ENERGY ACCESS AND HOUSEHOLD INCOME IN SUBSAHARAN AFRICAN COUNTRIES

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ABSTRACT

This study empirically examined the energy access and household income in Sub-Saharan African countries between 1990 and 2015. The study employed five variables: energy access, per capita income, energy price, FDI and trade openness, as well as panel unit root test using two criteria to test stationarity. Panel cointegration test was also conducted to test long-run cointegration between the variables employed. Panel granger causality test was employed to check the degree of causality between the dependent and explanatory variables and Auto Regressive Distributive Lag method of estimation was employed to check the long-run and short-run relationships between the variables. The results of the panel unit root test from the LLC and IPS methods show that the order of integrations is mixed with some of the variables being stationary at levels (household income, Foreign Direct Investment and Trade Openness) and first difference (Energy Access and Fuel Price) at the same time. The result of Pedroni cointegration test indicated the bivariate long-run cointegration equation between the variables employed except for EA and GDPPC. The panel granger causality test revealed that there is causality between these three variables (EA, GDPPC and FUELP) and the direction of causality only flows from these variables to energy access. The ARDL result revealed that all explanatory variables accounted for 60% variation of energy access in SSA. However, the study made the following policy implications: energy policy needs to be orientated in favor of expanding the supply of energy to reach an enhanced degree of sustainable economic growth and development, and governments in this region can subsidize energy products to increase its consumption and promote the welfare of their citizens.

1. INTRODUCTION

Commercial energy resources in Africa, primarily petroleum and natural gas, are concentrated in coastal and offshore regions. Electricity in Africa is generated through thermal (57.8 percent of installed capacity) or hydroelectric (42.2 percent) resources. Natural gas could take a more significant role in the Community's energy sector as fields in Nigeria and Côte d'Ivoire are developed. Due to a relatively small urban population in Africa (approximately 33.9 percent) and lack of infrastructure, access to commercial energy sources is limited. In 2005, Nigeria had petroleum exports of 2.3 million barrels per day (bbl/d), while Côte d'Ivoire, exported 39,000 bbl/d of petroleum. All other Africa countries are net energy importers (Othieno &Awange, 2016; Peng &Poudineh, 2017).

Access to modern and clean sources of energy is known to have an important relationship to human development indices such as GDP. The geographical, cultural and climatic diversity of the poverty map is huge both within the region and within each country. The countries in the region vary widely in average per capita consumption, average access to equipment and degree of asymmetry between different income quintiles for these variables (Watts et al, 2015).

Sub-Saharan Africa as a region is a representative case of the problem of inequality in access to energy. The countries do not have 100% access to electricity, together with one of the lowest electricity consumption rates per capita in the residential sector – a clear demonstration that access to energy should be accompanied by access to appliances (Ouedraogo, 2013; Frelat et al, 2016; Schwerhoff &Sy, 2017). First, the basic issue that needs to be addressed is the recognition that by itself access to energy is a necessary but not a sufficient target. People do not want access to energy but to the range of services that energy can provide.

Sub-Saharan Africa offers an opportunity to analyze a very good example of both socio-economic and energy-related realities. These countries are low-income countries, a power exporter and an importer of oil products with a low level of access to electricity, and with significantly low per capita consumption and a low level of energy service satisfaction (Munasinghe, 2013).

Access to modern energy services is crucial to fulfilling basic social needs, driving economic growth and fuelling human development. This is because energy services have a significant effect on productivity, health, education, availability of safe water and communication services. (Berkhout et al, (2010); McMichael, (2011); Raworth, (2012); Varey, (2012); Domazet et al, (2014) Afsharzade et al, (2016); Brand-Correa &Steinberger, (2017)). Contemporary energy sources such as electricity, natural gas, modern cooking fuels and mechanical power are essential for enhanced health and education, better access to information and agricultural productivity.

