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Information communication technology and economic growth: Evidence from sub-Saharan Africa

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Abstract
This paper investigates the effect of Information Communication Technology (ICT) on economic growth in the sub-Saharan African. The traditional panel and generalized method of moments were used as estimation techniques. A sample of 45 countries was considered from 2008 to 2017. The results reveal that ICT has a positive and significant effect on economic growth in the region. However, education harms economic growth in the region. This may be due to the low level of education in the region compared to other regions of the world. Thus, we recommend that policymakers should pay attention to policies that will increase the use of ICT. Equally, strict measures should be put in place to check the factors that are hindering the attainment of basic education in the region.

Keywords: Economic growth; information & communication technology; subs-Saharan Africa.

Introduction

In this era of globalization and economic integration, Information Communication Technology (ICT) is seen as an important instrument of economic growth and development. It helps in reducing information cost, information asymmetry, financial development and economic growth processes (Pradhan *et al*., 2015; World Bank, 2016). ICT provides a platform for collaboration between business partners, reduces geographical barriers, facilitates innovation and enhances the competitiveness of businesses. Currently, about half of the world population are now using the internet, while mobile communication subscription has increased by threefold; exceeding 4 billion active subscriptions (IEA, 2017).

The ICT facility such as the internet, aids access to information, creates business and economic opportunities, enhances market efficiency, improves productivity and promote entrepreneurship participation. The mobile phone promotes speedy communication, reduces the cost of transportation and enhances logistic in business. Due to the increasing relevance of ICT facilities in human activities, the United Nation (UN) has considered access to the internet and mobile subscription as one of the basic human rights. Thus, countries of the world have accorded priority to the development of communication facilities (Haftu, 2018).

However, unlike developed countries, the benefit of ICT infrastructure for economic growth and reducing corruption have not

been fully utilized in sub-Saharan Africa. The level of education in African countries is seen as one of the reasons preventing the region from harnessing the full benefits of ICT facilities. For instance, online settlement of transactions requires both parties (buyer and seller) to not only know about communication via mobile phones, but also the knowledge of internet usage (Donou-Adonsou, 2018). Hence, the level of education also hinders the level of mobile phone and internet usage in Africa.

Even though the economic output of sub-Saharan Africa is increasing, the level of output is suggestively low. For instance, the economic output of about 82 million people in Germany is significantly greater than that of 940 million (a ratio of about 1:12) people in sub-Saharan Africa (AEO, 2014). This is partly due to poor ICT penetration in the region such as the internet and mobile phone subscription for businesses and entrepreneurial activities. ICT facilities reduce the transaction cost of firms, increase production technology and leads to economic growth (Pradhan *et al*., 2018).

Furthermore, the ranking of the 10 best countries in sub-Saharan Africa in terms of ICT development is spread across the regions. Mauritius and Seychelles which are from the East Africa region are rated as the first and second sub-Saharan African countries with the highest ICT development index in 2017. Southern Africa, Botswana and Namibia from the Southern region are rated the third, fifth and eighth country in terms of ICT development index in sub-Saharan Africa in 2017. On the other hand, Cape Verde, Ghana, Cote d'Ivoire and Sao Tome and Principe from the Western African region are ranked the fourth, seventh, ninth and tenth country in terms of ICT development index respectively (IT News Africa, 2017). However, compared to the global average, sub-Saharan Africa has alow ICT development index (International Telecommunication Union, 2017).

This paper examines the role of ICT such as the internet and mobile phone usage on economic growth of sub-Saharan Africa and thus, filled the following knowledge gaps. First, fewer studies have used both internet and mobile phone subscription to measure ICT in Africa (Donou-Adonsou, 2018; Haftu, 2018). Other studies have used either the internet alone or mobile phone subscription to measure ICT. Second, this study accounted for the level of education by including an important measurement which is the ratio of pupil to the teacher in primary school. Including primary school enrolment assist in capturing the true level of education of the region. It also explains the relevance of education as an important instrument for acquiring information technology. Third, traditional panel and generalized method of moments (GMM) were combined to analyze more recent dataset compared to previous studies.

