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Does internet affect economic growth in sub-Saharan Africa?

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Abstract

The purpose of this study is to examine the long-run and short-run relationship between internet usage and economic growth for 42 sub-Saharan African countries, with the help of panel autoregressive distributed lag (ARDL) model for the period 1998 to 2014. The ARDL bounds test results indicate that the internet usage and economic growth are cointegrated, and share a long-run relationship. The results show that the internet usage has a positive and significant impact on the economic growth in the long-run. However, the relevant short-run parameter is negative. Our findings have important implications for formulating the internet and economic growth policies in sub-Saharan African countries.

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1. Introduction

The Internet has potential for inclusive growth and socio-economic development (Gillen and Lall 2002). It increases the productivity and contributes to economic development (Pradhan *et al.* 2013a) by not only accelerating diffusion of information but also unleashing new ways for innovations, entrepreneurship, and social development. Many countries across the world have realized the potential of the internet and its crucial role in economic growth. They have followed favorable internet policies to escalate economic growth. The US government has invested $ 7.2 billion for the broadband and wireless internet access along with $ 290 million investment for information technology (IT) platforms upgradation in a package called "American Recovery and Reinvestment Act" created in 2009. The European Commission have also ensured that all their citizens should get at least 30 Mbps internet speed, and 100 Mbps speed to at least 50% of their citizens by the year 2020 (Cardona *et al.* 2013). India, the largest democracy of the world, has recently started "Digital India" program on 1st July 2015 to ensure that government services are easily accessible to their citizens. As far as the developing countries are concerned, the internet has played a vital role in stimulating the economic growth. The internet is a boon to the economic development in many ways, i.e., ensuring access to government services, improving information flow in important sectors like health and education, and connecting marginalized populations to various markets. But still, there is enormous possibility of growth in the internet in developing countries.

In the light of the role of the internet in developing countries, it is pertinent to look into the findings of world development report, 2016. This report states that, in sub-Saharan African countries, mobile phones adoption rates are 63% while internet adoption rates are only 10% (World Bank Group 2016). The same report further tells the story that sub-Saharan African countries are falling behind in the access of internet as compared to the rest of the world. Sub-Saharan Africa is the geographical area of Africa continent that lies south of the Sahara dessert. As it is evident that the internet has become a substantive force for change in the world, it is interesting to get the insights about the impact of the internet on the economic growth of sub-Saharan African countries where potential of the internet is still far from exploited. This is the motivation behind this study. This study focuses on the role of the internet in the economic growth of sub-Saharan African countries and the potential internet has for the future advancements in these countries.

2. Literature Review

Authors had started studying the relationship between the internet and economic growth in early 1990's. Most of the studies have shown a positive relationship between the internet and economic growth (Choi and Yi 2009, Pradhan *et al.* 2013a). Apart from direct relationship between internet and economic growth, authors have also studied other relationships such as effect of internet on service trade (Choi 2010), effect of internet on international trade (Freund and Weinhold 2004), impact of internet on energy intensity (Romm 2002), and effect of internet on transportation systems (Kenyon 2010). Effect of the internet on these things indirectly contribute to economic growth. Authors have used the internet as an important component of information and communication technology (ICT) in the literature (Sadorsky 2012, Saidi *et al.* 2015). They have used internet connections as a component for ICT and has found a positive and significant relationship between ICT and energy consumption, and ICT and economic growth. Telecommunication infrastructure plays an important role for the proper access to the internet to the users. Telecommunication infrastructure has a major role in economic growth (Lam and Shiu 2010, Madden and Savage 2000). Authors have mostly found a bidirectional causal relationship between telecommunication infrastructure and economic growth (Chakraborty and Nandi 2003, Cronin et al. 1991, Wolde-Rufael 2007). Telecommunication infrastructure has both direct benefits in the form of lower transaction cost and indirect benefits in the form of accelerated dissemination of information (Antonelli 1991) which is the basis for effective diffusion of the internet. The Internet is a modern emerging technology, and Solow (1957) points out that technological development helps in economic advancement. The reason for such advancement is that ICT leads innovations which, in turn, leads economic development (Cardona *et al.* 2013).