Access to modern energy is also an indispensable input for achieving most Sustainable Development Goals, which are a reference of progress against poverty by 2030 and a benchmark for possible progress beyond that date (Oyedepo, 2014). Even though the provision of affordable modern energy and energy services are highly regarded as catalysts for economic development, improving peoples' livelihoods, and promoting sustainable development, it has been noted the lacking access to modern energy and energy services in many developing countries. An estimated 1.3 billion people, approximately a fifth of the world's population, lack access to electricity at home and the vast majority of these people live in rural areas of Sub-Saharan Africa (SSA) and South Asia (Yadoo &Cruickshank, 2012) In SSA, 81% of the region's population rely on traditional bio mass fuels for cooking and heating (Wicke et al, 2011). This, in spite of the traditional use of bio mass, has several disadvantages such as being associated with significant amount of time spent on fuel-wood collection; indoor air pollution; and deforestation and soil degradation (Wicke et al, 2011). Arguably, these disadvantages will likely be exacerbated as some projections show that the number of people relying on traditional bio mass will increase by 10%, from 585 million in 2009 to 645 million in 2030 under a business-as-usual scenario, as the rate of electricity connections will not be able to keep pace with population growth (Glemarec , 2012).

The description of the energy situation in Africa has been only partially addressed in scientific literature. Understanding the link between energy consumption and economic growth is also often investigated, trying to highlight the key parameters, and hence the most proper policies to promote development (Kebede et al, 2010; Eggoh, 2011; Abanda, 2012; Kahsai, 2012; Ben Aïssa; 2014). Energy is arguably one of the major challenges the world faces today, touching all aspects of our lives. For those living in extreme poverty, a lack of access to modern energy services dramatically affects health, limits opportunities and widens the gap between the *haves and have nots*. The vulnerability of the poor is only worsened with recent challenges from climate change, a global financial crisis, and volatile energy prices (Hallegatte et al, (2015); Watts et al, (2015)).

The majority of the rural population are 'energy poor', with over 80% of their household energy consumption dominated by cooking needs (Fall, 2010; Sokona et al, 2012), which is primarily met by using traditional biomass cook stoves with efficiencies less than 20% (Sanga and Jannuzzi, 2005). The over-reliance on traditional biomass to meet basic energy needs comes at a significant price in terms of the poor quality of fuels, the amount of time spent on collection and the use of fuels and the associated health impacts and deaths from the use of such fuels (World Health Organization (WHO), 2009; Sokona, Mulugetta &Gujba (2012); González-Eguino (2015) and Sovacool &Drupady (2016)).

Energy access for all must go beyond electricity to ensure that people have access to clean fuels for meeting their heating and cooking requirements, and also to help in livelihood enhancement and diversification.

The relationship between energy consumption and economic growth has been extensively investigated (Muhammad et al, 2015), but the literature on energy access – household income nexus is rare. As far as it is known, only few empirical studies investigate the correlation between energy access and household income. The reason could be that the correlation between energy access and household income is not as direct as that of energy consumption and economic growth (Ozturk, Aslan & Kalyoncu, (2010); Jayanthakumaran, Verma & Liu (2012); Rao (2012); Ozturk & Acaravci (2013)). Apart from contributing to the academic literature on energy access and household income in West Africa, the approach used in this study adds value to the previous studies in Africa by measuring the level of energy access achieved by the participating countries in terms of their response to per capita income. The methodologies used in the previous studies do not allow the direct measurement of energy access of individual countries and their response to monetary shocks. However, this study will serve only as reference literature to capture the energy access and household income in the coastal countries of West Africa. This study is part of the efforts to fill the identified gaps in the available literature. It is against the backdrop of the above highlighted problems and the gaps in the extant literature as the study investigates the energy access and household income nexus in Sub-Saharan Africa.

It is not an overstatement that this study bridges this gap in knowledge and will be resourceful to the Governments, our environmentalists, policy makers and other stakeholders in formulating quantitative policies, directives and regulations to enhance development of the power sector in Sub-Saharan African countries.

The main objective of this study is to examine the link between energy access and household income in Sub-Saharan African countries. Specifically, the study sought to:

1. Examine the effect of household income on energy access in Sub-Saharan African countries
2. Check for the existence of causal relationship between energy access and household income in Sub-Saharan African countries

To achieve these objectives, the paper was structured into five sections. The first section provides the introduction to the subject matter justifying the need for the study. Section two presents related literature on the household income and energy access nexus. Section three discusses the research methodology, while data presentation and analysis including the research design, sources of data, model formulation and estimation techniques are given in section four. Concluding comments in section five reflect on the summary and policy implications.

