run electric power consumption. Further analyses are required.

As shown in Table 2(a) and Table 2(b) the order of integration of time series for the ADF seems to match that of the KPSS. Panel unit root tests as subsequently discussed. *ELEC* is I(0) as per LLC but I(1) in regards to IPS and Hadri. For *LGDP*, all tests appear to converge. As per LLC and IPS tests, *LGDP* is most likely to be I(1) while for Hadri's test H_0 is accepted for the first-differenced data at 5% significance level when controlling for serial correlation.

As highlighted in table 4(a), the NH test statistics support cointegration. Results for Pedroni's tests are presented in Table 4(b). In terms of power when T is small, the group-adf statistic usually performs best, followed by the panel-adf statistic, whereas panel-v and the group-ρ statistics do poorly (Pedroni, 1997). H_0 is systematically rejected when referring to the group-adf and panel-adf statistics.

As exposed in Table 5, various models of Income Elasticity of Electric Power Consumption, YEEPC, are applied and compared. Using pooled OLS, an error correction mechanism[3] (ECM) is estimated. The short run income elasticity is 0.39. The two-way causality raises need for efficient methods.

Table 6 illustrates the long run elasticities. The YEEPC of the DOLS ranges from -1.90 (Gabon) to 3.70 (Benin). With a few exceptions (Gabon, Nigeria, Senegal, South Africa), some elasticities are discovered to be significantly less than zero. This denotes evidence against the ordinary economic connection. Other control variables are needed for the individual time-series regressions to really assess the impact of *LGDP* on *ELEC*. Both short run and long run estimates are close to those found in the literature.

[3] See Appendix 2 for derivation.

Table 5: Regression Results

Variables	Pooled OLS	Between-Effects (BE)	Fixed-Effects (FE)	Random-Effects (RE)	Prais-Winsten (PW)	ECM
$LGDP_{it}$	0.89	0.88	1.18	1.16	0.89	-
	(0.05)*	(0.28)*	(0.08)*	(0.07)*	(0.03)*	-
$\Delta LGDPPC_{it}$	-	-	-	-	-	0.39
	-	-	-	-	-	(0.19)**
ε_{it-1}	-	-	-	-	-	-0.03
	-	-	-	-	-	(0.01)**
Constant	-0.36	-0.28	-2.25	-2.12	-0.36	-
	(0.31)	(1.84)	(0.49)*	(0.53)*	(0.14)*	-
R^2	0.40	0.41	0.33	0.40	0.41	0.05
Observations	512	512	512	512	512	496
Countries	16	16	16	16	16	16
Period	71-02	71-02	71-02	71-02	71-02	72-02

Source: Computed. Note: The standard errors are given in parentheses. Excluding the Prais-Winsten model, all of these are robust ones. R^2 is between- R^2, within-R^2 and overall-R^2 for BE, FE and RE models respectively. In case disturbances are not *iid*, Prais and Winsten (1954, PW) recommend a panel-corrected standard error, which can correct for both correlated and heteroskedastic residuals. The PW parameters are estimated using OLS while assuming there is no first-order autocorrelation (refer to Table 6).

YEEPC is modelled in relation to business cycles. An indicator for the latter is obtained as a cyclical component of the Hodrick-Precott[4] (HP) decomposition of natural logarithm of GDP. A YEEPC series is compiled by running cross-sectional regressions[5] over the period 1971-

[4] The HP filter is a two-sided linear filter that computes the smoothed series *s* of *y* by minimizing the variance of *y* around *s*, subject to a penalty that constrains the second difference of *s*. The smoothing parameter λ = 100 as per the frequency power rule of Ravn and Uhlig (2002) i.e. the number of periods per year divided by 4, raised to a power of 2 and multiplied by 1600.The HP chooses *s* to minimize: $\sum_{t=1}^{T}(y_t - s_t)^2 + \lambda\sum_{t=2}^{T-1}\left((s_{t+1} - s_t) - (s_t - s_{t-1})\right)^2$.

[5] Expect for the year 1972, the cross-country estimates of YEEPC were found to statistically significant at conventional levels.

2002. The population-averaged generalized estimating equations (GEE) model is utilized as it enables complex correlation structures modelling and accommodates individual/cluster-level variables which are fine-tuned for within-individual/cluster correlation. The number of repeated observations is allowed to vary among individual countries whilst the interpretation of the coefficients is left unaffected. In Table 7, the significantly positive coefficient implies that electric power consumption follows a pro-cyclical pattern. Put more plainly, low levels of YEEPC are associated with recession periods while high levels of YEEPC are associated with expansion periods. Such behaviour is consistent with electricity being a necessity.

4. Conclusion

In this paper we have examined the YEEPC for 16 African countries over the period 1971-2002. Bi-directional causality is established between *ELEC* and *LGDP*. These variables follow an I(1) process and are cointegrated. Electric power is found to be a necessity both in the short run and long run. YEEPC is also found to be pro-cyclical.

YEEPC studies have practical applications. Results from the panel data techniques can provide some insights at embryonic stages of research to African policy makers in regards to institutional reforms in the electric utility sector. Per se, the plan of action of the Union of Producers, Transporters and Distributors of Electric Power in Africa (UPDEA) to promote major reforms in the power sector is well supported. In addition to being a necessity, electric power is found to Granger-cause economic growth and vice versa. Greater access to electricity is bound to sustain economic growth and promote welfare in Africa.