Literature Review

Several works of literature have examined the link between Information Communication Technology (ICT) and economic growth and arrived at inconclusive result (Pradhan *et al*., 2015; Salahuddin and Alam, 2016; Jorgenson *et al*., 2016; Erumban and Das, 2016; Haftu, 2018; Donou-Adonsou, 2018; Céspedes-Lorente *et al*., 2018; Pradhan *et al.,* 2018). Jorgenson *et al*. (2016) revealed significant evidence of the role of information technology in the post-war economic growth of the United States of America. Their industry data set suggest that output expansions in the postwar period are stimulated partly by the information technology industries, but the replication of existing technologies via labour and capital accounted for the largest share of the United State economic output.

Similarly, Erumban and Das (2016) investigate the source of economic growth in India with an emphasis on the direct and indirect role of ICT. Even though ICT benefit has not yet been widespread in the economy, their finding suggests increasing importance of ICT investment in driving the Indian economic growth. Equally, Céspedes-Lorente *et al*. (2018) explore the impact of information technologies (IT) and downsizing on the economic performance of Spain. They maintained that since IT improves knowledge, innovation, organizational management and learning, it plays an important role in the downsizing of organizations and thus the economic performance of Spain. Pradhan *et al*. (2015) and Pradhan *et al*. (2018) have established a causal relationship between ICT infrastructure, economic growth and financial development in a panel of Asian and G20 countries, respectively.

In the case of sub-Saharan Africa, Haftu (2018) and Donou-Adonsou (2018) have examined the impact of ICT variables such as the mobile phone and the internet subscription on economic growth. While the former found a positive impact of mobile phones on economic growth and an insignificant effect of internet usage on economic growth, the latter observed that internet contributes to economic growth in countries with better access to education but mobile phones do not. Although Donou-Adonsou (2018) included an education variable in his analysis, this study differs from his study by using the ratio of primary school pupils to their teachers as a measure of education.

Other recent related literature in sub-Saharan Africa has also emerged (Njoh, 2018; Howell et al., 2018; Kouton, 2019; Asongu et al., 2019; Asongu et al., 2020). For example, Njoh (2018) used human development index to measure development and found a positive relationship between development in Africa and information and communication technology. Kouton (2019) found that ICT development exacts a positive and significant effect on energy consumption while Asongu (2019) investigated inequality, information technology and inclusive education in sub-Saharan Africa and computed the ICT thresholds for inclusive education. Furthermore, ICT indicators have been found to modulate foreign direct investment and subsequently induced a positive net effect on economic growth (Asongu and Odhiambo, 2020).

Furthermore, there exist four important hypotheses establishing a link between Information Communication technology (ICT) and economic growth notably: the ICT led economic growth hypothesis; the economic growth led ICT hypothesis; the bidirectional causality between ICT and economic growth hypothesis and finally the neutral hypothesis (Pradhan *et al*., 2015).

The ICT-led economic growth suggests that technological infrastructure such as the mobile phone, the internet and computer gadgets are the catalyst for economic growth. Increased use of these facilities along with the adoption of other inputs such as labour and entrepreneur would promote economic growth. The growth led ICT hypothesis posits that it is the need for economic growth that leads to the use of ICT infrastructure, thus, a unidirectional causality runs from economic growth to ICT. The bidirectional hypothesis assumes a mutual causal link between ICT and economic growth while the neutral hypothesis suggested the absence of a causal relationship between the two variables.

Thus, this study investigates the relationship between the information communication technology and economic growth in sub-Saharan Africa by employing static panel and

generalized method of moments (GMM) to contribute to an existing body of knowledge.

Methodology

Model and estimation techniques

In most panel data sets where the number of cross-section observation is greater than the period, the basic issue is how to model the error term in the regression equation. The estimation technique for this paper proceeds from the use of a static panel and generalized method of moments (GMM). The essence of using these methods is to enhance the robustness of results. The fixed effect assumes that each unit has its intercepts while restricting the slope to be homogenous. On the other hand, the GMM include the lagged dependent variable in its estimation to control for endogeneity problem.