2. LITERATURE REVIEW

Balachandra (2011) assessed the dynamics of rural energy access in India. In his study, he stressed that India's rural energy challenges are formidable with the presence of majority being energy poor. In 2005, out of a rural population of 809 million, 364 million lacked access to electricity and 726 million to modern cooking fuels. This indicates low effectiveness of government policies and programs of the past, and the need for a more effective approach to bridge this gap.

Subhes (2012) critically reviewed and analyzed energy access programs and sustainable development. The study provides an overview of the debate on energy access and development, and argues that despite some progress in enhancing energy access, the programs promoting energy access are neither sustainable nor adequately contributing to development. The study substantiates this argument by considering the experience of energy access and performing a simple multi-dimensional sustainability analysis. There has been a disproportionate emphasis on electrification in the past, which can neither resolve the energy access problem nor address the sustainable development issue. Ensuring access to clean energies to meet the demand for cooking and heating energy and providing economically viable and affordable options remain the greatest challenge. The study suggests that rebalancing approaches to energy access provision is required to ensure their sustainability.

Massimo and Lester (2012) estimated a US frontier residential aggregate energy demand function using panel data for 48 states over the period 1995-2007 using stochastic frontier analysis (SFA). Utilizing an econometric energy demand model, the inefficiency of each state is modelled and it is argued that this represents a measure of the inefficient use of residential energy in each state (i.e. 'waste energy'). This underlying efficiency for the US is therefore observed for each state as well as the relative efficiency across the states. Moreover, the analysis suggests that energy intensity is not necessarily a good indicator of energy efficiency, whereas by controlling a range of economic and other factors, the measure of energy efficiency obtained via this approach is. This is a novel approach to model residential energy demand and efficiency and it is arguably and particularly relevant given the current US energy policy discussions related to energy efficiency.

Rigoberto and Boris (2016) examined Privation of energy services in Mexican households. The study pointed out that energy poverty affects millions of families in Mexico, so there is a need for overcoming this social justice problem.

Hence, the paper presented a methodological framework to characterize families according to their levels of deprivation of energy services and, furthermore, identify the determining factors of these different levels of deprivation. The results indicated that five groups of homes exist: one group which does not lack any energy service; two groups which lack only one energy service and two more groups which lack the majority of energy services. Those variables which most precisely explain the probability of finding a home in each of these groups are per-capita income, size of settlement (urban or rural), and type of climate. They concluded their findings with public policy implications, characterizing households based on their level of deprivation of energy services. Sound strategies may be designed and implemented to attend to the specific needs of each household group.

3. METHODOLOGY

3.1. Theoretical Structure

Pokrovski (2003) noted that energy can be considered a driving force of production. By using the empirical values for the U.S. economy for the period 1890-1999, he argued that there is a strong correlation between output and input factors, and that the value of production has to be determined by productive energy and capital services provided by the capital stock and labor.

Subsequently, Ghali & El-Sakka (2004) proposed a production function framework to study the relationship between different factors of production (including energy) and output in Canada. To this end, they employed a multifactor one-sector neoclassical production function. By adopting a similar approach in which energy was regarded as an essential factor of production, Beaudreau (1995, 1998) and Nourzad (2000) used a modified aggregate production function, and it is this multifactor neo-classical one sector aggregation production function that is cited in the research as follows:

$$Q_{it} = f(E_{it}\ L_{it}KS_{it}) \quad \text{.........(16)}$$

Where Q is real GDP, E is the energy input, L is the labor input, and KS is the real capital stock. Furthermore, it is assumed that the aggregate production function is of the Cobb-Douglas type and exhibits constant returns to scale. Just as in the main macroeconomics and growth theory textbooks, he divides the input factors—Q, E and KS by labor input (representative unity) as a per unit form of output, and by taking logarithms we obtain the following empirical equation of the energy-dependent function:

$$LGY_{it} = \alpha_{it} + \beta_{it} + \lambda_{1t}LEC_{it} + \lambda_{2t}LK_{it} + \mu_{it} \quad \text{.........(17)}$$