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Appendix 1

First, the Levin-Lin-Chu (2002, LLC) *t*-statistic, which is based on the Augmented Dickey-Fuller (ADF) *t*-statistics, is given as:

$$t_{\rho}^{*} = \frac{t_{\rho=0} - N\tilde{T}\hat{S}_{NT}\hat{\sigma}_{\varepsilon}^{-2}\hat{\sigma}_{\rho}\mu_{\tilde{T}}^{*}}{\sigma_{\tilde{T}}^{*}} \qquad (3)$$

$\mu_{\tilde{T}}^{*}$ and $\sigma_{\tilde{T}}^{*}$ are obtained via Monte Carlo simulations. The standard errors and variances are $\hat{S}_{NT}$, $\hat{\sigma}_{\varepsilon}^{2}$ and $\hat{\sigma}_{\rho}$ respectively. LLC test is based on the idea of the homogeneity.

Im, Pesaran, and Shin (2003, IPS) propose a test which is a based on heterogeneity. The *t*-bar statistics are defined as the average of the individual Dickey-Fuller τ-statistics as:

$$\bar{t}_{NT} = \frac{1}{N}\sum_{i=1}^{N}\tau_i \qquad , \tau_i = \frac{\hat{\rho}_i}{\hat{\sigma}_{\phi_i}} \qquad i = 1, 2, \ldots \ldots, N \qquad (4a)$$

where τ_i is the ADF test statistic for the ith country. The standardized *t*-bar statistic is:

$$\psi_{\bar{t}} = \frac{\sqrt{N}\left\{\bar{t}_{NT} - \frac{1}{N}\sum_{i=1}^{N}E\left[t_{iT}(\rho_i, 0)\right]\right\}}{\sqrt{\frac{1}{N}\sum_{i=1}^{N}Var\left[t_{it}\left(\rho_i, 0\right)\right]}} \qquad (4b)$$

where N is the number of panels, $\bar{t}_{NT}$ is the average of the ADF test for each series across the panel and values for $E[t_{iT}(p_i,0)]$ and $Var[t_{it}(p_i,0)]$ are obtained from Monte Carlo simulation results. Ψ_t statistics are compared to critical values of the $N(0,1)$ distribution.

The third unit root test is Hadri's (2000) Lagrange Multiplier (LM) test which is based on the KPSS (Kwiatkowski *et al*, 1992) LM-statistics:

$$L\widehat{M}_{\mu} = \frac{1}{N}\sum_{i=1}^{N}\eta_i \tag{5a}$$

where H_0 of level or trend stationary is tested against the alternative of unit root in panel. Assuming $\mathrm{E}\left[u_{i,t}\right] = \mathrm{E}\left[\varepsilon_{i,t}\right] = 0$, $u_{\mathrm{i,t}}$ and $\varepsilon_{\mathrm{i,t}}$ are independent and identically distributed (*iid*) across *i* and over *t*, the test statistic's limiting distribution is:

$$Z_{\mu} = \frac{\sqrt{N}\left(L\widehat{M}_{\mu} - \xi_{\mu}\right)}{\zeta_{\mu}} \Rightarrow N\left(0,1\right) \tag{5b}$$

where $\Rightarrow$ represents weak convergence in distribution, ξ_{μ}, ζ_{μ} are mean and variance of the standard Brownian bridge. In general, the IPS unit root test tends to have high and low power in panels with large *T* and small *T* respectively (Karlsson and Löthgen, 2000) while the Hadri test performs well for panel data with short *T* (Barhoumi, 2005).

Two panel cointegration tests are considered. First, Nyblom and Harvey (2000, NH) postulate a test of common trends where H_0 is the stationarity of the series around a deterministic trend, i.e. there exists $k < n$ common trends (i.e. rank $(\Sigma\eta) = k$), against the alternative of a random walk component occurrence i.e. there exists more than *k* common trends (i.e. rank $(\Sigma\eta) > k$). In other words, the NH technique tests for the H_0 of 0 common trends against the hypothesis of common trends among the variables. If A, the $r \times n$ matrix of cointegrating vectors is known, then NH test statistic is written as:

$$\xi r(A) = tr(ASA')^{-1}ACA' \tag{6a}$$

where *S* is the nonparametric estimator of the spectral density at frequency zero using a Bartlett Window as stated by KPSS:

$$S = \widehat{\Gamma}_0 + \sum_{j=1}^{m}\left[1 - \frac{j}{m+1}\right]\left[\widehat{\Gamma}_j + \widehat{\Gamma}_{j'}\right] \tag{6b}$$

where *m* is the number of lags in the transitory component and

$$\widehat{\Gamma}_j = \frac{1}{T}\sum_{t=j+1}^{T}\left(y_t - \overline{y}\right)\left(y_{t-j} - \overline{y}\right)' \tag{6c}$$

add C is an estimator of the second moments of partial sums of the time series:

$$C = \frac{1}{T^2}\sum_{i=1}^{T}\left[\sum_{i=1}^{i}\left(y_t - \overline{y}\right)\right]' \tag{6d}$$

This test is specifically a test of the pre-specified cointegrating vectors, i.e. a test of A.

