THE ICT-ECONOMIC GROWTH NEXUS IN THE 21ST CENTURY: EVIDENCE FROM NIGERIA.

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Abstract

The strategic role ICT plays in shaping the growth trajectory of any nation especially in the 21st century cannot be over-emphasized. ICT has been recognised as the plug that connects modern economies unprecedented ways. Despite huge potentials and opportunities inherent in technological innovations and development, Nigeria still lag behind in closing digital divides with the rest of the modern economic world. It is however against this background that this study examined the impact of ICT on economic growth in Nigeria in the 21st century. The study employed Generalized Method of Moments (GMM) with time series data spanning between 2010 and 2020. The study used GDP per capita as proxy for economic growth and Number of Internet Users (NOI), High Technology Export (HTE), ICT service export, and Foreign Direct Investment (FDI) as proxy for ICT. The study found bi-directional relationship between ICT and economic growth. The study therefore found that number of internet users and ICT service export have positive and significant relationship with economic growth in Nigeria. Population is also found to have positive and significant relationship economic growth in Nigeria. However, High technology Export (HTE), and Foreign Direct Investment (FDI), which is major source of technological import has negative and significant relationship with economic growth.

Keywords: ICT, Economic Growth, GMM, 2SLS.

Introduction

The critical role innovation and Information and Communication Technology (ICT) play in shaping modern economies' growth trajectory cannot be over-emphasized. The impact innovations and technology expansion have on economic development has long been recognised, as ICT aids the increase in availability of information, forms new communication methods, reshaped productive processes and improves the efficiency of many different economic activities (Kurniawati, 2020).

ICT is not only one of the fastest growing industries in the world, but also a critical enabler of innovation and economic prosperity (Alani, 2012). The sector has created millions of jobs over the last 3 decades, contributing significantly to GDP growth with 95 per cent of businesses in OECD countries having online presence. It has also led the emergence of new services and industries with numerous public services now being rendered online and through mobile services. A study shows that Facebook app created 182 thousand jobs in 2011, with economic value exceeding 12 billion dollars in the United States alone(Kvochko, 2013). It has also contributed to global GDP growth with approximately 5 percent of total GDP growth between 2003 and 2008, and it represented 5.4 percent of world's GDP in 2008.That share is expected to reach 8.7 percent by 2020 (Beardsley et al., 2010).

Contemporary discussions on development consistently identify ICT as a prerequisite for economic growth and important factor for the improvement of social conditions. However, this discussion had pre-existed since the advent of computers in the latter parts of the 20th century as government policy advisors and international development agencies have pointed to the opportunities inherent in technology development for development. More recently, the link between ICT and development has been seen as the difference between developed and developing countries and continuous advocacy for the need to bridge the 'digital divide' as a means of reducing global poverty. There is concern that developing countries are deprived of the opportunities for economic growth and life improvement generally enjoyed by advanced economies because of the scarcity of ICT, particularly limited Internet connectivity (Avgerou, 2003).

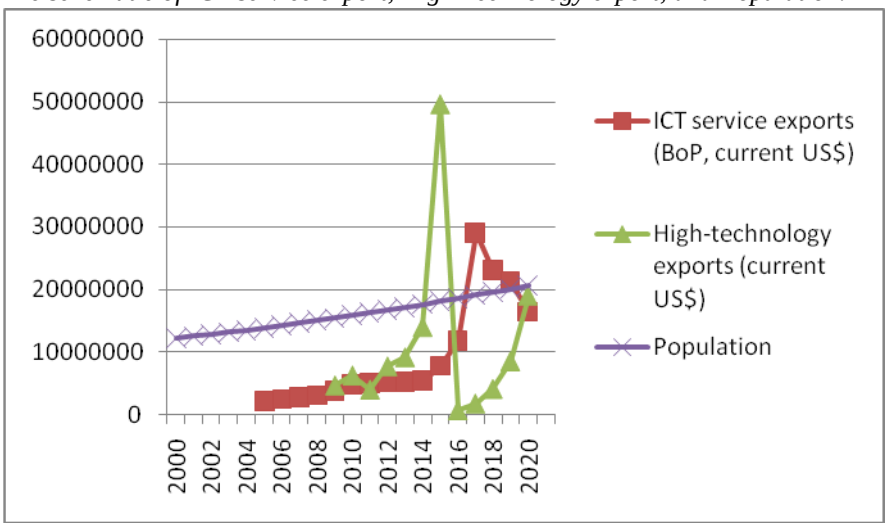
Since the turn of new millennium, ICT has also have tremendous impact on the Nigerian economy. The mobile cellular subscription (per 100 people) in Nigeria increased from 0.03 per 100 people in 2000 to 83 per 100 people in