The GMM estimator is said to be more robust than the fixed effect estimator because it addresses the problem of country and time-specific effects using the first differencing and instrumental variables (Arellano and Bond, 1991). This estimator has the power to solve the country's heterogeneity problem and time-specific effect (Arellano and Bover, 1995; Blundell and Bond, 1998).

Despite that, the GMM is more robust than the fixed effect, recent literature has combined both to verify the consistency of results (see, Donou-Adonsou; 2018). The choice of using fixed effect and GMM estimators was further informed by the nature of the data (micro panel data) which include a large cross-section of countries (45 countries) and small-time period (10 years). Furthermore, micro panel data with a large cross-section and small-time period has a stationarity property, as such, does not require a unit root test (Arellano and Bond, 1991). Thus, the study modifies Donou-Adonsou (2018) to arrive at the following equation (1-3).

$$lngdpc_{i,t} = \pi_o + \pi_1 lnict_{i,t} + \pi_2 lnlit_{i,t} + \upsilon_{i,t} \dots\dots\dots\dots\dots\dots\dots\dots (1)$$

$$lngdpc_{i,t} -= \pi_o + \pi_1 (lgdpc_{i,t-1} - lngdpc_{i,t-2}) + \pi_2 (lnict_{i,t} - lnict_{i,t-1}) + \pi_3 (lnlit_{i,t} - lnlit_{i,t-1}) + (\upsilon_{i,t} - \upsilon_{i,t-1}) \dots\dots\dots\dots (2)$$

$$\upsilon_{i,t} = \theta_i + \sigma_t + \epsilon_{i,t} \dots\dots\dots\dots\dots\dots\dots\dots (3)$$

where $lngdpc$ represents gross domestic product per capita of country i at t; π_o is the constant term; $lnict$ represent information communication technology (mobile phone subscription and internet usage), symbolized by $lnict - mobile$ and $lnict - intterest$ respectively. $lnlit$ is literacy level; $\upsilon_{i,t}$ is the residual term; θ_i is the country-specific effect; σ_t is the time-specific effect while $\epsilon_{i,t}$ is the residual term. We expect a positive relationship between the outcome variable economic growth with the hypothesized variables ICT and education.

Data source, measurement and description

The data for this paper was collected from World Development Indicators (WDI) for 45 countries covering 2008-2017 period. The list of 45 countries in the sample period is presented in Table A1 in the Appendix. The variable includes economic growth, two ICT variables and education as a conditional variable. Economic growth is measured by gross domestic product per capita. The ICT is measure by internet and mobile phone subscription.

The Internet is measured by internet users (per 100 people) while the mobile phone is measured by mobile phone subscriptions (per 100 people). The use of these ICT variables is consistent with the existing literature (Pradhan *et al*., 2015; Jorgenson *et al*., 2016). The variable of education is proxy by the pupil-teacher ratio in primary school which represents the mean number of pupils per teacher in primary school in sub-Saharan Africa.

The sample period and coverage of countries are guided by the availability of data. The descriptive statistics of the variables are presented in Table 1. The descriptive statistics include the mean, standard deviation, minimum and maximum observation. The descriptive statistics show that the average value of gross domestic product per capita has dominated the other variables followed by a mobile phone subscription. More, so, the standard deviation reveals that internet usage is the most volatile variable while education variable is the less volatile variable.

Table 1. Descriptive statistics

Variables	Mean	Standard dev.	Minimum	Maximum
$lngdpc$	7.059	1.088	5.386	9.920
$lnict-mobile$	3.937	0.725	0.854	5.089
$lnict-internet$	1.860	1.145	-1.386	4.035
$lnlit$	3.659	0.362	2.529	4.608

Results and discussion

The result of the relationship between ICT and economic growth is presented in Table 2. Two estimation techniques were used to compute the results. The essence of using these techniques is to enhance the robustness of our findings. These techniques include the fixed effects and generalized method of moments.

