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INFORMATION COMMUNICATION TECHNOLOGY ACCESS AND USE TOWARDS ENERGY CONSUMPTION IN SELECTED SUB SAHARAN AFRICA

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Abstract. Major new opportunities abound from energy integration among regions in Africa with the sole aim of reducing transaction costs and with the role of ICT, it would take energy from where it is easily affordable to places where it is needed. This study takes on a new perspective, that is, employing household energy consumption, to ascertain the use of ICT by household in accessing energy. The study explores the degree to which energy integration among the five regional power pools in Africa can achieve ending energy poverty among regional adherents. The study utilizes the Pooled Ordinary Least Squares technique on data from the SSA economies over the period 2000-2019. The study confirms the viability of the ICT adoption – Energy Consumption hypothesis statistically at five (5) percent level of significance. More specifically, the findings show that a one-unit increase in household mobile technology will lead to an average of 1.4 unit increase in energy consumption. The findings indicate that the adoption of such mobile technology impacts energy consumption, which suggests the need for the acceleration of ICT development in Africa (Sub-Saharan) nations, given the universal communal mission of sustainable energy consumption.

1. Introduction

Towards a way of supportable advancement for Africa, bearings prompting clean energy have become clearer for strategy making. As a model of advancement, it accentuates an improvement procedure that coordinates energy worries in objective seven (7) into economic and social goals to ensure sustainable development. It gives chance to an economy to develop and create while likewise utilizing resources in a feasible way that doesn't pollute the environment and create health concerns. There is no uncertainty that sustainable development is the most favored methodology for accomplishing advancement destinations as embodied in the objectives (SDGs) of the United Nations [1].

The power hole alludes to both the gracefully request ambiguity in network associated areas and the inadequacy of access in off-grid locales. Shutting the power hole in Sub-Saharan Africa (SSA) is a multidimensional assignment with focal ramifications for how to outline the regions energy issue in general [2-4]. The Africa Union perceives this potential and expectations that Africa Continental Free Trade Agreement will go far toward accomplishing its objective of 20% ozone harming substance decrease by 2030 by showing ICT for energy effectiveness through energy integration among the different Power Pools [5]. All partners need to guarantee that the impact of ICT on the energy segment is utilized lengthways with the other energy arrangements.

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United Nations has ordered Twelve (12) ICT-based innovations with potential contact with respect to the energy segment to acknowledge manageable turn of events. African Countries ought to think about every one of these advancements in the energy policy [6]. The youngsters in African nations are a lot of sharp about the ICT, and government should capitalize on it by giving stable force and power in ICT applications, for example, load analysis, sensors for remote measuring, chips and controllers for observing, smart meters and automated dispatch programming ([7].

On this note, the current study looks at the field procreated by these two mains two primary issues: ICT's own energy consumption and ICT's capability to induce energy efficiency across the economy. In the study's way to deal with these issues, the investigation grasps energy integration to decrease the energy imbalance among African countries. The study goals are to feature the pattern of energy utilization, and inspect the effect of energy joining towards energy gracefully. To accomplish this goal, the investigation uses the Pooled Ordinary Least Squares method of estimation. The rest of the paper is designed as follows. Section 2 relates arrangements with issues identifying with writing literature encompassing access and utilization of ICT in energy utilization; section 3 gives the exploration technique (methodology) as appear to be appropriate for the investigation and data about the SSA nations. Section 4 gives exact outcomes and the last segment concludes the paper.

2. Brief Review of Literature

The present improvement of ICT being in transit of energy saving is still under discussion. While numerous investigations uncovered that the ICT had an energy sparing impact [8-10] with studies contended that it could animate energy use through different means [11], and a few examinations noticed the distinctions of ICT's effects among sectors [12] or set of economies [13]. As indicated by Takase and Murota (2004), the general effect can be separated into income impact and a substitution impact.

Concerning the income impact, the ICT as a sort of universally useful innovation, is extensively identified with creation action and private life which include energy use, so its advancement can prompt energy request by invigorating financial development (Zhou and Zhou, 2018). With respect to replacement impact, the ICT area may diminish energy use by supplanting the customary areas, given that the ICT part and its items are generally less energy concentrated [14-16]. Additionally, [17] contended that, while the above impacts occurred in short and medium term, the most mixing effect of ICT on human conduct and society may happen over the long haul.

