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## Article

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## Provided in Cooperation with:

International Journal of Energy Economics and Policy (IJEPP)

*Reference:* Ejemeyowwi, Jeremiah/Adiat, Queen et. al. (2019). Energy usage, internet usage and human development in selected Western African countries. In: International Journal of Energy Economics and Policy 9 (5), S. 316 - 321.  
<http://econjournals.com/index.php/ijeep/article/download/7611/4524>.  
doi:10.32479/ijeep.7611.

This Version is available at:  
<http://hdl.handle.net/11159/5110>

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## Energy Usage, Internet Usage and Human Development in Selected Western African Countries

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**Received:** 10 March 2019

**Accepted:** 01 July 2019

**DOI:** <https://doi.org/10.32479/ijeeep.7611>

### ABSTRACT

The examination of energy usage and information and communication technology (ICT) usage in terms of their role in the improvement of human development (HD) was the study's objective. A panel analysis is carried out on World Bank data (2000-2014) from selected Western African countries, with notable energy usage within the region. The study utilizes generalized least squares, the fixed effect model and the random effect model econometric estimation techniques to determine the degree of relationship and impact existing between the variables of interest. The results indicate that internet usage and energy usage affect HD in the selected West African countries. The policy implication from the findings posit that it is expedient that the government and private sector, exert financial and non-financial contributions to ensure that energy and ICT facilities are readily available for use. This would improve the level of the two major HD components (health and education).

**Keywords:** Energy Usage, Information and Communication Technology Usage, Human Development, Western Africa

**JEL Classification:** Q4

### 1. INTRODUCTION

In recent times, information and communication technology (ICT) and energy consumption, have proven to be key factors that greatly influence human development (HD). According to Kuyoro et al. (2012), ICT is being integrated into, virtually, all aspects of human activity, at a rapid rate. This advancement, has been accompanied by a thriving argument on the actual contribution of ICT in relation to productivity and growth as well as in human welfare both for developed and developing countries. Notwithstanding, Niebel (2018), stated that productivity and growth form the basis to enhance the standard of living of a country and that adopting ICT is a "key driver" of this productivity and growth.

This swift integration of ICT is believed to create a platform for HD to assume a certain pattern on several influential fronts (Imhonopi

et al., 2013). Research is ongoing as to the key functions ICT can perform in supporting crucial aspects of HD such as education, health, eliminate poverty and in improve the employment rate. In accordance with Niebel (2018), these researches, show that ICT has ample potential to provide and foster, stable platforms, expand growth opportunities and incur advancements in modern economies globally.

As regards energy in relation to HD, high levels of energy use is most often, associated with an improved level of HD (Pirlogea, 2012). A certain criterion known as HD index (HDI) is adopted to measure the amount of HD in relation to certain factors and it has been shown that advanced countries with a low per capita energy consumption have high index scores. In the analysis of regression, it is revealed that the HDI experiences steady increment for certain levels of energy consumption (Steinberger and Roberts, 2009).

Hence, under-developed countries incur low HDI values in relation to energy consumption while more advanced countries with high HDI scores have a corresponding high energy consumption level (Martínez and Ebenhack, 2008).

Adequate energy supply, plays a vital role in economic and social development which also translates to HD. Energy evolution (from use of traditional fuels; such wood, to use of electricity), over time, and the enhancement of energy systems, has led to an improvement in the quality and standard of energy types (Inaki et al., 2014). Energy in clean and reliable forms, positively affect, the HD rationale which includes health and education (Pirlogea, 2012). The standard and quality of resources which provide energy, are evaluated based on the availability of usable energy outputs and adequate levels of emission depth (Ray et al. 2016). Hence adoption of efficient energy resources cannot be overemphasized in the provision of an array of advantages to a country's economy and HD (Akerkar et al., 2016).

Drawing from the above introductory paragraphs, the objective of this study is to examine the effect of ICT adoption and energy consumption on HD (labour force) in Western Africa. To achieve this, the outline of the study entails five sections. Section one contains the introductory section, section two consists of the literature review on the subject matter, section three consists of the methodology, section four consists of the results and discussion, while section five discusses the conclusion and recommendation of the study.