2016, and mobile cellular subscriptions rose from 30 000 subscribers to an outrageous 154.3 million subscribers by 2016 (World Bank Development Indicators, 2018). Furthermore, the number of individual using the internet also increased from 0.06% in 2000 to 25.7% in 2016. sector has reached 70 billion dollars in 2017, and the mobile-broadband penetration has increased within the space of one year from less than 10% in 2015 to 21% in 2016, although the target is 30% by year 2018 (Danbatta, 2017). The contribution of the telecommunication sector to GDP was also steady at 9% in 2017 (CBN, 2017).

Figure 1 below shows the trajectory of ICT export, High Technology export, and the country's population since the turn of the new millennium. High technology export rose steadily from 42million dollars in 2004, peaked in 2016, and then fell sharply in 2017 before rising again. This fall can be attributed to global economic meltdown between 2016 and 2018 which affected the global demand for goods and services. Similarly, ICT export also rose from 20.4 million dollars in 2005 to 290 million in 2017 and the continue to fall till 2020. This fall can be also attributed to decrease in global demand for goods and services following the global economic crisis which engulfed the world. However, population of the country continued to rise steadily over the same period from 122m in 2000 to over 200m in 2020. Figure 2 shows the trend of Scientific and technological Journal Articles, GDP per capita, and the number of individual with internet (% of the total population). The figure shows that while the number of scientific and technological journal articles rose steadily over the period, GDP per capita rose from 567.6 dollars in 2000 to 3099 dollars in 2014, then began to fall till 2020.

Figure 1

The schematic of ICT service export, High Technology export, and Population.

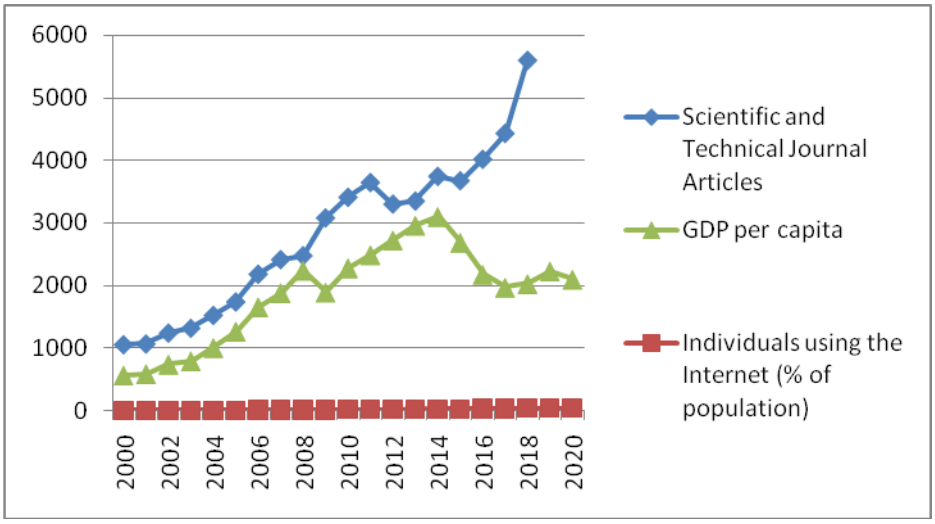


Source: World Development Indicators, 2021

This decline is as a result of a combinations of global economic meltdown to fall in price of crude oil at the international oil market which had serious implications of the country's fiscal regimes, as well as the COVID-19 pandemic which causes unprecedented disruption to the global economy particularly in developing economy like Nigeria. The percentage of individual using the internet has also risen over the period moving from less than 1 per cent in 2000 to 35.5 per cent in 2020.