3. Data

This study takes internet subscribers per 10000 as a proxy to measure the usage of internet. Economic growth could be proxied by real gross domestic product (GDP) per capita. The data used in this study, internet subscribers per 10000 people and GDP per capita (constant 2005 US $), have been obtained from the World Bank (World Development Indicators). As per World Bank database, 48 countries come in sub-Saharan Africa zone. Due to the data constraints, this study has taken only 42 sub-Saharan countries for the period 1998 to 2014 (17 years). All the sample countries have been listed in Appendix 1. Some values for internet are missing in the data,[1] therefore, linear trend values have been placed based on simple trend regression. Since only two values are missing in the entire dataset, such replacement should not have any significant effect on the results. Both the variables have been transformed as natural logarithm of actual values. Table 1 reports the summary statistics for variables at actual and logarithmic level.

Table 1. Descriptive statistics

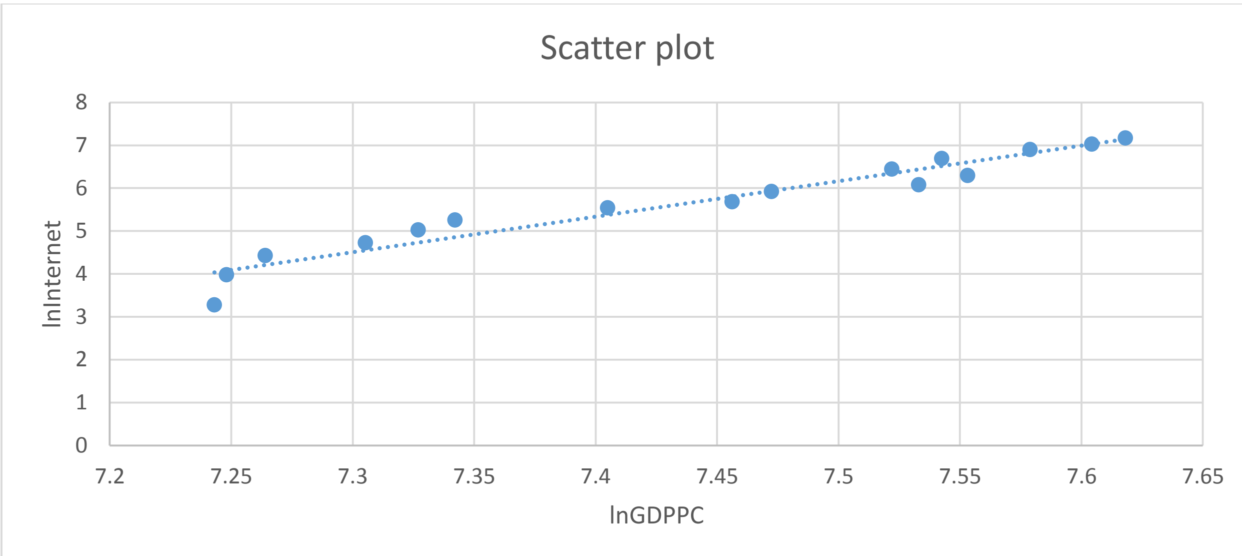
Variables	At level		At log level	
	GDPPC	INTERNET	GDPPC	INTERNET
Mean	1733.87	521.96	6.66	4.92
Median	554.84	182.68	6.32	5.21
Maximum	15592.17	5426.00	9.65	8.60
Minimum	129.78	0.04	4.87	-3.19
Std. Dev.	2794.14	875.74	1.14	1.97
Skewness	2.67	2.92	0.92	-0.60
Kurtosis	10.15	12.17	2.88	3.24
Jarque-Bera	2371.58	3515.39	101.30	45.22
Probability	0.00	0.00	0.00	0.00
Observations	714	714	714	714

Note: GDPPC and INTERNET stand for real GDP per capita and internet subscribers per 10000, respectively. EViews 9 has been used for all computations.

