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Article

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IJEEP

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2019, 9(6), 222-233.

Electricity Availability, Human Capital Investment and Sustainable Economic Growth Causality in Sub Sahara Africa: Revisited Evidences

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Received: 31 May 2019 **Accepted:** 24 August 2019 **DOI:** https://doi.org/10.32479/ijeep.8201

ABSTRACT

The paper examines the impact of electricity availabilities proxy by electricity supply, human capital development and the role of institutional qualities on economic growth in Sub-Sahara African countries using a panel data spanning from 1980 to 2016. The study utilized various dynamic panel models (dynamic ordinary least square, DOLS, PMG, DFE and FMOLS) and several panel unit roots model were adopted to check the degree of integration of the variables. Our empirical results found that electricity consumption, electricity availability and control of corruption have a positive impact on economic growth in Sub-Sahara Africa (SSA) countries. However, human capital development has a negatively significant impact on economic growth in SSA countries. A deregulated energy sector is likely to yield smaller net benefits than a regulated market due to nature of African economies due to the level of corruption in the region. We therefore suggest a policy to improving their institutions qualities and build a good political structure to utilities government expenditure on electricity supply and human capital development to ensure economic growth in SSA countries.

Keywords: Electricity Availability, Institutional Qualities, Human Capital Development, Sub-Sahara Africa
JEL Classifications: K32, D73, O15, Q4

1. INTRODUCTION

In recent times, there are various literatures focusing on the interconnectivity among electricity availability and economic growth but very few have included human capital and institutional qualities in the electricity availability and economic growth model see, Lin and Moubarak (2014), Al-Mulali et al. (2015) among others. However, balancing the challenge between development and environment therefore provides us with a goal of ensuring everyone has access to enough sustainable energy to maintain a high standard of living. Also, from empirical and policy point of view, the connection between energy availability, human capital and gross domestic product (GDP) has a significant implication on the welfare of resident of a nation Chu et al. (2019). However, Wolde-Rufael (2006) argued that, if a nation wants to continue growing economically and working towards poverty elimination, efficient management of electricity availabilities are highly imperative for sustainable growth.

1.1. Electricity Availability, Institutions and Sustainable Economic Growth

The role electricity plays in our present day lives cannot be over emphasized, especially its contributions in vital sectors of the economy, such as manufacturing sectors and communication, Agriculture and Education (Adebola and Opeyemi, 2011; Aker and Mbiti, 2010). However, electricity availability is typically more dependent on national infrastructure development whose availability relied on good institutional qualities such as control of corruption, government effectiveness and institutional qualities. According to World Bank (2014) corruption and other institutional inefficiencies are crucial factor affecting the African's total factor productivity, and lack of government's concerns on efficient control of the region environmental quality.

Additionally, access to electricity has been steadily increasing globally over the last few decades. In 1990, about 73% of the world's population had access; this has increased to 85% in 2014. High-income countries have typically maintained close-to-maximum (95-100%) access since 1990. Meanwhile, Africa representing about 15% of the world's population, consumes just 3% of the world's energy output, and 587 million people close to three-quarters of those living in sub-Saharan Africa, still have no access to electricity via national grids. According to the World Bank report (2012), the 48 Sub-Saharan Africa countries put together with an estimated population of 800 million people, generates just about same amount of electricity as Spain with an estimated population of 45 million people. In addition, an average electricity consumption in Africa is about 124 kilowatt hours per capita per year and falling, just enough energy to power a 100 watt bulb per person for around 3 h, this is shockingly just about the tenth of what is obtainable elsewhere in the developing world.

Unquestionably, electricity crisis in Africa is significantly undermined the sustainable growth effort and economic competitiveness in global and regional markets, job creation and poverty alleviation. Arguably, aside the issue of oil on African environments, electricity banes is apparently one of the major banes hindering growth process in the region. The intractable black-out and reliance on self-generated electricity directly affect production cost and cause social adversity that have battered economic growth in Sub-Sahara African for over 10 years. The inefficiency of electricity industry has been traced to weak institution qualities in the region as well as policy challenge as reported that over $1.2 billion Naira was embezzled in providing electricity infrastructure in Nigeria, Africa largest economy.

1.2. Energy Resources and Supply in Africa

Africa population continue growing geometrical and meeting the growing population demand for energy and providing modern energy services in relation to the environment is the priority of many African nations. EIA (2018) hinted that energy consumption in Africa rose by 45% in early 2000 due to economic growth in some of Africa economies and foreign investors demands. However, this served as a challenge to many of the countries as a result of under-developed regional energy systems and inability to meet the required population needs. Even though the region is blessed natural energy resources are more than abundant to meet the needs of their population, weak institution has encouraged government officers diverting the government resources meant to provide infrastructures in servicing energy system to their private pocket thus limit the access to modern energy services in the region. More evidently, around two-thirds of African population representing over 620 million people does not have access to electricity and availability is very expensive as compared with other emerging economies. Almost 730 million out of 1.216 billion people cook with traditional solid biomass. Furthermore, people that do have access to traditional solid biomass settled for a low quality and very expensive energy supply (EIA, 2018).

In 2014, the demand for primary energy rose sharply to around 752 million tons of oil out of which Northern African sub-region accounted for about 20% (EIA, 2018). However, on a global scale Sub-Sahara Africa (SSA) countries' demands are just only 4% of the world's demand for energy which accounted for only one over four of the of the world population. Additionally, Nigeria and South African countries have the largest energy consumer in the region with the demand of 133 million (Mtoe) and 141 million (Mtoe) respectively which account for over 40% of the total demand in Africa (EIA, 2018) with these internal economic advantage, weak institution and social crises had made the country to suffer from epileptic power supply. According to the report, "The total estimated financial loss to Nigeria from corruption in the electricity sector starting from the return to democracy in 1999 to date is over Eleven Trillion Naira (N11 Trillion Naira) (Dickson and Ezirim (2017). This represents public funds, private equity and social investment (or divestments) in the power sector. It is estimated that may reach over Twenty Trillion Naira (N20 Trillion Naira) in the next decade given the rate of Government investment and funding in the power sector amidst dwindling fortune and recurrent revenue shortfalls". More evidently, energy consumption per capita on average is only one-third of the world consumption in Africa. However, the region consumes just 50% of the total energy consumption in Southeast Asia which rank Africa as the second world energy-poor region (EIA, 2018).