Figure 2

The trend of Scientific and Technological Journal Articles, GDP per capita, and Individual using the internet (% of the total population)



Source: World Development Indicators, 2021.

In spite of the tremendous contributions ICT to the Nigerian economy, the number of people with access and usage is still very low. The people that have access do not use it for productive activities which will drive economic growth. Most young people in Nigeria use this technology to engage in cyber crime. A survey of computer and cyber crime reported that Nigeria has number of cyber crime in Africa and third most in the world (Isizoh et al., 2013). Today, many financial institutions have been subject of cyber risks and attacks from hackers who gained accesses to their databases thereby siphoning large chunk of their operating capital. Corporate and Individual accounts have also been hacked into by these fraudsters defrauding them huge amount of money with attendant impact of the national economy. A study suggests that banks loses N3.5 billion in 2020 due to cyber crime representing 534 per cent increase from 2019 figure. reports also suggests that web-based related crime represents highest number of fraudulent cases with 35.5 per cent of total financial crime (NIBSS, 2020). Furthermore, the rise in terrorism in Nigeria especially in the Northern region can also be attributed to advancement in ICT, which aided effective communication and operations of the perpetrators (Isizoh, 2013). It is however against this background that this study examines the empirical linkage between ICT and economic growth in Nigeria.

The significance of ICTs in shaping the country's growth trajectory is borne out of fast growth in technological advancement and their market at the turn of the 21st century where the country began to harness ICT for economic growth and sustainable development (Hodrab et al., 2016). Recently, ICT is believed to foster sustainable long-term growth as a production technology through carefully designed ICT systems (Alani, 2012). The principal function of ICT is in enabling humans, governments and organizations to transform information into knowledge as a strong driver in evolving lasting change in the economy and society (Kim, 2013; Lyon, 2013). In this light, plethora of studies have engulfed economic literature on the linkage between ICT and economic growth (Avgerou, 2003; Beardsley et al., 2010; Bilan et al., 2019; Kurniawati, 2020; Stanley et al., 2015; Toader,2018). Several studies examined this linkage in developing countries (Bahrini & Qaffas, 2019; Majid & Ayub, 2018; Nchofoung & Asongu, 2022; Nasab & Aghaei, 2009). Host of studies have also been done on the impact of ICT on economic growth in Nigeria (Akinwale & Sanusi, 2018; Kajugbola, 2004; Ukwuoma, 2019). This study contributes to these body of knowledge by examining new evidence in the ICT-growth nexus. This involves employing new dataset from the turn of new millennium which marks the birth of ICT development in Nigeria. The study is divided into five sections; section two looks at the literature review, section three examines data and methodology of the study, section four presents and analyse the results and section five concludes and provides recommendations for the study.

Various scholars and ICT practitioners have conceptualized ICT in different ways and in varying circumstances. Stanley et al. (2015) refers ICT to a wide variety of technologies, including landlines, cell phones and other mobile communication, computing, and Internet connectivity. Carlaw and Lipsey (2002) see ICT as General Purpose Technology (GPT) which can impact the economy through varieties of spill over and technological complementarities. They posit that, “expand the space of possible inventions and innovations, creating myriad new opportunities for profitable capital investment, which in turn create other new opportunities, and so on in a chain reaction that stretches over decades, even centuries” (p. 1306). Murakami (1997) describes ICT in terms of hardware

and software technologies. ICT is regarded as "hard technology" when refers to as computing equipments used in office settings, among which includes personal computers, workstations, servers, and related equipments. They can also be describes as the entire microelectronic revolution, that is, all products of semiconductor such as computers, telecommunication and broadcasting equipments, as well as, microprocessors in transportation vehicles and home electrical appliances (Carlaw & Lipsey, 2002). On the other hand, ICT is regarded as computer system when the software technology is incorporated with the hardware technology. In broadest term, ICT refers to the entire information revolution. It includes microelectronic revolution, social change, and intensive use of information goods and services throughout the digital economy (Murakami, 1997). It is the New economy where business processes are optimised to achieve greater productivity and the productivity function in some industries enjoy increasing returns to scale. Oloruntoyin and Adeyanju (2013) postulate that ICT is a tool that is capable of enforcing sustainable economic and social development in the society. They further stated that the resultant effect of ICT adoption can be seen in various sector in Nigeria. Similarly, Jakhar (2015), postulates that the ICT play a major role in economic growth and economic development of India. He examined and analyzed how ICT has driven economic growth of India.