Second, the Pedroni (1999, 2004) panel cointegration tests are calculated by using the residuals of Engle and Granger (1987) regression. The residuals are computed from:

$$y_{i,t} = a_t' + \ddot{a}_t t + \widehat{a}_{1t}x_{1i,t} + \widehat{a}_{2t}x_{2i,t} + \ldots + \widehat{a}_{Mt}x_{Mi,t} + e_{i,t} \tag{7a}$$

for $t = 1, \ldots \ldots, T$; $i = 1, \ldots \ldots, N$; $m = 1, \ldots \ldots, M$. T refers to the number of observations over time, N refers to the number of individual members in the panel and M refers to the number of regression variables. The $\hat{a}_{1i}$, $\hat{a}_{2i}$, ..., $\hat{a}_{Mi}$ are permitted to vary across individual members of the panel. The parameter a' is the fixed effects parameter which is also allowed to vary across individual members. These are specific to individuals and are captured by the term $\ddot{a}_t t$.

The standardized distributions are given by:

$$\frac{x_{N,T} - \mu\sqrt{N}}{\sqrt{v}} \Rightarrow N(0,1) \tag{7b}$$

where $x_{N,T}$ is the appropriately standardized form for each of the N, T statistics and the values for μ and v are the mean and variance as given by Pedroni (1999) respectively.

Appendix 2: Derivation of the First-Order Panel ECM model

Consider the equation below:

$$ELEC_{it} = \beta_0 + \beta_1 LGDP_{it} + \varepsilon_{it} \qquad (1)$$

To derive the long run equilibrium dynamics (Engle and Granger, 1987) equation (1) is re-written as follows, at the same time as assuming $ELEC_{it}$ and $LGDP_{it}$ are I(1) and ε_{it} is white-noise:

$$ELEC_{it} = \beta_0 + \beta_1 LGDP_{it} + \beta_2 LGDP_{it\text{-}1} + \beta_3 ELEC_{it\text{-}1} + \varepsilon_{it}$$

Subtracting $ELEC_{it\text{-}1}$ on both sides:

$$ELEC_{it} - ELEC_{it\text{-}1} = \beta_0 + \beta_1 LGDP_{it} + \beta_2 LGDP_{it\text{-}1} + \beta_3 ELEC_{it\text{-}1} - ELEC_{it\text{-}1} + \varepsilon_{it}$$
$$\Delta ELEC_{it} = \beta_0 + \beta_1 LGDP_{it} + \beta_2 LGDP_{it\text{-}1} + (\beta_3 - 1) ELEC_{it\text{-}1} + \varepsilon_{it}$$

Reparametrizing the above equation:

$$\Delta ELEC_{it} = \beta_0 + \beta_1 LGDP_{it} - \beta_1 LGDP_{it\text{-}1} + \beta_1 LGDP_{it\text{-}1} + \beta_2 LGDP_{it\text{-}1} + (\beta_3 - 1) ELEC_{it\text{-}1} + \varepsilon_{it}$$

$$\Delta ELEC_{it} = \beta_0 + \beta_1 \Delta LGDP_{it} + (\beta_1 + \beta_2) LGDP_{it\text{-}1} + (\beta_3 - 1) ELEC_{it\text{-}1} + \varepsilon_{it}$$

$$\Delta ELEC_{it} = \beta_1 \Delta LGDP_{it} + (\beta_1 + \beta_2) LGDP_{it\text{-}1} + \beta_0 + (\beta_3 - 1) ELEC_{it\text{-}1} + \varepsilon_{it}$$

$$\Delta ELEC_{it} = \beta_1 \Delta LGDP_{it} - (1 - \beta_3)\left[ELEC_{it\text{-}1} - \frac{\beta_0}{1 - \beta_3} - \frac{\beta_1 + \beta_2}{1 - \beta_3} LGDP_{it\text{-}1} \right] + \varepsilon_{it}$$

$$\Delta ELEC_{it} = \beta_1 \Delta LGDP_{it} - \lambda\left[ELEC_{it\text{-}1} - \lambda_0 - \lambda_1 LGDP_{it\text{-}1} \right] + \varepsilon_{it}$$

$$\therefore \Delta ELEC_{it} = \beta_1 \Delta LGDP_{it} - \lambda \varepsilon_{it,\text{-}1} + \varepsilon_{it},$$

The disequilibrium error $\varepsilon_{it,\text{-}1} = ELEC_{it\text{-}1} - \lambda_0 - \lambda_1 LGDP_{it\text{-}1}$ and is assumed to be I(0). λ measures the speed of adjustment towards the long run equilibrium.