At the end of 2015, Africa consumes most all energy sources increase to 42%, gas rose to 28%, coal moved to 22%, hydro is only 6%. Meanwhile, renewable and nuclear energy are 1%. According to 2015 statistics, African countries produces 9.1% of the total world oil and consumes just 4.2% of it and consume only 0.4% of world's nuclear energy, 0.3% of hydroelectricity and 1% of other renewable energies. However, with all the abundant energy resources in Africa, the region remains a major net energy exporter in the world. In light of energy problem, weak institutional in the region, the study aimed to investigating the impact of electricity availability/supply and role of institution on economic growth in Sub-Sahara. In Figure 1, the electricity supply in Sub-Sahara Africa as compared with other emerging economies is relatively low. As depicts in the figure below, electricity supply in Sub-Sahara countries is significant from 2010 to 2016 below the total energy supply in Latin America, South East Asia, Arab World and Australia. In all these regions, they have a better electricity supply than what will observed in Sub-Africa countries.

Figure 2 illustrates the electricity growth rate as well as economic growth rate in SSA from 2001 to 2016. The brown bar is the electricity output growth rate for African countries within the sample years. The red solid line depicts the economic growth rate for all the 48 countries in SSA and showed that contribution of electricity production to economic growth is not significant from 2010 to 2014, however 2014 to 2018 electricity production declines along with economic growth in the SSA. It is thus interesting to explore whether and to what extent the industrial electricity production contributes to region's economic prosperity within the core-periphery framework. Also, Figure 3 present the control of corruption among the economic regions such as East Asia, SSA, South Asia and Latin America from 2010 to 2016, among the regions, the output growth in SSA is lowest, for more a decade no significant or appreciated growth on the SSA region's output. Further, it could be observed that control of corruption is relatively low in Sub Sahara Africa countries as compared with other emerging economies which has a linkage to the economic performance in that region. The Africa's growth declined for a decade and low to around 1.7% in 2016 from 3.7% in 2015, below both the global rate (2.3%) and that in most other developing regions. However, poor growth in Africa countries has been traced to weak institution in the region. According to Transparency International (2018) hinted that 75 million of African people pay bribe and around 80% of African people live below US$2 a day. Corruption is one of the factors perpetuating poverty. Poverty and corruption combined force to make impossible choices. The issue of corruption has been an order of day, people pay bribe to get a treatment at the clinic, no meaning transaction can be done in Africa without been extorted by policemen and government officers in order to bridge bureaucracy. Also, electricity generation has been relatively low to the demand of the people in which is insufficient to the needs of resident resulted from corruption as various African government have been diverting money budgeted for electricity to their private pocket. Empirical evidences have shown that no nation can attain sustainable growth without a constant electricity supply at a cheaper rate.

Figure 1: Electricity supply in Sub-Sahara African countries, 2010-2016. The electricity supply for all regions is proxy by electricity production. The data is sourced from World Bank national accounts data, and OECD (National Accounts data files, 2019).

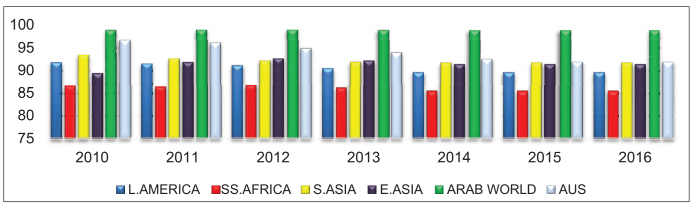
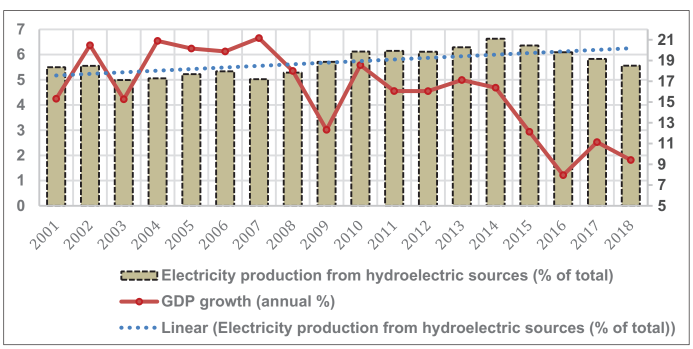


Figure 2: Electricity and gross domestic product growth rate in Sub-Sahara Africa (2001-2018). The gross domestic product (GDP) growth (annual %) represented by annual percentage growth rate of GDP at market prices based on constant local currency. Electricity Production/ Growth refer to the inputs used to generate electricity. Hydropower refers to electricity produced by hydroelectric power plants. The data is sourced from World Bank national accounts data, and OECD National Accounts data files (2019)



From Figures 4 and 5 respectively show electricity consumption and human capital index for North-America, Arab World, East Asia, Latin America, European and SSA Region from 2010 to 2018, we found that human capital index of showed a slight increase in the year 2010 to 2012 fall in 2013 and slightly increased in 2014. However, Human capital development at the end 2014 sharply fall (around 3 digits), in 2016 human capital development in SSA is in bad state (negative) while other regions like North-America, Middle east (Arab), East Asia and European region ranked high. According world bank report (2018) across Africa, 71 million children do not reach their full potential due to poverty and poor health, nutrition, and care. In another instance, Africa is also the only region of the world where the number of out-of-school adolescents has risen in recent years, partly because of rapid population growth (World Bank, 2018). Also, SSA's electricity consumption is poor from 2010 to 2018 when compared with North-America, Middle East (Arab), East Asia and European region reason which has retarded the economic performance of the region as it can be seen in Figure 2. The aim of this paper is to provide an examination of the human capital development–electricity supply link to economic growth in Sub Sahara Africa. Theoretically, human capital can be linked to energy consumption through multiple channels. First, human capital can increase income, which may then cause more energy consumption. Second, human capital can stimulate research

Figure 3: Control of corruption in East Asia, Sub-Sahara Africa, South Asia and Latin America, 2013-2016. The data is sourced from World Governance Indicators (2019)