The correlation coefficient between the number of internet subscribers and GDP per capita is 0.498, which is quite high and explains a significant association between variables under study. Scatter plot of the variables shows that both variables are sharing a positive linear relationship. This scatterplot has been plotted (Figure 1) by using average values across countries. The pictorial

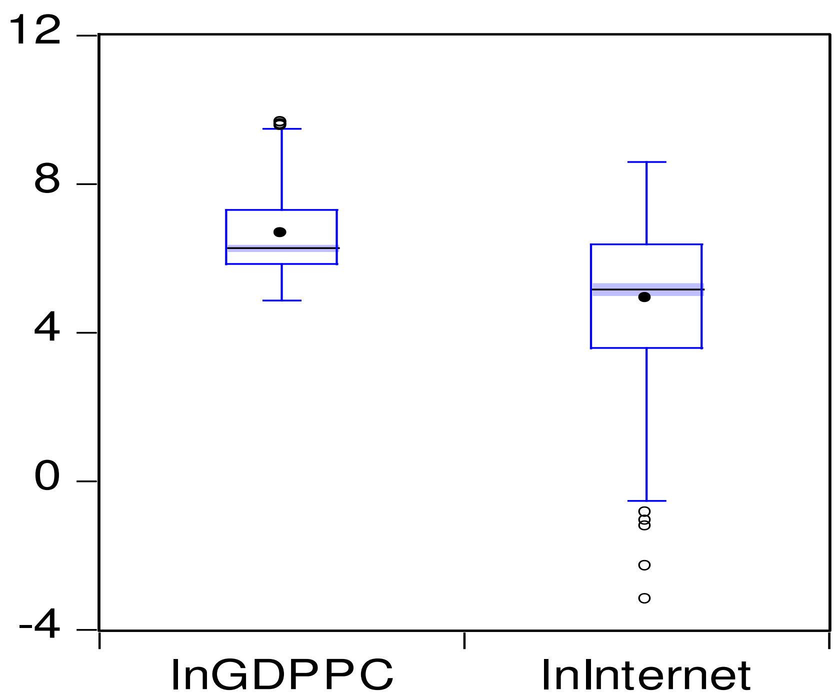
[1] We began with 48 countries in sub-Saharan African countries panel. But due to inadequate data available, six countries (Eritrea, South Sudan, Sudan, Liberia, Somalia, and SaoTome and Principe) have been removed from the sample. Data for internet subscribers per 10000 people are missing for the Rwanda (2006), and Seychelles (2009) which are replaced by linear trend values.

representation of descriptive statistics has been shown by making a boxplot in Figure 2. It shows that mean values are around the median values, which shows that the distribution is approximately normal. There are no extreme or far outliers in the sample. In the case of Internet variable, there are some near outliers (dots outside the whiskers) because of logarithmic transformation of the variable. When we transform a variable having a value less than 1, it gives us a negative value. The lower the number, the higher the negative value. Therefore, our data is appropriate to proceed for panel analysis.



Note: The correlation coefficient is 0.498 and dotted shows the linear trend which is a good fit to our data. This scatterplot has been plotted by using average values across countries. EViews 9 has been used for all computations.

Figure 1. Scatter plot showing the association between GDP per capita and Internet variables at log level



Notes: Dark dots in the boxes are mean and the line in the box is median, and dots outside the whiskers are near outliers. We have not found any far outlier in the sample. EViews 9 has been used for all computations.