Where ε is the error term; the real per-capita number of LGY stands for ln (Q/L), LEC stands for ln (E/L), and LK stands for ln (KS/L), 13 all of which allow for cointegrating vectors of differing magnitudes between countries, as well as for a country (αi) and trend-effects (β_{it}). These trend effects are intended to capture any disturbances that are common across different members of the panel, such as global disturbances and international business cycles. All the variables are expressed in natural logarithms so that the elasticities can also be interpreted, and the ʎs are the parameters of the model and represent the input elasticities of output.

3.2. Method of Estimation

In analyzing the impact of household income on energy access in Sub-Saharan Africa, the study leans on five Variable ARDL models, following Sims et al. (1980) argument that ARDL models provide a lucid and reliable approach to data description, forecasting, structural inference and policy analysis. It should be noted, however, that this model is appropriate for this study so as to cater for endogeneity.

The following model was considered for the general estimation of this study:

$$EA_{it} = \propto_0 + \propto_1 GDPPC_{it} + \propto_2 FUELP_{it} + \propto_3 FDI_{it} + \propto_4 TOPN_{it} \text{ ....(18)}$$

3.3. Estimation Techniques

The study leans on ARDL estimation techniques and since it has been adjudged from empirical enquiries that time series data have two central properties i.e. non-stationarity and time varying volatility, Philips (1986) regression analysis with variables that contain such properties may produce misleading and spurious results, thereby causing biased economic analysis. As such, stationarity tests were adopted to eliminate the problem.

The linear unit root test was adopted to check whether the time series data were stationary or not, Levin, Lin and Chut, and Im, Pesaran and Shin W, while the non-linear unit root test was KSS and Solis which is a modification to KSS and it was developed by Solis (2009).

$$\Delta y = \rho + \alpha y_{r-1} + \sum_{t=1}^{p} \vartheta \Delta y_{r-1} + \mu_t \text{ ......(19)}$$

$$\Delta y = \rho + \alpha y_{r-1}^{3} + \sum_{t=1}^{p} \vartheta \Delta y_{r-1} + \mu_t \text{ ......(20)}$$

$$\Delta y = \rho + \alpha_1 y_{r-1}^{3} + \alpha_2 y_{r-1}^{4} + \sum_{t=1}^{p} \vartheta \Delta y_{r-1} + \mu_t \text{ ......(21)}$$

NB: specification for equation (19) above is for a linear unit toot at first difference, while (20) and (21) are non-linear unit root test at first difference, i.e. KSS and Solis respectively

3.4. Sources of data

The data for this study are obtained mainly from secondary sources; particularly from the World Development Indicator (World Bank, 2016) and the Energy International Agency (EIA data base, 2017).

4. PRESENTATION AND ANALYSIS OF RESULTS

This section presents the data analysis and the empirical analysis from the estimations of the two models. In particular the current chapter offers statistical estimates and empirical results to verify the hypotheses in this study. First to begin with, the chapter presents some descriptive and graphical evidence for the variables in the model. Second, the chapter presents the panel unit root test using the two criteria, and then proceeds to examine the panel cointegration test between each of the regressors and the dependable variable. Having obtained the result of the panel unit cointegration test, the coefficients of the variables are estimated using the panel Autoregressive Distributed Lag (ARDL) method. Finally, the panel granger causality test is applied to the variables and the implication of the study is presented in the last section of this chapter.

4.1. Empirical Results and Discussion

The fundamental thrust of this study is to empirically examine the energy access and household income nexus and thus offer some illuminating evidence on the validity of the absolute income hypothesis for Sub-Saharan African countries. As it is conventional in empirical studies such as this one, some data evaluation and testing analysis will be pertinent in order to ensure that the empirical estimates obtained in this way are empirically valid and reliable. Hence, as previously stated in chapter three the first test exercise is the panel unit root test analysis which is presented in table 4.3 below.