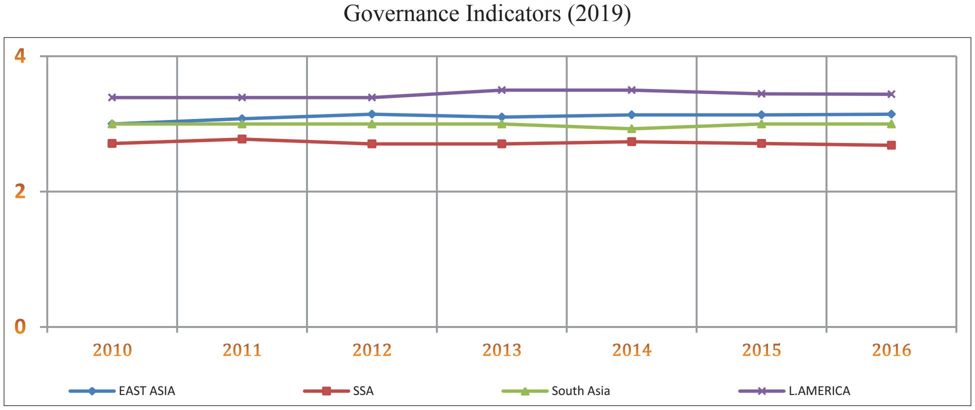


Figure 4: Regional electric power consumption (kWh per capita) (2001-2018). Regional electric power consumption (kWh per capita) is the electric power consumption measures the production of power plants and combined heat and power plants less transmission, distribution, and transformation losses and own use by heat and power plants. The data is sourced from World Bank Development Indicators (2019)

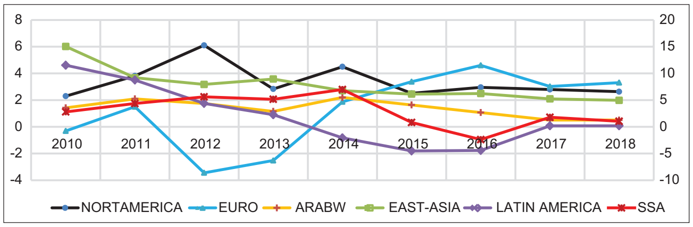
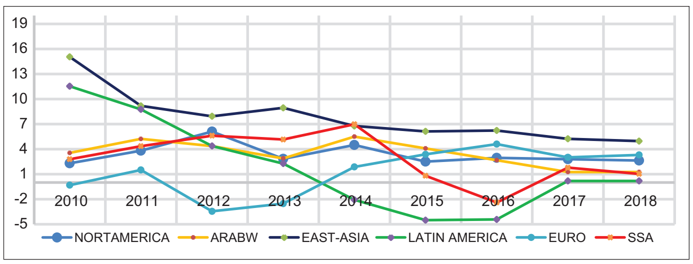


Figure 5: Regional human capital index (2010-2018). Regional human capital index (2010-2018) is average annual growth of gross fixed capital formation based on constant local currency. The data is sourced from World Bank Development Indicators (2019)



and development of new energy and accelerate the transition to energy-efficient technologies (Li and Lin, 2016). Third, if human capital is accumulated through education and campaign on energy conservative awareness among the common people, more human capital is linked to less energy consumption (Fang and Chen, 2017). Lastly, economic structure also matters. With the development of human capital, economies that experience rapid industrialization and urbanization may see huge reliance on energy; but when the country develops to a service led economy, energy reliance may be reduced with further development of human capital (Arbex and Perobelli, 2010). By and large, the relationship between energy and human capital is uncertain and a rigorous analysis is required.

2. BRIEF OVERVIEW OF THE LITERATURE

The empirical studies on the relationship connecting between electricity availability and economic growth and the direction of causality has been subjected to debate among scholars and has generated controverting opinion in the literature (Iyke, 2015). The opinions of scholars were divided into two which the first argument favors a unidirectional causal relationship running from energy supply to economic growth (growth hypothesis) see, (Akinlo, 2008; Chang, 2010; Iyke, 2015; Paul and Bhattacharya, 2004). However, the second groups conclude that economic growth causes energy supply see, (Bayraktutan et al., 2011; Dincer, 2011; Lean and Smyth, 2010; Sarker, 2010; Stern, 1993). Additionally, a mixed result and conflicting findings were produced by the third group see,(Karanfil and Li, 2015; Shahbaz and Lean, 2012; Shahbaz et al., 2011; Stern, 2011). However, the evidence of no correlation between electricity supply and growth were found among (Alam et al., 2012; Bhattacharya et al., 2016; Karanfil and Li, 2015). Additionally, Cowan et al. (2014), Apergis and Payne (2012), Ohler and Fetters (2014), Michieka (2015), Omri (2014), and Lin and Moubarak (2014), Al-Mulali et al. (2015) among others support the existence of bidirectional causality between economic growth and electricity supply. In light of the above empirical evidences of mixed results, we observed no consistency findings among the scholars with regards to the direction of cause effect and strength of energy supply and economic growth.

On the methodological ground, we observed that most literatures examine relationship between energy consumption and economic growth used dynamic fixed effects (DFE) model, Granger causality and cointegration methods to explore the relationship between these two variables see, (Al-Mulali et al., 2015; Karanfil and Li, 2015; Alege et al., 2018; Hassan et al., 2018; Nayan et al., 2013) among others. None have been done using various advanced dynamic techniques like dynamic ordinary least square (DOLS) model, generalize method of moments (GMM), mean group estimator (MGE) and the PMGE and, aside these dynamic techniques, we applied panel cointegration test such as Pedroni, Kao and Westerlund to confirm long run association running from electricity availability and good governance to economic growth in Sub-Sahara African countries. Additionally, we employed various units test like LLC, Breitung, IPS, Fisher and Hadri to check the degree of integration of the variables which gave the valid to process for the dynamic panel models stated above. Furthermore, Numerous experimental studies had faced serious difficulty with the one-way fixed effects model in the context of a dynamic panel data (DPD) model particularly in the "small T, large N" context as well as endogeneity, fixed individual effects, unobserved heterogeneity, heteroskedasticity and autocorrelation within individual units' errors which is solved by dynamic ordinary least square (DOLS) model, generalize method of moments (GMM), mean group estimator (MGE) and the PMGE. These served as the motivation to use these various techniques to investigate the long run association running from electricity availability and good governance to economic growth in Sub-Sahara African countries.

3. METHODOLOGY

3.1. Theoretical Framework

We follow Cobb-Douglas production function to establish the linkage between electricity supply, human capital development and economic growth in SSA:

$$Y_{i,t} = A_{i,t} + K_{i,t}^{\alpha} L_{i,t}^{1-\alpha-\beta-\gamma} H_{i,t}^{\beta} E_{i,t,}^{\gamma} \tag{1}$$

Note that the subscript i and t represents the cross-section and time (year), respectively. $Y_{i,t}$ = is the aggregate output for all SSA; $K_{i,t}$ physical capital and $H_{i,t}$ denotes human capital development index, $L_{i,t}$ is the labour force; while, electricity supply in the region is denoted by $E_{i,t}$. We therefore take linear function of equation (1) by introducing the natural logarithm thus:

$$\ln Y_{i,t} = c_{i,t} + \alpha \ln K_{i,t} + \beta \ln H_{i,t} + \gamma \ln E_{i,t} + \varepsilon_{i,t} \quad (2)$$

Note that, α, β, and γ are coefficients which signifies the elasticities of output with respect to physical capital, human capital development and electricity supply in the SSA region, respectively.