Figure 2. Boxplot of GDP per capita and Internet variables at log level

4. Methodology

4.1. Econometric model

Since we have only 17 years' data for each country, panel data analysis will be most suitable. Panel data gives us more number of observations, hence, more information is available. Therefore, panel unit root, panel cointegration, and panel vector error correction model (VECM) would be used to explain the relationship between these two variables. The long-run relationship between the internet and economic growth could be shown by the following model:

$$GDPPC_{it} = \alpha_{2it} + \beta_{2i}INTERNET_{it} + \varepsilon_{2it} \tag{1}$$

$$INTERNET_{it} = \alpha_{1it} + \beta_{1i}GDPPC_{it} + \varepsilon_{1it} \tag{2}$$

Where INTERNET is natural log of internet subscribers per 10000 people, GDPPC is natural log of real GDP per capita, α is an intercept term, β_1 and β_2 are the long-run elasticity estimates, ε stands for residuals, subscript i ant t are cross-section and time-period index, respectively. INTERNET is considered a resource, which can channelize the capital and labor towards economic growth. Hence, we hypothesize that $\beta_2 > 0$ and significant. Similarly, GDP or economic growth may also cause internet usage as INTERNET has become a comfort need rather than luxury.

4.2. Panel ARDL and bounds test

Auto-Regressive and Distributed Lag (ARDL) test could be used when variables, to be investigated for cointegration, are either I(1) or I(0) but not I(2), i.e., they could be integrated of different order such as one variable is I(1) and other is I(0) but they must not be I(2). Since our variables are mixture of I(0) and I(1) variables (as shown in the unit root test results), pooled mean group (Panel ARDL) method by Pesaran *et al.* (1999) is an appropriate technique. Panel ARDL could be used to test for short-run and long-run causality between the variables under study. The ARDL specification for our analysis is as follows:

$$Y_{it} = \sum_{j=1}^{p} \gamma_j^i Y_{it-j} + \sum_{j=0}^{q} \delta_j^i X_{it-j} + \mu_i + \varepsilon_{it} \tag{3}$$

Where Y and X are (2×1) vectors of dependent and independent vectors respectively, p and q are lag-lengths for dependent and independent variables respectively, which may vary across countries, and μ_i are fixed effects for countries. This model can be transformed in the following vector error correction model (VECM):

$$\Delta Y_{it} = \theta_i (Y_{it-1} - \beta_i X_{it-1}) + \sum_{j=1}^{p-1} \gamma_j^i \Delta Y_{it-j} + \sum_{j=0}^{q-1} \delta_j^i \Delta X_{it-j} + \mu_i + \varphi.Trend + \varepsilon_{it} \tag{4}$$

Where β_i are the long-run parameters and θ_i are adjustment coefficient for the i^{th} country, Trend is simple time trend, Δ is first difference operator, and ε_t are standard normal residuals of model. Here we are interested to examine the causality from internet to economic growth. While estimating Equation (3) and (4), choice of appropriate lag-length $(p \;\; and \; q)$ is necessary. The optimal lag selection is based upon Akaike Information Criterion (AIC).

We employ ARDL bounds test (Pesaran *et al.* 2001) to determine the cointegration relationship between economic growth and internet usage. For ARDL bounds test, we need to estimate the following unrestricted VECM:

$$\Delta Y_{it} = \beta_1 Y_{it-1} + \beta_2 X_{it-1} + \sum_{j=1}^{p-1} \gamma_j^i \Delta Y_{it-j} + \sum_{j=0}^{q-1} \delta_j^i \Delta X_{it-j} + \mu_i + \varphi.Trend + \varepsilon_{it} \tag{5}$$

Where β_1 and β_2 are unrestricted coefficients for one period lagged dependent and independent variables, respectively. The ARDL bounds test approach is based on the joint F-statistic, which tests the null hypothesis of no cointegration, $H_0: \beta_1 = \beta_2 = 0$. The value of the computed F-statistic is compared with the upper and lower bounds of the critical values. If the computed value of F-statistic is more than the critical value of the upper bound, we can infer that there exists a long-run relationship or cointegration between economic growth and internet usage. If the computed value of F-statistic is less than the critical value of the lower bound, we can infer that there is no cointegration between economic growth and internet usage. However, if the computed value of F-statistic lies between these bounds, a conclusion cannot be made about the cointegration relationship. The critical values for the lower and upper bounds of the F-statistic have been obtained from Pesaran *et al.* (2001) for the case of unrestricted intercept and unrestricted trend in the model with one independent variable.

