



Effect of Information and Communications Technology on Economic Growth in Africa



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Abstract: Information and communications technology (ICT) has been identified as one of the factors that drive economic growth and development. Thus, various empirical studies have been conducted with a view to examining the effects of ICT on economic growth. However, such studies failed to examine whether real per capita income influences the effect of ICT on economic growth, and whether the effect of ICT on economic growth differs among sub-regions of African countries. This study, therefore, sought to (a) investigate the effect of ICT on economic growth, (b) examine whether real per capita income influences the effect of ICT on income level and economic growth and (c) whether the effect of ICT on economic growth differs among the sub-regions of African countries. While a panel regression analysis was carried out, Hausman, Poolability and Breusch-Pagan LM tests were employed to choose the appropriate estimator between the fixed-effect and random-effect estimators. Data were obtained from the World Bank's World Development Indicators and International Monetary Fund classification of Africa countries. Results were evaluated at 0.05 level of significance. The results showed that ICT did not have significant effect on economic growth, and that the effect of ICT on economic growth did not differ among the sub-regions of African countries. However, we found that real income per capita influenced the effect of only mobile cellular subscription (an indicator of ICT) on economic growth. Therefore, policymakers should not rely on ICT for sustained output growth because it can only lead to only one-shot, unsustainable change in income level.

Keywords: Economic growth; ICT; Hausman test; Fixed Effect; Random Effect.

1. INTRODUCTION

Information and communications technology (ICT)—the use of electronic equipment, especially computers, phones and the Internet, for storing, analysing and distributing or communicating information—has become an important part of an economy. The importance of ICT in economic and social development, which cannot be overemphasised, arises naturally since its inception in the mid-nineties (Hodrab et al., 2016). Most firms and consumers now use computers and the Internet for their economic activities to provide themselves with more diversified and customized products as well as improved product quality (Farhadi et al., 2012). CIT reduces the economic impact of physical distances, the costs of access to information and the cost of establishing new small businesses, and thereby makes businesses more efficient and more competitive (Can & Terziev, 2016).

Consequently, many developing countries now consider ICT a significant contributor to productivity growth and an important part of development strategies. ICT offers a unique opportunity for developing countries to free themselves from historical and geographic

constraints, allowing trade and economic activities to be conducted as efficiently as it is in the developed world. An evolving and increasingly powerful ICT infrastructure has fundamentally changed the nature of global relationships, sources of competitive advantage and opportunities for economic and social development. Technologies such as the internet, personal computers, broadband and wireless telephony have created an interconnected global network of individuals, firms and governments (Veeramacheneni et al., 2011).

Meanwhile, economic growth—a pre-occupation of policy makers all over the world—has been uninspiring and unsatisfactory in most developing African countries. Such uninspiring growth experiences can be partly explained by inappropriate policies, which can be addressed if policy makers are better informed of growth determinants. In order to assist policymakers in this regard, theoretical and empirical studies have sought to shed light on factors determining growth, one of which has been considered to be ICT. The impact of ICT on economic growth has become a theoretical as well as an empirical issue that has lingered on. The role of ICT activities in promoting economic growth is at the heart of the debate on the impact of investment in ICT on economic growth and development (Veeramacheneni et al., 2011). The bone of contention is that, by investing in ICT, is it possible for developing countries to leapfrog stages of development rather than play a catch-up effect with developed countries?

A line of research has attempted to provide an answer to this question. Some have found a certain impact of the adoption of ICT on economic growth (e.g., Abasiz & Sezer, 2018; Aghaei & Mahdieh, 2017; Asongu & Odhiambo, 2019; Bahrini & Qaffas, 2019). However, such studies were bedevilled with certain methodological pitfalls. It would have been more informative if such studies had examined the differentials in the effect of ICT on economic growth. Furthermore, such studies would have shed more light on policy issues if they had examined whether the level of real per capita income influences the effect of ICT on both income level and economic growth. Besides, there is a need to know from such studies whether the effect of ICT on economic growth differ among sub-regions of African: Eastern Africa, Western Africa, North Africa, Southern Africa, and Middle Africa.

Given these research problems, we therefore sought to (1) investigate the effect of ICT on economic growth in Africa, (2) examine whether real per capita income influences the effect of ICT on economic growth, and (3) whether the effect of ICT on economic growth differs among the sub-regions of African countries.

This research was carried out with annual data spanning 2008 to 2017 across African countries. This period was considered in this study because data for ICT variables were not available both before 2008 and beyond 2017 at the time of data analysis for the study. The year 2008 coincides with the emergence of ICT development in Africa.

Fifty-four African countries were considered and grouped into five sub-regions—the Eastern, Western, Northern, Southern, and Middle African countries. The six Eastern African countries are Tanzania, Kenya, Uganda, Rwanda, Burundi, South Sudan Eritrea, Mauritius, Djibouti, Comoros, and Seychelles. The sixteen African Countries belonging to the Western sub-region are Nigeria, Ghana, Cote d’Ivoire, Niger, Mali, Senegal, Guinea, Benin, Liberia, Mauritania, Gambia, Guinea-Bissau, Cabo Verde, Togo, Sierra Leone, and Burkina Faso. The six Northern sub-region consists of Egypt, Algeria, Sudan, Morocco, Tunisia, and Libya. The ten African countries belonging to Southern sub-region includes Mozambique, Malawi, Zambia, Zimbabwe, South Africa, Namibia, Botswana, Lesotho, Eswatini/Swaziland, and

Angola. Lastly, the eleven Middle African countries are Rwanda, Burundi, Democratic Republic of Congo, Angola, Cameroon, Chad, Congo, Central African Republic, Gabon, Equatorial Guinea, Sao Tome & Principe.

This paper is divided into four sections. While Section 1 consists of the introduction, Section 2 is composed of the methodology adopted. Results and discussion are contained in Section 3 and conclusive remarks are given in Section 4.

2. METHOD

This section consists of the theoretical framework, model specification, and estimation technique as well as measurement and sources of the data for the study.

2.1 Theoretical Framework

The theoretical foundation of growth of GDP per capita (i.e., economic growth) model can be found in neoclassical growth model, which models economic growth in terms of the Cobb-Douglas production function

$$Y = AK^a N^{1-a} \quad (1)$$

where A = technological progress or total factor productivity, K = Capital stock, N = Labour, and Y = output.

Dividing both sides of Equation (1) by N gives the function in per capita terms

$$\frac{Y}{N} = A \left(\frac{K}{N}\right)^a \left(\frac{N}{N}\right)^{1-a} \quad (2)$$

Taking the logarithm of Equation (2) yields

$$\ln\left(\frac{Y}{N}\right) = \ln A + a \ln\left(\frac{K}{N}\right) + (1-a) \ln\left(\frac{N}{N}\right) \quad (3)$$

$$\ln\left(\frac{Y}{N}\right) = \ln A + a \ln\left(\frac{K}{N}\right) + (1-a) \ln 1 \quad (4)$$

$$\ln(y) = \ln A + a \ln(k) \quad (5)$$

where $y \equiv \frac{Y}{N}$ and $k \equiv \frac{K}{N}$

Equation (5) indicates that output per capita is equal to capital per capita plus the total factor productivity. This theoretical postulation of the effect of a factor on output and its growth would be useful in evaluating the results of the analysis of this study.