More theoretical evidence linking electricity supply, labour, capital stock and economic growth explained by Hicks (1932). It was developed to augment the biasness of Kendrick and others that ignores technological change as the important driver of economic growth. As argued by Hicks, who theorized that a change in relative factor prices would lead to a bias in technical change away from more expensive factors and toward the cheaper factor (Sweezy, 2018). Therefore, an increase in supply falls the electricity price which reduces the inputs price. Furthermore, the cumulative technical change in Hicks' model have an indirect effect on output, namely via affecting the output elasticities (capital and labor). Empirically, there are four possible hypotheses on the interconnectivity between energy supply, human capital development and economic growth (Kahouli, 2017). First, the growth hypothesis argued that energy consumption significantly promotes economic growth of a nation. Second, the conservation hypothesis suggests that electricity consumption has no effects on growth. However, bi-directional causal association between energy consumption and GDP is suggested by feedback hypothesis. Finally, the neutrality hypothesis supports no existence of causality between energy consumption and economic growth.

3.2. Empirical Model

Following Alley et al. (2016) we estimate the relationship between the electricity availability and corruption on economic growth in Sub Sahara African countries, a panel dynamic regression model for 48 Sub-Sahara African countries for the period 1980-2016 is employed. Therefore, we investigate the linear relationship between the endogenous and exogenous variable via GMM, DOLS MGE and PMGE model to capture the problem of endogeneity and also to have a robust regression result. We specified our linear model as thus:

$$GDP = f\,(ELECC, ELECP, HCD, DI, COC, REER, INT) \quad (3)$$

$$GDP_{it} = \beta_0 + \beta_1 ELECC_{it} + \beta_2 ELECP_{it} + \beta_3 HCD_{it} + \beta_4 COC_{it} + \beta_5 REER_{it} + \beta_6 INT_{it} + \varepsilon_{it} \quad (4)$$

Where GDP_{it} is GDP per capita index in country i and year t, $ELECC_{it}$ electricity consumption in country i and year t, $ELECP_{it}$ Electricity consumption in country i and year t; HCD_{it} human capital development proxy by school enrolment in country i and year t; COC_{it}, control of corruption index in country i and year t; $REER_{it}$, real exchange rate in country i and in year t and INT_{it}, interest rate in country i and in year t. The data for variables were obtained from World Development Indicators and institution qualities are retrieved from World government Indicator.

4. FURTHER EXPLANATION FOR ECONOMETRIC MODELS

4.1. Panel Unit Root Test

In order to investigate the possibility of panel cointegration, it is high imperative to check the stationarity of the series Since time series data fluctuate over time. The study employed the first-generation unit root test such as Levin et al. (2002), Im et al. (2003), Hadri (2000) and Breitung (2001). Levin et al. (2002) propose a test which has an alternative hypothesis that the ρi are identical and negative.2 Because ρi is fixed across i. However, Breitung (2001) proposes an alternative set of procedures to Levin-Lin-Chu that use unbiased estimators rather than bias-corrected ones. Im, Pesaran and Shin (IPS, hereafter), which is based on the well-known Dickey-Fuller procedure. Im, Pesaran and Shin denoted IPS proposed a test for the presence of unit roots in panels that combines information from the time series dimension with that from the cros- section dimension, such that fewer time observations are required for the test to have power. Since the IPS test has been found to have superior test power by researchers in economics to analyze long-run relationships in panel data, we will also employ this procedure in this study. IPS begins by specifying a separate Augmented Dickey-fuller (ADF) regression for each cross-section with individual effects and no time trend:

$$\Delta y_{it} = \alpha_i + \rho_i y_{i,t-1} + \sum_{j=1}^{p_i} \beta_{ij} \Delta y_{i,t-j} + \varepsilon_{it} \quad (5)$$

Where i = 1,…,N and t = 1,…,T.

IPS use separate unit root tests for the N cross-section units. Their test is based on the ADF statistics averaged across groups. After estimating the separate ADF regressions, the average of the t-statistics for p_1 from the individual ADF regressions, $t_{iTi}(p_i)$;

$$\bar{t}_{NT} = \frac{1}{N} \sum_{i=1}^{N} t_{iT} \left(p_i \beta_i \right) \quad (6)$$

The t-bar is then standardized, and it is shown that the standardized t-bar statistic converges to the standard normal distribution as N and T→∞. IPS (1997) showed that t-bar test has better performance when N and T are small. They proposed a cross-sectionally demeaned version of both tests to be used in the case where the errors in different regressions contain a common time-specific component.

4.2. Panel Cointegration Test

Just like panel unit root tests, the panel co-integration is divided into two categories, first category deals with the assumption of no cross-sectional dependence in the case of Kao test, 1999; McCoskey and Kao test, 1999; and Pedroni (1999; 2004). Kao test (1999) emerge the asymptotic distribution of the least square dummy variable (LSDV) estimator along with several conventional statistics from the spurious regression (panel data) showing the consistency of OLS estimator's co-efficient and with the asymptotics' different from the spurious regression in pure time series. Further, Pedroni co-integration is residual dynamics based which cater for problem of heterogeneity and endogeneity in the panel model. However, cross-sectional dependence problem is not included.

$$\Delta \hat{\mu}_{it} = \rho \hat{\mu}_{i,t-1} + \sum_{j}^{p} \varphi_{ij} \Delta \hat{\mu}_{i,t-j} + \varepsilon_{it} \quad (7)$$

Where i is the country and t is the year, and conduct a one-sided test of the null hypothesis that the parameter of adjustment to long-run equilibrium ρ = 0, against the alternative that ρ < 0. It is performed the cointegration test suggested by Pedroni (1999; 2004) which allows for heterogeneity of the adjustment parameter. In order to have a robust result, we also employed the second type of panel cointegration tests Westerlund's (2007) which is based on structural dynamics and different from that of residual-based tests and the common factor restriction is not required. To observe the existence of co-integrating relationship exists between the dependent variable and independent variable of the study $\{y_i,\}$ and $\{x_{i,t}\}$, assume the error-correction model as follows:

$$\Delta y_{it} = \delta_i' d_t + \alpha_t \left(y_{it-1} - + \beta_i' x_{i,t-1} \right) + \sum_{j=i}^{pi} \alpha_{ij} \Delta y_{i,t-j} + \sum_{-qi}^{pi} \gamma_{ij} \Delta x_{i,t-j} + \varepsilon_{it} \quad (8)$$