Appendix 3

Table 1: Panel Causality Tests

	ΔELEC									
Y1	*0.686*	*0.475*	*0.529*	*0.536*	*0.515*	*0.532*	*0.528*	*0.529*	*0.573*	*0.551*
(-1)	*(0.033)**	*(0.040)**	*(0.048)**	*(0.049)**	*(0.049)**	*(0.052)**	*(0.052)**	*(0.051)**	*(0.055)**	*(0.056**
		0.240	*0.177*	*0.154*	*0.184*	*0.171*	*0.173*	*0.169*	*0.138*	*0.162*
(-2)		*(0.037)**	*(0.046)**	*(0.054)**	*(0.055)**	*(0.057)**	*(0.059)**	*(0.058)**	*(0.061)***	*(0.064**
			0.048	*0.030*	*-0.071*	*-0.078*	*-0.080*	*-0.092*	*-0.097*	*-0.11*
(-3)			*(0.040)*	*(0.048)*	*(0.055)*	*(0.057)*	*(0.059)*	*(0.058)*	*(0.061)*	*(0.061‡*
				0.010	*-0.025*	*0.011*	*0.015*	*0.020*	*0.026*	*0.00*
(-4)				*(0.042)*	*(0.049)*	*(0.058)*	*(0.053)*	*(0.059)*	*(0.063)*	*1*
					0.105	*0.096*	*0.092*	*0.085*	*0.074*	*(0.0*
(-5)					*(0.043)***	*(0.052)**	*(0.060)*	*(0.060)*	*(0.063)*	*63)*
						-0.027	*-0.016*	*-0.055*	*-0.044*	*0.08*
-6)						*(0.044)*	*(0.053)*	*(0.059)*	*(0.062)*	*0*
							-0.017	*0.023*	*0.019*	*(0.0*
(-7)							*(0.046)*	*(0.052)*	*(0.062)*	*64)*
								-0.013	*0.001*	*-*
(-8)								*(0.045)*	*(0.054)*	*0.05*
									-0.024	*6*
(-9)									*(0.047)*	*(0.0*
										63)
(-10)										*0.01*
										6
										(0.0
										62)
										0.00
										3
										(0.0
										62)
										-
										0.05
										8
										(0.0
										54)
										0.03
										7
										(0.0
										47)

	ΔLGDP									
Y1	0.953	1.210	1.246	1.262	1.251	1.214	1.262	1.209	1.231	*1.205*
(-1)	(0.019)*	(0.044)*	(0.048)*	(0.047)*	(0.049)*	(0.047)*	(0.051)*	(0.051)*	(0.054)*	*(0.054)**
		-0.283	-0.318	-0.365	-0.360	-0.393	-0.422	-0.282	-0.307	*-0.253*
(-2)		(0.044)*	(0.070)*	(0.072)*	(0.075)*	(0.072)*	(0.076)*	(0.078)*	(0.082)*	*(0.084)**
			0.005	0.022	0.045	0.126	0.155	0.089	0.047	*0.054*
(-3)			(0.046)	(0.070)	(0.073)	(0.070)‡	(0.076)**	(0.075)	(0.081)	*(0.082)*
				0.032	-0.047	-0.113	-0.174	-0.153	-0.126	*-0.216*
(-4)				(0.045)	(0.069)	(0.068)‡	(0.072)**	(0.072)**	(0.077)‡	*(0.080)**
					0.032	0.113	0.142	0.098	0.077	*0.145*
(-5)					(0.045)	(0.063)‡	(0.070)**	(0.069)	(0.074)	*(0.075)‡*
						-0.070	-0.012	-0.015	0.005	*-0.043*
-6)						(0.041)	(0.065)	(0.066)	(0.071)	*(0.073)*
							-0.065	0.034	-0.004	*0.022*
(-7)							(0.042)	(0.062)	(0.067)	*(0.066)*
								-0.078	-0.005	*-0.023*
(-8)								(0.040)‡	(0.063)	*(0.066)*
									-0.055	*0.012*
(-9)									(0.041)	*(0.061)*
										-0.067
(-10)										*(0.041)‡*
Y2	-0.009	0.019	0.001	-0.098	-0.009	0.006	0.006	0.009	0.007	*0.007*
(-1)	(0.009)	(0.052)	(0.010)	(0.017)	(0.017)	(0.016)	(0.016)	(0.015)	(0.016)	*(0.016)*
		-0.012	-0.317	0.028	0.024	0.028	0.017	0.019	0.023	*0.027*
(-2)		(0.014)	(0.070)	(0.019)	(0.019)	(0.017)	(0.018)	(0.017)	(0.018)	*(0.018)*
			0.031	0.042	0.049	0.027	0.033	0.020	0.024	*0.021*
(-3)			(0.015)**	(0.017)**	(0.019)*	(0.018)	(0.018)	(0.017)	(0.018)	*(0.017)*
				-0.047	-0.075	-0.032	-0.029	-0.026	-0.020	*-0.018*
(-4)				(0.015)*	(0.017)*	(0.018)‡	(0.019)	(0.018)	(0.018)	*(0.018)*
					0.031	0.009	-0.014	-0.010	-0.003	*-0.002*
(-5)					(0.015)**	(0.016)	(0.018)	(0.018)	(0.018)	*(0.018)*
						0.015	0.023	-0.005	-0.011	*-0.007*
(-6)						(0.014)	(0.016)	(0.018)	(0.018)	*(0.018)*
							0.006	0.021	0.039	*0.032*
(-7)							(0.014)	(0.016)	(0.018)**	*(0.018)*
								0.001	-0.008	*0.319*
(-8)								(0.014)	(0.015)	*(0.018)**
									-0.001	*-0.011*
(-9)									(0.014)	*(0.015)*
										0.016
(-10)										*(0.013)*
	-0.0004	-0.0004	-0.001	-0.0001	-0.0004	-0.001	-0.001	-0.0004	-0.0007	*-0.001*
Constant	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0004)	(0.0004)**	(0.0004)‡	(0.0004)	(0.0004)	*(0.0004)‡*
Obs	*480*	*464*	*448*	*432*	*416*	*400*	*384*	*368*	*352*	*336*
Sargan Test	*0.187*	*1.000*	*1.000*	*1.000*	*1.000*	*0.997*	*1.000*	*0.997*	*1.000*	*1.000*
AR(1)	*0.000**	*0.000**	*0.000**	*0.000*	*0.000**	*0.000**	*0.000**	*0.000**	*0.000**	*0.000**
AR(2)	*0.024***	*0.551*	*0.119*	*0.001**	*0.040***	*0.023***	*0.007**	*0.335*	*0.104*	*0.258*
Wald	*0.94*	*1.51*	*5.03*	*14.82*	*25.50*	*24.13*	*15.62*	*11.44*	*17.39*	*22.67*
Tests	*[0.332]*	*[0.469]*	*[0.170]*	*[0.005]**	*[0.000]**	*[0.001]**	*[0.03]***	*[0.178]*	*[0.043]***	*[0.012]***