4.1.1. Panel Unit Root Test Results

The panel unit root test methods utilized for the purpose of evaluating the stationarity property of the panel series employed in this study are those that have been widely employed in empirical analysis such as ours. Specifically, Lin, Levine and Chu (LLC) and the Imp, Pesaran and Shin (IPS) are the basic criteria that have been used in this study because of their widespread application in previous empirical studies. The result of the panel unit root test based on the LLC and the IPS methods is presented in table 4.1 below.

Table 4.1: Panel Unit Root Test Results

Variables	Lin, Levine and Chu Test		Imp-Pesaran-Shin Test		Conclusion on the Order of Integration	
	Levels	1st Diff.	Levels	1st Diff.	Levels I(0)	1st Diff. I (1)
EA	1.77130 (0.9617)	-10.3461 (0.0000)	2.74458 (0.9970))	-9.5744 (0.0000)	No	Yes
GDP per capita	-7.53071 (0.0000)	-13.5789 (0.0000)	-8.36123 (0.0000)	-17.085 (0.0000)	Yes	Yes
FUELP	-0.07921 (0.4684)	-708113 (0.0000)	1.33331 (0.9088)	-9.5254 (0.0000)	No	Yes
FDI	-3.96627 (0.0000)	-18.5652 (0.0000)	-5.48038 (0.0000)	-21.143 (0.0000)	Yes	Yes
TOPN	-1.97043 (0.0244)	-13.8986 (0.0000)	-1.6344 (0.0509)	-14.218 (0.0000)	Yes	Yes

Source: Authors' calculation (2017)

The unit root test is carried out with constant and trend specifications for the respective series. The lag-selection was based on the default selection of the Akaike-Information Criterion (AIC). The table contains the LLC and the IPS test statistics at levels and first difference of the panel series. The numbers in the brackets represent the probability values of the estimate test statistics of the LLC and IPS test.

The unit root test result from the LLC and IPS methods shows the order of integrations mixed with some of the variables being stationary at levels and first difference at the same time. In particular, the stationarity of the general unit root process for the set of panel data series for the variables shows that they are all significant at least at the 5 percent level for the first difference of all the variables and thus the null hypothesis of unit root in the data cannot be upheld.

4.1.2. Panel Cointegration Test Result

In view of the panel unit root test result, some empirical investigation on the long-run relationship in the model can be examined. Though the unit root test does not strictly satisfy the condition for embarking on a cointegration, doing this will help establish if any of the set of variables may be cointegrated. The most prominent and widely used panel cointegration test technique in the literature has been the one developed by Pedroni (2004). The Pedroni (2004) panel cointegration test is based on the general form of the Engel-Granger method.

The hypothesis tested in the Pedroni (2004) approach states that there is no cointegration for all the units or equations specified. The alternative states the reverse. Hence if the probability values of the Pedroni cointegration test statistics are less than 5 percent then the null hypothesis cannot be upheld.

Table 4.2: Pedroni Cointegration Test

Cointegrating Equations	v-statistic	rho statistic	PP-statistic	ADF-statistic
Model 1: EA, GDPPC	0.960926 (0.1683)	-0.305048 (0.3802)	-0.955972 (0.1695)	-0.438958 (0.3303)
Model 2: EA, FUELP	5.536547 (0.0000)	-5.162313 (0.0000)	-5.569203 (0.0000)	-4.366980 (0.0000)
Model 3: EA, FDI	1.331960 (0.0914)	-1.453057 (0.0731)	-2.093114 (0.0182)	-0.799802 (0.2119)
Model 4: EA, TOPN	1.679929 (0.0465)	-1.538046 (0.0620)	-2.411170 (0.0080)	-0.946543 (0.1719)

Source: Authors' calculation (2017)