In [18], coordinating physical framework is an important however insufficient condition for accomplishing further regional integration and expanded exchange among African nations [19]. Featuring the role of regional integration in power maintainability in Southern Africa, [20]) opined that three key components are significant in utilizing integrated regions to add to improved power manageability in the SAPP area. These variables incorporate harmonized policies and administrative systems, sufficient basic organizations and specialized framework, and composed execution. Likewise, there is additionally the presence of power pools (PP). PP have been seen as the best and best system for handling Africa's energy issues [21] and furthermore amplifying Africa's unevenly conveyed energy assets. There are five territorial force pools in Africa, to be specific SAPP, WAPP, Central Africa Power Pool (CAPP/PEAC), East Africa Power Pool (EAPP) and Comite Maghrebin de l'Electricite (COMELEC) which is the North Africa locale. A PP is characterized as a gathering of associations that work their capacity frameworks together for shared advantages [22].

As indicated by [23], provincial cooperation, which is upgraded by power pools and cross□border transmission systems, will be basic to shutting the power hole in SSA. Its advantages go from economies of scale to a solid and secure gracefully of energy, streamlining of assets, energy cost differential, justifying venture and expanding the volume of power exchange, among others. It can likewise lessen reliance on petroleum product imports by empowering huge concentrated sustainable assets to be shared [24].

ICT improvement can animate economic development with not exactly proportionate increment of energy use (that is. energy efficiency improvement.) if the ICT does not identify with energy improvement, we ought to reexamine its role in accomplishing our practical advancement objectives and should start relating approaches. Be that as it may, as far as we could possibly know, existing literature only concentrate on such a point of view. Albeit a few researchers noticed that ICT could improve energy efficiency [25-26] unfortunately such a perspective right now needs support from empirical studies.

To summarize, regardless of whether ICT can advance energy reserve funds at the macroeconomic level is as yet a significant under-banter issue. To comprehend the connection among ICT and energy consumption, past examinations gave distinctive effect instruments. Among these instruments, energy profitability improvement is a key measure to accomplish sustainable energy consumption in theory. Subsequently, empirical examinations on the connection among ICT and energy profitability can give new confirmations with respect to the above discussion.

3. Methodology and Data

3.1. Model Specification

Literature of both theoretical and empirical literature such as [27-28] the general model detail of the energy/power consumption work appears in condition/equation 1.

$$ENC = f(MOT, INSTI, ENI, GDPGR, TRD) \quad (1)$$

Where EC stands for energy consumption, ICT is mobile technology, INSTI is institutions, ENI is energy intensity, GDPGR is GDP growth rate and TRD is trade openness.
Equation 1 is changed into equation 2 when introduced as an econometric estimation model.

$$ENC = \beta_0 + \beta_1 ICT_{it} + \beta_2\, INSTI_{it} + \beta_3\, ENI_{it} + \beta_4\, GDPGR_{it} + \beta_5 TRD_{it} + \varepsilon_{it} \quad (2)$$

Note: β_0 is the intercept, β_1 represents the coefficient of mobile technology, β_2 is the coefficient of institutions, β_3 is the coefficient of energy intensity, β_4 is the coefficient of GDP growth rate, β_5 is the coefficient of trade, and ε is the error term. In this analysis, only significant coefficients are interpreted giving the ceteris paribus argument, therefore mobile technology (ICT), energy intensity, GDP growth rate and trade openness are the variables with significant parameter estimates which all have a positive relationship except GDP growth rate.

Regarding the justification of the variables in the model and the respective [29] says that a positive relationship exists among ICT and energy/power consumption. Be that as it may, as indicated by [30-31], ICT was found to have negatively affected energy utilization. Inglesi-Lotz and Morales (2017) expressed that more elevated levels of training had a critical positive effect on energy utilization in creating nations. [32] ICT had a significant effect on energy productivity. Study uncovers that the higher the levels of growth economically, the more the expansion in the quantity of economic activities which utilizes and require heaps of power [3].In line with [32], trade openness increases the quantity of energy utilize connected manufacturing sector in the economy, anyway it could likewise negatively affect energy use [33]

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3.2. Technique of Estimation - Pooled Ordinary Least Squares (POLS)