Source: Computed. The p-value for the Sargan test, AR(1) and AR(2) serial correlation tests is reported. *, ** and ‡ denote 1%, 5% and 10% significance level respectively. The standard errors are given in parentheses while the p-values are in square brackets. For the panel regression, the Arellano & Bond (1991) one-step dynamic generalized methods-of-moments (GMM) estimators are computed. Their consistency depends on the Sargan test of overidentifying restrictions, which tests the overall validity of the instruments. Absence of second order correlation in the error term is also a pre-requisite. So, H_0 should not be rejected. Their p-values are reported.

Table 2(a): Individual ADF statistics

Country	ELEC							
	Level Form				First Difference			
	With C and Without Trend		With C and With Trend		With and Without Trend		With C and With Trend	
	ADF	ρ	ADF	ρ	ADF	ρ	ADF	ρ
Algeria	-1.885	0	-0.876	0	-3.508**	0	-3.697**	2
Benin	-2.020	2	-4.084*	0	-5.264*	1	-5.382‡	1
Cameroon	-1.432	0	-2.139	1	-3.434**	0	-3.409‡	0
Congo,	-0.525	0	-1.442	0	-4.658*	0	-5.057*	0
Dem.	-0.517	1	-1.687	3	-2.321	3	-11.606*	0
Congo,	-0.692	0	-1.546	0	-4.298*	0	-4.723*	1
Rep.	-2.624	3	-0.336	2	-0.999	2	-4.021*	3
Egypt	-2.753	1	-3.119	1	-3.998*	1	-3.898**	1
Gabon	-1.698	0	-2.553	0	-4.876*	0	-4.940*	0
Ghana	-2.067	2	-1.952	0	-5.269*	1	-5.775*	1
Kenya	-2.291	0	-1.626	0	-4.841*	0	-4.635*	1
Nigeria	-4.550*	0	-1.360	0	-2.444	0	-3.622**	0
Senegal	-1.929	0	-3.041	2	-3.614**	0	-3.605**	0
South	-1.815	0	-1.616	0	-2.011	3	-3.647**	2
Africa	0.721	0	-2.242	0	-4.191*	0	-5.065*	0
Sudan	-1.647	1	-2.138	1	-2.576	1	-3.285‡	1
Tunisia								
Zambia								
Zimbabwe								

Country	*LGDP*							
	Level Form				First Difference			
	With C and Without Trend		With C and With Trend		With C and Without Trend		With C and With Trend	
	ADF	ρ	ADF	ρ	ADF	ρ	ADF	ρ
Algeria	-2.070	1	-.15	3	-6.63*	0	-4.38*	2
Benin	-2.001	0	-2.22	1	-3.90*	0	-3.50‡	1
Cameroon	-1.721	3	-1.58	2	0.19	3	-0.79	3
Congo, Dem.	0.180	1	-3.02	3	-4.65*	0	-5.05*	0
Congo, Rep.	-1.778	1	-2.28	1	-2.12	0	-2.16	0
Egypt	-1.113	0	-.53	0	-2.45	0	-5.98*	3
Gabon	-2.552	1	-3.27	1	-3.08**	0	-3.10	0
Ghana	-1.886	0	-.83	0	-3.33**	0	-3.57‡	0
Kenya	-1.686	3	-2.39	3	-3.78*	2	-3.69**	2
Nigeria	-2.855‡	3	-2.33	3	-1.47	3	-1.37	3
Senegal	-2.886‡	0	-4.08**	1	-5.77*	1	-5.54*	1
South Africa	-1.565	0	-1.95	0	-3.63**	0	-3.92**	0
Sudan	-3.862*	2	-3.88**	2	-4.42*	2	-4.36*	2
Tunisia	-3.030*	0	-3.257	0	-7.39*	0	-7.81*	0
Zambia	-.0133	0	-3.64**	0	-6.37*	0	-6.12*	0
Zimbabwe	-3.218*	2	-2.74	1	-3.55**	2	-4.07**	2