2.2 Model Specification

This section contains three models adapted for this study. It includes (1) Model 1, which represents the effects of ICT indicators and some control variables on economic growth; (2) Model 2, representing whether per capita income influences the effect of ICT on economic growth, (3) Model 3, representing how the effect of ICT on economic growth differs across sub-regions of Africa.

Incorporating the relevant explanatory variables in Equation 5 gives rise to the following models:

Model 1:

$$\left(\frac{\Delta y}{y}\right)_{it} = \beta_0 + \beta_1 \ln INV_{it} + \beta_2 \ln ICTI_{it} + \beta_3 \ln GEXP_{it} + \beta_4 \ln EXPT_{it} + \beta_5 \ln F_{it} + \mu_{it}$$

Model 2:

$$\left(\frac{\Delta y}{y}\right)_{it} = \beta_0 + \beta_1 \ln INV_{it} + \beta_2 \ln ICTI_{it} + \beta_3 \ln ICTI_{it} * y + \beta_4 \ln GEXP_{it} + \beta_5 \ln EXPT_{it} + \beta_6 \ln F_{it} + \mu_{it}$$

Model 3:

$$\left(\frac{\Delta y}{y}\right)_{it} = \beta_0 + \beta_1 \ln INV_{it} + \beta_2 \ln ICTI_{it} + \beta_3 \ln ICTI_{it} * E + \beta_4 \ln ICTI_{it} * W + \beta_5 \ln ICTI_{it} * S + \beta_6 \ln ICTI_{it} * N + \beta_7 \ln GEXP_{it} + \beta_8 \ln EXPT_{it} + \beta_9 \ln INF_{it} + \mu_{it}$$

where $\frac{\Delta y}{y}$ = growth in real per capita gross domestic product (i.e., economic growth), y = real per capital income proxied by GDP per capita, $ICTI$ = ICT indicators, alternatively proxied by FTS, IU, FBS, and MCS. While E , W , S , and N are dummy variables representing Eastern, western, Southern and Northern regions, respectively, $\beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6$, and β_7 represent parameters of the models, and subscripts i and t indicate country and year, respectively, μ_{it} is the stochastic error term, and INV = gross fixed capital formation as percentage of GDP. In all the models, $\frac{\Delta k}{k}$ which represents the growth of capital stock per capita was replaced by the share of gross fixed capital formation in the GDP, denoted by INV . This is because the data for $\frac{\Delta k}{k}$ is not available and the only nearest suitable proxy for growth of capital stock per capita that comes to mind is the share of gross fixed capital formation in the GDP (INV). This study realizes this to be far from being a good approximation, but this is the best that the study can do in view of the fact that there is no growth of capital stock statistics, and it is hoped that the use of INV as a proxy is better than not including any proxy at all.

For estimation purposes, the natural log of the $ICTI$, $GEXP$, and $EXPT$ variables, except INF , are employed in the models, thereby permitting the estimated slope parameters to be interpreted as elasticities.

Model 1 was specified for the purpose of meeting our first objectives. Four ICT indicators were included one after another during estimation to give four equations that were estimated from Model 1. The four alternative ICT indicators were included one after another in order to avoid a high degree of multicollinearity. This is in line with previous studies such as Bahrini and Qaffass (2019) and Toader et al. (2018).

To achieve the second objective of this study—that is, to examine whether per capita income influences the effect of ICT on economic growth—we specified Model 2 which shows economic growth as a linear function of ICT indicators and their interactions with real income per capita. The ICT indicators were into the model introduced one after another during estimation, yielding four equation estimates.

To examine whether the effect of ICT on economic growth differs across the sub-regions of African countries—the third objective—each of the four alternative ICT indicators with regional dummy variables were interacted in Model 3. The dummy variables used were E , W , S and N , with each taking a value of 1 for its corresponding African sub-region, and 0 otherwise. The reference category for these four dummies is the Middle African countries. Models 3 and 6 show economic growth as linear functions of ICT indicators ($ICTI$) as well as their interactions with the sub-regional dummies. In order to avoid serious multicollinearity problems during estimation, the ICT indicators and their interactions with sub-regional dummies are also included one after another.

2.2.1 Definition and Measurement of Variables

The definitions of the variables employed and their measurement are described below. The data for the variables were obtained from World Bank's World Development Indicators (2019).

1. ICT indicators

ICT indicators (ICTI)—measured by the number of internet users, fixed telephone subscriptions, mobile cellular subscription, and fixed broadband subscriptions—are assumed to impact positively on economic growth. An increase in the level of each ICT indicator is posited to lead to increase in technological progress, which in turns leads to economic growth. This is because technological progress would improve the efficiency of production and distribution of goods and services. This postulation is in line with Farhadi et al. (2012), Abasiz and Sezer (2018), Bahrini and Qaffas (2019), and Eboagu and Adeleye (2019). The ICT indicators are operationalized as (1) number of fixed telephone subscriptions per 100 inhabitants, (2) mobile cellular subscription per 100 inhabitants, (3) number of internet users as percentage of population, and (4) number of fixed broadband subscriptions per 100 inhabitants.

Number of Fixed Telephone Subscriptions per 100 inhabitants (FTS) refers to the sum of active number of analogue fixed telephone lines, voice-over-IP (VoIP) subscriptions, fixed wireless local loop (WLL) subscriptions, ISDN voice-channel equivalents and fixed public payphones (World Bank, 2019).

Mobile Cellular Subscription per 100 Inhabitants (MCS) According to World Bank (2019), mobile cellular telephone subscriptions are subscriptions to a public mobile telephone service that provides access to the PSTN, using cellular technology. It includes the number of postpaid subscriptions, and the number of active prepaid accounts that have been used during the last three months. The indicator applies to all mobile cellular subscriptions that offer voice communications. It excludes subscriptions via data cards or USB modems, subscriptions to public mobile data services, private trunked mobile radio, telepoint, radio paging and telemetry services.

Number of Internet Users as Percentage of Population (IU) represents individuals who have used the Internet (from any location) in the last 3 months (World Bank, 2019). The Internet can be used via a computer, mobile phone, personal digital assistant, games machine, digital TV, etc. It is measured as a percentage of population.

Number of Fixed Broadband Subscriptions per 100 Inhabitants (FTS) refers to fixed subscriptions to high-speed access to the public internet (a TCP/IP connection), at downstream speeds equal to, or greater than, 256 kbit/s (World Bank, 2019). This includes cable modem, DSL, fiber-to-the-home/building, other fixed (wired)-broadband subscriptions, satellite broadband and terrestrial fixed wireless broadband. This total is measured irrespective of the method of payment. It excludes subscriptions that have access to data communications (including the internet) via mobile-cellular networks. It includes fixed WiMAX and any other fixed wireless technologies. It also includes both residential subscriptions and subscriptions for organizations.