Panel data analysis denotes to the statistical analysis of data set comprising and consisting of multiple observations on each sampling unit. It is a combination of a variety of time series and cross-sectional units. Pooled OLS, Fixed effects and random effects are the three (3) major methods for panel data regression. The pooled OLS is a pooled linear regression that is arguably sufficient and may not require fixed or random effects. This estimation technique for panel data adopts a constant intercept term irrespective of the duration and cross-section of the group. Furthermore, this model does not recognize distinct homogeneities in data. A pooled OLS model is usually a stationary and balanced panel. Here, dummy variables are included despite its homogenous nature. This study is using a sample with over fifty (50) observations. This model has a common intercept and is expressed as follows:

$$Y_{it} = \beta_0 + \beta_1 X_{1it,} + \beta_2 X_{2it,} + \beta_3 X_{3it,} + \beta_4 X_{4it,} + \beta_5 X_{5it,} + \varepsilon_{it} \quad (3)$$

The dependent and independent variables are inserted into the equation 3 to give the equation below which is same with equation 2

$$ENC = \beta_0 + \beta_1 ICT_{it} + \beta_2\ INSTI_{it} + \beta_3\ ENI_{it} + \beta_4\ GDPGR_{it} + \beta_5 TRD_{it} + \varepsilon_{it} \quad (2)$$

Here, β_0 is the intercept term, $X_{1,}$ is the proxy variable for ICT which is mobile technology, X_2 represents the variable institutions, X_3 is energy intensity, X_4 is the variable GDP growth rate and $X_{5,}$ is trade openness with the error term represented by variable (ε)

3.3. Data and Variable Description

This investigation utilized a board information extending from 2000 to 2019 for the chosen SSA nations as appeared in the Table 1. The information was acquired from World Development Indicators of the World Bank (2020) "Sustainable Energy for All (SE4ALL) database from the SE4ALL Global Tracking Framework drove together by the World Bank, International Energy Agency, the Energy Sector Management Assistance Program and World Bank". The Description of factors used in the investigation is found in Table 2.

Table 1: Description of Selected SSA Countries

Central African Countries (CAC)	East African Countries (EAC)	Southern African Countries (SAC)	West African Countries (WAC)
1. Angola	1. Burundi	1. Botswana	1. Benin
2. Cameroon	2. Comoros	2. Eswatini	2. Burkina Faso
3. Central African Republic	3. Eritrea	3. Lesotho	3. Cape Verde
4. Chad	4. Ethiopia	4. Namibia	4. Ivory Coast
5. Democratic Rep of Congo	5. Kenya	5. South Africa	5. Gambia
6. Rep of Congo	6. Madagascar		6. Ghana
7. Equatorial Guinea	7. Malawi		7. Guinea
8. Gabon	8. Mauritius		8. Guinea Bissau
9. Sao Tome and Principe	9. Mozambique		9. Liberia
	10. Rwanda		10. Mali
	11. Seychelles		11. Mauritania
	12. South Sudan		12. Niger
	13. Tanzania		13. Nigeria
	14. Uganda		14. Senegal
	15. Zambia		15. Sierra Leone
	16. Zimbabwe		

		16. Togo

The specific description of variables utilized in the study is found in Table 2. The table gives a description of the variables in terms of the proxies used to capture the various variables (dependent and independent) and their a priori expectation for each variable based on theory intuitions, alongside the kind of relationship that exists between each explanatory variable and the dependent variable.

Table 2: Variables and Apriori Expectation

Variable	Proxy	Relationship	Expected Sign
Energy Consumption	Energy Consumption	Not applicable	N.A
Information Communication Technology	Mobile Technology	Direct	Positive
Institutions	Human capital quality, public administration, property rights and rule-based government and business regulatory environment.	Indirect	Positive
Energy Intensity	Energy Intensity	Direct	Positive
Economic growth	GDP growth rate	Indirect	Positive
Trade openness	Trade	Indirect	Positive

Based on a-priori expectations, mobile technology has a direct and positive relationship with levels of energy consumption. Supporting the a-priori expectation in the table, Aye and Edoja (2017) noted that increased levels of growth in the economy in turn increases the number of economic activities which results in rise in the use of electricity. A direct and positive relationship also exists between energy intensity and energy consumption, a positive relationship also exists between trade openness and energy consumption however, the impact is indirect, this same applies to institutions.