Note that d_t represent the deterministic component, which is presumed to be zero, one, or else a vector of (1,t)' and p_i and q_i are the lead and lag orders for unit i. The co-integration is stated by $y_{(i,t-1)} \pm \beta_i' x_{(i,t-1)} = 0$. The co-efficient measures the speed of adjustment towards long run equilibrium which negative value shows long association (co-integration relationship). However, $\alpha_i = 0$ indicates no adjustment toward long-run equilibrium and no co-integration. The Westerlund (2007) test statistics proposed for the first alternative hypothesis are called panel test, which are:

$$P_T = \frac{\hat{\alpha}}{SE(\hat{\alpha})'} \text{ and } P_\alpha = T\hat{\alpha} \quad (9)$$

Where $\hat{\alpha}$ is the homogenous speed of error correction for all units and $SE(\hat{\alpha})$ is the standard error of $\hat{\alpha}$ the group-mean test statistics for the second alternative hypothesis are:

$$G_T = \frac{1}{N} \sum_{i=i}^{N} \frac{\hat{\alpha}i}{SE(\hat{\alpha}i)'} \text{ and } G_\alpha = \frac{1}{N} \sum_{i=i}^{N} \frac{T\hat{\alpha}i}{\hat{\alpha}i(1)} \quad (10)$$

Where is the parameter estimate for unit i, $SE(\hat{\alpha})$ is the associated standard error, $\hat{\alpha}i\,(1) = 1 - \sum_{j=i}^{pi} \hat{\alpha}_{ij}$. We therefore employ Westerlund co-integration test to solve the problem of heterogeneity and cross-sectional dependence that may arise from panel data.

4.3. Estimating Panel Cointegration Model

Having established cointegration, we estimate (1) using the FMOLS (fully modified OLS), DOLS (dynamic OLS), PMGE (pooled mean group estimator), MG (mean group) and DFE (dynamic fixed effect) methods. Following Pedroni (2001), the FMOLS estimator corrected for heterogeneity (with fixed effects) and the OLS estimator adjusted for serial correlation take the form:

$$\hat{\beta}_{NT}^* - \beta = \left(\sum_{i=1}^{N} \hat{L}_{22i}^{-2} \sum_{t=1}^{T} (X_{it} - \bar{X}_i)^2 \right)^{-1} \sum_{i=1}^{N} \hat{L}_{11i}^{-1} \hat{L}_{22i}^{-1} \left(\sum_{i=1}^{T} (X_{it} - \bar{X}_i) \mu_{it}^* - T\hat{\gamma}_i \right) \quad (11)$$

Where $\hat{L}_i$ is a lower triangular decomposition of the covariance matrix Ω_1, Γ_1 a weighted sum of autocovariances, with $\hat{L}_{11i} = (\Omega_{11i} - \Omega_{21i}^2 / \Omega_{22i})^{1/2}$ and $L_{22i} = \Omega_{22i}^{1/2}$ being the long-run standard errors of the conditional process. Here $\hat{\beta}_{NT}$ is a fully modified estimator (FMOLS) with the individual specific mean of the form:

$$\mu_{it}^* = \mu_{it} - \frac{\hat{L}_{21i}}{\hat{L}_{22i}} \Delta X_{it}, \hat{\gamma}_i \circ \hat{\Gamma}_{21i} + \hat{\Omega}_{21i}^{\circ} - \frac{\hat{L}_{21i}}{\hat{L}_{22i}} (\hat{\Gamma}_{22i} + \hat{\Omega}_{22i}^{\circ}) \quad (12)$$

Pedroni (2001) proposes a dynamic OLS estimator (DOLS) of the form:

$$\hat{\beta}_{i,DOLS} = \left[N^{-1} \sum_{i=1}^{N} \left(\sum_{t=1}^{T} z_{it} z_{it}' \right)^{-1} \left(\sum_{t=1}^{T} z_{it} \bar{y}_{it} \right) \right]_1 \quad (13)$$

Where z_{it} is the 2(K+1) × 1 vector of regressors:

$$Z_{it} = \left\{ (X_{it} - \bar{X}_i), \Delta X_{it-K}, \ldots, \Delta X_{it+K} \right\}; \tilde{y}_{it} = y_{it} - \bar{y}_i \quad (14)$$

Correcting for endogeneity and serial correlation in the panel by including leads and lags of the differenced I(1) regressors. Following the approach of Pesaran and Smith (1995), and Pesaran et al. (1999) for nonstationary dynamic panels with heterogeneous parameters we estimate our dynamic panel using MG, PMGE and DFE in the form:

$$\Delta y_{it} = \phi(y_{i,t-1} - \phi_i' X_{it}) + \sum_{j=1}^{p-1} \lambda_{ij}^* \Delta y_{i,t-1} + \sum_{j=0}^{q-1} \delta_{ij}'^* \Delta X_{i,t-j} + \mu_i + \varepsilon_{it} \quad (15)$$

Following Pesaran et al. (1999) we estimate an ARDL (2,2,2) model:

$$y_{it} = \sum_{j=1}^{p} \lambda_{ij} y_{i,t-j} + \sum_{j=0}^{q} \delta_{ij}' x_{i,t-j} + \gamma_i' d_t + \varepsilon_{it} \quad (16)$$

Where i = 1, 2,…, 119 stands for the country; t = 1, 2,…, 41 for the time period; x_{it} = (k×1) and d_t (s×1) for the vectors of explanatory variables (regressors).

Re-parameterising (6) we obtain an error correction model of the form:

$$\Delta y_{it} = \phi_i y_{i,t-1} + \beta_i' x_{it} + \sum_{j=1}^{p-1} \lambda_{ij}^* \Delta y_{i,t-j} + \sum_{j=0}^{q-1} \delta_{ij}^{*\prime} \Delta x_{i,t-j} + \gamma_i' d_t + \varepsilon_{it} \quad (17)$$

Where

$$\phi_i = -(1 - \sum_{j=1}^{p} \lambda_{ij}),\ \beta_i = \sum_{j=0}^{q} \delta_{ij},\ \lambda_{ij}^* = -\sum_{m=j+1}^{p} \lambda_{im},\ j=1,\ldots,p-1 \quad (18)$$

And

$$\delta_{ij}^* = -\sum_{m=j+1}^{q} \delta_{im},\ j=1,\ldots,q-1,\ i=1,\ldots,N$$

As in Pedroni (1999, 2004) we estimate the long-run relationship as follows:

$$y_{i,t} = \alpha_i + \delta_i t + \beta_{1i} x_{1i,t} + \beta_{2i} x_{2i,t} + \ldots + \beta_{Mi} x_{Mi,t} + e_{i,t} \quad (19)$$

For t = 1,…, T; i = 1,…, N; m = 1,…, M with T being the number of observations (time), N the number of individual countries in the panel and M the number of regression variables. After estimating (7) and identifying the long-run relationships, we estimate a panel VECM model:

$$\Delta y_{it} = \theta_{1i} + \lambda_{1i} EC_{i,t-1} + \sum_{k=1}^{m} \theta_{11ik} \Delta y_{i,t-k} + \sum_{k=1}^{m} \theta_{12ik} \Delta p_{i,t-k} + \sum_{k=1}^{m} \theta_{13ik} \Delta e_{i,t-k} + u_{1it} \quad (20)$$

And then test for multivariate causality with lag length m (SIC = 2) to examine the direction (patterns) of causality between the variables in both the short and the long run.