2. Gross Fixed Capital Formation (INV)

Gross fixed capital formation, as described by World Bank (2019), includes land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. According to the System of National Accounts (SNA) (1993), net acquisitions of valuables are also considered capital formation. The variable was measured as a ratio of GDP, in nominal terms and in local currency.

3. *Economic Growth ($\frac{\Delta y}{y}$)*

This is the annual percentage change in the real GDP per capita in local currency. According to World Bank (2019), GDP per capita is gross domestic product divided by midyear population. GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant local currency. The growth rate of per capita output is computed as the first difference of the natural log values and it is expressed in percentage.

4. *Real Per-Capita Income (y)*

This refers to gross domestic product divided by midyear population. The data were the same the ones used in computing per capita output growth in (3) above, except that the data used for the latter were measured at levels.

5. *General Government Final Consumption Expenditure (GEXP)*

This variable represents all government current expenditures for purchases of goods and services, including compensation of employees (World Bank, 2019). It also includes most expenditures on national defense and security, but excludes government military expenditures that are a part of government capital formation. The variable was measured as a ratio of GDP, in nominal terms and in local currency. General government final consumption expenditure was postulated to have a negative effect on productivity growth. Spending on public goods and services, as anecdotal evidence suggests, may be wasteful due to bribery and corruption or the varieties of taxes imposed by government on citizens may be higher, thereby affecting productivity adversely. Inclusion of this variable is in line with the findings in some of such studies as Asongu and Odhiambo (2019) and Bahrini and Qaffas (2019).

6. *Export of Goods and Services (EXPT)*

This represents the value of all goods and other services provided to the rest of the world. According to the data source, they include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude compensation of employees and investment income (formerly called factor services) and transfer payments. Data are measured as a ratio of GDP, with both being nominal terms and in local currency before expressing one as a ratio of the other. An increase in export of goods and services (EXPT) was hypothesized to lead to an increase in net export through an increase in local production, low consumption of foreign goods by citizens and low excise duties. By this, an increase in net export would lead to an increase in aggregate expenditure, productivity growth and economic growth. In their respective studies, Pham and Martin (2007) and Hesse (2008) have confirmed that export has a non-linear positive effect on economic growth in their estimation.

7. *Inflation Rate (INF)*

Price stability, which is usually measured by inflation rate (INF), is important for economic agents to make accurate resource allocation decisions. Some previous studies, such as Bahrini and Qaffas (2019), Asongu and Odhiambo (2019) and Eboagu and Adeleye (2019) have empirically confirmed that inflation rate has a negative effect on economic growth. Inflation rate is, therefore, expected to have a negative effect on productivity growth.

8. Regional Dummies (E, W, S, N, and E)

The varying impacts of ICT on economic growth and income level among the African sub-regions are measured by the regional dummy variables E, W, S and N, which take a value of 1 for its corresponding African sub-region, and 0 otherwise. The reference category or sub-region for the four dummies is Middle African countries. The five-way classification is adopted from the International Monetary Fund (IMF) classification of Africa countries.

2.3 Estimation Techniques

Three panel methods of estimations were considered in this study: *pooled-OLS*, *fixed effect* (FE), and *random-effect* (RE) methods. The pooled OLS method of estimation, also called *common constant method*, assumes that there are no differences between the estimated cross-sections (African countries). In other words, the model estimates a common constant for all the cross-sections (Africa countries), and, the unobservable individual effect is assumed to be zero in pooled OLS estimator (Asteriou & Hall, 2007).

The FE estimator, known as the *least-square dummy variables (LSDV) estimator*, allows for the estimation of different constants for each group and includes a dummy variable for each group. It captures all effects that are specific to a particular individual and which do not vary over time. It is possible to extend the fixed-effect model by including a set of time dummies as well. This is known as the *two-way fixed effect model* and has the advantage of capturing any effects that vary over time but are common across the whole panel (Asteriou & Hall, 2007). The fixed effect is an appropriate specification when focusing on a specific set of *N* units, say countries. However, it suffers from a large loss of degrees of freedom when many dummies are included and inclusion of too much dummies aggravates the problem of multicollinearity among the regressors. Furthermore, it cannot be used to estimate the effect of any time-invariant variable like sex, race, religion, and other categorical variables (Baltagi, 2005). The overall significance of the dummies is tested by F-test statistics.

The RE method is an alternative method of estimating a model. The major difference between the fixed effects and the random effects method is that the former treats the constant for each group as fixed while the latter treats the constant as random parameters (Asteriou & Hall, 2007).

In order to choose among these three estimators, we carried out four decision rules tests: poolability test, Hausman test, Breusch-Pagan Lagrange multiplier (LM) test. The *poolability test* is used to know whether the constant of a function is treated as homogeneous or heterogeneous. The test assists in knowing the appropriate estimators to use, whether pooled regression that follows OLS approach or FE estimator. Before assessing the validity of the fixed effects method, we need to apply tests to check whether fixed effects (i.e., different constants for the various units) should indeed be included in the model. To do this, the standard F-test can be used to check fixed effects against the simple common constant OLS method. The null hypothesis is that all the constants are the same (homogeneity) and the alternative hypothesis is that all the constants differ (heterogeneity). If the p-value of F-test is less than 0.05 level of significance (or any other chosen level of significance, say 0.01), then we reject the null hypothesis (Asteriou & Hall, 2007).

Hausman test is a test used to select the better model between FE and RE because both have their demerits and merits. In general, the difference between the two panel data models is that the FE model assumes that each country differs in its intercept term, whereas the RE model

assumes that each country differs in its error term. Usually, when the panel is balanced, one might expect that the FE model will work best. In other cases, whereby the sample contains limited observations of the existing cross-sectional units, the random effects model might be more appropriate (Asteriou & Hall, 2007).

Breusch-Pagan Lagrange multiplier (LM) is a test for the random-effects model based on the OLS residual. It helps to select between a RE regression and a simple pooled OLS regression. The null hypothesis is that variance across entities is zero, that is, there is no significant difference across units. A study rejects the null hypothesis if the p-value of LM test is less than 0.05 significance level or any other chosen level of significance (Kalita & India, 2013). LM test should be conducted based on the following two conditions: (a) if the Poolability test indicates that simple pooled OLS regression is better than FE regression and (b) if the Hausman test shows that RE is better than FE regression. The Lagrange Multiplier Test is required only if the above two conditions are met (Kalita & India, 2013).

We equally carried out four post-estimation tests—multicollinearity test, autocorrelation test, heteroscedasticity test, and non-normality of the residuals test—in order to test the validity of the regression model, to determine if they actually violate the assumptions underlying OLS method.

3. RESULTS AND DISCUSSION

This section provides the descriptive and correlation statistics, estimates of the panel regression equations and the associated post-estimation test results.