Table 3: Variables Definition, Measurements and Source of Data

Variable	Data Source	Measurement
Energy Consumption	World Bank (2020)	
Information Communication Technology	World Bank (2020)	
Institutions	World Bank (2020)	
Energy Intensity	World Bank (2020)	
GDP growth rate	World Bank (2020)	Annual percentage
Trade openness	World Bank (2020)	

4. Results and Discussion

4.1. Pattern of Energy Consumption and Electricity Access in SSA

General Access to Electricity in SSA

Access to electricity Africa (sub-Saharan) has particularly improved throughout the years, as seen in countries like Ethiopia, Ghana, Ivory Coast and Kenya. The pace of electrification has almost tripled between the years 2000 and 2012, and in 2014, power efforts surpassed growth for the first time as 50 percent SSA population do not have access to electricity making it the largest concentration of people in the world without electricity access as explained through the International Energy Agency shown in Figure 1:

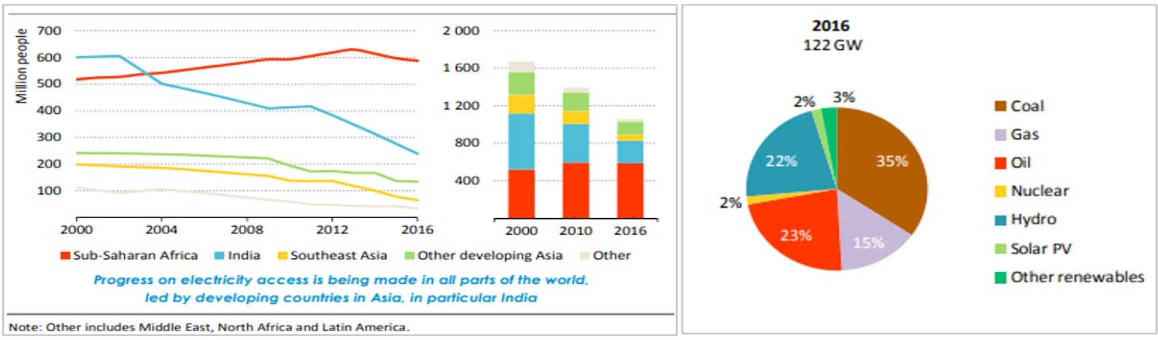

Figure 1: Population without access to electricity by region and installed capacity generating capacity in Africa (sub-Saharan) and other regions by fuel
[34].

Sub-Saharan Africa is becoming aware of the importance of investment in sustainable clean energy establishments as opposed to the customary enormous scope frameworks as appeared in table 1, which depend for the most part on oil and coal. What's more, its natural advantages, renewables energy is probably going to contribute towards economic development too. ICT of energy frameworks empowers utilities to keep up lattice solidness and unwavering quality, screen the network and recognize purposes of disappointments, diminish tasks and upkeep costs, enhance and gauge energy creation and broaden the operational lifetime of benefits (Bloomberg, 2017; OECD, 2005).

Table 4: Primary Energy Consumption by source, SSA.

Energy source	**2000**	**2018**
OIL	1,421.07 TWh	2,225.14 TWh
Natural Gas	963.27 TWh	1,499.91 TWh
Goal	556.82 TWh	1,179.7 TWh
Hydropower	75.25 TWh	132.84 TWh
Wind	13.01 TWh	14.69 TWh
Nuclear	2.22 TWh	11.09 TWh
Solar	0.18 TWh	9.03 TWh
Other renewables	0.02 TWh	8.16 TWh

Summary of Africa's Energy Pool generation

In [28] with around 48 nations in SSA, 21 nations have an all-out capacity generation of under 200 Mega Watts. South Africa (SA) produces 45percent of the mainland all out power age while North Africa creates 30percent and the remainder of Africa (48 out of 54 nations) creates 25percent. Normal jolt level situations are at 24percent, which is the most minimal in developing nations. As a rule, about 25percent of the created energy is inaccessible at some random time. Force blackouts in days out of every year are as per the following: Burundi (144), Tanzania (63), Senegal (25) days while Continental normal is 56. In West Africa, generators utilized as back-up provisions represent 17percent of intensity created and this is because of successive blackouts. SSA is the main area on the planet where per-capita get to rates are diminishing. As of late, over 60percent of SSA will in any case need access to power by 2020 with the expense of Electricity progressively costly in SSA contrasted with different pieces of the world. Electrical matrix operational misfortunes are around 23 percent contrasted with the worldwide normal of 10percent with just 10 percent of the populace approaching lattice influence, 75percent of these are rich individuals. Under 2 percent of the country populaces of Malawi, Ethiopia, Niger, and Chad approach electrical force [22]