Multivariate causality as in Engle and Granger (1987) is tested by means of Wald tests of the null $H_0: \theta_{12ik}, \theta_{13ik} = 0$, $H_0: \theta_{22ik}, \theta_{23ik} = 0$, $H_0: \theta_{31ik}, \theta_{32ik} = 0$ (i.e. the independent variables do not cause the dependent ones in the model) for all i and k in (9). To examine the long-run relationship between independent and dependent variables we test $H_0: \lambda_{1i}, \lambda_{2i}, \lambda_{3i} = 0$ for all i and k in (19) (i.e., no long-run stable relationship between independent and dependent variables in the model).

4.4. Empirical Results and Discussions

Firstly, we conduct three different co-integration analysis (Pedroni, Kao and Waterlunds). we used these techniques due to their statistical powers, suitability to the data used and to compare results of various cointegration techniques for meaningful conclusion of the existence of long run association between electricity availabilities, corruption and economic growth in SSA. Furthermore, due to nature of time series data which by their nature fluctuate over time, so we made different unit root tests in order to confirm the degree of integration of the variables of the model to determine the appropriate panel technique to be used to achieve the objectives of this study. Table 1 is the description and sources of the variables employed for this study. Meanwhile, Table 2 shows the results of the various unit root tests (LLC, Bretung, IPS, Fisher and Hadri) on the first difference based on the Mackinnon p values at various lag lengths. The preferred lag length based on the Akaike information criterion indicates that co-integration is generally accepted. Table 3 represents the estimation results of three co-integration analysis Pedroni, Kao and Waterlunds respectively. We found that African economic growth is measured by the electricity availability and good institutional qualities.

Table 2 shows correlation coefficients all variables employed to examine the association between the dependent variable and independent variables under consideration for the study in SSA. Besides providing insight on the nature and degree of relationship among individual variables, correlation coefficient serves the purpose of preliminary diagnostic check for the problem of multicollinearity. We observed a low correlation among the variables used and all are significant. Considering this, we are free from possibility of multicollinearity among the exogenous variable.

Table 1: The determinants of growth in Sub-Sahara Africa

Variable	Description	Expected sign	Source
GDP	GDP per capita	+	WDI (WorldBank)
ELECC	Electricity consumption	+	WDI (WorldBank)
ELECP	Electricity Generation	+	WDI (WorldBank)
HCD	Human capital development	+	WDI (WorldBank)
COC	Control of corruption	+	WGI (WorldBank)
REER	Real exchange rate	+	WDI (WorldBank)
INTL	Interest Rate	−	WDI (WorldBank)

Source: Author's computation 2018

The results from LLC, Bretung, Im, Pesaran and Shin IPS, Fisher and Hadri, the panel unit root tests conducted for the seven variables (GDP, electricity availability, electricity consumption, corruption, human capital development, domestic investment, corruption index, exchange rate and interest rate). According to Table 3 below, all the seven variables were not stationary at level. Consequently, the panel unit root tests of Levin, Lin and Chin and Im, Pesaran and Shin were again tested for all the variables at first differenced. Both the unit root test results reveal that the null hypothesis of unit root for the selected variables such as GDP, Electricity availability, electricity consumption, corruption, Human Capital Development, Domestic Investment, Corruption Index, Exchange Rate and Interest rate in case of each individual country was not rejected at levels. But, when the series are first differenced, both the series are found to be stationary and integrated at the order of one I(1). The results indicate that all the variables are stationary at I(1) or in other words all the variables are integrated of the order of one.

Proven that both the series are I(1) variables that is, integrated of same order. We have the valid to process for long run relationship tests. The Pedroni, Kao and Westerlunds were performed to examine the presence of long-run relationship between Electricity availability, electricity consumption, corruption and gross domestic product for the Sub Sahara African SSA countries and its result is presented in Table 4. In Table 4, the Pedroni, Kao and Westerlunds results for SSA nations indicates that the null hypothesis of no cointegrating vector (r = 0) can be rejected at 5% significance level, and the alternative hypothesis of at most one cointegrating vector (r ≥ 1) can be accepted. Therefore, the results support the hypothesis of cointegration between Electricity availability, electricity consumption, corruption and gross domestic product, implying that there are stable long-run relationships or in other word sufficient electricity supply/availability with good institution determines long run sustainable growth in Sub Sahara African SSA countries. This is in line with Glaeser et al. (2004) and Aparicio et al. (2016), who concluded that good institutional qualities and sustainable growth are connected in the long-run.

After confirming the existence of cointegrating vector among Electricity availability, electricity consumption, corruption and gross domestic product for the Sub Sahara African SSA countries, we should search for proper vector error correction model (VECM) to determine the direction the degree of convergence of long-run causation running from electricity availability and institution summed together to economic growth in SSA following (Granger, 1987. For the purpose, the VECM is estimated and it is presented in Table 5. In Table 5, the VECM result for SSA shows that the error correction coefficient, ECT_{t-1}, (−0.81) and (−0.76)

Table 2: Panel correlation test

	GDP	ELECC	ELECA	HCD	COC	REER	INTL
GDP	1.000						
ELECC	0.266	1.000					
	0.0000						
ELECP	0.1812	0.9331	1.0000				
	0.0000	0.0000					
HCD	−0.358	−0.0754	−0.1961	1.0000			
	0.0000	0.0036	0.0000				
COC	0.2729	−0.0772	0.0515	−0.106	1.0000		
	0.0000	0.0029	0.0471	0.0000			
REER	0.3167	−0.1713	−0.2713	0.1697	−0.008	1.0000	
	0.0000	0.0000	0.0000	0.0000	0.7368		
INTL	0.4125	−0.3080	−0.3883	0.7384	0.1067	0.2151	1.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	