3.1 Descriptive Statistics

Table 3.1 summarises the descriptive statistics for each of the variables employed in the study. It includes the mean, median, maximum, minimum, standard deviation (overall, within and between), skewness and kurtosis for all the variables.

Table 3.1 Selected Descriptive Statistics

Variables	Mean	Min.	Max.	Overall Std.	Between	Within	Skewness	Kurtosis	† Coef. v.
INV	23.28	3.29 58.83		9.26	8.24	4.68	0.7	3.66	0.3978
$\frac{\Delta y}{y}$	1.75	-62.38	121.78	7.88	2.29	7.58	4.97	118.15	4.5029
FTS	3.65	0	32.67	6.02	5.97	0.95	2.75	10.91	1.6493
MCS	69.07	2.36	175.87	38.84	34.22	18.98	0.5	2.49	0.5623
IU	14.8	0.25	64.19	14.91	12.46	8.38	1.34	3.95	1.0074
FBS	1.09	0	19.45	2.56	2.31	1.02	4.09	21.89	2.3486
INF	8.58	-4.29	379.84	21.76	13.99	17.09	12.56	193.01	2.5361
Y	5595	637	40368	6703	6551	1317	2.28	8.8	1.1981
GEXP	15.41	2.05	79.17	6.65	5.76	3.41	2.43	20.24	0.4315
EXPT	33.76	4.43	158.27	21.27	22.82	6.65	2.07	10.05	0.63

Source: Authors' computation, 2021.

† Coef. v = coefficient of variation.

Table 3.1 depicts the overall standard deviation for gross fixed capital formation to be about 9.26, indicating variations in both over time and across units and the *between* standard deviation is 8.24, indicating variations across African countries irrespective of the time period while the *within* standard deviation, with the value of 4.68, shows the variations over time. The *within* standard deviation is lower compared to *between* that is, data set for the variable

do not really change over time when compared to how it varies across African countries. The mean of gross fixed capital formation is about 23.28 with the coefficient of variation of about 0.40.

3.2 Correlation Analysis

Table 3.2 shows the sample correlations between each pair of the variables. The p-values of the correlation coefficients in Table 3.2 indicate the statistical significance of the correlation between each pair of the variables. A correlation is interpreted to exist in this study if the p-value is not more than 5 percent, (i.e., 5% is the chosen cut-off significance level in the study).

Table 3.2 Correlation Matrix

Variables $\frac{\Delta y}{y}$	$\frac{\Delta y}{y}$	LINV	LFTS	LMCS	LIU	LFBS	INF	lny	LGEXP	LEXPT
$\frac{\Delta y}{y}$	1									
LINV	0.200 (0.000)	1								
LFTS	0.094 (0.038)	0.212 (0.000)	1							
LMCS	0.021 (0.639)	0.219 (0.000)	0.463 (0.000)	1						
LIU	-0.014 (0.749)	0.177 (0.000)	0.523 (0.000)	0.794 (0.000)	1					
LFBS	0.056 (0.224)	0.221 (0.000)	0.688 (0.000)	0.658 (0.000)	0.715 (0.000)	1				
INF	-0.107 (0.019)	-0.175 (0.000)	-0.252 (0.000)	-0.209 (0.000)	-0.056 (0.220)	-0.272 (0.000)	1			
lny	-0.007 (0.880)	0.257 (0.000)	0.682 (0.000)	0.601 (0.000)	0.652 (0.000)	0.649 (0.000)	-0.060 (0.189)	1		
LGEXP	-0.014 (0.765)	0.158 (0.001)	0.332 (0.000)	0.158 (0.001)	0.168 (0.000)	0.164 (0.000)	-0.045 (0.315)	0.162 (0.000)	1	
LEXPT	0.030 (0.504)	0.265 (0.000)	0.343 (0.000)	0.370 (0.000)	0.282 (0.000)	0.343 (0.000)	-0.045 (0.332)	0.542 (0.000)	0.286 (0.000)	1

Explanatory Note: LINV = log of gross fixed capital formation as a ratio of GDP, $\frac{\Delta y}{y}$ = economic growth, LFTS = Log of fixed telephone subscriptions per 100 inhabitants, LMCS = Log of mobile cellular subscription per 100 inhabitants, LIU = Log of internet users as percentage of population, LFBS = Log of fixed broadband subscriptions per 100 inhabitants, lny = log of real income per capita, INF = inflation rate, LGEXP = log of general government final consumption expenditure, LEXPT = log of export of goods and services. Probability values are reported in parentheses next to the coefficients.

Source: Authors' computation, 2021.

3.3 Estimates of the Effect of ICT on Growth (Model 1)

Model 1 was estimated in three alternative equations in Table 3.3. Equation 1 examines the impact of fixed telephone subscriptions (FTS) on economic growth. In Equation II, FTS is replaced with mobile cellular subscriptions (MCS). Equation III substitutes IU for MCS and Equation IV, IU is replaced with fixed broadband subscriptions (FBS). The table below shows the estimates of the four equations.

The Hausman test results shown in the Table 3.3 indicate that we reject the null hypothesis that Random Effect (RE) is preferred to Fixed Effect (FE) because the probability values in all equations are less than 0.05 level of significance and conclude that FE is preferred. The Poolability test results also indicate that FE estimator is preferred compared to pooled OLS regression because the p-values of F-test for each of the equations is less than 0.05 significance level. Therefore, following the decision rule spelt out for both Hausman and Poolability tests, FE method is considered as the better one for all the equations.

Variables are interpreted to have significant effect in this study if the p-values of the coefficients are not more than 5 percent.

Table 3.3 Estimates of the Effect of ICT on Economic Growth ($\frac{\Delta y}{y}$)

	Equation I			Equation II			Equation III			Equation IV		
	No of Obs. = 424			No of Obs. = 447			No of Obs. = 442			No. of obs. = 413		
Variables	Coeff	T-stat.	p-value	Coeff	T-stat.	p-value	Coeff	T-stat.	p-value	Coeff	T-stat.	p-value
LINV	4.988	2.53	0.014	5.815	2.81	0.007	5.541	2.63	0.011	4.498	2.14	0.038
LFTS	1.591	1.87	0.067									
LMCS				-1.227	-2.14	0.038						
LIU							-0.769	-1.97	0.055			
LFBS										-0.296	-1.58	0.124
LGEXP	-5.471	-1.90	0.063	-1.988	-0.66	0.510	-0.970	-0.25	0.805	-0.594	-0.20	0.840
LEXPT	4.410	3.39	0.001	2.365	1.06	0.295	2.475	1.17	0.248	2.142	0.93	0.358
INF	0.099	1.85	0.071	-0.025	-1.05	0.298	-0.171	-1.51	0.139	-0.030	-1.08	0.286
Hausman (P-value)			0.000			0.000			0.001			0.000
Poolability (P-value)			0.000			0.000			0.000			0.000
No of Countries	50			50			50			49		
Overall Rsquared	0.027			0.028			0.034			0.011		
Within Rsquared	0.207			0.104			0.134			0.077		
Between Rsquared	0.003			0.030			0.057			0.005		
F (P-value)			0.000			0.0002			0.000			0.002

Explanatory Note: LINV = log of gross fixed capital formation, $\frac{\Delta y}{y}$ = Economic growth, LFTS = Log of fixed telephone subscriptions per 100 inhabitants, LMCS = Log of mobile cellular subscription per 100 inhabitants, LIU = Log of internet users as percentage of population, LFBS = Log of fixed broadband subscriptions per 100 inhabitants, and INF = inflation rate, LGEXP = log of general government final consumption expenditure, LEXPT = log of export of goods and services. Hausman (p-value) indicates the probability values to select the preferred estimator between Fixed and Random Effect estimator. Poolability (p-value) indicates the probability values to select the preferred estimator between pooled OLS regression and Fixed Effect estimator.