4.2. Econometric Analysis

The study confirms from the Pooled OLS result in Table 4.2 the viability of the Household ICT adoption – Energy Consumption hypothesis in SSA. The results in terms of general significance shows a good overall fit for the model as well as joint significance. This is shown by the value of the R Squared, Adjusted R Squared and the F statistic. The R Squared and Adjusted R Squared are acceptable due to the fact that they lie between 0.1 and 0.5 as acceptable for any standard panel dataset. The F-statistic is acceptable because its probability value (P value) is significant at five (5) percent significance level (less than 0.05). This implies that the joint significance of the model is significantly acceptable.

For the coefficients of interest, mobile technology is seen to have a positive relationship for all the models (see columns 2, 3, 4, and 5). Furthermore, the t-statistics of there out of four are variables are greater than 2, having 2.41 (column 3), 2.53 (column 4) and 2.63 (column 5). This implies that household mobile technology has an individual statistically significant impact on energy consumption in SSA. In terms of the magnitude of impact, the coefficients lie within 1.30-1.47 which implies that a one-unit increase in mobile technology will impact energy consumption by an average of 1.4 units, which is a very elastic impact.

The individual statistical significance shows that in SSA, further confirms the viability of the ICT adoption – Energy Consumption hypothesis statistically at five (5) percent level of significance also. More specifically, the value of the statistically significant coefficient of mobile technology (the measure of household ICT adoption) is positive. This indicates that the adoption of such mobile technology impacts the energy consumption to further drive the economy as seen in [6-10].

Table 5: Pooled OLS Results for ICT Energy Hypothesis in SSA

Dependent Variable	Energy Consumption	Energy Consumption	Energy Consumption	Energy Consumption
Mobile Technology	1.45* (1.77)	1.30* (2.41)	1.36* (2.53)	1.47* (2.63)
Human Capital Quality	-31.95 (-1.28)			
Public Administration		2.24 (0.06)		

Property Right and Rule-Based Government			-25.27 (-0.83)	
Business Regulatory Environment				-24.8 (-0.98)
Energy Intensity	10.31* (2.67)	11.05* (3.90)	10.05* (3.73)	10.38* (4.11)
Gross Domestic Product Growth Rate	-1.61 (-0.46)	-2.55 (0.98)	-1.87 (-0.53)	-2.09* (-0.60)
Trade	0.39 (0.67)	0.64* (0.98)	0.45 (0.75)	0.37 (0.59)
F-statistics	5.22	4.84	5	5.06
Prob> F	0.0002	0.0004	0.0003	0.0003
R Squared	0.1448	0.1358	0.1396	0.14
Adj R Squared	0.1171	0.1077	0.1117	0.11
Root MSE	183.33	184.29	183.89	183.73

The discoveries of this investigation on the connection among ICT and energy consumption in sub-Saharan nations show comparable aftereffects of a positive relationship with [20] which uncover a positive connection among ICT and energy consumption in the European Union nations for the two examinations. This features the most ideal approach to improve the energy part in Africa through provincial participation. Access to present day energy services is basic for financial turn of events.

5. Conclusions and Recommendations

The study was enthused by the argument on the importance ICT in the energy sector. The study utilized panel data for SSA nations within the period 2000 to 2019. The study is considered vital because of the challenges SSA faces in meeting her energy demand and closing the gaps in the energy system to reduce energy poverty. This study argues that an improvement ICT utilization as well as regional cooperation will bring about improvement that will make available SSA countries end energy poverty. The investigation suggests that regional energy participation and combination is one of the most encouraging and financially savvy choices for Africa to promote the advancement of its energy segment, so as to pick up the ecological, social and monetary advantages gathering from an increasingly productive utilization of assets. Four significant advantages are related with local energy coordination: improved security of gracefully, better financial proficiency, and upgraded natural quality.

Future investigations could likewise expand this work by distinguishing extra transmission channels, especially relevant ones, through which ICT infiltration influence the activities requiring energy/electricity consumption in rural areas in the sub-Saharan regions. Another area of further research could be on the impact of institutions on the implementation and penetration of ICT in sub-Saharan regions or specific countries. Also, areas of further research could include the unidirectional relationship between ICT use, institutional policies and energy efficiency.

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