The results of the test of the respective equation specifications are contained in table 4.4 above. The hypotheses testing statistics are the v-statistics, rho statistics, PP-statistics and the ADF-statistics. Notice that each row in table 4.4 indicates the bivariate long-run cointegration equation. The first row investigates the long-run relationship between energy access and GDPP per capita, followed by the second row which investigates the long-run relationship between energy access and fuel prices and subsequently models 3 and 4 which examine the long-run relationship between Energy access and FDI and trade openness respectively. It can be seen from the table that the probability values for all hypothesis testing statistics except for the v-statistics are significant at the 5 per cent level for models 2, 3 and 4, but not significant at least at the 5 percent level for model 1 where the long-run relationship between Energy access and household income is investigated. The outcome of the cointegration provides strong confirmation of the existence of significant long-run relationship between the variables in the model. In particular the result provides evidence suggesting that climate change resilience has long-run relationship with fuel price, FDI and trade openness. Hence, the null hypothesis of no cointegration cannot be upheld for the Pedroni cointegration test. However, in the case of household income, the study fails to reject the null hypothesis and hence it can be inferred from this result that there is no long-run relationship between energy access and household income among the sample covered.

4.1.3. Long-Run Estimates

Having established the fact that some of the explanatory variables in the model do have long-run relationship with the dependent variable it will also be necessary to examine the direction and magnitude impact of the relationship between energy access and the set of explanatory variables captured in the model. In this sense the aim is to obtain empirical estimates measuring the impact of regressors on the dependent variable.

For this purpose the panel Autoregressive Distributed Lag (ARDL) is employed for the estimation. The ARDL is a long-run parameter estimation method in which the steady state converging relationship can be evaluated and examined based on the parameter estimates obtained from the estimation exercise.

The result of the regression analysis is shown in table 4.5 below. The table contains the parameter estimates obtained from the panel ARDL estimation approach. The variables are estimated in their logarithm form for the purpose of data demeaning and to avoid outliers which can lead to heteroscedasticity problems.

In the table the values in the brackets are the probability values of the parameter estimates of the model. The last two columns to the right of the table show the conclusion on the sign and the test of significance of the parameter estimates of the variables. The negative or positive sign indicates negative or positive impacts of the explanatory variable on the dependent variable respectively. The significance of the estimated coefficients is tested from the probability value of the estimated coefficients. If the probability value of the estimated coefficient is less than 5 percent then the explanatory variable has a significant impact on the dependent variable. Hence the research hypothesis cannot be upheld.

Table 4.3: Long-run and short-run relations in Panel ARDL Model

REGRESSOR	ARDL		
	Long-Run	Short-Run	
Constant		1.515317 (0.0003)***	
GDPPC	0.022392 (0.0363)**	-0.002245 (0.0009)***	
FUELP	0.050240 (0.0000)***	-0.006814 (0.6560)	
FDI	-0.060654 (0.4870)	0.000503 (0.6805)	
TOPN	-0.032501 (0.1414)	0.044682 (0.0751)*	
ECM(-1)	-0.229802 (0.0001)***		
R-squared	0.608049	Akaike info criterion	3.332536
Adjusted R-squared	0.543017	Schwarz criterion	3.710833
Long-run variance	105561.4	Hannan-Quinn criterion	3.692654

Note: ***, ** and * denote asymptotic significance at 1%, 5% and 10% respectively. Values in parenthesis are the p-values of the parameter estimate.

Source: Authors' calculation (2017).

The above result depicts the long-run and short-run equations of the model. From the result, it is shown that household income has a significant inverse relation with energy access while trade openness has a positive and significant relation. All other variables (fuel price and FDI) were insignificant at this economic time.

In the long run, household income has a significant positive relation with energy access. One percent increase in household income leads to 23% increase in energy access in SSA countries. This result conforms to a priori expectation. It is quite clear that household income is an important determinant of energy access in the long run.

Fuel price has a significant positive relation with energy access. The result does not conform to a priori expectation. However, 1% increase in fuel price will lead to 50% increase in energy access. This result is not surprising because majority of the populace may prefer access to clean energy irrespective of price consideration. Hence, fuel price is a significant factor determining energy access in SSA. Foreign direct investment that captured the foreign investment in energy sector and trade openness depict an inverse relation with energy access. However, the results show that those variables are not significant. The R2 statistics shows that explanatory variables accounted for 60% variation of energy access in SSA. This is supported by higher adjusted R2 value of 54%.