5. Econometric Analysis and Results

5.1. Panel unit root test results

This paper aims at analyzing the long-run relationship between economic growth and internet usage. To examine the long-run relationship, we will be using cointegration test and vector error correction model (VECM) test. Before testing for cointegration, we need to ensure that both series are non-stationary and integrated of the same order. Therefore, various panel unit-root tests would be applied to identify the stationary properties of the variables under study. Following Pradhan *et al.* (2013b), we have used four panel unit-root tests (Levin-Lin-Chu: LLC, Im-Pesaran-Shin: IPS, and Fisher types: ADF and PP tests). The Im-Pesaran-Shin test is considered a better test for small samples as it considers the heterogeneity among cross-sections and controls for serial correlation. These unit-root tests are very standard tests and have not been discussed in detail to conserve space. These all panel unit-root tests have the null hypothesis of the non-stationarity. If we reject the null hypothesis, it could be inferred that series is stationary. Akaike Information Criteria (AIC) has been used for optimum lag selection for these tests with the maximum lag length of two. While testing for stationarity, only intercept has been included in the model. We have conducted unit root test results by including intercept and trend as well, however, the results are qualitatively similar. Unit root results are reported in Table 2.

Table 2. Panel unit root test results

Tests	GDPPC			INTERNET		
	Level	First Difference	Inference	Level	First Difference	Inference
Levin, Lin and Chu	-1.16	-12.89***	I (1)	-15.41***	-18.30***	I (0)
Im, Pesaran and Shin	3.86	-12.26***	I (1)	-9.89***	-14.90***	I (0)
ADF - Fisher	72.58	301.99***	I (1)	288.26***	359.28***	I (0)
PP - Fisher	77.89	383.98***	I (1)	993.59***	497.95***	I (0)

*Note: *** shows the significance at the 1% level of confidence. Only the test-statistics results are reported here. EViews 9 has been used for all computations.*

Our results indicate that GDP per capita is non-stationary at level (I(1)), but internet variable is stationary(I(0)). Therefore, we cannot use Johansen cointegration methodology for testing for cointegration as used by Pradhan *et al.* (2013b). We will be using panel Auto Regressive Distributed Lag (ARDL) model, which is also an alternative to Generalized Method of Moment (GMM) estimators when the sample size is small. If there exists a long-run relationship between GDPPC and INTERNET, VECM can be estimated to check for short-run causality.

5.2. Panel ARDL results

We have estimated Equations (1) and (2) for panel ARDL estimation. The results of the panel ARDL tests are shown in Table 3 and Table 4. EViews 9 has been used for all the computations. We are aware that GDPPC and INTERNET are positively correlated with each other, hence, we need to examine both-way causality to find a relationship between these variables. After determining optimal lag length, the cointegration between economic growth and internet usage is tested with the help of the ARDL bounds test. When GDP per capita is the dependent variable, the output of ARDL bounds test is shown in Table 3. Akaike information criterion (AIC) has been used to select the optimal lag length for estimating the model. The maximum lag length for AIC has been set as two for the dependent (GDPPC) and three for the independent variable (INTERNET). While estimating ARDL model, intercept and trend have been included in the model. The ARDL model (2, 3) has been selected as per AIC, and the results of ARDL bounds test are presented in Table 3.