## 2. LITERATURE REVIEW

The link between ICT adoption, electricity consumption and HD is largely an under researched topic. While scholars focus their studies on either the correlation between ICT adoption and HD (Kuyoro et al., 2012) or energy consumption and HD (Karekezi et al., 2012, Niu et al., 2013) Only scanty literature exist to effectively explain how ICT adoption works through electricity consumption to improve outcomes in education and health. In the event that studies have related all three, as in (Salahuddin and Alam, 2016) and Salahuddin et al. (2016) the emphasis was on economic growth. However, economic growth alone does not represent HD but rather longevity, good health and high education levels (Stanton, 2007). In fact the HDI was created to challenge policies that encourage increasing GNI per capital at the expense of improved outcomes in knowledge and standard of living (United Nations Development, 2018).

Poor electricity coverage in African countries forces most households to rely primarily on biomass fuel in the form of wood for cooking (Youssef et al., 2016) hence increasing their energy footprints and making them the worst hit by the adverse effects of climate change which is poor health. The energy/carbon footprint concept has been represented in most studies to assess the overall GHG emissions associated with the life cycle of a product or process at the national level, (Arto et al., 2014, Allen and Pentland 2011) organizational level (Malmodin and Lundén, 2018) and household level (World Health Organization, 2008). Arto et al., 2014 found that in developed countries the

energy footprints was higher than energy consumption at +13% compared to underdeveloped regions at -16%. (Chowdhury et al., 2013), recommend that investment in modern forms of electricity, wireless networks and cloud computing would lead to a reduction in power consumption and consequently reduce the energy footprint. These recommendations although isolated, draw up a pattern, that outline how innovations in ICT have led to better and more modern forms of electricity reducing the energy footprints, thereby conserving energy and improving health, especially for future generations.

The Sustainable Development Goals (SDG's) particularly SDG 7: Ensure access to affordable, reliable, sustainable and modern energy for all, (United Nations, 2015) reiterated that developing clean forms of energy was a global issue. Scholars have proposed that investing in education, would lead to developments in ICT and overcome this challenge (Aziz et al., 2015, Dias et al., 2006). Indeed (United Nations, Economic and Social Council, 2014) highlighted how ICTs could mitigate the harmful effects of waste and carbon emission to improve processes for economic growth and HD while highlighting its dependence on human intellect to drive this potential. Houghton, 2009 also proposed that ICT can be used to generate smart grids, motor systems and efficient transport systems to effectively reduce energy emissions. The study went further to highlight how investments in telecommunications and mobile technology was a catalyst for development in some rural communities in Kenya, Indonesia and the Philippines.

Notably, increase in ICT adoption has led to inescapable increase in energy usage over time (Chandramouli, 2015, Salahuddin and Alam, 2016). Heddeghem et al., 2014 reported that ICT advancements led directly to increase in electricity consumption from communication networks, personal computers and data centers causing a percentage increase in global electricity consumption from 3.9% in 2007 to 4.6% in 2012. While this also led to emission of greenhouse gases, which are established to have adverse effects on human health and positive effect in the agriculture sector (Ejemeyovwi et al., 2018). There is evidence that the pros to electricity consumption far outweigh the cons (Salahuddin and Alam, 2016; Ouedraogo, 2013). This is especially true of African countries where low electricity consumption had a strong correlation with mortality of children under 5 years and low life expectancy in 5 countries including Ivory Coast and Tunisia. (Youssef et al., 2016). The study went further to recommended advancement in ICT in order to expand electricity sources specifically for cooking that would improve the mortality indicators across Africa.

Nonetheless, if policy makers continue to ignore the need to conserve energy, while pursuing more advanced technology, the appropriate policies would not be driven, to improve the life of citizen's and protect their right to good health and long life. Dincer, 1999, opined that in establishing developmental policies, sustainability is important, and that a balance should be created between human needs for development, and energy conservation. Dias et al. 2006 corroborated these findings in concluding that driving material needs should not be the primary focus of developing countries but it was in their best interest to

intensify investment in advanced technology, while at the same time understand the energy implications and ensure that these innovations are environment friendly. Thus, it is important to develop sources of energy that were not harming human lives in a bid to make them better (Dias et al., 2006, Goldemberg and Coelho, 2004). In a study on electricity consumption in hospitals providing intensive care, (Pollard et al., 2014) concluded that it was possible to predict electricity consumption patterns, in order to deliver care whilst maintaining safety.