Source: Computed. Note: To select the order of lag ρ, we start with a maximum lag length of 3 and pare it down as per the Akaike Information Criterion. There is no general rule on how to choose the maximum lag to start with. Researchers usually employ a rule of thumb which is the cube root of the number of observation (Al Mamun and Nath, 2005). Hence, $\sqrt[3]{32} \approx 3.174$. Critical values for the individual ADF tests are computed by means of the Cheung and Lai (1995) response surface equation. The critical values for the ADF test at level form are given as follows: For lag 0, 1, 2 and 3 the critical values for ADF unit root tests which include only a constant are -3.676, -3.660, -3.650 and -3.645; -2.972, -2.953, -2.935 and -2.919; and -2.627, -2.607, -2.588 and -2.569 at 1%, 5% and 10% significance level respectively. For lag 0, 1, 2 and 3 the critical values of the ADF unit root tests which include a constant and a trend are -4.323, -4.298, -4.282 and -4.277; -3.586, -3.561, -3.537 and -3.517; and -3.235, -3.209, -3.183, -3.158 at 1%, 5% and 10% significance level respectively. In addition, the critical values for first-differenced variables are as follows: The critical values for the ADF test at level form are given as follows: For lag 0, 1, 2 and 3 the critical values for ADF unit root tests which include only a constant are -3.687, -3.672, -3.662 and -3.660; -2.977, -2.958, -2.939 and -2.925; and -2.629, -2.609, -2.590 and -2.571 at 1%, 5% and 10% significance level respectively. For lag 0, 1, 2 and 3 the critical values of the ADF unit root tests which include a constant and a trend are -4.340, -4.317, -4.300 and -4.297; -3.594, -3.569, -3.545 and -3.524; -3.239, -3.213, -3.189 and -3.164 at 1%, 5% and 10% significance level respectively.

Table 2(b): Individual KPSS η-statistics

Country	*ELEC*							
	Level Form				First Difference			
	η_m	ρ	η_t	ρ	η_m	ρ	η_t	ρ
Algeria	1.220*	2	0.310*	2	0.647*	2	0.080	2
Benin	1.660*	2	0.133‡	2	0.142	2	0.111	2
Cameroon	0.331	2	0.249*	2	0.213	2	0.050	2
Congo, Dem.	1.140*	2	0.176**	2	0.080	2	0.069	2
Congo, Rep.	0.481**	2	0.250*	2	0.213	2	0.105	2
Egypt	1.240*	2	0.296*	2	0.263	2	0.090	2
Gabon	0.750*	2	0.281*	2	0.283	2	0.086	2
Ghana	0.173	2	0.104	2	0.040	2	0.039	2
Kenya	1.180*	2	0.240*	2	0.387‡	2	0.041	2
Nigeria	0.852*	2	0.296*	2	0.510‡	2	0.047	2
Senegal	1.140*	2	0.158‡	2	0.158	2	0.154‡	2
South Africa	1.090*	2	0.294*	2	0.680**	2	0.124‡	2
Sudan	1.080*	2	0.061	2	0.075	1	0.074	1
Tunisia	1.260*	2	0.275*	2	0.392‡	2	0.090	4
Zambia	1.210*	2	0.233*	2	0.262	1	0.112	2
Zimbabwe	0.308	2	0.129‡	2	0.300	3	0.142‡	2
Country	*LGDP*							
	Level Form				First Difference			
	η_m	ρ	η_t	ρ	η_m	ρ	η_t	ρ
Algeria	0.322	2	0.257*	2	0.539**	2	0.226*	2
Benin	0.675**	2	0.136**	2	0.158	2	0.082	2
Cameroon	0.268	2	0.264*	2	0.330	2	0.151‡	2
Congo, Dem.	1.200*	2	0.257*	2	0.267	2	0.086	2
Congo, Rep.	0.342	2	0.262*	2	0.262	2	0.068	2
Egypt	1.220*	2	0.266*	2	0.222	2	0.074	2
Gabon	0.356‡	2	0.080	2	0.145	2	0.086	2
Ghana	0.353‡	2	0.305*	2	0.548**	2	0.049	2
Kenya	0.743*	2	0.224*	2	0.354	2	0.049	2
Nigeria	0.604**	2	0.198**	2	0.092	5	0.076	5
Senegal	0.255	2	0.178**	2	0.150	2	0.049	2
South Africa	0.860*	2	0.134‡	2	0.080	2	0.075	2
Sudan	0.760*	1	0.179**	1	0.119	2	0.054	2
Tunisia	1.240*	4	0.156‡	4	0.259	2	0.195**	2
Zambia	1.240*	2	0.144‡	2	0.155	2	0.119‡	2
Zimbabwe	0.115	2	0.073	2	0.103	2	0.074	2

Source: Computed. Note: η_m and η_t are the level and trend stationarity cases respectively. The 1%, 5% and 10% critical values are 0.739, 0.463 and 0.347 for level stationarity and 0.216, 0.176 and 0.119 for trend stationarity correspondingly. Theses critical values are given by Kwiatkowski *et al* (1992). The order of lag ρ is determined by the automatic bandwidth selection procedure as proposed by Newey and West (1994). The test's denominator is computed by employing the Quadratic Spectral kernel function.

Table 3(a): LLC Panel Unit Root Test statistics

Variable	Deterministics	Level Form		First Difference	
		t-value	*t**	*t*-value	*t**
ELEC	Constant	-4.17	-2.02 [0.022]**	-21.30	-13.78 [0.000]*
	Constant + Trend	-10.61	-4.35 [0.000]*	-25.08	-14.14 [0.000]
LGDP	Constant	-4.21	-1.16 [0.122]	-18.19	-12.32 [0.000]
	Constant + Trend	-8.90	-1.86 [0.031]**	-18.82	-9.07 [0.000]*

Source: Computed. Note: The LLC test can be viewed as a pooled Dickey-Fuller test, or an Augmented Dickey-Fuller (ADF) test when lags are included, with the null hypothesis that of non-stationarity (I(1) behavior). The lag lengths for the panel test are based on those employed in the univariate ADF test. These statistics are distributed as standard normal as both *N* and *T* grow large. Assuming no cross-country correlation and *T* is the same for all country, the normalized *t** test statistic is computed by using the *t*-value statistics. After transformation by factors provided by LLC, the *t** tests is distributed standard normal under the null hypothesis of non-stationarity. Hence, it is compared the 1%, 5% and 10% significance levels with critical values of the lower tail of the *N*(0,1) distribution i.e. -2.326, -1.645 and -1.282 correspondingly. The p-values are in square brackets.