Source: Authors' computation, 2021.

The analysis of Table 3.3 are as follows: In Table 3.3, the overall R^2 is less than 10 percent in each Equation. Although the p-values of the F-statistics of the R^2 of the Equations I, II, III, and IV are 0.000, 0.0002, 0.000, and 0.002, respectively. This indicates the overall statistical significance for all the Equations. However, the four equations have very low goodness of fit or explanatory powers.

Concerning the presence or absence of autocorrelation of the residuals, we carried out Wooldridge test, and the p-value is 0.0307 for Equation I, 0.0053 for Equation II, 0.0025 for Equation III, and 0.0006 for Equation IV. We, therefore, concluded that autocorrelation was present in all the equations, and estimated a robust version of fixed-effect regression to correct for the autocorrelation.

Furthermore, concerning the presence or absence of heteroscedasticity of the residuals, we carried out the panel modified Wald heteroscedasticity test for fixed-effect regression and the p-value is 0.000 for all the equations. Thus, we rejected the null hypothesis of homoscedasticity in the equations and concluded that heteroscedasticity was present in the equations. Given this problem, we estimated a robust version of fixed-effect regression to correct for the heteroscedasticity.

Furthermore, normality test was carried out using Galvao et al. (2013) test. The test showed that the error terms were not normally distributed as the probability value of chi-square in each equation was less than 0.05 level of significance except for Equation II and IV, of which their probability values are greater than 0.05 sig level. We, therefore, rejected the null hypothesis of normality of the residuals in Equation I and III and concluded that the residuals were not normally distributed. However, we did not reject the null hypothesis of normality of the residuals in Equation II and IV and thus concluded that the residuals were normally distributed. The situation was corrected by running a robust version of fixed-effect regression for Equations I and III to correct for the non-normality.

As regards the presence or absence of multicollinearity of the explanatory variables, we carried out the Tolerance test. Given the results of the test, we failed to reject the hypothesis of absence of multicollinearity in the equations as the Tolerance exceeds 0.1 in all cases. By implication, all equations are devoid of severe multicollinearity.

Having just evaluated the overall diagnostic statistics of each of the equations, we proceeded to examine the significance of the explanatory variables in the equations estimated in Table 3.3 as follows.

From Table 3.3, the coefficients of *Log of Share of Gross Fixed Capital Formation in GDP (LINV)* in Equations I through IV are 4.99, 5.82, and 5.54, respectively: they all are positive and statistically significant. This suggests that gross fixed capital formation had a positive effect on economic growth. These results conform with our a priori expectation and are in line with the findings reported by Bahrini and Qaffas (2019), Hodrab et al. (2016), and Shanmugam and Kuppusamy (2007).

In Equation I (Table 3.3), the *Log of Fixed Telephone Subscriptions (LFTS)* has a coefficient of 1.591 with the p-value of 0.067, which is positive and statistically insignificant. This implies that the fixed telephone subscription had no effect on economic growth. The coefficient of *Log of Mobile Cellular Subscriptions (LMCS)* is negative and statistically

significant at less than 5% level of significance (Equation II, Table 3.3). This suggests that mobile cellular subscription had a negative effect on economic growth. Equation III (Table 3.3) shows that the coefficient of *Log of Internet Users as percentage of total population (LIU)* is -0.769 (p-value = 0.055), which shows that the coefficient is negative and statistically insignificant. This implies that internet usage had no effect on economic growth. In Equation IV of Table 3.3, the *Log of Fixed Broadband Subscriptions (LFBS)* has a coefficient of -0.296 (p-value = 0.124), which shows that the coefficient is negative and statistically insignificant. This indicates that fixed broadband subscription had no impact on economic growth.

Of all the four ICT indicators variables, only mobile cellular subscription had a statistically significant (negative) effect on economic growth. This suggests that there is no robust evidence that ICT indicators had a significant effect on economic growth. The effect of ICT does not lead to sustained growth of output but rather one-shot increase in the level of income. This result does not conform to our a priori expectations, and is not in line with the empirical findings reported by Shanmugam and Kuppusamy (2007), and Hodrab et al. (2016). This is probably because the study by Shanmugam and Kuppusamy (2007) did not employ cross-sectional data, and that of Hodrab et al. (2016) was conducted on Arab African countries.

The coefficients of *log of share of General Government Final Consumption Expenditure in GDP (LGEXP)* are negative and statistically insignificant (Table 3.3). These results do not conform to our a priori expectations and are not in tandem with the findings by Asongu and Odhiambo (2019) and Bahrini and Qaffas (2019). This is probably because government recurrent expenditure is small compared to spending on capital project. The little effect recurrent expenditure is supposed to have on GDP might have been crowded out by imposing high commodity and income taxes. Thus, general government final consumption expenditure could not have a significant effect on economic growth.

In Table 3.3, the coefficients of *log of Export of Goods and Services (LEXPT)* in Equations II, III, and IV are positive and statistically insignificant whereas its coefficient in Equation I is also positive but statistically different from zero. The results suggest that exportation of goods and services did not have a significant effect on economic growth. This is against our a priori expectation, and does not conform to the empirical findings reported by Pham and Martin (2007) and Hesse (2008). It could be that the effect of export on economic growth was crowded out by excessive borrowing from private and public foreign sources which leads to distortion of balance of trade and devaluation of domestic currency.

For equations I, II, III, and IV in Table 3.3, the variable *Inflation rate (INF)* is not statistically significant in explaining economic growth. Hence, the results are not consistent with our hypothesis and the findings by Asongu and Odhiambo (2019) and Eboagu and Adeleye (2019). The rising rate of inflation fails to have effect on economic growth probably because the production capacity is low causing GDP to rise slowly below the desired level that can lead to economic growth; unemployment becomes high and stagflation occurs as inflation and unemployment rises together over time.

3.4 Economic Growth with Interactions of Per Capita Income and ICT Indicators

Four alternative equations of Model 2 are estimated in Table 3.4. Equation I examines whether real per capita income influence the effect of fixed telephone subscriptions (FTS) on economic growth. While in Equation II, FTS is replaced with mobile cellular subscriptions

(MCS), in Equation III, MCS is replaced with internet usage (IU), and IU is replaced with fixed broadband subscriptions (FBS) in Equation IV.