*Significane at 10%, **significane at 5%, ***significane at 1%

Table 3: Panel unit root test

Variables	LLC	Bretung	IPS	Fisher
	t*Stat	t-Stat	W-Stat	ADF. Chi-square
GDP	−29.9***	−18.7***	0.0***	81.63***
ELECC	−33.1***	−19.1***	−23.1***	679.2***
ELECA	−30.7***	−19.8***	−23.2***	683.1***
HCD	−24.3***	−14.3***	−14.48***	404.4***
COC	−57.7***	−30.2***	−49.4***	2071.3***
REER	−44.5***	−23.8***	−36.1***	1191.8***
INT	−52.7***	−25.1***	−39.8***	1433.3***

*Significane at 10%, **significane at 5%, ***significane at 1%

Table 4: Panel cointegration test

Tests	Cointegration test	Statistics
Pedroni	Panel-v	2.03***
	Panel-rho	−5.71***
	Panel-PP	−6.68***
	Panel-ADF	−2.65***
	Group-rho	−2.79***
	Group-PP	−6.33***
	Group-ADF	−1.13
Kao	t	11.56***
Westerlund	Gt	−2.72**
	Ga	−6.67
	Pt	−11.12**
	Pa	−22.47***

Pedroni and Kao tests are generated on Eviews, while Westerlund test is generated on Stata with the command "xtwest." *Significance at 10%. **Significance at 5%. ***Significance at 1%

which is negative and statistically significant at 1% level for pool mean group and dynamic fixed effect, implying the validity of long-run equilibrium relationship among electricity availability, electricity consumption, corruption and gross domestic product. It also implies that 81% of long run relationship determined from the previous period's shock and converges back in the current period. Also, signifies that 81% of long-run causality between Electricity availability and good institution to economic growth runs in SSA. Similarly, the VECM result for DFE showed existence of 76% convergence to long run equilibrium relation between electricity availability and good institution to economic growth runs in SSA. This indicates the electricity supply/availability and good institution has greater speed of adjustment to the previous period's deviation to full employment in SSA. Besides ECT(−1) results coefficient estimation results for short run and run were also presented in Table 5.

After confirming the existence of long run relationship and the rate of convergence of independent variables to dependent variable, we process for coefficient estimation in order to investigate the extent at which individual exogenous variable determine growth in SSA. We start from the short run of PMG since it takes care of endogeneity problem. The short-run impact of Electricity consumption ELECC on Economic growth GDP is statistically significant and positive in SSA countries. As presented in the table, the results show that, ceteris paribus, GDP increases by 0.405% in SSA, if the electricity consumption per person increases by 1. This indicates that increased electricity consumption in SSA causes economic growth; thus, upholding the endogenous hypothesis. This finding is also similar to those obtained by Karanfil and Li (2015) and Salahuddin et al. (2015). Electricity availability also significant and positively determines GDP by 0.164 for 1 unit increase per person. This implies that sustainable growth in SSA is explained by electricity availability in the region. This finding, therefore, support the proposition that the presence of cheap and sufficient electricity supply reduces transactional cost of producers thus increase their productivities which lead to growth. This is in line with the finding of Rubin et al. (2015), Bento and Moutinho (2016) and Zhang et al. (2017). According to Zhang et al. (2017) concludes that Consistent and reasonable supply of electricity is imperative for economic growth in China as electricity consumption decrease discourages the progress of the industrial economy via increase in transactional cost. Also, control of corruption is positively significant to determine GDP in SSA. This shows that if necessary, measures are put in place to control corruption in SSA countries, economic growth will increase by 10% for 1 unit increase in the effort of anti-corruption agency in the region. This result is similar to that of (Chang and Hao, 2017; Huang, 2016; Musibau et al., 2017). However, Human capital human development is negatively and significantly influenced growth in the region. Unquestionably, education is a most important element through which skills and knowledge can be acquired, curbing corruption in education sector in the country is highly imperative so that human capital will be developed effectively for sustainable economic growth. Arguably, (Musibau et al., 2017; Oni, 2000) hinted that, the recent rapid economic miracle of Southeast Asia country (Asian Tigers) in the latter part

Table 5: Estimations/robustness

Estimations	DOLS	FMOLS	GMM	PMG	ARDL
Variables	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.
ELECC	0.909	0.3388	3.863	2741	0.2803
	0	0.0061	0.0001	0	0
ELECP	0.279	0.124	0.092	0.4527	0.463
	0.005	0.4901	0.63	0	0
HCD	−0.064	−0.215	−6.189	753	−0.077
	0.0007	0	0	0	0.3334
COC	1.0745	0.8958	4.863	3260	0
	0	0	0	0	0.3334
REER	0.938	2.118	0.41	1523	0.1557
	0	0	0	0	0
INT	0.5127	0.5802	−1678.2	941	967
	0	0	0	0	0
Short-Run			**PMG**		
ELECC			0.405		
			0		
ELECA			0.064		
			0		
HCD			−0.051		
			0		
COC			0.101		
			0		
REERP			0.607		
			0		
INTP			0.162		
			0		
ECT(−1)			−0.081		

*Significane at 10%, **significane at 5%, ***significane at 1%

of the 20th century has been influenced by largely to their deliberate policy on capacity building through investment in education, motivating graduate and post graduate scholarship i.e. human capital and institutional building. However, most African nations including Nigeria, Ghana, Liberia and Gambia have shown lack of attention to the relevance and development of institutional capacity building. More evidently, improper budget spending and insufficient access to education, to poor teaching practices and nepotism, corruption in education is rampant across Africa, robbing millions of young people of their right to knowledge and a decent future (Agbiboa, 2012).

All long run results for dynamic panel models are presented at first eleven column of Table 5. We employed five different dynamic models in the table above FMOLS, DOLS, GMM, PMG and DFE due to their statistical power over other tests. Aside that FMOLS and DOLS supports I(1) variables and GMM is done on fact that our N(Cross sections) is greater than T. However, PMG is justified on the assumption of (Arif et al., 2017; Attiaoui et al., 2017; Martins, 2011; Njoupouognigni, 2010; Pesaran et al., 1999). Furthermore, PMG, GMM tests take into consideration endogeneity problem and DOLS takes care of endogenous and lag and to obtain more robust result is obtained see, (Chudik et al., 2017; Eberhardt and Presbitero, 2015; Égert, 2015; Suliková et al., 2015; Woo and Kumar, 2015). More evidently, the FMOLS and DOLS techniques remove the asymptotic bias terms and requires the estimation of long run variance matrices and correct for the (second-order) endogeneity bias which little studies take into consideration. We also used PMG, GMM and DFE to cater for cross-sectional heterogeneity problem, and thus, it is conducive to empirical study. The presence of these problems (asymptotic bias, endogeneity bias and cross-sectional heterogeneity) make other estimations techniques non-sufficient to estimate long-run relationship between the variables of interest.