The Akaike info criterion, Schwarz criterion and Hannan-Quinn criterion value of 3.33, 3.71 and 3.69 respectively indicate that the model selection is good.

4.1.4 Panel Causality Test

Having established the magnitude of the impact of the set of explanatory variables that entered the regression equation, the study prods further to investigate nature of causality among the variables paying particular attention to the causality of the household Income variables and Energy Access. The causality test is carried out using the logarithm of the variables, i.e. using one lag-length as stipulated by the Akaike Information Criteria (AIC). The test method is the Stacked test method with common coefficients. The hypothesis testing procedure follows similar procedures as stated in other aspects of this study. The result of the causality test is contained in table 4.6. The arrows between the variables indicate the hypothesized direction of causality while the asterisks *** and ** denote the asymptotic significance of the F-test statistics.

Table 4.4: Panel Causality Test

Direction of Causality	Null Hypothesis (H_0)	F-statistics	P-values	Decision
GDPPC→EA	No Causality	5.50989*	0.0043	Reject H_0
EA→GDPPC	No Causality	0.35097	0.7042	Do not reject H_0
FUELP→EA	No Causality	3.52427	0.0303	Reject H_0
EA→FUELP	No Causality	0.47295	0.6235	Do not reject H_0
FUELP→GDPPC	No Causality	2.19080	0.1130	Do not reject H_0
GDPPC→FUELP	No Causality	3.60153	0.0281	Reject H_0

Source: Authors' calculation (2017)

The result from the pairwise panel causality test indicates that the null hypothesis can only be rejected in three causality relations. Specifically, the result shows that GDP per capita and fuel price has a strong causality relation with energy access and hence their null hypothesis cannot be upheld. Though there is causality between these three variables the direction of causality flows only from these variables to energy access. Given this outcome it can be said that there is a unidirectional causality between GDPPC and FUELP on EA.

The result from the causality test most adequately lends credence to the validity of the regression previously obtained from the ARDL regression exercise. It provides robust evidence linking the household income and energy access. The results can be presented in a flow below:

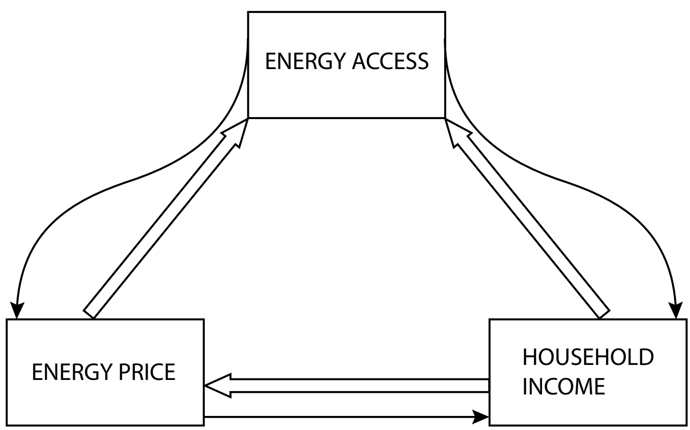

Figure 4.2: ENERGY ACCESS AND HOUSEHOLD INCOME FLOW IN SSA
Source: Authors (2017)

From the above diagram, the thick arrow shows the direction of causality between fuel price and household income on energy access while the thin curve arrow indicates no causality. The figure vividly demonstrates that household income and energy price have a unidirectional causality on energy access. By implication, it shows that the two variables have joint effect on energy access in SSA.

4.3. Comparison of the Result with Previous Studies

The outcome of this study revealed that GDP per capita proxy for household income and fuel price proxy for energy price have significant effect on accessibility and affordability of modern energy in Sub-Saharan African countries. The energy price shows a direct response to energy access. This is because demand for energy is derived demand and the elasticity is inelastic, thereby leading to anticipatory buying. Household income has also a positive relation with energy access since affordability of energy by the household depends on their income level.