The Hausman test results shown in Table 3.4 indicate that we reject the null hypothesis that random-effect method is preferred to fixed-effect method because the probability values for all equations are less than 0.05 level of significance. Therefore, fixed-effect method is employed for all the equations. The Poolability test results also indicate further that FE estimator is preferred compared to pooled OLS regression because the p-values of F-test for all equations are less than 0.05 significance level. We thus employed the fixed-effect method for all the equations.

Table 3.4 Economic Growth and Interactions of Per Capita Income (y) with ICT Indicators

Variables	Equation I			Equation II			Equation III			Equation IV		
	No of Obs. = 420			No of Obs. = 443			No of Obs. = 438			No of Obs. = 409		
	Coeff	T-stat.	p-value	Coeff	T-stat.	p-value	Coeff	T-stat.	p-value	Coeff	T-stat.	p-value
LINV	5.036	2.54	0.015	5.285	2.42	0.019	5.595	2.63	0.012	3.934	1.90	0.063
LFTS	1.916	1.61	0.114									
LFTSy	-0.00011	-0.57	0.569									
LMCS				-2.020	-3.13	0.003						
LMCSy				0.002	3.20	0.002						
LIU							-0.900	-2.26	0.028			
LIUy							0.000031	0.58	0.566			
LFBS										-0.033	-0.12	0.904
LFBSy										-0.000070	-1.60	0.116
LGEXP	-5.495	-1.87	0.067	-1.202	-0.41	0.684	-1.100	-0.27	0.785	0.600	0.22	0.825
LEXPT	4.626	3.37	0.001	2.492	1.11	0.271	2.656	1.20	0.238	1.778	0.73	0.47
INF	0.095	1.92	0.061	-0.026	-1.24	0.221	-0.171	-1.50	0.141	-0.032	-1.16	0.250
Hausman (P-value)			0.000			0.000			0.000			0.009
Poolability (P-value)			0.000			0.000			0.000			0.000
No of Countries	49			49			49			48		
Overall Rsquared	0.028			0.0001			0.021			0.001		
Within Rsquared	0.210			0.121			0.135			0.094		
Between Rsquared	0.0002			0.02			0.023			0.019		
F-test (P-value)			0.000			0.000			0.000			0.000

LINV = log of gross fixed capital formation, $\frac{\Delta y}{y}$ = Economic growth, LFTS = Log of fixed telephone subscriptions per 100 inhabitants, LMCS = Log of mobile cellular subscription per 100 inhabitants, LIU = Log of internet users as percentage of population, LFBS = Log of fixed broadband subscriptions per 100 inhabitants, and INF = inflation rate. LGEXP = log of general government final consumption expenditure, LEXPT = log of export of goods and services. y = real per capita income. LFTSy, LMCSy, LIUy, and LFBSy indicate the interaction of per capita income with each ICT indicators.

Source: Authors' computation, 2021.

In Table 3.4, the overall R^2 is less than 10 percent in each equation. Although the p-values of the F-statistics of the R^2 of the Equations I, II, III, and IV are 0.000, 0.000, 0.000, and 0.000, respectively, which indicates the overall statistical significance for all the equations. However, the four equations have very low goodness of fit or explanatory powers.

Concerning the presence or absence of autocorrelation of the residuals, we carried out Wooldridge test, and the p-value is 0.0327 for Equation 1, 0.0059 for Equation II, 0.0025 for Equation III, and 0.0003 for Equation IV. This suggests that autocorrelation is present in all the equations. We, therefore, estimated a robust version of fixed-effect regression to correct for the autocorrelation.

In order to detect the presence of heteroscedasticity of the residuals, we carried out the panel modified Wald heteroscedasticity test for fixed-effect regression and the p-value is 0.000 for all the equations. Hence, we rejected the null hypothesis of homoscedasticity in the equations and concluded that heteroscedasticity was present. We then estimated a robust version of fixed-effect regression to correct for the heteroscedasticity.

Normality test was carried out using Galvao et al. (2013) test. The test showed that the error terms were not normally distributed as the probability value of chi-square in each equation is less than 0.05 level of significance except for Equation II and IV, of which their probability values are greater than 0.05 significance level. For this reason, we rejected the null hypothesis of normality of the residuals in Equation I and III and concluded that the residuals were not normally distributed. On the other hand, we failed to reject the null hypothesis of normality of the residuals in Equation II and IV and concluded that the residuals were normally distributed. Therefore, the situation was corrected by running a robust version of fixed-effect regression for Equations I and II to correct for the non-normality.

To test for the presence of multicollinearity of the explanatory variables, we carried out the Tolerance test, on the basis of which we failed to reject the hypothesis of absence of multicollinearity in the equations, for the Tolerance coefficient exceeds 0.1 in all cases. By implication, all equations are devoid of severe multicollinearity. Having evaluated the overall diagnostic statistics of each of the equations, we proceeded to examine the significance of the explanatory variables included in the equations.

Table 3.4 shows that the coefficients of *Log of Gross Fixed Capital Formation (LINV)* in Equations I through III are positive and statistically different from zero while its coefficient in Equation IV is statistically insignificant. This suggests that gross fixed capital formation had a positive impact on economic growth. These results partly conform to our a priori expectation, and are in line with that of Bahrini and Qaffas (2019), Hodrab et al. (2016), and Shanmugam and Kuppusamy (2007).

As shown in Table 3.4 (Equation I), *Log of Fixed Telephone Subscriptions (LFTS)* and its interaction with per capita income (*LFTSy*) are statistically significant in explaining economic growth. This implies that the fixed telephone subscription had no effect on economic growth and per capita income did not make it have an effect on economic growth. As regards the impact of *Log of Mobile Cellular Subscriptions* and its interaction with economic growth (*LMCS* and *LMCSy*), Equation II of Table 3.4 shows that the coefficients of *LMCS* and *LMCSy* are negative and positive respectively, and that both of them are statistically significant at 0.05 level of significance. This indicates that mobile cellular subscription had a negative effect on economic growth and this effect is weakened or even removed as per capita income increases, meaning that the observed negative effect applies to only low-income countries and not higher income countries in Africa. These results contradict our a priori expectation.

Table 3.4 (Equation III) shows that the coefficients of *Log of Internet Users* as percentage of total population and its interaction with per capita income (*LIU* and *LIUy*) are negative and positive, respectively, and only the former is statistically significant. This implies that internet usage had a negative effect on economic growth, with the effect being invariant with the level of per capita income attainment. This evidence does not conform to the a priori expectations.

In Equation IV (Table 3.4) the coefficients of Log of Fixed Broadband Subscriptions and that of its interaction with per capita income (*LFBS* and *LFBSy*) are both negative and statistically insignificant. This suggests that fixed broadband subscription had no effect on economic growth and per capita income did not influence the effect of fixed broadband subscription on economic growth.