Table 3(b): IPS Panel Unit Root Test statistics

Variabl	Data	Determinist	Level Form		First Difference	
			t-bar	Ψ_t	*t*-bar	Ψ_t
ELEC	Raw	Constant	-2.17*	-2.97 [0.001]*	-4.62*	-13.99 [0.000]*
		Constant + Trend	-2.54**	-1.86 [0.031]**	-5.32*	-15.34 [0.000]*
	Demeaned	Constant	-1.58	-0.32 [0.371]	-5.35*	-17.25 [0.000]*
		Constant + Trend	-2.70*	-2.63 [0.001]*	-5.99*	-18.62 [0.000]*
LGD	Raw	Constant	-1.91**	-1.82 [0.034]**	-4.44*	-13.20 [0.000]*
		Constant + T	-2.23	-0.37 [0.356]	-4.18*	-9.83 [0.000]*
	Demeaned	Constant	-1.72	-0.98 [0.164]	-4.44*	-13.18 [0.000]*
		Constant + T	-2.25	-0.47 [0.317]	-4.56*	-11.65 [0.000]*

Source: Computed. Note: The IPS test statistics are computed as the average ADF statistics across the sample. The lag lengths for the panel test are based on those employed in the univariate ADF test. These statistics are distributed as standard normal as both *N* and *T* grow large. *t*-bar is the panel test based on the ADF statistics. Critical values for the *t*-bar statistics without trend at 1%, 5% and 10% significance levels are -1.980, -1.850 and -1.780 while with inclusion of a time trend, the critical values are-2.590, -2.480 and -2.410 respectively. Assuming no cross-country correlation and *T* is the same for all country, the normalized Ψ_t test statistic is computed by using the *t*-bar statistics. The Ψ_t-tests for H_0 of joint non-stationarity and is compared to the 1%, 5% and 10% significance levels with critical values of the lower tail of the *N*(0,1) distribution i.e. -2.326, -1.645 and -1.282 correspondingly.

Table 3(c): Hadri Panel Unit Root Test LM Statistics

Variables	Level Form					
	Homoskedastic Disturbances		Heteroskedastic Disturbances		Controlling for Serial Dependence in Errors	
	Z_μ	Z_t	Z_μ	Z_t	Z_μ	Z_t
ELEC	57.007 [0.000]*	35.528 [0.000]*	50.847 [0.000]*	34.889 [0.000]*	20.371 [0.000]*	14.194 [0.000]*
LGDP	56.655 [0.000]*	39.226 [0.000]*	35.682 [0.000]*	31.982 [0.000]*	19.159 [0.000]*	13.339 [0.000]*

Variables	First Difference					
	Homoskedastic Disturbances		Heteroskedastic Disturbances		Controlling for Serial Dependence in Errors	
	Z_μ	Z_t	Z_μ	Z_t	Z_μ	Z_t
ELEC	-1.856 [0.968]	-3.129 [0.991]	3.268 [0.001]*	-0.390 [0.6519]	0.029 [0.488]	-0.008 [0.503]
LGDP	3.487 [0.000]*	4.225 [0.000]*	3.894 [0.000]*	3.807 [0.000]*	1.544 [0.061]‡	2.478 [0.007]*

Source: Computed. Note: Z_μ and Z_t denote the statistics without and with a deterministic trend respectively. The panel LM test statistics are defined as the mean of the individual test statistic under the null of stationarity.

Table 4(a): Nyblom-Harvey Panel Cointegration Test Statistics

	Statistics	*ELEC*	*LGDP*
Fixed Effects and Time Trends	NH-*t*	8.6200*	9.352*
	NH adj-*t*	22.3523*	23.483*
	Critical Values 10%	0.837<CV<1.580	0.837<CV<1.580
	Critical Values 5%	0.900<CV<1.665	0.900<CV<1.665
	Critical Values 1%	1.035<CV<1.843	1.035<CV<1.843
Fixed Effects	NH-*t*	8.639*	9.362*
	NH adj-*t*	20.329*	18.680*
	Critical Values 10%	2.282<CV<4.179	2.282<CV<4.179
	Critical Values 5%	2.533<CV<4.496	2.533<CV<4.496
	Critical Values 1%	3.139<CV<5.114	3.139<CV<5.114

Source: Computed. Note: The H_0 of the test is no cointegration (H_0: rank(var-cov)=K=0) against the alternative hypothesis of cointegration (H_1: rank(var-cov)=K≠0). H_0: 0 common trends among the 16 series in the panel. NH-*t*: the test is performed under the hypothesis of iid errors. NH *adj-t*: errors are allowed to be serially correlated and the test is performed using an estimate of the long-run variance derived from the spectral density matrix at frequency zero. No model needs to be estimated as the test is based on the rank of covariance matrix of the disturbances driving the multivariate random walk. The critical values (CV) pertain to *N* equals to 10 and 20 respectively.