Several theoretical studies have linked ICT to economic growth. The Neoclassical (Solow) growth model growth is driven by exogenous technological change. In contrast, endogenous growth theory emphasizes how growth naturally unfolds from investments in human capital and technology development. Endogenous growth theory views ICT as contributing to economic growth through the development of new products, processes and business models (Czernich et al., 2011). ICT is said to result in a permanent (rather than a one-time) increase in productivity growth and thereby raising a country's economic growth rate and creating new employment opportunities. However, negative effects are also theoretically possible where there is no clear and large impact of ICT on economic growth something Brynjolfsson's (1993) is his classic article and Solow on the US economy referred to as "Productivity Paradox". The neo-Schumpeterian theories also suggest that ICT enters as an input into the economic supply in the form of capital and causes the improvement of the production process through deepening capital and making advancements in technology and labour force quality. As a result, ICT creates added value at both the firm level and at the industry level, and therefore leads to the improvement of productivity and economic growth at the country level (Quad, 2002; Aghaei & Rezagholizadeh, 2017). Moore's Law states that the degree of technological progress has beenphenomenal. It extends beyond processing power, with some estimating the increase to be nearly a billion fold to a ten million fold improvement in memory storage and a ten thousand fold improvement in communications speed (Kessler, 2015). The effect of ICT on economic growth isoften studied under the rubric of total factor productivity, a measure of rising outputs holding constant capital and labour inputs.

Although, theoretical literature shows a positive linkage between ICT and economic growth, empirical investigations have produced mixed results. Empirical literatures propose various ways in which ICT can boost economic growth of a country. This can either be through direct and indirect manners: direct through increase in productivity and growth of the industry that produce ICT goods and services; and indirectly through rise in the quality of investment and productivity in industries that use ICT assets as part of their production function (van Ark et al., 2011). This productivity increase manifests in a number of ways. Gruber and Koutroumpis (2010) found using data from 192 countries between 1990 to 2007 that there exist significant positive relationship between mobile telecommunications diffusion and GDP and productivity growth period. Similarly, Vu (2013) finds using econometrics and growth accounting that the intensity of ICT use in Singapore has a significant positive linkage with value-added and economic growth, most of which comes the manufacturing sector. He therefore suggests that government should expansion fiscal allocation in building ICT infrastructure to boost manufacturing and output growth. Bertschek et al. (2015) employ survey methods and use broadband internet to proxy telecommunication. Their results reveal a positive relationship between broadband internet and economic growth. Commander et al.(2011) in their own study found a positive relationship between ICT capital and the productivity of firms in Brazil and India. Brynjolfsson and Hitt (2003) investigate the association between ICT and productivity at both individual firm and industry level. They found a positive relationship between computer investment and firm productivity levels in which the firms that invested more in computers produced more output per unit of input than firms that invest less. In contrast to earlier empirical study, Pohjola (2002) employs panel data of 42 countries between 1985 and 1999 and could not find any significant relationship between ICT and economic growth. Similarly, Stiroh (2002) founds using pooled OLS and Instrumental Variable (IV) model between 1984 and 1999 a negative output elasticity of ICT capital on US manufacturing industries. For similar studies in African countries, Andrianaivo and Kpodar (2011) use a wide range