Improved outcomes in education is mostly defined in terms of the causal relationship it has on ICT adoption, and electricity consumption (Dias et al., 2006, Houghton, 2009), few studies have demonstrated how HD in education could also be an effect of ICT advancement and electricity consumption. (Niu et al., 2013) demonstrated that this interaction was both cause and effect. Very recently big data sprung up from advancements in ICT and has been used as an effective tool in increasing student performances, fuelling better research and improving administration within educational institutions. (Ekong et al., 2019; Huda, et al., 2017). In 2013, 1% of energy consumed globally was from three billion personal computers, while 1.5% of electricity was consumed by 30 million computer servers. It is extrapolated that in 2020 there would be up to 50 billion internet connected devices. (Chandramouli, 2015, Stauffer, 2013). This is of particular importance because not only does big data drive HDs in education, it is also a useful tool to track energy consumption patterns both at the household and organizational level in order to drive sustainable electricity consumption (Koseleva and Ropaite, 2017).

However, there persists an ongoing debate as to whether there are any economic benefits of ICT investments particularly in Sub Saharan Africa with studies producing opposing findings Ejemeyovwi et al. (2018) found that while there is no direct relationship between investment in telecommunications and HD, an investment in telecommunications in ECOWAS countries would lay the foundation for ICT adoption which would then lead to HD. Bomah, (2014) on the other hand, blames the digital divide for the low HDI in African countries, by deducing a proportional relationship between HD and access to digital resources. Yet (Kuyoro et al., 2012) argued that despite the digital divide, the ubiquitous nature of ICT can spread information, improve trade investments, and serve as a catalyst for HD. The study however pointed out that if ICT was not driven properly by government, private sector and development stake holders, it had the potential to deepen inequality. One salient point being overlooked by these studies is the fact that ICT adoption requires the availability electricity (energy) for effective operation which ensures HD. This shows the gap in literature to be filled by this study.

## 3. METHODOLOGY

### 3.1. The Empirical Model

The empirical model that underpins this relationship takes its cue from the empirical model of Ejemeyovwi and Osabuohien (2018); Ejemeyovwi et al. (2018) which assumes the HD model and expresses HD as a function of institutions, technology and other growth components with some augmentation. The model

explains that for HD to be achieved, a number of exogenous factors must be present such as technology adoption, energy usage, institutions, and other control variables should be put in place. This study augments the empirical HD model by the introduction of energy usage as it is necessary for the occurrence of HD. The implicit functional form of the model is given as:

$$Y = f(ENER, INTUS, PSE, RULE, CREDIT, GDPCGR) \quad (1)$$

The explicit form of the model is given as:

$$Y_{it} = \alpha_0 + \alpha_1 ENER_{it} + \alpha_2 INTUS_{it} + \alpha_3 PSE_{it} + \alpha_4 RULE_{it} + \alpha_5 CREDIT_{it} + \alpha_6 GDPCGR_{it} + \mu_{it} \quad (2)$$

The error term is hypothesised to be purely random while the all parameters ( $\alpha_0, \alpha_2, \alpha_3, \alpha_4, \alpha_6, \alpha_1$  and  $\alpha_5$ ) are hypothesised as positive values while the variables are transformed by taking the natural logs and the result is seen in equation (3).

$$Y_{it} = \alpha_0 + \alpha_1 ENER_{it} + \alpha_2 INTUS_{it} + \alpha_3 PSE_{it} + \alpha_4 RULE_{it} + \alpha_5 CREDIT_{it} + \alpha_6 GDPCGR_{it} + \mu_{it} \quad (3)$$

Where “ $Y_{it}$ ” represents HDI which proxies economic development of country ‘i’ at time ‘t’ as used in Ejemeyovwi and Osabuohien (2018); Ejemeyovwi et al. (2018) as a proxy; “ $ENER_{it}$ ” stands for energy utilisation of country ‘i’ at time ‘t’, which represents the consumption of energy by the consumers within an economy and a major contribution to this empirical model; “ $INTUS_{it}$ ” represents internet usage of country ‘i’ at time ‘t’; “ $PSE_{it}$ ” stands for primary school enrolment of country ‘i’ at time ‘t’; “ $RULE_{it}$ ” represents the rule of law (an institutional variable) which shows the perception of the consumers about the level and impact of law enforcement within a country ‘i’ at time ‘t’; “ $CREDIT_{it}$ ” represents domestic credit available to the private sector which represents the financial sector of country ‘i’ at time ‘t’; and “ $GDPCGR_{it}$ ” which represents economic production and components of country ‘i’ at time ‘t’.