Table 4(b): Pedroni Panel Cointegration Test statistics

	Statistics	Without Trend	With Trend
ELEC Model	Panel v-statistic	-0.512	1.207
	Panel ρ-statistic	-0.712	-2.029*
	Panel pp-statistic	-1.737**	-3.835*
	Panel adf-statistic	-1.755**	-3.145*
	Group ρ-statistic	-0.951	-0.217
	Group pp-statistic	-2.681*	-2.873*
	Group adf-statistic	-2.909*	-2.526*

Source: Computed. Note: The *panel* statistics are the within-dimension statistics while *group* statistics are between-dimension ones. Panel-v, panel-ρ, and panel-pp represent the non-parametric variance ratio, Phillips-Perron ρ, and student's t-statistics respectively while panel-adf is a parametric statistic based on ADF statistic. Group-ρ, group-pp and group-adf represent Phillips-Perron ρ-statistic, Phillips-Perron t-statistic and the ADF-statistic correspondingly. The number of lag truncation is equalled to 2. These are one-sided standard normal test with critical values of 1%, 5% and 10% given by -2.326, -1.645 and -1.282. A special case is the panel v-statistic which diverges to positive infinity under the alternative hypothesis. Rejection of the H_0 of no cointegration requires values larger than 2.326, 1.645 and 1.282 at 1%, 5% and 10% significance level. The critical values for the mean and variance of each statistic are obtained from Pedroni (1999). H_0 corresponds to no cointegration.

Table 6: Panel Specification Tests

Tests	Results
Hausman specification test	$\chi^2(1) = 1.10$ [0.295]
Breush-Pagan Lagrangian multiplier test (RE)	$\chi^2(1) = 6260.70$ [0.000]*
Green groupwise heteroskedasticity test (FE)	$\chi^2(511) = 798.28$ [0.000]*
Green groupwise heteroskedasticity test (RE)	$\chi^2(420) = 1101.84$ [0.000]*
Wooldridge first-order autocorrelation test	F(1,27) = 2.93 [0.107]

Source: Computed. Note: According to the Hausman specification test, H_0: difference in coefficients not systematic. The FE model is defined as $\boldsymbol{y}_{it} = \alpha_i + \gamma_t + \beta\boldsymbol{x}_{it} + v_i + \varepsilon_{it}$. The constant term α_i varies over individual countries but not with time. α_i can be treated as an additional random error. The RE model can be defined as $\boldsymbol{y}_{it} = \alpha + \beta\boldsymbol{x}_{it} + v_i + \varepsilon_{it}$. v_i is the unit-specific residual. The coefficients are assumed to be constant across individuals and the variance unit-specific error term is zero. Hausman's (1978) specification test favours the RE against the FE model but the Breusch and Pagan's (1980) LM test rejects the H_0 of Var(v) = 0. The H_0 of Var(v) = 0 is tested by the Breusch and Pagan Lagrangian multiplier. As derived by Greene's groupwise heteroskedasticity test, H_0: homoskedasticity, while for under Wooldridge's test, H_0: no first-order autocorrelation. Groupiwese heteroskedadasticity is found while autocorrelation is rejected.

Table 6: Individual and Panel FMOLS and DOLS Estimators

Country	FMOLS		*DOLS*	
	Coefficient	*t*-statistic	Coefficient	t-*statistic*
Algeria	-0.93	-0.45	0.26	*0.20*
Benin	2.48	1.97**	3.70	*3.73**
Cameroon	0.47	4.05*	0.49	*5.60**
Congo, Dem	0.99	10.12*	1.03	*14.33**
Congo, Rep.	0.97	1.81**	1.52	*4.56**
Egypt	1.70	37.59*	1.73	*45.46**
Gabon	0.05	0.05	-1.90	*-4.64**
Ghana	1.87	3.65*	1.72	*3.31**
Kenya	1.56	2.34*	3.07	*7.28**
Nigeria	-1.51	-2.91*	-1.82	*-4.67**
Senegal	-0.36	-0.40	-1.09	*-1.50*‡*
South Africa	-0.91	-1.63‡	-1.46	*-3.88**
Sudan	1.02	2.67*	1.34	*3.39**
Tunisia	2.44	11.49*	2.62	*19.04**
Zambia	1.12	8.41*	1.17	*13.53**
Zimbabwe	0.19	0.70	-0.15	*-0.36*
Panel	*0.70*	*19.87**	*0.76*	*26.35**

Source: Computed. Note: For the panel DOLS, the choice of leads and lags is based on data dependent criteria (Nelson and Donggyu, 2003). The maximum lag and lead length are set to 1. For the FMOLS, the selection of bandwidth for kernels is automatically computed. Given the lack of evidence of correlated residuals across countries, these models exclude common time dummies.

Table 7: GEE estimations of YEEPC with Business Cycles

Variable	Semi-Robust Estimations
Cyclical component of natural logarithm of GDP	0.0123966 (0.0072002)‡
Constant	0.8960711(0.0000856)*
Wald $\chi^2(1)$	2.96 [0.0851]‡
Overall observations	512
Number of groups	16
Observations per group	32

Source: Computed. Note: Since the *T* is not large, an unstructured intra-individual/cluster correlation matrix *R* which imposes no restriction on the pairwise correlations is applied (Liang and Zeger, 1986). YEEPC income elasticity of electric power consumption