Table 3. ARDL bounds test results

Dependent variable	F-Statistic	k
GDP per capita	44.98	1

Critical Value Bounds		
Significance level	I(0) Bound	I(1) Bound
10%	5.59	6.26
5%	6.56	7.3
1%	8.74	9.63

Notes: k represents the number of independent variables in Equation (5). Critical values are obtained from the study by Pesaran et al. (2001). I(0) bound is the lower bound, and I(1) bound is the upper bound of the ARDL bounds test.

The F-statistic in Table 3 is 44.98, which is more than the upper bound critical value, 9.63, at 1% level of confidence. Therefore, it could be inferred that the economic growth and internet usage are cointegrated or have a long-run relationship. Hence, panel ARDL models could be estimated in order to examine the long-run and short-run dynamics between the economic growth and internet usage. Table 4 shows the ARDL results for the long-run and short-run dynamics, when GDPPC is the dependent variable and INTERNET is the independent variable.

Table 4. ARDL results when GDPPC is the dependent variable

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
Long Run Equation				
INTERNET	0.086***	0.006	13.812	0.000
Short Run Equation				
ECT	-0.461***	0.092	-5.020	0.000
$\Delta GDPPC_{t-1}$	0.122	0.085	1.440	0.151
$\Delta INTERNET$	0.002	0.012	0.179	0.858
$\Delta INTERNET_{t-1}$	-0.021**	0.010	-1.989	0.047
$\Delta INTERNET_{t-2}$	0.012	0.008	1.525	0.128
Intercept	2.802***	0.535	5.236	0.000
TREND	0.000	0.003	-0.061	0.952

*Notes: ECT stands for error correction term which is nothing but the one period lagged residuals of the long-run equation. *** and ** show the significance at the 1% and 5% level of confidence, respectively. GDPPC and INTERNET stand for log of real GDP per capita and log of internet subscribers per 10000, respectively. EViews 9 has been used for all computations.*

Table 4 reveals that the internet causes the economic growth in both short-run and long-run. Long-run equation results show that the internet is causing GDP positively and significantly.

The coefficient of the INTERNET is 0.086 which indicates that 1% increase in internet subscription leads 0.086% increase in GDP per capita. The error correction term (ECT) coefficient is -0.461 which is negative and significant as per the expectations. ECT coefficient indicates that GDPPC and INTERNET are cointegrated at 1% level of significance, and any disequilibrium from long-run relationship gets corrected at the rate of 46.1% in the one-year period. Short-run equation results indicate that the coefficient of INTERNET at lag one is negative and significant. These results show that the internet usage has a positive and significant impact on the economic growth in the long-run. However, the relevant short run parameter is negative. The possible explanation for such phenomenon could be the high initial costs involved in the infrastructure development of providing internet services. However, the investments in the internet infrastructure may provide huge benefits in the long-run due to various externalities and network effects. Therefore, INTERNET may have a negative impact on the GDPPC in the short-run but positive impact in the long-run.

When INTERNET is the dependent variable, the output of ARDL estimation is shown in Table 5. There are only two variables in the Equation (5), GDP per capita and internet usage. Hence, if GDP per capita is cointegrated with internet usage as shown by ARDL bounds test results in Table 3, it implies that internet usage is also cointegrated with GDP per capita. However, we have conducted ARDL bounds test when internet usage is the dependent variable. The computed F-statistic is 74.18, which is more than the upper bound critical value, 9.63, at 1% level of confidence. It indicates that internet usage and economic growth are cointegrated. AIC has been used to select the optimal lag length for estimating the model. The maximum lag length for AIC has been set as two for the dependent (INTERNET) and three for the independent variable (GDPPC). While estimating ARDL model, intercept and trend have been included in the model. The ARDL model (2, 3) has been selected as per AIC, and the results are presented in Table 5.