of ICT indicators from 1988–2007, including mobile phone and fixed telephone penetration rates and the cost of local calls, confirmed that ICT contributed significantly to the economic growth of African countries over the. Similarly, Lee et al. (2012) examine the link between telecommunication infrastructure investments such as land line telephony and mobile phones and economic growth in the SSA. They employ linear GMM estimator on data from 44 SSA countries between 1975 and 2006 and found that mobile phone expansion is an important determinant of the rate of economic growth in Sub-Saharan Africa. Studies on the ICT-Growth nexus in Nigeria take different methodological perspectives, Akinwale and Sanusi (2018) employ the Autoregressive Distributed-Lag (ARDL) model to examine the effect of ICT on economic growth in Nigeria using time series data between 1997 and 2016. They found long run linkage between ICT and economic growth. However, in the short run, only secured internet (per 1 million) and mobile cellular subscription have positive and significant relationship with economic growth. Their study therefore suggest that there is need for strong political will to provide enabling environment for ICT sector to have meaning impact on economic growth.

Data and Methodology

We begin the building block of our growth model from the neo-classical Solow-swan growth theory in which long run (steady) growth is determined by technological progress, labour, and capital (Solow, 1956). The neoclassical growth model is given as:

$Y = Af(K, L)$..... (1)

where Y represents output, K stands for share of capital, and L is number of unskilled labour. A represent the level of technology (technical efficiency) (Gordon, 2022). Empirical literature uses two principal approaches to investigate the impact of ICT on economic growth. One, is the use of the Cobb- Douglas production approach, and secondly, is the growth accounting approach. Given the neoclassical growth model in eqn. (1), if we include N which is the population we can rewrite eqn. (1) as:

$Y_t = A_t K_t^{\alpha} L_t^{\beta} N_t^{\gamma}$ ..... (2)

where subscript t represent time period. Linearizing eqn. (2) we have;

$InY_t = InA_t + \alpha InK_t + \beta InL_t + \gamma InN_t + \varepsilon_t$ ..... (3)

where ε_t is the stochastic disturbance term. If we take eqn. (3) with respect to t, we obtain the growth accounting model given as;

$\dot{Y}_t = \dot{A}_t + \alpha \dot{K}_t + \beta \dot{L}_t + \gamma \dot{N}_t + \varepsilon_t$ ..... (4)

The empirical form of our model can therefore be written as;

$InY_t = \alpha_0 + \alpha_1 NOI_t + \alpha_2 HTE_t + \alpha_3 FDI_t + \alpha_4 POP_t + \alpha_5 ISE_t + \varepsilon_t$ .....(5)

where Y is GDP per capita, NOI is the number of internet users percentage of the population, HTE represent high technology export, FDI is foreign direct investment, POP is the population, and ISE is ICT service export. This study has employed the Cobb-Douglas production function because it has less restrictive assumption and most suited when examining ICT-growth nexus (Nasab & Aghaei, 2009). This study employs time series data between 2000 and 2010. This time frame is chosen to reflect the beginning of internet revolution in Nigeria, and account for when ICT and service sector begin to have considerable impact on the GDP. The study uses the Generalized Method of Moments (GMM) to investigate the impact of ICT on economic growth due to the bi-directional causality between ICT and economic growth and the attendant endogeneity problem associated with such relationship (Kurniawati, 2020). This allows setting orthogonal restriction where the number of sample moment is greater than the number of parameters to be estimated i.e. over-identified restriction. The study uses a combination of omitted explanatory variables, lagged values of the dependent and explanatory variables as instrument to create over-parameterized restriction where the number of moment is greater than the parameters to be estimated. The study uses the Wald test to tests for over-identified restriction and Hansen J test to examine the presence of endogeneity in the model. The GMM model can therefore be written as;

$y_t = \beta' X_i + \beta' Z_i + u_i$ ……(6)

Where y_t is the vector of the dependent variable (GDP per capita), x_i is the vector of independent variable and z_i is the instrument. The study obtains data from the World Bank Development Indicators, National Bureau of Statistics (NBS), and Central Bank of Nigeria (CBN).