The long run results in Table 5 for all models found similar results to PMG short run result presented above, DOLS, FMOLS, GMM, PMG and DFE model confirmed a positive and significant relationship between electricity consumption, electricity availabilities, and control of corruption on economic growth in SSA. However, human capital development is significant and negatively on economic growth. The dynamic OLS and PMG results showed the long impact of electricity consumption on GDP significant and positive in Africa. As showed in Table 5, electricity consumption impact is higher representing about 90% influence on economic growth in the region. Meanwhile, PMG showed 27% influence on GDP. Electricity supply/availability is positive and significant variables to explain economic growth in the long run in SSA countries. This shows that it influenced economic growth by 28% and 45% from DOLS and PMG. Upholding the assumption of neoclassical economists that energy and capital are perfectly substitutable (Solow, 1974; Solow and Wan, 1976). A decline in energy use does not, under conditions of economic efficiency; result in a reduction in economic growth due to minor impact on production. In contrast, they have been strongly criticized by proponents of ecological economics argued that, since all production involves the transformation or movement of matter in some way, energy is therefore necessary for economic production and, as a result, economic growth. We conclude that electricity availability is highly significant in promoting economic growth in SSA nations. This is support of empirical findings of (Aboagye and Alagidede, 2016; Beidari et al., 2017; Wolde-Rufael, 2009) hinted that energy is a key input in economic activity stretching from household level to industrial level more especially in developing countries like Africa. Theoretically supports growth hypothesis. The growth hypothesis argued that energy consumption significantly promotes economic growth of a nation.

In addition, control of corruption is positive and significantly influenced GDP in SSA by 93% for every 1% increase in control of corruption based on DOLS results. Meanwhile, it determines GDP by 15% per 1% increase using PMG outcome. The two tests confirmed that good institutional quality is imperative for economic growth in SSA countries. Our result is similar to (Musibau et al., 2017; Nurudeen et al., 2015; Ozturk and Al-Mulali, 2015). However, Human capital development is negatively and significantly influenced growth in the region. The coefficient estimates for human capital development (HCD) showed a decrease of 0.06416 for 1 unit increase in expenditure human capital development. Meanwhile.,0753 decrease on growth following PMG result. The negative impact of HCD on growth in SSA is as a result of weak institution in the region when the money allocated for human capital building (education) has been diverted for private use. The state of human capital development in SSA has been undermined and retarded by the menace of corrupt practices. Since developing the human capital of any economy serves as a catalyst that promote transformation for the development of socio-economic of any country. It is therefore imperative to pay much

Table 6: Panel granger causality analysis

Equation/excluded	Probability value
GDP: Dependent variable	
ELECC	6.038 (0.005)**
ELECP	3.463 (0.009)**
HCD	13.189 (0.016)**
COC	11.468 (0.028)**
ELECC: Dependent variable	
GDP	0.953 (0.360)
ELECP	0.467 (0.760)
HCD	0.815 (0.419)
COC	0.645 (0.514)
ELECP: Dependent variable	
ELECC	0.498 (0.787)
GDP	7.237 (0.032)**
HCD	7.815 (0.029)**
COC	0.645 (0.765)
HCD: Dependent variable	
ELECC	6.614 (0.036)**
ELECP	12.967 (0.01)**
GDP	4.815 (0.045)**
COC	0.645 (0.873)

**Significant at 5% level

attention on the policy promote human capital with improvement in the quality of an institution in SSA. It is also imperative to mobilize the required financial for development of human capacities to achieve sustainable in the region. The electricity supply of the SSA economies must be improved to trail economic growth and environmental protection. In general, control of corruption has a significant impact on energy electricity supply and economic growth. Therefore, we suggest policy to reduce corrupt practices in the region since strong institution plays a vital role on energy efficiency role as it maximizes production while minimizing electricity consumption.

To estimate the presence and direction of causality among the variables of interest, the panel granger causality analysis is presented in Table 6. The results explain that there is evidence of causality running from GDP through ELECC and from EXDBT through DEBTIN, each with a feedback. This is evident from the rejection of the null hypothesis at 5% level of significance and goes in line the growth hypothesis. These show that there are bi-directional causalities between GDP and EXDBT, as well as between EXDBT and DEBTIN since the probability value in each case is less 5%. Similarly, while there is a uni-directional causality running from GDP through CORR, there are independence between GDP and DEBTIN, EXDBT and CORR and between CORR and DEBTIN, since the null hypothesis cannot be rejected at any of the significance levels.

5. CONCLUSION AND POLICY IMPLICATION

The large of amount of African's economies struggle to maintain an affordable and reliable supply of energy to ensure stability of their economies and energy sustainability. Energy sustainability of any nation relied on environmental sustainability, energy equity and Energy security as core dimensions (World Energy Council, 2016). Meanwhile, ensuring sustainable energy supply is high imperative for sustainable growth of an economy with good institutional qualities as a mediating factor when measuring direct and indirect effects on economic growth. Considering this, the study investigates the relationship among electricity consumption, electricity availability, human capital development, and economic growth in Sub-Sahara African countries. Data spanning 37 years (from 1980 to 2016) were obtained from various sources such as World Bank WDI and WGI; and the long-run estimation techniques were used to analyze the data of the study.

The findings indicate that there is a positive relationship between electricity consumption, electricity availability, control of corruption and economic growth in SSA countries – hence, upholding the growth hypothesis in SSA countries. The indicates that energy drives the wheels of economic growth in Sub-Sahara African countries since it is a key factor of production, along with capital, and labor. Meanwhile, our results also support a negative relationship between human capital development and economic growth in SSA countries. This supports the human capital theory, which upholds that, ceteris paribus, personal incomes vary according to the amount of investment in human capital; that is, the education and training undertaken by individuals or groups of workers. Quality labour as a factor of production is imperative in a country for sustainable growth. We therefore suggest a policy to improving their institutions qualities and build a good political structure to utilities government expenditure on electricity supply and human capital development to ensure economic growth in SSA countries.

6. ACKNOWLEDGEMENT

We appreciate the effort of Research and Innovation Management Centre, Universiti Sultan Zainal Abidin, Malaysia in financing this research.

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