Table 5. ARDL results when INTERNET is the dependent variable

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
Long Run Equation				
GDPPC	0.957***	0.297	3.226	0.001
Short Run Equation				
ECT	-0.535***	0.053	-10.035	0.000
$\Delta INTERNET_{t-1}$	0.105*	0.055	1.930	0.054
$\Delta GDPPC$	-0.469	0.747	-0.628	0.531
$\Delta GDPPC_{t-1}$	-0.189	0.622	-0.304	0.761
$\Delta GDPPC_{t-2}$	-0.613	0.604	-1.016	0.310
Intercept	-1.484***	0.285	-5.200	0.000
TREND	0.112***	0.018	6.209	0.000

*Note: ECT stands for error correction term which is nothing but the one period lagged residuals of the long-run equation. *** and * show the significance at the 1% and 10% level of confidence, respectively. GDPPC and INTERNET stand for log of real GDP per capita and log of internet subscribers per 10000, respectively. EViews 9 has been used for all computations.*

Table 5 reveals that the internet is the consequence of the economic growth in long-run. Long-run equation results show that GDPPC is causing the INTERNET positively and significantly in the long-run. The error correction term (ECT) coefficient is -0.535 which is negative and significant as per the expectations. ECT coefficient indicates that GDPPC and INTERNET are cointegrated at 1% level of significance, and any disequilibrium from long-run relationship gets corrected at the rate of 53.5% in the one-year period. Short-run equation results indicate that GDPPC does not cause the INTERNET in the short-run as none of the coefficients of the lagged GDPPC variable are significant. It suggests that GDPPC does not lead the INTERNET in the short-run, however, GDPPC has a positive and significant impact on the INTERNET in the long-run. The possible explanation for such phenomenon could be that with a higher level of income, the internet becomes a comfort need rather than a luxury. Therefore, GDPPC may have no impact on the INTERNET in the short-run but positive impact in the long-run. Overall, it could be concluded that GDP per capita and Internet usage are cointegrated in the long run, and has bi-directional causality.

6. Policy Implications and Conclusions

The obvious implication of this study is that it provides a documented research which could be useful for policy makers. They could make more efficient decisions regarding internet usage policies in the sub-Saharan African countries. As it is clear from our results that the internet usage positively affects economic growth of sub-Saharan African countries in the long run. Hence, policymakers should encourage the use of internet in various sectors, such as health, education, and agriculture to explore the role of the internet as a strategic tool in these sectors. This study has come at a point when internet potential of sub-Saharan African countries is still unexploited. This study has the potential to pave the path for future research in internet-growth relationship in sub-Saharan African countries.

This study examines the short-run and long-run relationships between GDP per capita and internet usage. Using panel data of 42 sub-Saharan African countries for the period 1998 to 2014, the results reveal that GDP per capita and internet usage are cointegrated. Moreover, we find that there exists a bi-directional causality between these variables. The results indicate that internet usage plays a positive and significant role in economic growth of the sub-Saharan African countries. It happens because internet contributes to the spillover effect of knowledge across countries (Choi and Yi, 2009) which ultimately increases the productivity of a country. Similarly, increased GDP per capita is also responsible for the increase in the internet usage. These results have important implications for policymakers. This study has a limitation that it has included only two variables in the causality analysis which is not wrong for econometric analysis purpose, but future studies may include more variables to understand the relationship more precisely.

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Appendix 1: 42 Sub-Saharan countries in panel

The 42 countries in Sub-Saharan panel are Angola, Burundi, Benin, Burkina Faso, Botswana, Central African Republic, Cote d'Ivoire, Cameroon, Congo Dem. Rep., Congo Rep., Comoros, Cabo Verde, Ethiopia, Gabon, Ghana, Guinea, Gambia, Guinea-Bissau, Equatorial Guinea, Kenya, Lesotho, Madagascar, Mali, Mozambique, Mauritania, Mauritius, Malawi, Namibia, Niger, Nigeria , Rwanda, Senegal, Sierra Leone, Swaziland, Seychelles, Chad, Togo, Tanzania, Uganda, South Africa, Zambia, and Zimbabwe.