Results and Discussions

The results of our empirical analysis are presented in the Tables below. Table 1 shows the descriptive statistics of the variables under investigation with the view of understanding the statistical properties of the dataset. the study then presents the correlation matrix and the Granger causality of the ICT and economic growth with the view of achieving twin objectives of determining the direction of causality of the variables and provide justification for the use of the GMM estimation technique. The descriptive statistics in Table 1 below shows that the average percentage of FDI inflow to GDP is 1.51 which is very low for technology to engender meaningful growth on the Nigerian economy. The average internet users to total population (which on average is 162.5 million) is 15 per cent over the period. Furthermore, the average ICT exports and High technology export during the period are 92.5m and 108.2m dollars respectively. Generally, the data shows high variability and huge dispersion from their mean value. The implication of this result is that there is need to stabilise the dataset by taking the natural logarithm before using it for estimation to avoid biased and inconsistent estimates.

Table 1

Descriptive statistics of the ICT-Growth nexus

Variable	**Mean**	**Maximum**	**Minimum**	**Standard Deviation**	**Obs.**
FDI inflow (% of GDP)	1.51	2.9	0.2	0.804	21
ICT service exports (BoP, current US$)	92555046.95	290045404.4	20216899.47	84995886.51	21
Individuals using the Internet (% of population)	14.80446345	35.5	0.08990137	11.9120379	21
High-technology exports (current US$)	108221072.3	495095300	7388348	132179254.6	21
GDP per capita	1940.851869	3098.985791	590.381815	733.18459	21
Population	162560284.3	206139587	125394046	25292073.07	21

Source: Author Computation from Eviews 11.

Table 2 below shows the correlation matrix of the variables under consideration. The results show that there is presence of multicollinearity among the regressors. However, each of the regressor shows high degree of association with dependent variable (GDP per capita) except high technology export which shows very low degree of association with GDP per capita. This result is unsurprising given the technology development of the country. Furthermore, the government is investment little in technology innovations and development, as well as research and development to galvanise substantial increase in the GDP. Most technology innovations are still largely private sector driven and underdeveloped when compared to other sectors of the economy (such as, oil and gas and agriculture) that is enjoying significant government presence.

Table 2

Correlation matrix of the ICT and economic growth nexus

	GDP	FDI	HTE	NOI	POP	ISE
GDP	1	0.7654	0.1034	0.5432	0.9762	0.4567
FDI	0.7654	1	0.6543	0.4563	0.8765	0.4593
HTE	0.1034	0.6543	1	0.7682	0.8976	0.7986
NOI	0.5432	0.4563	0.7682	1	0.8954	0.9812
POP	0.9762	0.8765	0.8976	0.8954	1	0.7654
ISE	0.4567	0.4593	0.7986	0.9812	0.7654	1

Source: Author Computation from E-views 11.

This study proceeds to present the Granger causality test to provide valid justification for the use the GMM estimation methods. This is presented in Table 3 below.

Table 3

Granger Causality test of ICT and economic growth

Null Hypothesis	**Obs**	**F-stat**	**Prob**
InFDI does not Granger cause InGDP	21	4.325	0.016
InGDP does not Granger cause InFDI	21	0.156	0.872
InHTE does not Granger cause InGDP	21	1.325	0.616
InGDP does not Granger cause InHTE	21	1.156	0.572
InNOI does not Granger cause InGDP	21	4.325	0.003
InGDP does not Granger cause InNOI	21	5.156	0.001
InPOP does not Granger cause InGDP	21	12.345	0.0003
InGDP does not Granger cause InPOP	21	4.156	0.037
InISE does not Granger cause InGDP	21	7.325	0.006
InGDP does not Granger cause InISE	21	3.156	0.052

Source: Author Computation from E-views 11.

The results of Table 3 above show that there is bi-directional relationship between the ICT variables and GDP per capita except high technology export which amplifies the result of the correlation matrix in Table 2. There is bidirectional relationship between NOI and GDP at 1 per cent level. there is also bidirectional relationship between ISE and GDP at 1 per cent and 5 per cent level respectively.

Table 4

GMM Estimation using the 2SLS method

Dependent Variable: $InGDP$

Variable	Coefficient	Std. error	t-stat.	Prob.
C	12.457	0.243	(3.567)	0.015
$InNOI$	0.0245	0.124	(4.035)	0.003
$InHTE$	-1.432	-2.567	(0.563)	0.7645
$InFDI$	-0.351	0.0459	(3.702)	0.0043
$InPOP$	234.542	0.00342	(7.854)	0.0002
$InISE$	0.127	0.245	(3.042)	0.0506
R-squared	0.7894			
Adjusted R^2	0.7325			
Durbin-Watson Stat	1.87			
Instrument Rank	9			
J-Stat	1.543			
J (Prob)	0.7543			

Source: Author Computation from Eviews 11.