Tchamyu (2015); Ejemeyovwi et al. (2018) and Ejemeyovwi and Osabuohien (2018) affirmed the use of HDI as a measure of inclusive growth (consistent with the African knowledge economy); Number of internet users is used as one of the proxies of ICT adoption while the control variables are consistent with literature for inclusive growth – HD and also essential for the Schumpeterian growth model. The apriori expectations of study from theory state that internet usage should have a significant positive impact on HD in West Africa. The inclusion of these variables is necessary to eliminate omitted variable bias which could alter the reliability and validity of the estimated coefficients to be derived from the study.

### 3.2. Technique of Estimation

The study utilizes three econometric techniques of estimation, namely: the generalized least squares (GLS), the fixed effect model (FEM) and the random effect model (REM) panel data analysis. The techniques of estimation are supplemented by the Hausman test. The GLS methodology is utilized by this study as the baseline regression model to have a futuristic look at what is expected while the REM and the FEM techniques are the major regression models



**Table 1: Variables definition, mean, and source of data**

Data	Identifier	Data source	Measurement
Human development (proxied by Human development index)	HDI	UNDP, 2015	Unit
Energy usage	ENER	WDI, 2018	Unit
Number of internet users/100 people	INTUS	WDI, 2018	Unit
Primary school enrolment (pupils) – female	PSE	WDI, 2018	Number
Institution	RULE	WGI, 2018	Constant US\$
Domestic credit by financial institutions	CREDIT	WDI, 2018	Percent of GDP
Gross domestic product per capita growth rate	GDPPCGR	WDI, 2018	Percent

Source: Compiled by the Authors'

utilized given the objectives of the study and the nature of the panel dataset. The estimated coefficients could be used to determine the degree of relationship and impact existing between the variables of interest. The hausman test is usually performed after the FEM and REM to determine the most appropriate technique of analysis between the FEM and the REM techniques of estimation. The hausman test uses the probability value of its Chi-square test to determine the most appropriate estimation method.

The rule of thumb for deciding the most appropriate model (between the REM and FEM) states that: Given that the FEM was run first before the REM if the Chi-square probability value of the Hausman test is  $<0.05$ , the FEM is most appropriate and if the Chi-square probability value is  $>0.05$ , the REM is most appropriate for interpretation and policy recommendation. Furthermore, the use of the FEM signifies the of individual-specific fixed effects which could affect the result if not taken care of during the estimation process while the choice of the REM indicates the absence of the individual specific effects.

### 3.3 Sources of Data and Variable Description

The data utilised by this study encompasses data from 9 selected Western African countries because of their notable energy usage within the West African region, ICT adoption rate, HD level and reliable data availability from the World Bank (2018), spanning for the time period 2000 to 2014. The dataset consists of selected countries which include Benin, Cape Verde, Cote d'Ivoire, Ghana, Guinea Bissau, Niger, Nigeria, Senegal and Togo. The variables that were included in the model [Equations 1, 2, and 3] above are defined in Table 1 with the presentation of the sources of data.

## 4. ECONOMETRIC RESULTS AND DISCUSSIONS

The results for the baseline regression (GLS), fixed and REM (FEM and REM) estimation techniques utilised by the study are presented in this section. The section commences by the display of the results of the Hausman test which recommends the most appropriate model regression between the REM and the FEM. The rule of thumb for deciding the most appropriate model (between the REM and FEM) states that: Given that the FEM was run first before the REM, if the Chi-square probability value of the test is  $<0.05$ , the FEM is most appropriate and if the Chi-square probability value is  $>0.05$ , the REM is most appropriate for interpretation and policy recommendation. The probability value of the Hausman Chi-square test recommends the interpretation of the FEM result given that it is statistically significant ( $<0.05$ ). Table 2 shows the Hausman test result:

**Table 2: Hausman test result**

<b>Chi 2 (4): 206.54</b>	
<b>Prob Value: 0.00</b>	
<b>Decision Rule</b>	
<b>Fixed effect</b>	<b>Random effect</b>
accept	Reject

Source: Computed by the Authors'

Table 3 displays the empirical results of the study and the general interpretation indicate that the number of groups present within the dataset was nine (9). The correlation between the error term and independent variables show a negative correlation for the FEM technique which indicates presence of time-invariant characteristics unique to the countries captured in the constant while the correlation between the error term and independent variables for the REM technique report the zero. The F-statistics and its probability value that show the overall significance of the model indicate a good overall fit of the model following the rule of thumb because the probability value is "0.00" and more importantly  $<0.05$ . The Wald test also indicates a similar overall model fit like the F-statistics and given that the Chi-square values are not equal to zero, it is also acceptable.