Summarily, of all ICT indicators, it was only mobile cellular subscription that was influenced by per capita income to promote economic growth. Hence, this seems to suggest that per capita income did not influence the effect of ICT indicators on economic growth.

As reported in Table 3.4, the coefficients of the variable *log of General Government Final Consumption Expenditure (LGEXP)* are negative in Equation I, II, and III and positive in Equation IV and all are statistically insignificant. This points out that government final consumption expenditure had no effect on economic growth. These results do not conform to the a priori expectation stated in the Methodology section and contradict the finding by Asongu and Odhiambo (2019) and Bahrini and Qaffas (2019). This might be due small size of the government recurrent expenditures (e.g. payment of salaries to employees). The little effect recurrent expenditure was supposed to have on GDP could have been crowded out by the imposition of high commodity and income taxes.

The coefficients of *Log of Export of Goods and Services (LEXPT)* indicate that *LEXPT* in Equations I through IV are all positive and statistically insignificant, except in Equation I where the coefficient is statistically significant (Table 3.4). These results suggest that exportation of goods and services did not have a significant effect on economic growth. The results do not conform to the a priori expectation and are inconsistent with that of Pham and Martin (2007), and Hesse (2008). These results were obtained probably because the effect of export on economic growth had been crowded out by excessive borrowing, which leads to distortion of balance of trade and devaluation of domestic currency.

The coefficients of *Inflation rate (INF)* estimated from Equations I through IV are not statistically different from zero, implying that inflation rate did not have an effect on economic growth. This contradicts our a priori expectation, and is also not in tandem with the empirical results obtained by Asongu and Odhiambo (2019), and Eboagu and Adeleye (2019). The rising inflation rate failed to have effect on the economic growth probably because the production capacity is low causing GDP to rise slowly below a level that can lead to economic growth. As a result, unemployment rose and stagflation occurred as inflation.

3.5 Joint Effect of ICT and Region on Economic Growth

The estimates of the four alternative equations of Model 3 are reported in Table 3.5. Equation I examines whether the effect of Fixed Telephone Subscriptions (*FTS*) on economic growth differs among sub-regions of African countries. In Equation II, *FTS* is replaced with mobile cellular subscriptions (*MCS*). Equation III replaces *MCS* with internet usage (*IU*) while in

Equation IV, IU is replaced with fixed broadband subscriptions (FBS). Before estimating these equations, we conducted the following diagnostic tests.

The Hausman test results in Table 3.5 suggest we reject the null hypothesis that random-effect method is preferred to fixed-effect method. In addition, the poolability test indicates that the fixed-effect estimator is preferred compare to pooled OLS regression. Therefore, the fixed-effect method was employed for all the equations. Although the overall R^2 is less than 10 percent for each equation—an indication of low goodness of fit—the p-values of the F-statistic of the R^2 of all the equations indicate the overall statistical significance (Table 3.5).

To ascertain the presence or absence of autocorrelation of the residuals, we carried out the Wooldridge test ($p = 0.0188$) on the basis of which we concluded that autocorrelation was present in all the equations. We therefore estimated a robust version of the FE regression to correct for the autocorrelation. Furthermore, we carried out the panel modified Wald heteroscedasticity test for FE regression for all the equations. However, we rejected the null hypothesis of homoscedasticity in the equations and concluded that stochastic errors in the equations were heteroscedastic. Hence, we estimated a robust version of the FE regression to correct for the heteroscedasticity. The test of normality was carried out using Galvao et al. (2013) test, which showed that the error terms of Equations I and III were not normally distributed ($p < 0.05$) while those of Equations II and IV were ($p > 0.05$). We, therefore, rejected the null hypothesis of normality of the residuals in Equation I and III and concluded that their residuals were not normally distributed. On the other hand, we failed to reject the null hypothesis of normality of the residuals in Equation II and IV and concluded that their residuals were normally distributed. Thus, a robust version of FE regression was estimated for Equation I and III to correct for the non-normality.

Table 4.5 Estimates of the Joint Effect of ICT and Region on Economic Growth

Variables	Equation I			Equation II			Equation III			Equation IV		
	No of Obs. = 424			No of Obs. = 447			No of Obs. = 442			No of Obs. = 413		
	Coeff	T-stat.	p-value	Coeff	T-stat.	p-value	Coeff	T-stat.	p-value	Coeff	T-stat.	p-value
LINV	4.945	2.49	0.016	6.114	2.92	0.005	5.490	2.54	0.014	4.795	2.08	0.043
LFTS	1.231	0.64	0.524									
LFTSE	0.727	0.27	0.792									
LFTSW	0.006	0.00	0.997									
LFTSS	2.376	1.07	0.289									
LFTSN	-1.709	-0.78	0.438									
LMCS				-2.726	-1.21	0.230						
LMCSE				1.748	0.68	0.500						
LMCSW				1.040	0.40	0.694						
LMCSS				2.588	0.88	0.383						
LMCSN				5.462	1.92	0.061						
LIU							-1.311	-1.41	0.165			
LIUE							0.422	0.37	0.710			
LIUW							0.599	0.63	0.535			
LIUS							0.889	0.88	0.383			
LIUN							2.296	1.79	0.080			
LFB										-1.092	-1.81	0.076
LFBSE										1.215	1.58	0.121
LFBW										0.498	0.71	0.483
LFBSS										1.278	1.70	0.095
LFB										1.422	1.20	0.235
LGEXP	-5.359	-1.86	0.069	-1.675	-0.58	0.561	-0.892	-0.23	0.821	-0.423	-0.15	0.878
LEXPT	4.666	3.29	0.002	2.822	1.14	0.259	2.609	1.09	0.281	2.314	0.96	0.342
INF	0.097	1.98	0.053	-0.029	-1.11	0.274	-0.174	-1.55	0.128	-0.020	-0.63	0.532
Hausman (P-value)			0.000			0.000			0.016			0.000
Poolability (P-value)			0.000			0.000			0.000			0.000
No of Countries	50			50			50			49		
Overall Rsquared	0.028			0.018			0.036			0.010		
Within Rsquared	0.211			0.111			0.138			0.092		
Between Rsquared	0.01			0.027			0.066			0.015		
F-test (P-value)			0.000			0.000			0.000			0.001

LFTS, LFTSE, LFTSW, LFTSS, LFTSN, LMCS, LMCSE, LMCSW, LMCSS, LMCSN, LIU, LIUE, LIUW, LIUS, LIUN, LFB, LFBSE, LFBW, LFBSS, and LFB indicate both the reference categories and the ICT indicators interacted with the Sub-regional dummy variables. Hausman (p-value) indicates probability values to select the preferred estimator between Fixed and Random Effect estimator. Poolability (p-value) indicates the probability values to select the preferred estimator between pooled OLS regression and Fixed effect estimator.

Source: Authors' computation, 2021.