The empirical results obtained from this study show some interesting empirical regularities and resemblance with previous studies. Specifically, the results here in some aspects support those of previous studies on this subject. Recent empirical studies in this strand of the literature have noted that the issue of energy access switching from electricity access and other fossil fuel as a result of income and price is primary conditional on the elasticity of substitution between modern and primitive energy (Nadia, 2013; Chien-Chiang, Chun-Ping & Pei-Fen, 2008 and Rigoberto & Boris, 2016). In this regard, the result derived from the ARDL estimation confirms this assertion.

5. CONCLUSION

If the correlation between energy consumption and gross domestic product (GDP) is well-studied, the relationship between energy access and household income is not overwhelmingly compelling. This paper investigates the long-run relationship between the energy access and household income for a panel of 19 Sub-Saharan African countries over the period 1990-2015 by using recently developed panel data unit root tests and Pedroni panel data cointegration techniques. The panel unit root test results show that the series in the panel are integrated of order one when in levels.

The Pedroni panel cointegration test results based on seven test statistics show that there is a long-run relationship between energy access and the household income, as well as fuel price. Furthermore, the paper generates consistent estimates by employing the Pedroni ARDL procedure and finds that household income has a positive and significant effect on energy access in all nineteen countries in the long run. The effect of the energy price is positive on energy access over the period of investigation.

However, as the usage levels of energy are recognized to have an impact on the economic growth the access to energy is inextricably linked to improved welfare and human development. Modern energy is an indispensable factor of the social and economic development of societies, since modern energy like electricity has a direct impact on productivity, health, education, and communication.

As a result of this study, the following policy implications were suggested:

Energy policy needs to be orientated in favor of expanding the supply of energy to reach an enhanced degree of sustainable economic growth and development.

Efforts should be made by the stakeholders in addressing loop-sidedness in the distribution of income among the *Haves and the Have Nots* in this region.

Since this study revealed that energy price and energy access are positively related, governments in this region can subsidize energy products to increase its consumption and promote the welfare of their citizens.

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ПРИСТУП ЕНЕРГИЈИ И ПРИХОД ДОМАЋИНСТВА У ЗЕМЉАМА СУБСАХАРСКЕ АФРИКЕ

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САЖЕТАК

Ова студија се бави емпиријским истраживањем приступа енергији и приходима домаћинства у земљама Субсахарске Африке између 1990. и 2015. године. Студија је обухватила пет варијабли: приступ енергији, доходак по глави становника, цијену енергије, страна директна улагања и отвореност трговине, као и тест јединичног корјена, користећи два критерија за тестирање стационарности. Такође, спроведен је тест коинтеграције да би се тестирала дугорочна коинтеграција између кориштених варијабли. Грејнџеров тест узрочности је такође кориштен да би се провјерио степен узрочности између зависних и експланаторних варијабли, док је метод ауторегресивног дистрибутивног распона кориштен за провјеру дугорочних и краткорочних односа између варијабли. Резултати теста јединичног корјена добијених методама **Levin-Lin-Chu (LLC)** и **Im-Pesaran-Shin (IPS)** показују да је редослијед интеграција помијешан са неким варијаблама које су стационарне на нивоима (приход домаћинства, страна директна улагања и отвореност трговине) и првом разликом (приступ енергији и цијена горива) у исто вријеме. Резултати Педрони методе коинтеграцијског теста указују на биваријантну: дугорочну коинтеграцијску једначину између кориштених варијабли осим варијабли приступ енергији и БДП по глави становника. Грејнџеров тест узрочности показао је да постоји узрочност између ове три варијабле (приступ енергији, БДП по глави становника и цијена горива), а правац узорчности иде само од ових варијабли до приступа енергији. Резултат методе ауторегресивног дистрибутивног распона открио је да све експланаторне варијабле чине 60% варијације приступа енергији у Субсахарској Африци. Међутим, студија је дошла до сљедећих импликација: енергетска политика треба да буде оријентисана у корист проширења снабдијевања енергијом да би се достигао већи степен одрживог економског раста и развоја, а владе у овом региону би требале да субвенционишу енергенте да би се повећала потрошња и промовисало благостање грађана.

Кључне ријечи:
приступ енергији, доходак по глави становника, цијена енергије, страна директна улагања и отвореност трговине.