With regards to the variable-specific results, a major variable of interest in this study is energy usage and its empirical relationship with HD. The coefficient of energy usage indicates a statistically significant result for the GLS, FEM and REM, statistically significant values at 1% level were observed. This is shown by the probability values of the coefficient for which the decision rule for the probability values (P value) state that the P value for should be  $<0.01$  for statistical significance at 1% level, 0.05 for statistical significance at 5% level and  $<0.10$  for statistical significance at 10% level of significance respectively. This economically implies that for the selected West African countries, an increase energy usage will impact HD significantly at 99% level of significance. The result flows with the a priori (theoretical) expectation in terms of direction of relationship. The magnitude of relationship shows that a 1% increase in energy usage will contribute positively, a less than proportionate (0.14%) increase to HD in the selected West African countries. This result is in agreement with Pirlogea (2012).

In terms of another major variable of interest internet usage and its empirical relationship with HD, the coefficient indicates a statistically significant result at 1% level for the FEM estimation (as recommended by the Hausman test). The direction and magnitude of relationship flows with the apriori (theoretical) coefficient. The empirical result shows that a 1% increase in in

**Table 3: Econometric results (Dependent variable: Human development)**

Predictor variables	GLS	FEM	REM
Energy usage	0.24* (0.00)	0.14* (0.00)	0.24* (0.00)
Internet usage (lintusph)	-0.01*** (0.09)	0.02* (0.00)	-0.01*** (0.09)
Primary school enrolment	1.32* (0.00)	0.86 (0.00)	1.32* (0.00)
Rule of law (Institution)	-0.09* (0.00)	-0.02* (0.00)	-0.09* (0.00)
Domestic credit provided by financial sector	0.02 (0.12)	-0.007 (0.31)	0.02 (0.12)
GDP per capita growth rate	0.003 (0.5)	0.002 (-0.60)	0.003 (0.5)
Constant	-3.07* (0.00)	-0.2.29* (0.00)	-3.07* (0.00)
F-statistics		80.72	
Prob >F		0.000	
Wald chi <sup>2</sup> (5)	744.35		744.35
Prob >chi <sup>2</sup>	0.000	0.000	0.000
Corr (u <sub>i</sub> , X <sub>it</sub> )	0	0.10	0
Number of groups	9	9	9

The values in the parenthesis '(')' are the probability values; GLS: Generalised least squares; FEM: Fixed effect model; REM: Random effect model; \*\*\* and \* denotes that the coefficients are significant at 1%, 5% and 10% respectively. Source: The Authors'

energy usage will contribute positively, a less than increase of proportionate 0.02% to HD in the selected West African countries. This economically implies that for the selected West African countries, an increase internet usage will impact HD significantly at 99% level of significance and this finding, is in line with Ejemeyovwi et al. (2018); Ejemeyovwi et al. (2019).

The policy implication from the findings posit that priority should be put on HD as examined in this study, for which the components of HD include health and education. The average human needs a clean bill of health and sound mind to increase productivity in every field of endeavor while in terms of education, creating comfortable learning environments is also required for effective education administration. Learning environments in this modern era exceeds locations other the conventional classrooms. The advent of online learning requires one form of ICT device or the other to become a reality. Also, ICT devices like projectors, laptops etc., have proved useful as learning aids as they can be used in passing across information to students and other individuals involved in the learning process. Operation of ICT equipment also require one form of skillset or the other and this can be acquired through education. The equipment utilized also require one form of energy usage or the other for its operation.

## 5. RECOMMENDATION AND CONCLUSION

This study establishes a linkage between ICT, energy consumption and HD through the investigation of their effect on HD in utilizing the GLS, fixed and REM (FEM and REM) estimation techniques. Evidence from the analysis reveal that energy usage and internet usage have a significant impact on HD statistically at 5% level of significance which are in line with the findings of Pirlogea (2012) and Ejemeyovwi et al. (2019) respectively.

HD is necessary as well as ICT adoption and energy usage, hence, it is expedient that the government and private sector should exact more efforts in terms of financial and non-financial contributions to ensure that more energy and ICT facilities made available for usage since it helps to improve the level of HD for which the two major HD components are health and education parameters. Akin to the findings, further related researches are tasked with identifying the

impact of the interaction between ICT and energy usage and also the direction of relationship that exist between the ICT adoption, energy usage and HD within and outside Western Africa.

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