Finally, a multicollinearity test (the Tolerance test) was carried out, on the basis of which we failed to reject the hypothesis of absence of multicollinearity in the equations, for the Tolerance exceeds 0.1 in all cases. By implication, all equations are devoid of severe multicollinearity.

Having just evaluated the diagnostic tests of each of the equation, we proceeded to evaluate the explanatory power of independent variables in the equations estimated in Table 3.5 as follows.

The coefficients of the *Log of Gross Fixed Capital Formation* (LINV) in all equations are positive and statistically significant. These results, which conform to our a priori expectations, suggest that gross fixed capital formation had a positive effect on economic growth. Authors such as Bahrini and Qaffas (2019), Hodrab et al. (2016), and Shanmugam and Kuppusamy (2007) also found similar evidence.

The coefficients of *log of General Government Final Consumption Expenditure* (LGEXP) in all equations are negative and statistically insignificant, indicating that general government final consumption expenditure had no effect on economic growth. This does not conform to our a priori expectation, and thus not in consonance with the findings by Asongu and Odhiambo (2019), and Bahrini and Qaffas (2019). This is probably because government recurrent expenditures is small compared to capital expenditures. More so, the little effect recurrent expenditure was supposed to have on GDP had been crowded out by imposing high commodity and income taxes.

Our hypothesis that exportation of goods and services has an impact on economic growth was partly supported as the coefficients of the *Log of Export of Goods and Services* (LEXPT) in the equations in Table 3.5 are positive and statistically insignificant ($p > 0.05$) except in Equation I. This means that exportation of goods and services did not have a statistically significant impact on economic growth. This is contrary to our a priori expectations and the findings by Pham and Martin (2007), and Hesse (2008). This is because the effect of export on economic growth has been crowded out by excessive borrowing from private and public foreign sources which leads to distortion of balance of trade and devaluation of domestic currency.

In Equation I to IV, the coefficients of *Inflation Rate* (INF) are not statistically different from zero, suggesting that inflation did not have significant impact on economic growth. This finding and our a priori expectation are not in tandem, and also not consistent with the findings by Asongu and Odhiambo (2019) and Eboagu and Adeleye (2019). The rate of inflation could not exert perceptible influence economic growth due to the low production capacity, which caused GDP to rise slowly below the level that could lead to economic growth. Therefore, unemployment rose and stagflation occurred.

As regards the variables interacted, the p-values of the coefficients of the ICT indicators and the coefficients of ICT indicators interacted with the regional dummy variables (LFTS, LFTSW, LFTSS, LFTSN, LMCS, LMCSW, LMCSS, LMCSN, LIU, LIUW, LIUS, LIUN, LFBS, LFBSW, LFBSS, and LFBSN) are all greater than 0.05 level of significance. Based on this evidence, the study was able to deduce that the effect of ICT communication technology on economic growth neither existed nor differed among the various sub-regions of African countries.

4. CONCLUDING REMARKS

Given the findings above, this study has established that ICT, general government final consumption expenditure, export of goods and services, and inflation have no effect on economic growth and that only mobile cellular subscription has effect on economic growth in high-income group countries. It has also established that the effect of ICT on economic growth does not differ among sub-regions of Africa. Therefore, authorities should not rely on ICT and general government final consumption expenditure as factors for achieving sustained output growth.

However, this study establishes that, of all the explanatory variables, only gross fixed capital formation has positive effects on economic growth. Thus, to promote economic growth, policy makers need to embark on policies that will boost gross fixed capital formation. Authorities should consider allocation of resources to ICT infrastructure as a priority, and contain the negative effects of inflation and government consumption.

REFERENCES

- Abasiz, T., & Sezer, S. (2018). The effect of information and communication technologies on economic growth in OECD countries. *Annals of the Constantin Brâncuși University of Târgu Jiu, Economy Series, Issue 6*.
- Aghaei, M., & Mahdiah, R. (2017). The impact of information and communication technology (ICT) on economic growth in the OIC countries. *Environmental and Socio-Economic Studies 17*, 255–76.
- Asongu, S., & Odhiambo, N. (2019). Foreign direct investment, information technology and economic growth dynamics in sub-Saharan Africa. *EXCAS Working Paper WP/19/038*. Retrieved from <https://ssrn.com/abstract=3417047> or <http://dx.doi.org/10.2139/ssrn.3417047>.
- Asteriou D., & Hall, S.G. (2006). *Applied econometrics, A modern approach* (Rev. ed.). New York: Palgrave Macmillan.
- Bahrini, R., & Qaffas A. A. (2019). Impact of information and communication technology on economic growth: evidence from developing countries. *Economics*, 7(21), 1-13.
- Baltagi, B. H. (2005). *Econometric analysis of panel data* (3rd ed.). Southern Gate, Chichester: John Wiley & Sons Ltd.
- Can, H., & Terziev, V. (2016). The relationship economic growth and information technologies. Retrieved from SSRN: <https://ssrn.com/abstract=3383899> or <http://dx.doi.org/10.2139/ssrn.3383899>.
- Eboagu, C., & Adeleye, N. (2019). Evaluation of ICT development and economic growth in Africa. *NETNOMICS Economic Research and Electronic Networking*, DOI: 10.1007/s11066-019- 09131-6.
- Farhadi, M., Ismail, R., & Fooladi, M. (2012) Information and communication technology use and economic growth. *PLoS ONE* 7(11): e48903. doi: 10.1371/journal.pone.0048903.
- Galvo, A. F., Montes-Rojas, G., Sosa-Escudero, & Wang, L. (2013). Test for skewness and kurtosis in the one-way error component model. *Journal of Multivariate Analysis*, 12(2), 35-52.
- Hesse, H., (2008). Export diversification and economic growth. Working paper No. 21, Commission to growth and development, World bank, Washington, D.C.
- Hodrab R., Maitah M., & Lubos S. (2016). The effect of information and communication technology on economic growth: Arab world case. *Journal of Economics and Financial Issues*, 6(2), 765-775.
- Kalita, G. & India, R. T. (2013) Panel regression in Stata: An introduction to type of models and tests STATA Users Group Meeting 1st August 2013, Mumbai. Retrieved from: https://www.stata.com/meeting/india13/materials/in13_kalita.pdf
- Pham, C., & Martin W. (2007). Extensive and intensive margin growth and developing country exports. World bank, Washington D.C.
- Shanmugam, B., & Kuppasamy, M. (2007). Islamic countries economic growth and ICT development: The Malaysian case. *Journal of Economic Cooperation*, 28(1), 99-114.

- Toader, E., Firtescu, B. N., Roman A., & Anton S. G. (2018). Impact of information and communication technology infrastructure on economic growth: An empirical assessment for the EU countries.
- Veeramacheneni, B., Ekanayake, E.M., & Vogel, R. (2011). Information technology and economic growth: A causal analysis. *Southwestern Economic Review*, 5(2).
- World Bank. (2019). World development indicators. World bank, Washington, DC; ISBN 978-1- 4648- 0440-3.