The result shows that there is unidirectional relationship between FDI and GDP, and population and GDP respectively. There is no evidence of statistical relationship between HTE and GDP. The reason for this result is borne out of little or no government investment in ICT infrastructure in the country. Most ICT investments are still

largely private sector driven, which is grossly insufficient to engender economic growth through innovation and technology export. This result also shows that there may be endogeneity problem in the model and its attendant biased and inconsistent estimates if ignored by using the tradition OLS to estimate the parameters of the model. In this light, the study presents the GMM estimates in Table 4 below to avoid endogeneity problems associated with bi-directional models. The study employs the 2 Stage Least Squares (2SLS) approach to create over-identified restriction and makes use of lagged values of the GDP and the explanatory variables (lagged by 1 period) as instrument for the model. The model is said to be over-identified when the number of sample moments is greater than the number of parameters to be estimated (Greene, 2005; Woodridge, 2001).

From Table 4 above, the result shows that the number of internet users (per cent of population) has positive and significant effect on GDP per capital. A per cent increase in number of internet users increases the GDP per capita by 0.023 per cent. Population and ICT service export also have positive and significant influence on GDP per capita. One per cent increase in population and ICT service export will increase the GDP per capita by 234.5 per cent and 0.13 per cent respectively. However, High technology export is not only insignificant but also wrongly signed. Surprisingly, foreign direct investment, although significant is wrongly signed. The implication of this is that a per cent in FDI will decrease the GDP per capita by 0.35 per cent. The model shows good fit as 79 per cent of systematic variation in the GDP is jointly accounted for by the explanatory variables. The Durbin-Watson stat also shows there is absence of autocorrelation in the model. Furthermore, The J-stat reveals that the instruments are valid and satisfies that orthogonality condition. Therefore, we accept the null hypothesis that the parameters in the model is over-identified. This result is not only consistent with the neoclassical growth theory that long run (steady) is influenced by technological innovation and improvement, but also consistent with the works of Koutroumpis (2010);Bertschek et al. (2015); Akinwale & Sanusi (2018). However, the findings of this study contrast the submissions of Pohjola (2002) and Stiroh (2002). The Wald test (F-stat=14.6) shows that the model is quite robust and all variables in the model are relevant, significant at 1 per cent level. Finally, the result of the Hansen J-stat shows that there exist endogeneity problem in the regressors. This result justifies the use of the GMM estimation method to avoid estimation problems associated with the existence of endogeneity among the regressors. The policy implication of this empirical analysis is that technological innovations can be used to drive long run economic growth in Nigeria. The fact that FDI has negative significant relationship GDP per capita suggests that Nigeria's industrial and foreign policies is unfavourable too investors and would-be investors. Furthermore, little or no policy intentions is given to developing ICT infrastructure in the country that galvanise and attract foreign investment in the ICT sector.

Conclusion

This study examines the impact of ICT on economic growth in Nigeria using time series data between 2000 and 2020. The bi-directional relationship between ICT and economic growth in the literature informs the use of the GMM to test the parameters of the study. This enables the study create over-identified restriction where the number of sample moment is greater than the number of parameter to be estimated to avoid endogeneity problem in the literature. This is amplified by testing the Granger causality, which confirms bi-directional relationship between ICT and economic growth in the literature. The study therefore found that ICT has positive and significant relationship with economic growth in Nigeria. However, FDI which is major source of technological import has negative and significant relationship with economic growth. The study therefore recommends that more should be done on the part of the government to improve ICT infrastructure in Nigeria, as most ICT investments in the country are still largely private sector driven. Furthermore, concerted efforts should be made by the government to create enabling environment for ICT and FDI to not only attract investors and would-be investors, but also serve as an engine of economic growth.

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