Table 2. ICT and economic growth in sub-Saharan Africa

Variables	Fixed effect	GMM
$lngdpc_{i-t}$	-	0.706***
		(0.033)
$lnict-mobile$	0.078***	-0.106***
	(0.018)	(0.0256)
$lnict-internet$	0.025**	0.079***
	(0.010)	(0.0124)
$lnlit$	-0.063	-0.526***
	(0.056)	(0.103)
Constant	6.833***	4.263***
	(0.226)	(0.636)
Hausman test *p-value*	-	-
Breusch pagan test *P-value*		
R^2	0.407	-
AR(2) test P-value	-	0.627
Sargan test *p-value*	-	0.100

Number of instruments	-	13
Number of groups	-	45

Note: values in parenthesis are standard errors. *, ** and *** denote significance at 10%, 5% and 1% respectively. $lngdpc, lnict-mobile, lnict-internet$ and $lnlit$ are notations for GDP per capita, mobile phone subscription, internet usage and education level respectively. AR(2) is the test for over-identification restrictions.

The result of the fixed effect reveals that ICT (mobile phone subscription) has a positive and significant effect on economic growth. This implies that increasing mobile phone subscription will increase economic growth in sub-Saharan Africa. This result is consistent with the work of Njoh (2018). However, the result of the generalized method of moments for mobile subscription as a measure of ICT suggests a negative and significant effect on economic growth.

Similarly, the fixed effect results reveal that ICT measured by internet subscription has a positive and significant effect on economic growth. This suggests that an increase in internet usage will increase economic growth. Moreover, the result of the generalized method of moments also suggests a positive and significant effect of internet subscription on economic growth in sub-Saharan Africa. This result corroborates the findings of Kouton (2019). Since the coefficient of the generalized method of moments for internet subscription is greater than that of mobile phone subscription, we concluded that information communication technology has a positive and significant impact on economic growth in sub-Saharan Africa.

These results imply that mobile phone and internet usage are important facilitators of economic growth via promoting access to information and reducing its cost in sub-Saharan Africa. Access to information creates business opportunities, improves market efficiency and promote entrepreneurship innovation. Therefore, the study recommends that policymakers in the region should incentivize the use of internet and mobile phone subscription. Compared to the developed countries, there exists a huge potential for mobile phone and internet penetration in sub-Saharan Africa (Asongu *et al.,* 2018; Haftu, 2018).

Furthermore, the result of education shows a negative and significant effect of education on economic growth. This implies that inadequate basic education such as primary school education in the region is stagnating economic growth. This result is not surprising because a large population of people in the region have no access to the basic primary and secondary education. This finding is consistent with the work of Donou-Adonsou (2018). Although policies on basic primary and secondary school education are in place in the region, implementing them has become a challenge. Thus, strict measures are required to eliminate the practices that are hindering the achievement of basic education.

Conclusion and policy implications

The paper examines the relationship between information communication technology in sub-Saharan Africa. Fixed effect and generalized method of moments were used as the estimation strategy. A sample data of 45 countries were considered from 2008 to 2017. The result revealed a positive and significant effect of information communication technology on economic growth in sub-Saharan Africa. This implies that information infrastructure like the mobile phone and the internet are an important instrument of economic growth. They reduce information cost and increasing efficiency in economic activities. Therefore, the study recommends that policymakers

should pay attention to the implementation of policies that will increase the use of information infrastructure in the region.

Furthermore, education has shown evidence of a negative effect on economic growth. This may be associated with the large number of people who have no access to basic education in the region. Thus, we advocate strict measures by policymakers to checkmate the bottlenecks mitigating the implementation of basic education in the region.

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Appendices

Table A1. List 45 countries in the panel

Angola	Eritrea	Mozambique
Benin	Ethiopia	Namibia
Botswana	Gabon	Niger
Burkina Faso	The Gambia	Nigeria
Burundi	Ghana	Rwanda
Cabo Verde	Guinea	Sao Tome and Principe
Cameroon	Guinea-Bissau	Senegal
Central African Republic	Kenya	Seychelles
Chad	Lesotho	Sierra Leone
Comoros	Liberia	South Africa
Dem. Rep. of Congo	Madagascar	Tanzania
Congo, Rep.	Malawi	Togo
Cote d'Ivoire	Mali	Uganda
Djibouti	Mauritania	Zambia
Equatorial Guinea	Mauritius	Zimbabwe

Djibouti	Mauritania	Zambia
Equatorial Guinea	Mauritius	Zimbabwe